Montana Department of ENVIRONMENTAL QUALITY

Kootenai – Fisher Project Area Metals, Nutrients, Sediment, and Temperature TMDLs and Water Quality Improvement Plan

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ACRONYM LIST

Acronym	Definition
AAL	Acute Aquatic Life
AFDM	Ash-Free Dry Mass
AFDW	Ash Free Dry Weight
AL	Aquatic Life
AMB	Abandoned Mine Bureau
AML	Abandoned Mine Lands
ARM	Administrative Rules of Montana
BEHI	Bank Erosion Hazard Index
BFW	Bankfull Width
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
CAL	Chronic Aquatic Life
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
COOP	Cooperative Observer Program
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
DOI	Department of the Interior (federal)
DOT	Department of Transportation (Montana)
DQO	Data Quality Objectives
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
HBI	Hilsenhoff Biotic Index
HDPE	High-Density Polyethylene
HUC	Hydrologic Unit Code
INFISH	Inland Native Fish Strategy
IR	Integrated Report
KNF	Kootenai National Forest
LA	Load Allocation
LWD	Large Woody Debris
MARS	Montana Aquatic Resources Services, Inc.
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MFISH	Montana Fisheries Information System
MOS	Margin of Safety

Acronym	Definition
MPDES	Montana Pollutant Discharge Elimination System
NEPA	National Environmental Protection Act
NHCP	Native Fish Habitat Conservation Plan
NHD	National Hydrography Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PEL	Probable Effects Levels
PIBO	PACFISH/INFISH Biological Opinion
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAWS	Remote automatic weather stations
RIT/RDG	Resource Indemnity Trust / Reclamation and Development Grants Program (RIT/RDG)
SAP	Sampling and Analysis Plan
SMCRA	Surface Mining Control & Reclamation Act
SMZ	Streamside Management Zone
SNOTEL	Snowpack Telemetry
STORET	EPA STOrage and RETrieval database
SWPPP	Storm Water Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TR	Total Recoverable
TSS	Total Suspended Solids
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
UUILT	Ultimate Upper Incipient Lethal Temperature
WEPP	Water Erosion Prediction Project
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for seven impaired streams in the Kootenai-Fisher TMDL Project Area: Big Cherry Creek, Lake Creek, Libby Creek, Raven Creek, Snowshoe Creek, Stanley Creek, and Wolf Creek (**Figure A-8** in **Appendix A**). The 20 TMDLs in this document address impairment from sediment, nutrients, temperature, and metals (**Table DS-1**).

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

The project area encompasses approximately 2,503 square miles and contains the Fisher River watershed and a portion of the Kootenai River watershed, located in northwestern Montana (**Figure A-1** in **Appendix A**). The majority of the project area is contained in Lincoln County but a very small portion lies in Flathead County. The Salish and Cabinet Mountains create drainage divides to the east and south and the Yaak River drainage lies to the northwest. Bobtail Creek is within the project area but was excluded from this project because TMDLs were completed there in 2005 (Lindgren and Anderson, 2005). It is also important to note that the Kootenai River itself is not included in this TMDL project and will be addressed during future TMDL development efforts.

Sediment

Four sediment TMDLs are provided for four waterbody segments in the Kootenai-Fisher TMDL Project Area (**Table DS-1**): Lake, Libby, Raven, and Wolf creeks. Bristow and Quartz creeks are on the 2012 303(d) List for sediment impairment, but data collected to support TMDL development indicate they are no longer impaired for sediment and will be removed from the 303(d) list. For the four streams with sediment TMDLs, excess sediment is limiting their ability to fully support aquatic life. Water quality restoration goals for sediment were established in this document on the basis of fine sediment levels in trout spawning areas and aquatic insect habitat, stream morphology and available instream habitat as it relates to the effects of sediment, and the stability of streambanks. DEQ believes that once these water quality restoration goals are met, all beneficial uses currently affected by sediment will be restored.

Existing sediment loads are quantified for the following sources: streambank erosion, hillslope erosion, unpaved roads, and permitted point sources. To meet the TMDLs, permit conditions must be followed for point sources and nonpoint sources must implement all reasonable land, soil, and water conservation practices. Annual reductions in sediment loading of 12% to 29% are necessary to meet the TMDLs and 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 maintaining unpaved roads and improving upland land cover and expanding riparian buffer areas by using land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Nutrients

Three nutrient TMDLs are provided for three waterbody segments in the Kootenai-Fisher TMDL Project Area (**Table DS-1**): Nitrate/nitrite for Lake and Stanley creeks and total phosphorus for Raven Creek. Nutrient and/or biological data in these streams indicate nutrients are present in concentrations that can cause algal growth that harms recreation and aquatic life beneficial uses. Water quality restoration goals for nutrients were based on Montana's draft numeric nutrient criteria, measures of algal growth/density, and biological metrics for macroinvertebrates and periphyton.

Potential sources are mining (from blasting residuals), timber harvest, septic systems, and grazing. Based on monitoring data, mining is a dominant source of nitrate/nitrite loading to Stanley and Lake Creeks, but other sources are contributing as well. For Raven Creek, excess sediment associated with unpaved roads, streambank erosion, and upland sources is the primary source of phosphorus. For Stanley and Lake creeks, additional monitoring and refinement of the source assessment is recommended to help determine where and which type of BMPs will be most effective. For Raven Creek, BMPs necessary to meet the sediment TMDL are anticipated to result in meeting the total phosphorus TMDL. TMDL examples based on monitoring data indicate reductions up to 86% are necessary. However for all three streams, exceedances of the water quality standard are very sporadic, indicating only minor improvements are necessary to meet the TMDLs.

Temperature

A temperature TMDL was completed for Wolf Creek. Historic removal of riparian vegetation, which is important for regulating stream temperature by providing shade, is the primary cause of impairment. Water quality restoration goals focus on improving riparian shade, however, maintaining stable stream channel morphology and instream flow conditions during the hottest months of the summer are also important for meeting the TMDL. DEQ believes that once these water quality goals are met, all water uses currently affected by temperature will be restored given all reasonable land, soil, and water conservation practices.

The Wolf Creek temperature TMDL indicates that reductions in maximum daily water temperatures ranging from 0.7°F to 7.8°F are necessary. General strategies for achieving the instream water temperature reduction goals are also presented in this plan and include BMPs for managing riparian areas.

Metals

Twelve metals TMDLs are provided for four waterbody segments in the Kootenai Fisher TMDL Project Area (**Table DS-1**): Big Cherry, Lake, Snowshoe, and Stanley Creeks. The metals of concern include: arsenic, cadmium, copper, lead, and zinc. Water quality restoration goals for metals are established based on numeric water quality criteria defined in Montana's Numeric Water Quality Standards. DEQ believes that once these water quality goals are met, all water uses currently affected by metals will be restored.

Metals loads are quantified for natural background conditions, abandoned mines, and diffuse sources (e.g., land management practices that increase erosion of mineralized soils). The metals TMDLs require reductions in metals loads ranging from 0% to 98%, which mostly rely on reclamation of abandoned mines. State and federal programs, as well as potential funding resources, to address metals sources are summarized in this plan.

Water Quality Improvement Measures

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

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. 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.

Although most water quality improvement measures are based on voluntary measures, federal law specifies permit requirements developed to protect narrative water quality criterion, a numeric water quality criterion, or both, to be consistent with the assumptions and requirements of wasteload allocations (WLAs) on streams where TMDLs have been developed and approved by EPA. The sediment TMDL for the lower segment of Libby Creek includes wasteload allocations for two permitted discharges.

Table DS-1. List of Impaired Waterbodies and Their Impaired Uses in the Kootenai-Fisher TMDL Project Area with Completed Metals, Nutrients, Sediment, and Temperature TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s) [1]
BIG CHERRY CREEK, Snowshoe Creek to mouth (Libby Creek)	Cadmium	Metals	Aquatic Life
	Lead	Metals	Aquatic Life
	Zinc	Metals	Aquatic Life
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	Copper	Metals	Aquatic Life
	Lead	Metals	Aquatic Life
	Nitrate + Nitrite	Nutrients	Aquatic Life Primary Contact Recreation
	Sediment / Siltation	Sediment	Aquatic life
LIBBY CREEK, Highway 2 bridge to mouth (Kootenai River)	Sediment / Siltation	Sediment	Aquatic life
RAVEN CREEK, Headwaters to mouth (Pleasant Valley Fisher River)	Total Phosphorus	Nutrients	Aquatic life Primary Contact Recreation
	Sediment / Siltation	Sediment	Aquatic Life
SNOWSHOE CREEK, Cabinet Wilderness boundary to mouth (Big Cherry Creek)	Arsenic	Metals	Drinking Water
	Cadmium	Metals	Aquatic Life Drinking Water
	Lead	Metals	Aquatic Life Drinking Water
	Zinc	Metals	Aquatic Life

Table DS-1. List of Impaired Waterbodies and Their Impaired Uses in the Kootenai-Fisher TMDL Project Area with Completed Metals, Nutrients, Sediment, and Temperature TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s) [1]
STANLEY CREEK,[2] Headwaters to mouth (Lake Creek)	Copper	Metals	Aquatic Life
	Lead	Metals	Aquatic Life
	Zinc	Metals	Aquatic Life
	Nitrate + Nitrite	Nutrients	Aquatic life Primary Contact Recreation
WOLF CREEK, Headwaters to mouth (Fisher River)	Sediment / Siltation	Sediment	Aquatic Life
	Temperature	Temperature	Aquatic Life

[1.] Impaired uses given in this table are based on updated assessment results and may not match the “2012 Water Quality Integrated Report.”

[2.] The Stanley Creek waterbody segment location description reads as “Stanley Creek, headwaters to confluence with Fairway Creek” in the 2012 Integrated Report. The segment was extended to the confluence with Lake Creek and the new location description will be reflected in the 2014 Integrated Report

1.0 PROJECT OVERVIEW

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for metals, nutrients, sediment, and temperature problems in the Kootenai – Fisher TMDL Project Area. This document also presents a general framework for resolving these problems. **Figure A-1** found in **Appendix A** shows the location of the project area and **Figure A-8** shows the waterbodies in the Kootenai – Fisher TMDL Project Area with metals, nutrients, sediment, and temperature pollutant impairments. This project addresses streams from both the Kootenai TMDL Planning Area and the Fisher TMDL Planning area, and is thus called the Kootenai – Fisher TMDL Project Area.

1.1 WHY WE WRITE TMDLS

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.

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

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

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every two years the Montana Department of Environmental Quality (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, whereas TMDLs are not required for non-pollutant causes of impairments. **Table A-1** in **Appendix A** identifies all impaired waters for the Kootenai-Fisher TMDL Project Area from Montana's 2012 303(d) List, and includes non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a). **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 (see **Sections 10.0** and **11.0** of this document).

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 "2012 Water Quality Integrated Report" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a) that are addressed in this document (also see **Figure A-8** in **Appendix A**). Each pollutant impairment falls within a TMDL pollutant category (e.g., metals, nutrients, sediment, or temperature), and this document is organized by those categories.

New data assessed during this project identified new nutrient and metals impairment causes for seven 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). Instead, these waters will be documented within DEQ assessment files and incorporated into the 2014 IR.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 20 TMDLs (**Table 1-1**). There are several non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 9.0**. **Sections 10.0** and **11.0** also provide some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. This document only addresses those impairments identified in **Table 1-1**. This project did not include the Kootenai River or Lake Koocanusa. The Kootenai River is identified on the "2012 Water Quality Integrated Report" as having a temperature impairment and Lake Koocanusa has an identified selenium impairment in the 2012 IR (**Table A-1** in **Appendix A**). DEQ has been conducting water quality monitoring on both waterbodies and both will be addressed in a future project. Additionally, Cripple Horse, Dry, and Keeler creeks have non-pollutant impairments that were not addressed in this project, but are discussed in **Section 9.0**.

In 2005, a sediment TMDL was completed for Bobtail Creek, a tributary to the Kootenai River (**Figure A-1** in **Appendix A**). The "Water Quality Restoration Plan and Total Maximum Daily Loads (TMDL) for the Bobtail Creek Watershed" includes strategies for implementation and monitoring (Lindgren and Anderson, 2005). DEQ will conduct water quality monitoring and complete a TMDL Implementation Evaluation in the future to evaluate water quality conditions and determine if water quality standards are being met and Bobtail Creek's designated uses are being supported.

Table 1-1. Water Quality Impairment Causes for the Kootenai-Fisher TMDL Project Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2012 Integrated Report [3]
BIG CHERRY CREEK, Snowshoe Creek to mouth (Libby Creek)	MT76D002_050	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
		Cadmium	Metals	Cadmium TMDL completed	No
		Lead	Metals	Lead TMDL completed	No
		Zinc	Metals	Zinc TMDL completed	Yes
BRISTOW CREEK, headwaters to mouth at Lake Koocanusa	MT76D002_110	Nitrogen (Total)	Nutrients	Not impaired based on updated assessment	Yes
		Sedimentation / Siltation	Sediment	Not impaired based on updated assessment	Yes
CRIPPLE HORSE CREEK, Headwaters to mouth (Lake Koocanusa)	MT76D002_100	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
DRY CREEK, 1 mile upstream from State Highway 56 to mouth (Lake Creek)	MT76D002_020	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
FISHER RIVER, Silver Butte / Pleasant Valley junction to mouth (Kootenai River)	MT76C001_010	Lead	Metals	Not impaired based on updated assessment	Yes
KEELER CREEK, Headwaters to Lake Creek	MT76D002_030	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes

Table 1-1. Water Quality Impairment Causes for the Kootenai-Fisher TMDL Project Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2012 Integrated Report [3]
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	MT76D002_070	Cadmium	Metals	Not impaired based on updated assessment	Yes
		Copper	Metals	Copper TMDL completed	Yes
		Lead	Metals	Lead TMDL completed	Yes
		Mercury in water column	Metals	Not impaired based on updated assessment	Yes
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	NO_2 + NO_3 TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
		Zinc	Metals	Not impaired based on updated assessment	Yes
LIBBY CREEK, from 1 mile above Howard Creek to Highway 2 bridge	MT76D002_061	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
		Mercury	Metals	Not impaired based on updated assessment	Yes
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
LIBBY CREEK, Highway 2 bridge to mouth (Kootenai River)	MT76D002_062	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
QUARTZ CREEK, Headwaters to confluence with Kootenai River	MT76D002_090	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Not impaired based on updated	Yes
		Sedimentation / Siltation	Sediment	Not impaired based on updated assessment	Yes

Table 1-1. Water Quality Impairment Causes for the Kootenai-Fisher TMDL Project Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2012 Integrated Report [3]
RAVEN CREEK, Headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by TP TMDL	Yes
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Not impaired based on updated assessment	Yes
		Nitrogen (Total)	Nutrients	Not impaired based on updated assessment	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
SNOWSHOE CREEK, Cabinet Wilderness boundary to mouth (Big Cherry Creek)	MT76D002_040	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL	Yes
		Arsenic	Metals	Arsenic TMDL completed	No
		Cadmium	Metals	Cadmium TMDL completed	Yes
		Lead	Metals	Lead TMDL completed	No
		Zinc	Metals	Zinc TMDL completed	Yes
STANLEY CREEK, Headwaters to mouth (Lake Creek) [4]	MT76D002_010	Copper	Metals	Copper TMDL completed	Yes
		Lead	Metals	Lead TMDL completed	No
		Zinc	Metals	Zinc TMDL completed	No
		Nutrient / Eutrophication Biological Indicators	Nutrients	Impairment cause removed; replaced by NO_2 + NO_3	Yes
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	NO_2 + NO_3 TMDL completed	No
WOLF CREEK, Headwaters to mouth (Fisher River)	MT76C001_020	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
		Temperature, water	Temperature	Temperature TMDL completed	Yes

1. All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)
2. TP = Total Phosphorus, NO_2+NO_3 = Nitrite + Nitrate
3. Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in the 2014 Integrated Report.
4. The Stanley Creek waterbody segment location description reads as "Stanley Creek, headwaters to confluence with Fairway Creek" in the 2012 Integrated Report. The segment was extended to the confluence with Lake Creek and the new description will be reflected in the 2014 Integrated Report.

1.3 What This Document Contains

This document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy, as well as a strategy to address impairment causes other than metals, nutrients, sediment, and temperature. 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 Kootenai-Fisher Project Area Description:
Describes the physical characteristics and social profile of the project area.

Section 3.0 Montana Water Quality Standards
Discusses the water quality standards that apply to the Kootenai-Fisher project area.

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

Sections 5.0 – 8.0 Sediment, Temperature, Nutrients, 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 9.0 Non-Pollutant Impairments:
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 10.0 Water Quality Improvement Plan:
Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs.

Section 11.0 Monitoring Strategy and Adaptive Management:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Kootenai-Fisher Project Area Metals, Nutrients, Sediment, and Temperature TMDLs and Water Quality Improvement Plan."

Section 12.0 Public Participation & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of this plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 KOOTENAI – FISHER PROJECT AREA DESCRIPTION

This section includes a summary of the physical, ecological and cultural profile of the Kootenai-Fisher Project Area and is intended to provide background information to support total maximum daily load (TMDL) development. The maps referenced in this discussion are contained in **Appendix A, Table of Waterbody Impairments and Project Area Description Maps**.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Kootenai-Fisher TMDL Project Area and includes a discussion of location, topography, geology, soils, surface water, groundwater and climate.

2.1.1 Location

The project area encompasses approximately 2,503 square miles in northwestern Montana as shown in **Figure A-1**. The project area encompasses the Fisher River watershed and a portion of the Kootenai River watershed. Majority of the project area is contained in Lincoln County and includes the Town of Troy and the City of Libby. A very small portion of the project area lies in Flathead County. The project area is bounded to the north by Canada and to the west by the Idaho state line. The Salish and Cabinet Mountains create drainage divides to the east and south and the Yaak River drainage lies to the northwest. The omitted land inside the project area's perimeter is the Bobtail Creek watershed which is not included in the Kootenai-Fisher Project Area because it was the subject of previous TMDL work, resulting in the 2005 ”Water Quality Restoration Plan and Total Maximum Daily Loads (TMDL) for the Bobtail Creek Watershed” document (Lindgren and Anderson, 2005). It is also important to note that the Kootenai River itself is not included in this TMDL project, and therefore this project area description does not include a profile of the river or Lake Koocanusa.

2.1.2 Topography

Elevations in the Kootenai-Fisher Project Area range from approximately 1,800 feet above sea level where the Kootenai River flows out of the project area into Idaho, to approximately 8,700 feet on the summit of A Peak in the Cabinet Mountains. Valley bottom elevations average around 2,600 feet. The landscape is dominated by mountain ranges intercepted by large river valleys. Elevation is mapped on **Appendix A**, **Figure A-2**. Like topography, slopes in the project area vary greatly. The flat valley bottoms register 0° slopes but the steepest parts of the Cabinet Mountains have slopes over 80°. **Appendix A, Figure A-3** shows slopes calculated from the 30-meter National Elevation Dataset.

2.1.3 Geology

Appendix A, Figure A-4 and **Figure A-5** provide an overview of the generalized geology based on a 1:500,000 scale geologic map of the state (Raines and Johnson, 1995). The first map displays standard geologic units and the second map indicates the dominant type of rock found in each unit.

Bedrock

Metasedimentary rocks from the Precambrian Eon formed 1,600 – 1,000 million years ago are the oldest and most widespread basement rocks in the project area. The primary rock types comprising this Belt Supergroup series are meta-argillite, quartzite and carbonate. The first two listed are formed under intense heat and pressure making them reasonably resistant to erosion. Later in the Cretaceous Era (100

– 65 million years ago) the Belt Series was punctuate by igneous intrusions in small portions of the project area and extensive mountain building occurred. These intrusions are associated with the Idaho Batholith unit and are mostly granitic.

Glaciation
Within the last 3 million years, the Cordilleran ice sheet advanced and retreated numerous times across the project area producing three forms of Quaternary deposits: lake sediments (lacustrine), river sediments (fluvial) and glacially-derived sediment. During the most recent Pinedale glaciation (16,000 years ago), the Kootenai-Fisher project area was the southern-most extent of the Cordilleran ice sheet that stretched as far north as the Alaskan Peninsula and covered everything but the highest Cabinet Mountain peaks (**Figure 2-1**). The maximum thickness of the ice sheet near the confluence of the Fisher River was approximately 4,000 feet (Langer et al., 2011). As the glacier started to thin, more mountains ranges were exposed and northward-retreating glaciers were confined to valleys. The northward-flowing tributaries to the Kootenai River, such as Libby Creek, Lake Creek and the Fisher River, were ice-dammed lakes during this time. Water level in these individual glacial lakes fluctuated as the ice sheet melted and various spillways were created until the Kootenai River valley opened up and the smaller lakes merged into one Glacial Lake Kootenai (Langer et al., 2011). As the ice sheet continued to retreat-northward Glacial Lake Kootenai drained and became a braided river system downcutting through lacustrine deposits creating gravel terraces and point bars. Ice dams in present day Idaho caused portions of Glacial Lake Kootenai to reflood at least once more before draining for a final time around 11,000 years ago. Glacial processes formed cirques, moraines, and U-shaped valleys we recognize today as the landscape in the Kootenai-Fisher project area.

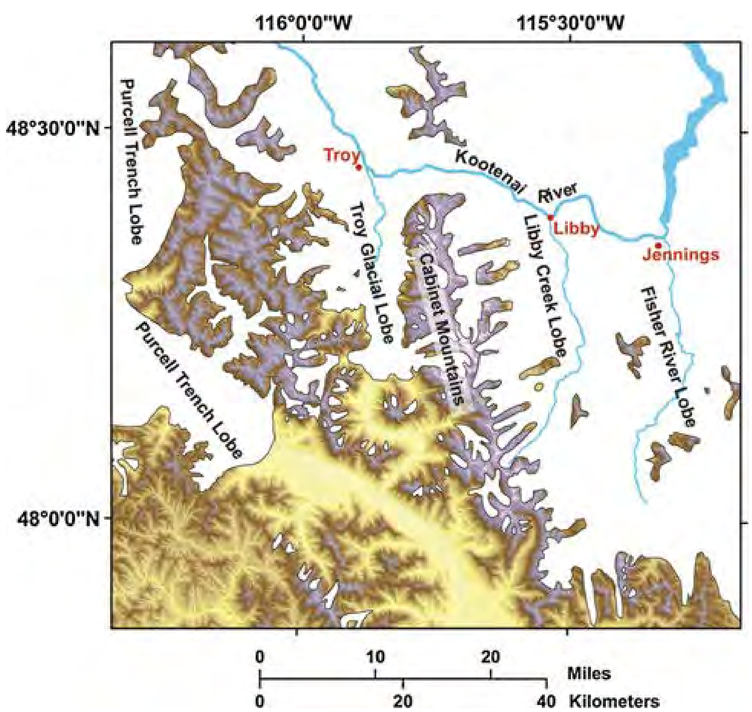

Figure 2-1. Map showing the maximum extent of the Cordilleran ice sheet in the Libby area (Langer et al., 2011)

2.1.4 Soil

The U.S. General Soil Map developed by the National Cooperative Soil Survey and based on the STATSGO2 dataset was used to evaluate soil properties in the Kootenai-Fisher Project Area. **Appendix A**, **Figure A-6** depicts coverage of the five soil orders that exist within the project area. Soil orders are the broadest level of soil taxonomy and combine soils into units with similar physical and chemical attributes. Soils of the same order typically share properties because they formed under similar scenarios. Investigating the distribution of soil orders in the project area can help better understand soil behavior and potential effects to water quality.

Inceptisols are the most common order in the project area and are known for only having a slight degree of weathering and soil development because they are considered geologically young or because the conditions under which they exist have only led to a slight modification from their original state. Inceptisols are found in the mountainous regions along with Andisols which are also considered relatively unweathered. Andisols are uniquely derived from ash and cinders deposited near or downwind of volcanic eruptions. When combined with sufficient organic matter, as is the case in the Kootenai-Fisher Project Area where evergreen forests dominate the landscape and precipitation is relatively high, Andisols have a high water-holding capacity and resist erosion. Valleys and portions of the Salish Mountains are classified under the Alfisol soil order. These soils are moderately weathered and distinguished by an accumulation of silicate clay in the soil profile. Alfisols are susceptible to erosion, especially if the soil is high in sand content and the natural litter layer is disturbed (Brady and Weil, 2002). The remaining soils (< 4% of the project area) are Entisols or Mollisols: Entisols are the least developed soil order; Mollisols are moderately weathered, typically develop under grasslands, and are distinguished by an accumulation of calcium-rich organic matter. The Entisol unit surrounding Lake Creek just south of Troy matches the location of a smaller glacier that became isolated from the Cordilleran ice sheet. As Glacial Lake Libby drained to the west, alluvial sediments were caught between this detached ice sheet and the western valley (Langer et al., 2011) thus explaining the early stage of soil development in that localized area.

A soil’s susceptibility to erosion is a property especially relevant to TMDLs when reviewing upland sources. Erodibility is mapped in **Appendix A**, **Figure A-7** using the K-factor from the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). The K-factor is an inherent property of the soil that is independent of rainfall, slope, vegetation cover, and management differences. Values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Soil erodibility is assigned to the following ranges: low (0.0-0.2), moderate-low (0.21-0.30) and moderate-high (0.31-0.40). Values of > 0.4 are considered highly susceptible to erosion. The majority of the project area has moderate-high susceptibility soils (41%) or low susceptibility soils (38%). Another 8% is identified as moderate-low susceptibility and less than 1% is high susceptibility. All soil units identified as highly susceptible to erosion are Alfisols, supporting the general properties described previously for that soil order. The remaining area (13%) is either open water or does not have data available to determine K-factors.

2.1.5 Surface Water

This project combines the Fisher River watershed (HUC 1710102) and a portion of the Upper Kootenai River watershed (HUC 17010101) into one TMDL project area. Water originating in the headwaters region of Fisher River joins the Kootenai River flowing out of Lake Koocanusa, which is filled by tributaries on both sides of the international boundary, and continues flowing westward as the Kootenai River until it exits the project area northwest of Troy. The Kootenai and Fisher watersheds are part of the larger Columbia River Basin which eventually discharges into the Pacific Ocean. No stream sections in the project area have been given National Wild and Scenic River status, although many are considered eligible candidates by the USFS (U.S. Forest Service, 2011). **Appendix A**, **Figure A-8** displays impaired waterbodies in the planning area according to the 2012 303(d) List. Some of these impairment determinations have been revised following assessments performed during this TMDL project and those adjustments will be captured on subsequent 303(d) lists. Also note that the Kootenai River and Lake Koocanusa have current impairment listings, but these waterbodies will be addressed separate from the Kootenai-Fisher Project Area TMDLs and therefore are not identified impaired in **Appendix A**, **Figure A-8**.

The United States Geological Survey (USGS) has established numerous gage sites in the project area. **Appendix A, Figure A-8** indicates which sites are actively recording continuous data and which have been retired. One of the active stations monitors the outflow of a wetland below Schrieber Lake. Summary information for the other two active stations is listed in **Table 2-1**.

Table 2-1. Active USGS stream gages

Site Name	Site Number	Period of Record *	Average Peak Flow (cfs)
Kootenai River bl Libby Dam nr Libby MT	12301933	1971-present (42 years)	30,110
Fisher River near Libby MT	12302055	1967-present (46 years)	3,374

* Present = 2012

The average monthly discharge for these two sites over the period of record is displayed in **Figure 2-2**, note the logarithmic scale. Forty-six years of recorded data on the Fisher River indicate flows most often peak during May and reach a minimum in September. This pattern is typical of snowmelt - dominated stream systems in Montana. The Fisher River hydrograph looks much different than the Kootenai River hydrograph due to alterations of the natural flow regime. The USGS gaging station on the Kootenai River is located 0.7 miles downstream of the Libby Dam and 2.8 miles upstream of the Fisher River confluence. Flows have been regulated by dam operations at this site since March 21, 1972.

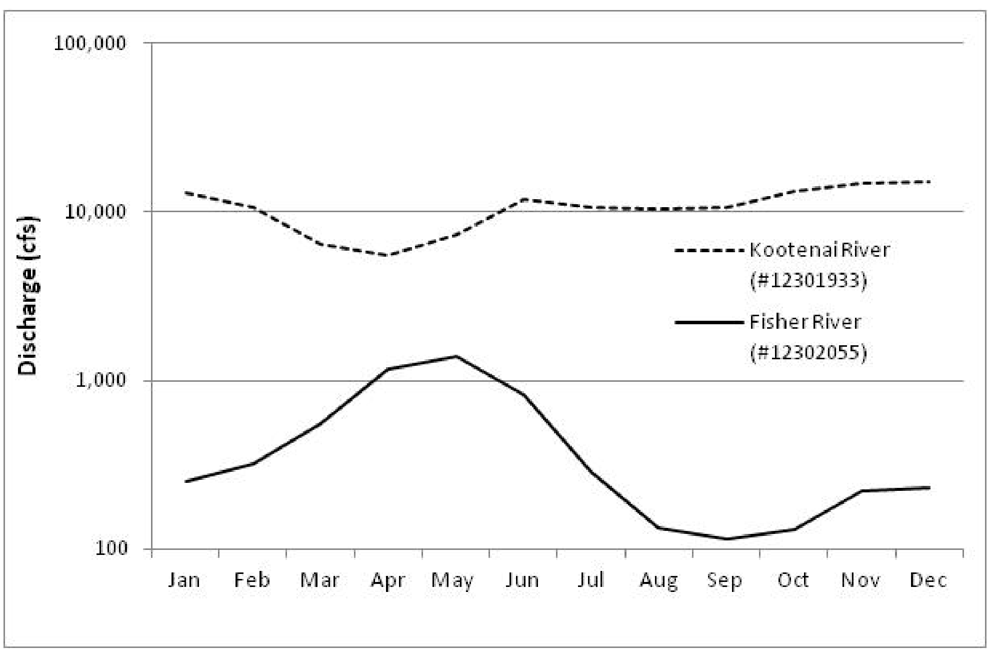

Figure 2-2. Average monthly discharge comparison

2.1.6 Groundwater

There are two main types of aquifers in the Kootenai-Fisher Project Area. The first are commonly found surrounding present day stream channels in alluvial sand and gravel material. These shallow aquifers are often unconfined and hydraulically connected to adjacent surface water. The second class is characteristically similar but derived from glacially deposited till and can be further removed from surface water. **Appendix A, Figure A-9** depicts groundwater wells and distinguishes those with water quality data available online from the Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center. As of November 2012 there are approximately 4,300 wells in the Kootenai-Fisher Project Area. Well distribution largely follows population density (**Appendix A, Figure A-14**) with the highest concentrations surrounding the towns of Rexford, Libby, and Troy and stretching south from Troy along the Bull River Highway (MT 56). Most wells in the vicinity of Libby utilize glacial aquifers

2.1.7 Climate

The Kootenai-Fisher Project Area's climate is characterized by long, cool winters and relatively short, temperate summers. This portion of Montana has a much wetter climate than the rest of the state. Moderated temperature extremes and higher annual precipitation prompt many to compare the climate with that of the Pacific Northwest. Slightly more precipitation falls in the Kootenai-Fisher Project Area during the winter months but overall precipitation remains fairly consistent at individual locations. Across the project area, precipitation varies dramatically from 13 inches a year near the town of Rexford up to 100 inches in the Cabinet Mountains. Precipitation trends follow elevation: significant moisture falls in the mountains and the quantity gradually decreases with elevation to the lowest spots of the Kootenai River Valley. Average annual precipitation isolines for the time period 1981-2010 are mapped on **Appendix A, Figure A-10** using data provided by Oregon State University's PRISM Group (PRISM Climate Group, 2013).

At least eleven weather stations have collected continuous climate data in the project area recently, and many are still collecting information. These stations are plotted in **Appendix A, Figure A-10** and symbolized according to the monitoring network they belong to. Remote automatic weather stations, or RAWS, is a multi-agency collaboration that focuses on conditions related to wildland fires. SNOTEL, short for snowpack telemetry, is an automated system of snowpack and related climate sensors used to develop water supply forecasts and operated by the Natural Resource Conservation Service (NRCS). The National Weather Service administers two additional climate systems in the region, the Cooperative Observer Program (COOP) stations, and the Missoula Weather Forecast Office (MSOWFO) stations. Finally, the Montana Department of Transportation (MT DOT) also collects weather data for road condition monitoring on US Highway 2.

In an attempt to show the range of observations, monthly climate averages are presented in **Table 2-2** and **Table 2-3** for stations at different elevations, both located on north-facing slopes. **Table 2-2** summarizes the National Weather Service's COOP site 245000 in Libby, Montana. In Libby, summer high temperatures peak in July and August in the mid-80s and minimum temperatures average 20 degrees in December and January. At 2,140 feet, this site has a warmer and drier climate than that of the Poorman Creek station shown in **Table 2-3.** Poorman Creek is a SNOTEL site located in the Cabinet Mountains at 5,100 feet. In addition to cooler temperatures, Poorman Creek has a much larger snowpack averaging a maximum of over seven and a half feet in March. According to climate records, snowfall has been observed in the project area during every month of the year.

Table 2-2. Monthly climate summary for Libby, MT (1998-2011)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Max Temp (°F)	32.7	38.4	47.4	57.9	68.0	75.3	87.0	84.1	71.4	54.4	39.0	30.6
Avg Min Temp (°F)	21.3	22.8	26.8	31.0	38.4	45.1	49.2	47.4	40.2	31.9	27.1	20.7
Avg Total Precip (in)	1.66	0.93	1.39	0.63	1.49	1.32	0.76	0.69	0.96	1.52	1.90	1.98
Avg Snowfall (in)	9.33	5.56	0.98	0.07	0.00	0.00	0.00	0.00	0.00	0.14	3.92	7.94
Avg Snowdepth (in)	15.77	13.15	10.69	1.00	0.00	0.00	0.00	0.00	0.00	0.15	3.29	11.50

Table 2-3. Monthly climate summary for Poorman Creek (1998-2011)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Max Temp (°F)	30.1	31.9	38.6	45.3	52.2	59.6	71.2	70.3	61.3	46.5	35.0	28.7
Avg Min Temp (°F)	19.7	20.5	25.0	29.5	35.0	40.6	48.2	46.9	40.5	33.3	25.2	18.5
Avg Snowdepth (in)	64.62	83.23	94.65	89.19	52.52	9.66	0.03	0.00	0.07	1.32	14.14	38.72

2.2 Ecological Parameters

The flowing information describes the ecological characteristics of the Kootenai-Fisher Project Area and includes a discussion of ecoregions, fires, aquatic life and terrestrial life.

2.2.1 Ecoregion

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Woods et al., 2002). The classification incorporates a wide array of subjects including geology, physiography, vegetation, climate, soils, land use, wildlife and hydrology.

Over 99.9% of the project area falls within the Northern Rockies Level III Ecoregion. The remaining 350 acres are isolated to the far northwestern corner of the project area and are classified as Canadian Rockies. According to the more detailed Level IV classification, 74% of the project area is identified as Salish Mountains. This ecoregion is typified as low forested mountains underlain by Precambian Belt Formations with volcanic ash on ridges and glacial till left by the Cordilleran Ice Sheet influencing slope hydrology. The extent and relative distribution of ecoregions is provided in **Table 2-4**. The second-most common ecoregion, Purcell-Cabinet-North Bitterroot Mountains, is dominant in the western portion of the project area. This ecoregion receives more precipitation than the Salish Mountains and is known for cedar-hemlock-pine forests. Peaks in the Cabinet Mountains are listed under the High Northern Rockies ecoregion and the Tobacco Plains and Stillwater-Swan Wooded Valley ecoregions are found surrounding the town of Rexford. The entire Kootenai-Fisher Project Area is influenced by Pacific moisture and has more diverse forests than elsewhere in Montana. **Appendix A, Figure A-11** maps the spatial extent of Level IV ecoregions.

Table 2-4. Ecoregion distribution in the Kootenai-Fisher Project Area

Level III Ecoregion	Level IV Ecoregion	Acres	Square Miles	% Total
Northern Rockies	Salish Mountains	1,182,631	1,848	73.8%
Northern Rockies	Purcell-Cabinet-North Bitterroot Mountains	312,584	488	19.5%
Northern Rockies	Stillwater-Swan Wooded Valley	49,831	78	3.1%
Northern Rockies	High Northern Rockies	44,123	69	2.8%
Northern Rockies	Tobacco Plains	12,034	19	0.8%
Canadian Rockies	Western Canadian Rockies	346	0.5	0.02%
Total		1,601,548	2,502	100%

2.2.2 Fire

Fire is a natural part of the Kootenai-Fisher ecosystem and many species have evolved to exist with the disturbance. For example, lodgepole pine developed serotinous cones that require heat from fires to open and disperse their seeds. It is well documented that fire suppression during the first half of the 20th century altered the natural fire regime in the western United States (National Wildfire Coordinating Group, 2012). Fire perimeters in the project area from 1889-2011 are shown in **Appendix A, Figure A-12**; however the impacts of fire suppression cannot be clearly distinguished in this figure.

Major stand replacing fires swept across the Kootenai-Fisher Project Area in 1910. In the aftermath, the Unites States Forest Service (USFS) adopted a practice of fire suppression for decades to come. The trend in acreage burned over the last century is displayed in **Figure 2-3**. In the last ten years 31,906 acres or 2% of the total project area has burned. The largest fire this decade was the 2007 Brush Creek fire and the most recent in available records occurred in 2011 when 174 acres burned near the confluence of the Fisher River and Wolf Creek.

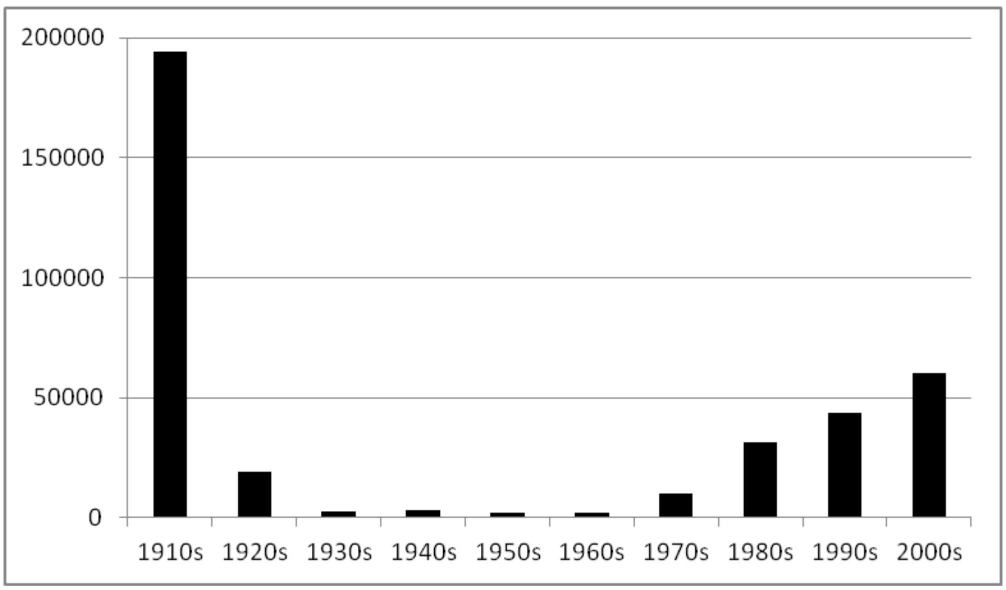

Figure 2-3. Estimated acreage burned in the Kootenai-Fisher Project Area per decade

2.2.3 Aquatic Life

There are numerous native fish species of concern present in the project area. Distributions are displayed in **Appendix A, Figure A-13** based on data provided by Montana Fish Wildlife and Parks (FWP) from 2010. The United States Fish and Wildlife Service (USFWS) lists two species on the federal Endangered Species Act: white sturgeon and bull trout. White sturgeon are limited to the Kootenai River within the project area.

Bull trout have been listed under the Endangered Species Act as threatened since 1998 due to habitat loss and degradation, introduction of non-native fish, fragmentation from dams and other barriers, and historical overharvesting. Bull trout populations in the Kootenai River are healthier than other Columbia River Basin populations however long-term monitoring has shown bull trout populations have declined since construction of the Libby Dam (U.S. Army Corps of Engineers, Seattle District, 2006). The species is acutely sensitive to environmental degradation because it requires cold, clean water. Bull trout spawn only in cobble/boulder substrate with sufficient groundwater upwelling to aerate eggs and low levels of silt to prevent smothering (Montana Department of Fish, Wildlife and Parks, 2012). While the dam impedes upstream migration, current operations consider bull trout by requiring minimum flows after spring sturgeon releases have been met and before flow augmentation for the fall spawning kokanee salmon starts in August. These minimum flows for bull trout avoid a double peaked hydrograph where large and rapid fluctuations in the wetted perimeter of the Kootenai River would be detrimental for fish habitat and water quality (U.S. Army Corps of Engineers, Seattle District, 2006). In 2000, the Plum Creek Timber Company finalized a 30-year agreement with the USFWS committing to specific conservation actions aimed at minimizing and mitigating impacts to bull trout from forest management activities on their land (Plum Creek Timber Co., 2000). An independent ten-year review indicated bull trout habitat has benefited from the partnership. Plum Creek's extensive work to date has included culvert replacement, stream channel restoration, and implementing best management practices. The Montana Department of Natural Resources and Conservation finalized a similar Native Fish Habitat Conservation Plan in 2010 (Montana Department of Natural Resources and Conservation, 2010) for activities on state trust land scattered across the project area.

The state of Montana also identifies torrent sculpin, Columbia Basin redband trout, westslope cutthroat trout and Yellowstone cutthroat trout as "species of concern" due to declining population trends, threats to their habitats, and/or restricted distribution. Cold, clean headwater streams in the Kootenai River drainage is the only place to find torrent sculpin in Montana, although their range extends into Washington, Oregon, and British Columbia. Native redband and cutthroat trout can hybridize and in some drainages of the Kootenai River these crosses are actually considered naturally occurring and historic; however, these three native species are threatened by their ability hybridize with introduced rainbow trout (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, 2012). In 1979 the US Army Corps built the Murray Springs Fish Hatchery in Eureka to mitigate westslope cutthroat habitat loss as a result of the Libby Dam. The US Army Corps continues to fund the hatchery's operations which are run by Montana FWP (Montana Fish, Wildlife and Parks, 2013).

2.2.4 Terrestrial Life

The Kootenai-Fisher Project Area encompasses the range of several terrestrial species of concern. Two mammals have been listed as federally threatened: grizzly bears since 1975 and Canada lynx since 2000. The USFWS also identifies wolverine, whitebark pine, and spalding's catchfly (a flowering perennial plant) as candidate species for protection under the Endangered Species Act (U.S. Department of the Interior, Fish and Wildlife Service, 2012).

2.3 Cultural Parameters

The flowing information describes the cultural profile of the Kootenai-Fisher Project Area and includes a discussion of population, transportation networks, land ownership, land cover/use, mining, and point sources.

2.3.1 Population

Native peoples migrated into the Kootenai-Fisher Project Area following the retreat of the Pinedale glaciation. The earliest found evidence of human inhabitants dates back 8,000 years (U.S. Forest Service, 2011). Members of the Kootenai and Salish Tribes consider the area part of their ancestral homeland. By the early 1800s European explorers and fur trappers frequented the region and used the Kootenai Valley as a travel route across the Continental Divide to the Columbia River. Miners flocked into the area starting in 1860s for a gold rush and mining precious metals continues to this day. See **Section 2.3.5** for more information on the history of mining in the project area. The next stage of European settlement revolved around the railroad. In the 1890s many men were employed harvesting timber for railroad ties. The first train hauling passengers and freight arrived to much fanfare in Libby on May 3, 1892. The railroad's existence opened the valley to the outside world and helped the region grow and prosper. In the 1900s the lumber and wood product industry grew to be a major sector of the economy. In the last 100 years the timber industry has gone through boom and bust cycles largely tied to the strength of the national housing and construction market. The recent trend has been downward. Since 1993 six lumber mills have closed in Lincoln County leaving only one mill still operating in Troy (City of Libby, 2010).

Today the Kootenai-Fisher Project Area is still very rural. According to the 2010 census, Lincoln County, which extends outside the boarders of the project area, had a population of 19,687 people. That equates to a county-wide average of 5.4 people per square mile. County demographics indicate roughly 20% of the population is under 18, another 20% is 65 or older and the majority (60%) falls within the 18 to 64 age class. Ninety-six percent of the population is white and the median household income is $30,800. The population of Lincoln County has risen 11% since 1980 and localized portions of the project area have experienced rapid development of formerly corporate timberlands (U.S. Forest Service, 2011).The population density of the project area is mapped on **Appendix A, Figure A-14**. As expected, the highest densities occur in the Libby, Troy, and greater Eureka areas. Libby is the county seat and the largest community with 2,628 people. Eureka, just outside the project boundary, had a population of 1,037 in 2010. Troy (938 people) and Rexford (105 people) complete the list of incorporated towns. The original Rexford town site was relocated 10 miles west during the construction of the Libby Dam. The nearest sizeable cities outside the project area are Kalispell, Montana (20 miles to the east) and Sand Point, Idaho (25 miles to the west).

2.3.2 Transportation Networks

US Highway 2 is a major transportation route which originates in the southeast corner of the project area near the Fisher River's headwaters, travels north to Libby and then turns west and follows the Kootenai River out of the project area past Troy. Montana Highway 56, also known as the Bull River Highway, begins off US Highway 2 near Troy and runs north-south. The Bull River Highway is the main route connecting Thompson Falls and Libby. Montana Highway 37 begins in Libby and traces the eastern side of Lake Koocanusa before ending at the US Interstate 93 junction slightly north of Eureka. At which point one can follow US 93 north to the international boarder at Roosville or south to Kalispell. Unpaved roads built for accessing timber stands are common. The network of unpaved roads on public and private lands will be further characterized as part of the sediment source assessment (**Section 5.5.3** and **Appendix D**).

An important rail transportation route enters the project area to the east and subsequently follows Wolf Creek, the Fisher River and the Kootenai River to Libby were it continues westward along the Kootenai River and US Highway 2. The tracks are owned by Burlington Northern Santa Fe which leases the transportation line to Amtrak as part of its Empire Builder route. Amtrak has one stop in project area at Libby. Troy, Eureka, and Libby also have small public airports.

2.3.3 Land Ownership

The Kootenai National Forest dominates the ownership landscape except in the southwestern portion of the project area where a checkerboard of public and private ownership exists. Ownership boundaries are shown in **Appendix A, Figure A-15** and detailed in **Table 2-5**. Public land ownership information was provided by the Montana Natural Heritage Program (2011). The extent of private timber lands was identified using the 2013 Montana Cadastral.

Table 2-5. Land ownership in the Kootenai-Fisher Project Area

Owner	Acres	Square Miles	% Total
U.S. Forest Service	1,054,820	1,648	66%
Private Timber Lands	349,882	546	22%
Other Private	146,598	230	9%
Montana State Trust Lands	39,668	62	2%
U.S. Fish and Wildlife Service	7,872	12	0.5%
Montana Fish, Wildlife and Parks	3,878	6	0.2%
U.S. Army Corps of Engineers	1,050	2	0.1%

The USFS is by far the largest land owner managing 66% of the total area. The project area encompasses three districts of the Kootenai National Forest: the entire Rexford Ranger District, most of the Libby Ranger District, and the southern portion of the Three Rivers Ranger District. The USFS manages its lands for sustainable forest harvest and resource extraction, a diverse array of recreational activities, the recovery of threatened and endangered species, and for overall ecological integrity (U.S. Forest Service, 2011). The newest version of the Kootenai Forest Plan explicitly lists as goals: to provide water quality to support beneficial uses, to support ecological function of riparian habitats, and to restore aquatic habitats where past management activities have affected stream channel morphology or wetland function (U.S. Forest Service, 2011). Congress designated 54,000 acres within the project area as wilderness in 1964 as part of the larger 94,000 acre Cabinet Mountains Wilderness Area.

Private timber companies are the second largest land holder. The overwhelming acreage of timber under both private and USFS ownership indicate the importance of timber harvest in the region. Remaining private lands are concentrated in the valley bottoms. Montana State Trust lands are scattered across 2% of the project area found mostly on 640 acre sections numbered 16 and 36, a relic of the framework which established them when Montana gained statehood in 1889. Other ownership categories account for less than 1%.

2.3.4 Land Cover and Use

Land cover within the project area is dominated by evergreen forests as indicated in **Table 2-6** and depicted in **Appendix A, Figure A-16**. The second most common land cover is shrub/scrub, as these two categories account for over 94% of the total area. The considerable size of Lake Koocanusa pushes the open water class to account for roughly 2% of the project area. Grassland/herbaceous is also represented on about 2% of the landscape. The other 14 land cover categories are rare and each account for less than half a percent. As previously discussed, developed areas are clustered around the towns of Libby, Troy, and Eureka. Human land use activities in the basin include silviculture, residential development, agriculture (primarily grazing and hay harvest), and road development/maintenance (forest roads, county roads, and private residential roads).

Table 2-6. Land cover distribution in the Kootenai-Fisher Project Area

Land Cover	Acres	Square Miles	% of Total
Evergreen Forest	1,200,983	1,876.5	74.97%
Shrub/Scrub	311,346	486.5	19.44%
Open Water	32,454	50.7	2.03%
Grassland/Herbaceous	29,108	45.5	1.82%

Table 2-6. Land cover distribution in the Kootenai-Fisher Project Area

Land Cover	Acres	Square Miles	% of Total
Developed, Open Space	5,750	9.0	0.36%
Emergent Herbaceous Wetlands	5,002	7.8	0.31%
Developed, Low Intensity	4,929	7.7	0.31%
Woody Wetlands	4,804	7.5	0.30%
Pasture/Hay	2,702	4.2	0.17%
Barren Land (Rock/Sand/Clay)	1,933	3.0	0.12%
Deciduous Forest	1,357	2.1	0.08%
Developed, Medium Intensity	1,262	2.0	0.08%
Cultivated Crops	586	0.9	0.04%
Perennial Ice/Snow	250	0.4	0.02%
Developed, High Intensity	53	0.1	0.00%
Mixed Forest	20	0.0	0.00%

2.3.5 Mining

Prospectors started exploring the Kootenai-Fisher Project Area in the 1860s. Successful returns from placer mines in Libby Creek lead to the establishment of a mining camp near the creek's mouth named Libbysville. Present-day Libby is just north of this original town site. Prospectors followed the source of these placer deposits upstream and a few decades later lode mines came into operation. Some evolved into sites with extensive underground workings and mills over the next 100 years.

The Kootenai-Fisher Project Area spans eight mining districts: Libby, Rainy Creek, Cabinet, Silver Butte, Sylvanite, Tobacco River, Troy, and Wolf Creek. MBMG's abandoned and inactive mines database estimates over 220 abandoned mines within the project area boundary. The Department of Environmental Quality's (DEQ) abandoned mine inventory has information on 76 mines. These sites are mapped on **Appendix A, Figure A-17** and operations predominately mined for precious metals although some quarries produced rock, gravel or sand. Commodities that drove production and exploration include gold, copper, silver, and lead.

The state of Montana identifies two sites in the Kootenai-Fisher Project Area as high priority abandoned mines. This distinction helps facilitate site cleanup by ranking them according to the public health risk. The Snowshoe Mine was originally ranked number 47 on the priority abandoned mines list until it was reclaimed by DEQ's Mine Waste Cleanup Bureau over a three year period ending in 2010. Historically, the Snowshoe Mine was the most prolific lode producer in the region and went through sporadic periods of production from 1889 through the 1960s. After the Snowshoe Mine closed, waste rock and mill tailings left in the floodplain contaminated the sediment and water quality of the Snowshoe Creek with heavy metals. The reclamation effort removed this waste from the immediate vicinity surrounding the mine and mill to a capped repository three miles away. DEQ also replaced floodplain wastes with clean, seeded soil and reconstructed the Snowshoe Creek channel (Pioneer Technical Services, Inc., 2010). A significant amount of tailings remain in the stream channel downstream of the mine site.

The second high priority abandoned mine in the project area is the Cherry Creek Mill site. The site, located 10 miles south of Libby and only 50 feet from Big Cherry Creek, was originally ranked number 100 by DEQ but because it is located on the Kootenai National Forest, reclamation duties were referred to the USFS. MBMG investigations report the Cherry Creek Mill was established to process tailings from the Snowshoe Mine because Cherry Creek was a more consistent water source (Hargrave et al., 1999a). The mill operated from 1958-1967. When DEQ investigated the site in 1993, approximately 4,500 cubic yards of moderately vegetated mill tailings remained at the site with elevated levels of heavy metals and cyanide (Pioneer Technical Services, Inc., 1995). Because no mining activities took place at the site there are no adits or mine shafts. Prior to 1993 the site was recontoured and reseeded, although detailed records of these activities could not be found.

The Big Cherry mill site has undergone significant reclamation. The Big Cherry Mill site originally contained approximately 3,600 bank cubic yards of waste that was a significant source of metals pollution. Downstream of the Mill site and adjacent to Big Cherry Creek another mine waste deposit area contained approximately 3,900 bank cubic yards of contaminated material which originated at the Snowshoe Mine. Reclamation activities include excavation of a total of about 10,455 bcy of material (including 6-12 inches of native underlying material) that was excavated from these areas and securely placed in an onsite repository. Clean soil was obtained from a local source on NFS (National Forest Service) land to backfill and blend the area with surrounding topography. The area has been reclaimed with native vegetation and seedlings. In 2010, approximately 700 cyd of amended material was brought to the Mill site location to improve vegetation, the area was again seeded and mulched.

The project area has one permitted hard rock mine (the Troy Mine) and another in the planning stages (the Montanore Mine) (U.S. Forest Service, 2011). The Troy ore body was discovered in the early 1960s, developed and mined by the American Smelting and Refining Company (ASARCO) from 1980 to 1993 and then brought back into production by a new owner, Revett Minerals, Inc., in 2004 (Revett Mining, 2012). Mining operations are located in the Stanley Creek (currently listed as impaired by copper) drainage south of the town of Troy and two miles west of Bull Lake and Highway 56. Revett Minerals expanded operations from 2004 through 2012 while producing 8.4 million ounces of silver and 69.5 million ounces of copper (Revett Mining, 2012). However in December 2012 a ceiling collapse in part of the underground workings blocked access to the surface. At this time production has stalled and a majority of the workforce has been laid off until access can be reestablished and safety inspections completed (Anon. 6/28/2013). The company anticipates reopening the Troy Mine in late 2014 with full production back online the following year (Associated Press, 10/19/2013). Revett Minerals Inc. is also operating under an exploratory license (#00663) while working through the application process for an operating permit at the Rock Creek Mine site, located just 16 miles southeast of the Troy Mine.

Operations at the Montanore Mine are located on the eastern slope of the Cabinet Mountains in the headwaters region of Libby Creek. Proposed workings would follow an ore body extending outside the project area. Mines Management Inc. is progressing through environmental review steps as required by the National Environmental Protection Act to obtain an operating license and move from an exploration phase into a production phase. The application has been delayed and created controversy due to the fact that the mine proposes to extract minerals from a federally designated wilderness area. Lastly, a vermiculite mine located in the Rainy Creek drainage northeast of Libby was operational for 70 years before closing in 1990. The vermiculite mine and its associated asbestos contamination has left the region a lasting legacy.

2.3.6 Point Sources

There are roughly 25 active point sources permitted under the Montana Pollutant Discharge Elimination System (MPDES) in the Kootenai-Fisher Project Area according to the Environmental Protection Agency's (EPA) Integrated Compliance Information System database as of September 2013. Many of these point sources discharge into either non-impaired waterways or waterbodies not investigated as part of this

TMDL project. Thus this discussion of point sources is limited to the 14 permits in the Libby Creek watershed depicted in **Appendix A, Figure A-18** which have the ability to affect TMDL streams.

Twelve of these permits are general permits to operate suction dredges, which are mechanical devices that float on the stream surface and pump stream water and stream bed material through a suction dredge intake to a sluice box, from which gold or other precious metals are recovered. Unwanted gravels and other naturally occurring stream bottom material fall off the end of the sluice box and are redeposited onto the stream bottom. Since the discharge consists of naturally occurring stream bottom material and no chemicals are allowed to be added to enhance gold recovery, the main concern from these operations in terms of TMDL development is sediment loading. Limitations contained in the general permit help address this concern by prohibiting a visual increase in turbidity at the end of a mixing zone.

The other two MPDES permits are held by Montanore Minerals Corporation: one is a general permit for stormwater discharges associated with construction activities (MTR104874) and the other is an individual permit for discharges related to mining operations at the Montanore Mine (MT0030279). The stormwater construction permit is associated with work at the Libby Creek adit site and is required because the surface disturbance is equal to or greater than one acre. Similar to the suction dredge operations, sediment is the pollutant of concern at this construction site from a stream loading perspective and following the conditions contained in the permit will help address sediment loading from this source. The mine's individual permit contains sediment, metals, and nutrient effluent limitation for three outfalls discharging to groundwater and Libby Creek.

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 and water quality standards in general include three main parts:

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

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

Nondegradation provisions are not applicable to the TMDLs developed within this document because of the impaired nature of the streams addressed. Those water quality standards that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards may be found in the Montana Water Quality Act (75-5-301,302 Montana Code Annotated (MCA)), and Montana's Surface Water Quality Standards and Procedures (Administrative Rules of Montana (ARM) 17.30.601-670) and Circular DEQ-7 (Montana Department of Environmental Quality, 2012a).

3.1 STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams and lakes within the Kootenai-Fisher TMDL Project are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses ((Administrative Rules of Montana (ARM) (17.30.623(1), State of Montana, 2014):

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

While 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 B**. DEQ's water quality assessment methods are designed to evaluate the most sensitive uses for each pollutant group addressed within this document, thus ensuring protection of all designated uses (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011b). For streams in Western Montana, the most sensitive use assessed for sediment is aquatic life; for temperature is aquatic life; for metals are drinking water and/or aquatic life; and for nutrients is aquatic life and primary contact recreation. DEQ determined that seven waterbody segments in the Kootenai-Fisher Project Area do not meet the sediment, temperature, metals, and/or nutrients water quality standards (**Table 3-1**).

Table 3-1. Impaired Waterbodies and their Impaired Designated Uses in the Kootenai-Fisher TMDL Project Area

Waterbody & Location Description	Waterbody ID	Impairment Cause [1]	Impaired Use(s)
BIG CHERRY CREEK, Snowshoe Creek to mouth (Libby Creek)	MT76D002_050	Cadmium	Aquatic Life
		Lead	Aquatic Life
		Zinc	Aquatic Life
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	MT76D002_070	Copper	Aquatic Life
		Lead	Aquatic Life
		Nitrate + Nitrite	Aquatic Life Primary Contact Recreation
		Sediment / Siltation	Aquatic life
LIBBY CREEK, Highway 2 bridge to mouth (Kootenai River)	MT76D002_062	Sediment / Siltation	Aquatic life
RAVEN CREEK, Headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030	Total Phosphorus	Aquatic life Primary Contact Recreation
		Sediment / Siltation	Aquatic Life
SNOWSHOE CREEK, Cabinet Wilderness boundary to mouth (Big Cherry Creek)	MT76D002_040	Arsenic	Drinking Water
		Cadmium	Aquatic Life Drinking Water
		Lead	Aquatic Life Drinking Water
		Zinc	Aquatic Life
STANLEY CREEK, Headwaters to mouth (Lake Creek) [2]	MT76D002_010	Copper	Aquatic Life
		Lead	Aquatic Life
		Zinc	Aquatic Life
		Nitrate + Nitrite	Aquatic life Primary Contact Recreation
WOLF CREEK, Headwaters to mouth (Fisher River)	MT76C001_020	Sediment / Siltation	Aquatic Life
		Temperature	Aquatic Life

[1] Only includes those pollutant impairments addressed by TMDLs in this document
[2] The Stanley Creek waterbody segment location description reads as "Stanley Creek, headwaters to confluence with Fairway Creek" in the 2012 Integrated Report. The segment was extended to the confluence with Lake Creek and the new description will be reflected in the 2014 Integrated Report.

3.2 Numeric and Narrative 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, frequency, and duration of specific pollutants so as not to impair designated uses.

Numeric standards apply to pollutants that are known to have adverse effects on human health 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 via drinking water and other pathways such as fish consumption, 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. Numeric standards also apply to other designated uses such as protecting irrigation and stock water quality for agriculture.

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition. This condition is often defined as an allowable increase above "naturally occurring." DEQ often uses the naturally occurring condition, called a "reference condition," to help determine whether or not narrative standards are being met (see **Appendix B**).

For the Kootenai-Fisher Project Area, a combination of numeric and narrative standards are applicable. The numeric standards apply to metals, and narrative standards are applicable for sediment, temperature, and nutrients, as well as metals. The specific numeric and narrative standards are summarized in **Appendix B**.

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: $TMDL = \Sigma WLA + \Sigma LA$, 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.

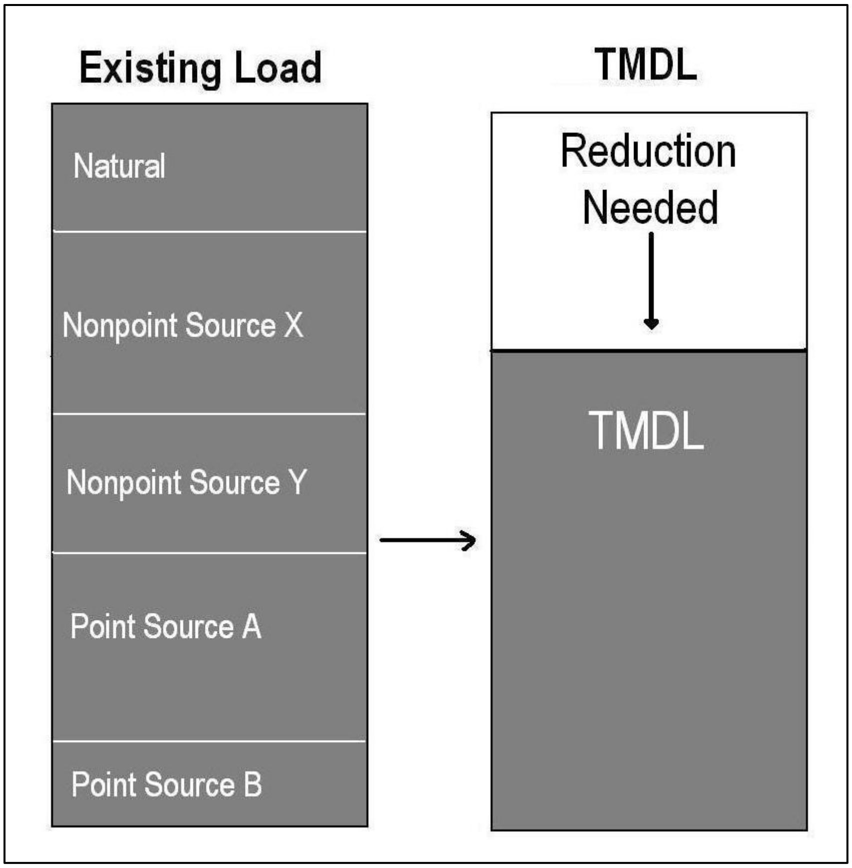

Figure 4-1. Schematic Example of TMDL Development

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, mining) and/or by land uses (e.g., crop production, timber harvest). 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 Code of Federal Regulations (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 a "TMDL" is specifically defined as a "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. 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.

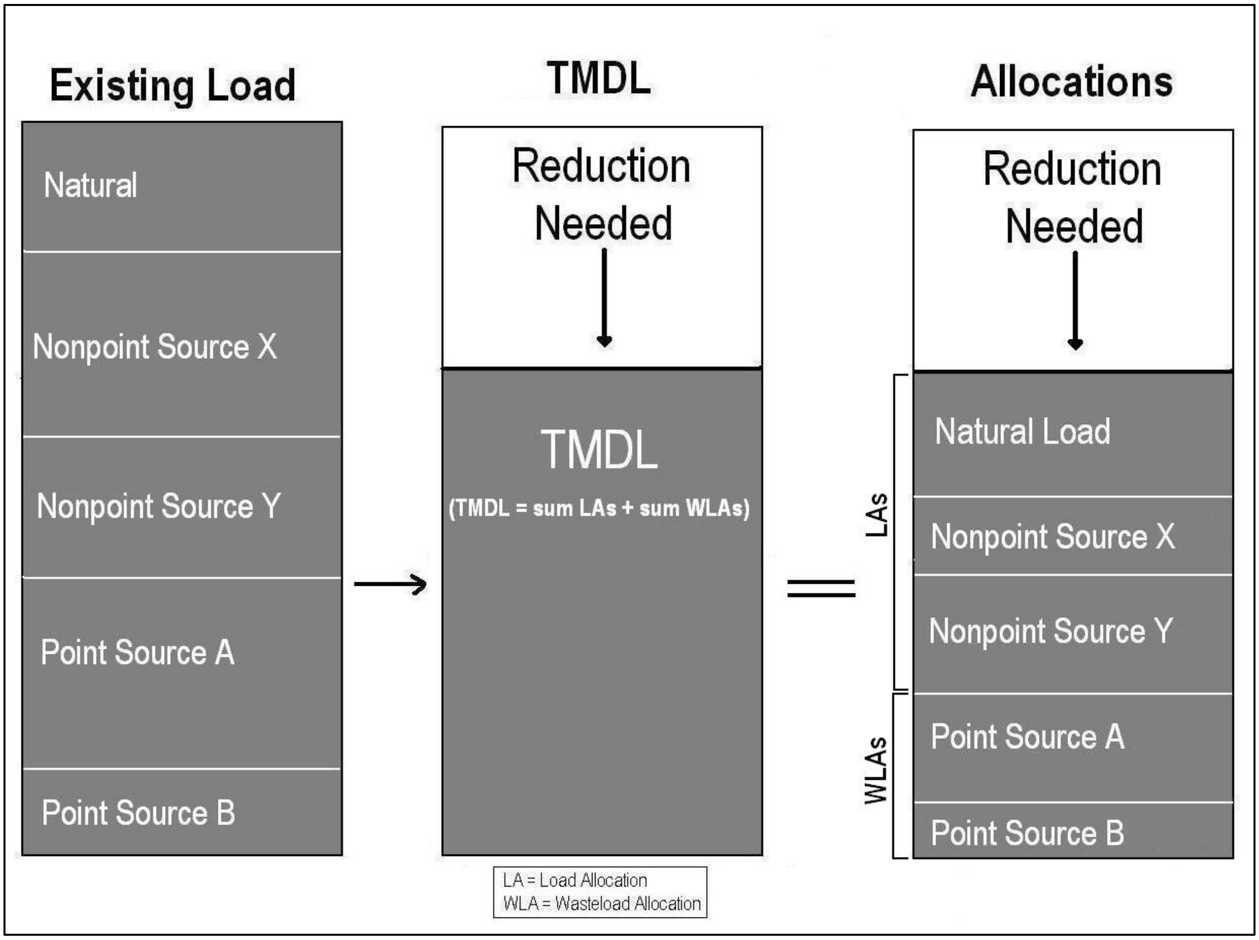

Figure 4-2. Schematic Diagram of a TMDL and its Allocations

TMDLs must also incorporate a margin of safety. The margin of safety accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. The margin of safety may be applied implicitly by using conservative assumptions in the TMDL development process, or explicitly by setting aside a portion of the allowable loading (i.e., a TMDL = WLA + LA + MOS) (U.S. Environmental Protection Agency, 1999b). The margin of safety is a required component to help ensure that water quality standards will be met when all allocations are achieved. In Montana, TMDLs typically incorporate implicit margins of safety.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. For TMDLs in this document where there is a combination of nonpoint sources and one or more permitted point sources discharging into an impaired stream reach, the permitted point source WLAs are not dependent on implementation of 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 permitted point source 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 pollutant.

4.5 Implementing TMDL Allocations

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 10.0** provides a water quality improvement plan that discusses restoration strategies by pollutant group and source category, and provides recommended best management practices (BMPs) per source category (e.g., urban development, unpaved roads, timber harvest, grazing, cropland, etc.). **Section 10.6** discusses potential funding sources that stakeholders can use to implement BMPs for nonpoint sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Watershed Protection Section (Nonpoint Source Program) helps to coordinate water quality improvement projects for nonpoint sources of pollution throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (available at http://www.deq.mt.gov/ wqinfo/nonpoint/nonpointsourceprogram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 11.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (75-5-703, Montana Code Annotated). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 SEDIMENT TMDL COMPONENTS

This portion of the document focuses on sediment as a cause of water quality impairment in the Kootenai-Fisher TMDL Project Area. It describes: (1) how excess sediment impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to sediment impairments in the watershed, (4) the sources of sediment based on recent studies, and (5) the proposed sediment TMDLs and their rationales.

5.1 EFFECTS OF EXCESS SEDIMENT ON BENEFICIAL USES

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Regular flooding allows sediment deposition to build floodplain soils and point bars, and it prevents excess scour of the stream channel. Riparian and wetland vegetation and natural instream barriers such as large woody debris (LWD), beaver dams, or overhanging vegetation help trap sediment and build channel and floodplain features. When these barriers are absent or excessive sediment loading enters the system from increased bank erosion or other sources, it may alter channel form and function and affect fish and other aquatic life by increasing turbidity and causing excess sediment to accumulate in critical aquatic habitat areas 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 six waterbody segments in the Kootenai-Fisher project area appeared on the 2012 Montana 303(d) List for sediment impairments (**Figure 5-1**): Bristow, Libby, Lake, Quartz, Raven, and Wolf Creeks. All but Bristow and Lake Creeks are also impaired for various forms of habitat alterations (**Appendix A, Table A-1**), which are non-pollutant causes commonly associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

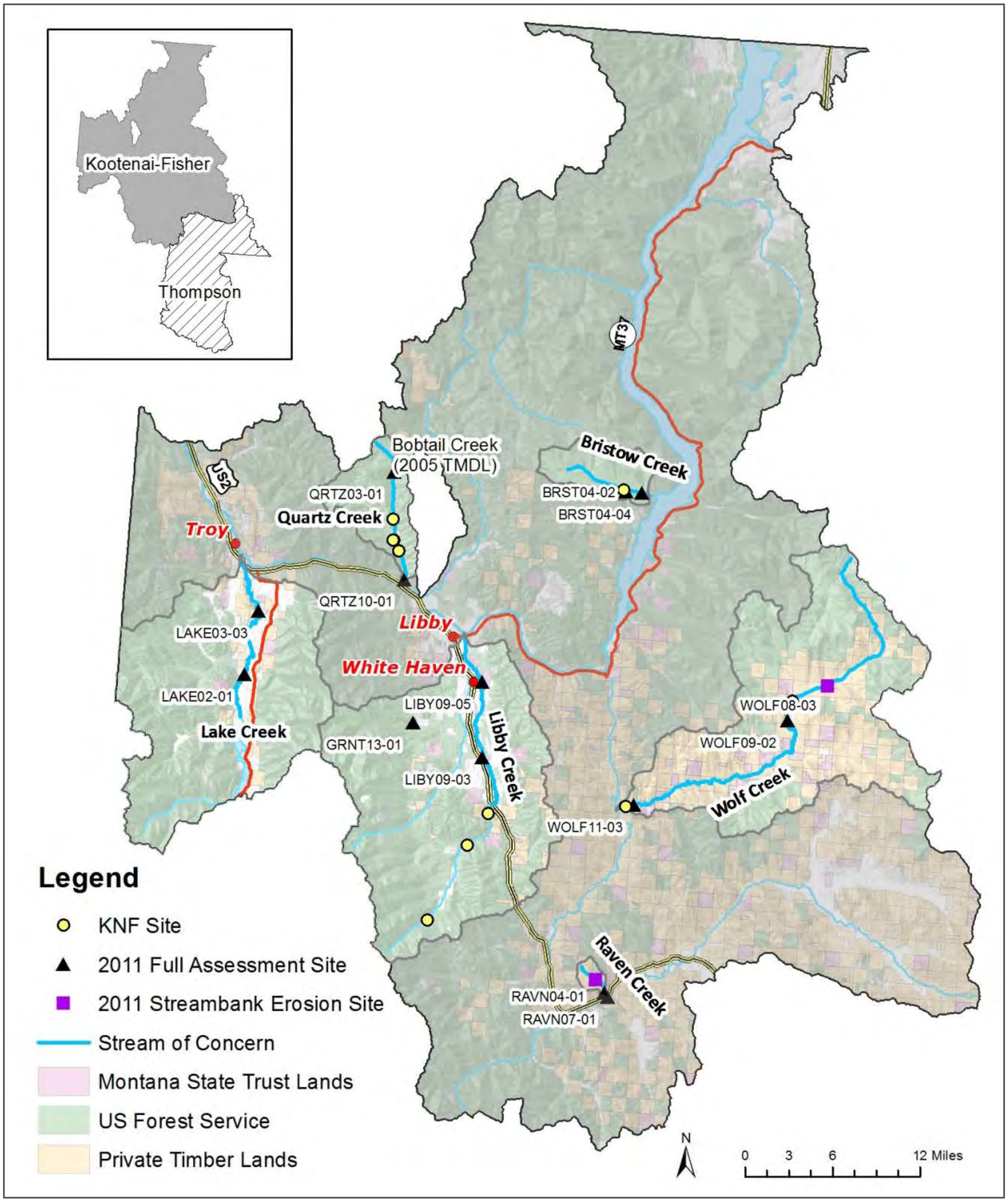

Figure 5-1. Sediment streams of concern and sampling sites in the Kootenai-Fisher Project Area

5.3 Information Sources and Assessment Methods

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed within this section, 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 2011. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- DEQ Assessment Files
- EPA 2011 Sediment and Habitat Assessments
- Kootenai National Forest Data
- Relevant Local and Regional Reference Data
- Other Data and Reports

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 and/or compiled 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 EPA's 2011 Sediment and Habitat Assessments

To aid in TMDL development, field measurements of channel morphology and riparian and instream habitat parameters were collected in August 2011 from 13 reaches (**Figure 5-1**). An additional two reaches were assessed in 2011 (denoted as bank erosion hazard index (BEHI) sites in **Figure 5-1**) to determine the severity of bank erosion and identify the source. Reaches were dispersed among the 6 segments of concern listed in **Section 5.2**, with two full assessment reaches on all streams and an additional reach on Granite Creek to broaden the range of conditions in the sample dataset and serve as a potential reference site.

Initially, all streams were assessed aerially to characterize reaches by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These attributes represent main factors influencing stream morphology, which in turn influence sediment transport and deposition.

The next step in the aerial assessment involved identifying near-stream land uses, since land management practices can have a significant influence on stream morphology and sediment characteristics. The result was stratifying 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, allowed DEQ to select the above-referenced monitoring reaches. Although ownership is not part of the reach type category (because of the distribution of private and federal land within the watershed), most reach type categories contain predominantly either private or public lands.

Monitoring reaches on sediment-listed streams were chosen to represent various reach characteristics, land-use categories, and human-caused influences. There was a preference toward sampling those reaches where human influences would most likely lead to impairment conditions, since one step in the TMDL development process is to further 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 303(d) listed waterbody with potential sediment 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 (**Table 5-1**). Although the TMDL development process necessitates this targeted sampling design, DEQ acknowledges this approach results in less certainty regarding conditions in 1st order streams and higher-gradient reaches, and that conditions within sampled reaches do not necessarily represent conditions throughout the entire stream.

Table 5-1. Stratified Reach Types and Sampling Site Representativeness within the Kootenai-Fisher Project Area

Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
NR-0-3-C	4		
NR-0-3-U	12	1	QRTZ10-01
NR-0-4-U	29	8	GRNT13-01, LAKE02-01, LAKE03-03, LIBY09-03, LIBY09-05, WOLF08-03*, WOLF09-02, WOLF11-03
NR-0-5-U	1		
NR-10-1-C	1		
NR-10-1-U	3		
NR-10-2-C	1		
NR-2-1-C	1		
NR-2-1-U	2		
NR-2-2-C	1	1	QRTZ03-01
NR-2-2-U	7	1	RAVN07-01
NR-2-3-C	1		
NR-2-3-U	9	2	BRST04-02, BRST04-04
NR-2-4-C	1		
NR-2-4-U	2		
NR-4-1-U	1	1	RAVN04-01*
NR-4-2-C	2		
NR-4-2-U	4	1	RAVN06-01
NR-4-3-U	2		
Total	**84**	**15**	

*Streambank erosion assessment only

The field parameters assessed in 2011 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion (Montana Department of Environmental Quality, 2011a). 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 2,000 feet (depending on the channel bankfull width) that were broken into five cells of equal length. Generally, a single cross section measurement, pebble count, and riffle grid toss are performed in each cell, and stream habitat, riparian, and bank erosion measures are performed throughout the reach. Field parameters are briefly described in **Section 5.4**, and summaries of all field data and sampling protocols are contained in the 2011 Sediment and Habitat Assessment report (**Attachment A**).

5.3.4 Kootenai National Forest Monitoring Data

The Libby District of the Kootenai National Forest (KNF) routinely collects streamflow, suspended sediment, physical, and biological monitoring data on streams throughout its district, which includes all sediment streams of concern except Lake Creek (i.e., Bristow, Libby, Quartz, Raven, and Wolf). Lake Creek is in the Three Rivers District, and most of land along it is private; USFS data in the Lake Creek watershed is limited to tributary watersheds that are managed by the USFS. For the purpose of evaluating current conditions, Rosgen channel morphology, pool and wood habitat, McNeill core data, and macroinvertebrate data from the previous 10 years were compiled. Core and macroinvertebrate data exist for most streams but only one site on Wolf Creek had channel morphology and habitat data collected within the past 10 years.

DEQ does not typically collect core samples but all data included in the data evaluation except the macroinvertebrate data were collected with similar protocols as those used by EPA in 2011. Channel morphology measurements followed Rosgen's method (Rosgen, 1996), pool and wood measurements followed the USFS R1/R4 fish habitat inventory procedures (Overton et al., 1997), and core samples were collected following standard protocols (McNeil and Ahnell, 1964). Macroinvertebrate samples were collected with a Hess or Surber sampler in pool and riffle habitat; effects of the methodology difference are discussed relative to "Biological Indices" in **Section 5.4.1.6**. Suspended sediment data and streamflow can be helpful for tracking suspended loads over the long term, or evaluating changes resulting from landscape disturbances but were not obtained from the Libby District for this project because the TMDL will not be based on instream sediment loads or include a suspended sediment target.

5.3.5 Relevant Local and Regional Reference Data

Regional reference data was derived from KNF reference sites and the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). There is reference data for channel morphology parameters (i.e., width/depth and entrenchment) for 151 sites assessed within all districts of the KNF between 1992 and 1999 and then a more extensive reference dataset (i.e., channel morphology, fine sediment, and habitat measures) for 77 sites within the Libby District collected between 1995 and 2004. The Libby District lies entirely within the Northern Rockies (Level III ecoregion) and Salish Mountains (Level IV ecoregion). The PIBO reference dataset (http://www.fs.fed.us/biology/fishecology/emp/) includes USFS and Bureau of Land Management (BLM) sites throughout the Pacific Northwest, but to increase the comparability of the data to conditions in the Kootenai-Fisher project area, only data collected within the Northern Rockies ecoregion were evaluated. Between 2001 and 2012, 72 PIBO sites have been established in the Northern Rockies, and several of the sites have been visited more than once (n=109). Eleven of the PIBO reference sites are located in the Kootenai National Forest. Much of the PIBO sampling protocol (Heitke et al., 2012) is similar to the DEQ protocol used by EPA in 2011; the methodologies are discussed in more detail within this section for any PIBO parameters considered for water quality targets.

5.3.6 Other Data and Reports

Several other documents that provide historical context to sediment sources, describe the sensitivity of watersheds to disturbance, and provide information about current conditions or sources were also used to help evaluate conditions within the stream segments of concern. These documents include: the Upper Kootenai Subbasin Review (U.S. Department of Agriculture, Forest Service, 2002); a thesis that evaluated the causes of instability in Libby Creek (Sato, 2000); KNF ecosystem and travel analysis reports (USDA Forest Service, 2007; USDA Forest Service, 2009a; USDA Forest Service, 2009b); and numerous National Environmental Policy Act (NEPA) documents for projects within the Bristow, Lake, Libby, Quartz, Raven, and Wolf watersheds (U.S. Department of Agriculture, Forest Service, 2003; Altman, 1990; Edwards, 2008; U.S. Department of Agriculture, Forest Service, Kootenai National Forest and

Montana Department of Environmental Quality, 2009; U.S. Forest Service and Montana Department of Environmental Quality, 2012; USDA Forest Service, Kootenai National Forest (KNF), 2010; USDA Forest Service, Kootenai National Forest (KNF), 2012; USDA Forest Service, Kootenai National Forest (KNF) and Montana Department of Environmental Quality, 2011). Additionally, for Quartz Creek there are several studies investigating the delta at the mouth (Zelch, 2003; Dibrani, 2003; Sylvester and Stephens, 2013) as well as a post restoration monitoring report by the KNF (Wegner, 1998).

5.4 Water Quality Targets

The concept of water quality targets was presented in **Section 4.1**. This section provides the rationale for each sediment-related target parameter and discusses the basis of the target values.

In developing targets, natural variation within and among streams must be considered. As discussed in more detail in **Section 3.0** and **Appendix B**, DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is using reference site data, but modeling, professional judgment, and literature values may also be used. DEQ defines “reference” 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, the reference condition reflects a waterbody’s greatest potential for water quality given past and current land use. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets protect all designated beneficial uses because they are based on the reference approach, which strives for the highest achievable condition.

Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations from climate, bedrock, soils, hydrology, and other natural physiochemical differences, yet it allows differentiation between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology from human activity.

The basis for each water quality target value varies depending on the availability of reference data and sampling method comparability to 2011 EPA data. As discussed in **Appendix B**, there are several statistical approaches DEQ uses for target development. They include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired (like with fine sediment), and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset is typically used.

If reference data are not available, and the sample streams are predominantly degraded, the 25th percentile of the entire sample dataset is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, how much the representativeness and range of data varies, how severe human disturbance is to streams in the watershed, and the size of the dataset.

In general, stream sediment and habitat conditions within the streams evaluated by EPA in 2011 reflected a minimal to moderate level of human disturbance (i.e., not severely disturbed). For each target, descriptive statistics were generated relative to any available reference data (e.g., KNF or PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given to the most protective reference dataset.

Additionally, the target value for some parameters may apply to all streams in the Kootenai-Fisher project area, whereas others may be stratified by bankfull width, reach type characteristics (e.g., ecoregion, gradient, stream order, and/or confinement), or by Rosgen stream type, if those factors are determined to be important drivers for certain target parameters. Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit margin of safety (MOS) and that are achievable. MOS is discussed in additional detail in **Section 5.7**. Field data from the reference site on Granite Creek are not discussed within this section but were compared with target values during the target development process to help evaluate the appropriateness and achievability of target values.

5.4.1 Targets

The sediment water quality targets for the Kootenai-Fisher project area are summarized in **Table 5-2** and described in detail in the sections that follow. Listed in order of preference, sediment-related targets are based on a combination of reference data from the KNF, reference data from the Northern Rockies portion of the PIBO dataset, and sample data from the EPA 2011 sampling effort. For target development purposes, sample dataset percentiles within this section are based on the data collected in the Kootenai-Fisher project area along with data collected by the same methods from 16 reaches in the adjacent Thompson TMDL Project Area (inset, **Figure 5-1**), which is also in the Northern Rockies. Percentiles specific to just the Kootenai-Fisher project area are presented in **Attachment A**. The raw data from the Thompson TMDL Project Area is available by request from DEQ and will be included within the Thompson TMDL document, which will be completed in 2014.

KNF reference data were incorporated (along with other sources) into target development for most of the other Montana sediment TMDLs that have been completed within the Northern Rockies to date: Bobtail Creek (Lindgren and Anderson, 2005), Grave Creek (Montana Department of Environmental Quality et al., 2005), Yaak (Montana Department of Environmental Quality, 2008b), St Regis (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2008), Prospect Creek (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2009), Lower Clark Fork (Montana Department of Environmental Quality, 2010), and Tobacco (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011a). Targets from these TMDLs and others that have been completed in Montana within the Northern Rockies (i.e., Flathead Headwaters and Swan) are referenced within this section to provide context for potential target values and/or to apply as target values.

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999b), water quality targets for the Kootenai-Fisher project area are comprised of a combination of measurements of instream siltation, channel form, biological health, and habitat characteristics that contribute to loading, storage, and transport of sediment, or that demonstrate those effects. Water quality targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight (i.e., fine sediment and biological indices). Target parameters and values are based on the current best available information, but they will be assessed during future TMDL reviews for their applicability and may be modified if new information provides a better understanding of reference conditions or if assessment metrics or field protocols are modified. For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends. The exceedance of one or more target values does not necessarily equate to a determination that the information supports impairment; the degree to which one or more targets are exceeded are taken into account (as well as the current 303(d) listing status), and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. Site-specific conditions such as recent wildfires, natural conditions, and flow alterations within a watershed may warrant the selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values.

Table 5-2. Sediment Targets for the Kootenai-Fisher TMDL Project Area

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of surface fine sediment in riffles via pebble count (reach average)	B & C stream types: 6mm ≤ 15%; 2mm ≤ 8% E stream types: 6mm ≤ 30%; 2mm ≤ 15%
	Percentage of surface fine sediment < 6mm in pool tails and riffles via grid toss (reach average)	B & C stream types: ≤ 9% for pool tails, ≤ 7% for riffles E stream types: ≤ 18% for pool tails, ≤ 14% for riffles
	Percentage of subsurface fine sediment <6.35mm in pool tails via McNeil Core (annual average)	≤ 26%
Channel Form and Stability	Bankfull width/depth ratio (reach median)[1]	B & C stream types with bankfull width < 30ft: ≤ 21 B & C stream types with bankfull width > 30ft: ≤ 32 E stream types: ≤ 8
	Entrenchment ratio[1] (reach median)	B stream types: > 1.4
		C stream types: > 2.7
		E stream types: > 2.3
Instream Habitat	Residual pool depth (reach average)	< 20' bankfull width : ≥ 0.6 (ft)
		20' - 35' bankfull width : ≥ 1.2 (ft)
		> 35' bankfull width : ≥ 1.6 (ft)
	Pools/mile	< 20' bankfull width : ≥ 81
		20' - 35' bankfull width: ≥ 38
		> 35' bankfull width : ≥ 25
		Libby & Lake creeks: : 12-24
	LWD/mile	< 20' bankfull width : ≥ 359
		20' - 35' bankfull width : ≥ 242
		> 35' bankfull width : ≥ 148
Riparian Health	Percent of streambank with understory shrub cover (reach average)	≥ 58% understory shrub cover
Sediment Source	Significant and controllable sediment sources	Identification of significant and controllable anthropogenic sediment sources throughout the watershed
Biological Indices	Macroinvertebrate bioassessment metric	O/E ≥ 0.90 for samples collected since 2011 O/E ≥ 0.80 for samples collected prior to 2011
	Periphyton Increaser Taxa	Probability of Impairment <51%

[1] For other channel types, Rosgen delineative criteria apply (Rosegen 1996)

5.4.1.1 Fine Sediment

The percent of surface fines <6 mm and <2 mm is a measurement of the fine sediment on the surface of a streambed and is directly linked to the support of the coldwater fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and smother fish eggs by limiting oxygen availability (Irving and Bjornn, 1984; Shepard et al., 1984; Suttle et al., 2004; Weaver and Fraley, 1991). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Zweig and Rabeni, 2001; Mebane, 2001).

Because similar concentrations of sediment can cause different degrees of impairment to different species (and even age classes within a species), and because the particle size defined as "fine" is variable (and some assessment methods measure surficial sediment while other measures also include subsurface fine sediment), literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10% to 40% fine sediment (Relyea et al., 2000; Bjornn and Reiser, 1991; Mebane, 2001). Bryce et al. (2010) evaluated the effect of surficial fine sediment (via reach transect pebble counts) on fish and macroinvertebrates and found that the minimum effect level for sediment <2 mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development; however, because increasing concentrations of fine sediment are known to harm aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B** and consistent with Montana's water quality standard for sediment as described in **Section 3.2.1**.

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

Surface fine sediment measured in riffles by the modified (Wolman, 1954) pebble count indicates the particle size distribution across the channel width and is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2011 were performed in four riffles per sampling reach for a total of at least 400 particles.

Pebble count reference data are available from the Libby District of the KNF and PIBO. Pebble counts for the Libby District were a composite of riffles and pools, which can increase the fine sediment percentage relative to a riffle-only pebble count; in a review of the field forms, pools did not typically increase the overall percentage of fines, indicating results between the Libby District and Kootenai-Fisher sample dataset are comparable. PIBO data were collected in riffles-only but were not stratified by Rosgen stream type and the sample size is small (n=16). Because the Libby District data are comparable to the DEQ data and the preferable reference dataset, the target for riffle substrate percent fine sediment is based on the 75th percentile of the KNF Libby District reference dataset and is set at less than or equal to 15% < 6mm and 8% < 2mm. PIBO data are not available for <2mm but the 75th percentile for particles <6mm is very close to Libby District value at 16%. The target for sediment < 6mm is the same or similar that set in other TMDL documents within the Northern Rockies (e.g., Lower Clark Fork: 10%, Tobacco/Grave Creek/Prospect Creek: 15%, Yaak/Flathead Headwaters/St. Regis: 20%), and the target for < 2mm is close to the macroinvertebrate minimum effect level of 10% found by Bryce et al. (2010). Rosgen E channels tend to have a higher percentage of fine sediment than B and C channels (which compose all but one of the 2011 EPA assessment reaches), but the KNF Libby District dataset only contains two E channel sites. The 75th percentile values at the KNF reference E channel sites are 1% and 16% for < 6mm and 0% and 8% < 2mm. By comparison, the E channel target value from 115 reference sites in the Beaverhead Deerlodge National Forest (Bengeyfield, 2004) is 30% fine sediment <6mm and there are no data for particles < 2mm.

For B and C channel types, 15% < 6mm and 8% < 2mm will be applied as fine sediment targets for riffle pebble counts. Because the E channel sample size from the Beaverhead Deerlodge National Forest is much greater than from the KNF, a target of 30% <6mm will be applied to E channels in the Kootenai-Fisher project area. Since the fine sediment <2mm target for B and C channels is roughly half of the <6mm target, 15% <2mm will be applied as the target for E channels. The pebble count target values for E channels will carry less weight than for the other channel types because they are based on another ecoregion and have a higher level of uncertainty. Target values should be compared to the reach average value from pebble counts.

Percent Surface Fine Sediment < 6mm in Pool Tails and Riffles via Grid Toss
Grid toss measurements in riffles and pool tails are an alternative measure to pebble counts that assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer et al., 1993) was used to estimate the percent surface fine sediment < 6mm in riffles and pool tails in the Kootenai-Fisher project area, and three tosses, or 147 points, were performed and then averaged for each assessed riffle and for the spawning gravel substrate portion of each assessed pool tail. Riffle grid tosses were performed at the same riffle per cell as pebble counts and pool tail grid tosses were performed at all pool tails with potential spawning gravel (i.e., not all sand or cobble).

For grid toss values, PIBO pool tail data is the only reference data currently available. The 75th percentile of the PIBO reference data for pool tails is 20% and the median is 9%. In the 2011 sample dataset, pool tail grid toss values were low with percentiles as follows: 25th= 4%, median = 7%, and 75th = 10%. The percentiles in the 2011 dataset are likely much lower than PIBO because the DEQ method excludes pool tails where the assessor determines sediment is too fine for spawning. This was done so pools with high levels of fine sediment and no spawning potential would not skew the dataset for a stream that does have pools with suitable spawning habitat and low levels of fine sediment. However, to be more comparable to available reference data, DEQ will be changing its method to match PIBO protocols for pool tail grid toss. This change should be considered during future collection and evaluation of grid toss data in this project area, as a different target value may be necessary.

Reference data sets used for target setting for other TMDLs in the Northern Rockies ecoregion such as St Regis, Grave Creek, Prospect Creek, and Tobacco resulted in pool tail grid toss targets between 8 and 10%. In the absence of reference data, the 75th percentile of the sample data (i.e., 10%) would be considered as a target value. Based on the reference-based target values, and the similarity of the PIBO median to the 75th percentile of the sample dataset, the PIBO median will be used as the basis for the pool tail grid toss target. Therefore, the grid toss target for fine sediment < 6mm in B and C channels is ≤ 9% for pool tails.

In the 2011 sample dataset, riffle grid toss values were less than pool tail values with percentiles as follows: 25th= 1%, median = 3%, and 75th = 7%. The 75th percentile of the sample dataset is less than conservative literature values for harm to aquatic life (i.e., 10%) and similar to the TMDL targets used in the Tobacco and Prospect Creek (i.e., 8 and 10%, respectively), the riffle grid toss target for fine sediment < 6mm in B and C channels is ≤ 7% based on the 75th percentile of the 2011 sample dataset.

A separate target will be applied to E channels because they tend to have a higher percentage of fine sediment than B and C channels. The reference based pebble count target for fine sediment < 6 mm for E channels is double that of B and C channels. That relationship will be used for the grid toss targets for fine sediment < 6 mm; for E channels, the pool grid toss target is ≤ 18% and the riffle grid toss target is ≤ 14%. For each habitat area, the target should be assessed based on the reach average grid toss value.

Percent Subsurface Fine Sediment < 6mm in Pool Tails via McNeil Core
The subsurface substrate in gravel-bottomed rivers tends to be finer than that of the surface layer (Parker and Klingeman, 1982). Because salmonid embryo development takes place in subsurface substrate, the percentage of subsurface fine sediment can be an important indicator of harm to aquatic

life. Although the creation of redds by salmonids effectively reduces the amount of fines compared to non-redd substrate (MacDonald et al., 1991; McNeil and Ahnell, 1964), over time, the interstices can refill with fine sediment (Zimmerman and Lapointe, 2005). DEQ not does typically collect subsurface sediment data, however, the Libby District of the Kootenai National Forest routinely collects it from reference and non-reference streams with a McNeil Corer (McNeil and Ahnell, 1964) in areas suitable for spawning. Results presented in this document represent an annual average based on 10 samples.

Based on core samples collected annually from six KNF reference streams since the mid to late 1990s, the 75th percentile is 26% (n=79) (unpublished KNF data). In a study of spawning areas within nine undeveloped watersheds within the Flathead Basin, McNeil core sample particles < 6.35 mm averaged <32% (Weaver and Fraley, 1991). Weaver and Fraley (1991) also looked at fry emergence success by westslope cutthroat and bull trout in response to increasing percentages of fine sediment <6.35 mm and observed a significant inverse relationship between emergence success and the percentage of fine sediment; survival was reduced by about 50 percent for westslope cutthroat when fine sediment approached 27% and for bull trout when fine sediment approached 28%. All of these values are in a similar range as reference based targets used for other TMDLs from the Northern Rockies (i.e., Bobtail Creek/Grave Creek/Prospect Creek/St Regis/Yaak <28% and Flathead Headwaters/Swan <30-35%).

A target value of <26% will be applied based on the 75th percentile of KNF reference data. Since the Kootenai National Forest collects data annually, the target will be applied based on yearly average results from a given stream reach or spawning segment. Particularly since there is such a long term dataset and core values can be variable from year to year, any target exceedances will be evaluated within the context of long-term trending for each stream. The target should only be applied in areas where bull trout or cutthroat trout spawning occurs or has the potential to occur under full support conditions.

5.4.1.2 Channel Form and Stability

Parameters related to channel form indicate a stream's ability 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 channel form. 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 Kootenai-Fisher project area and are described below.

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio provide a measure of channel stability as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (e.g., riffles, pools, and near-bank zones).

Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of 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 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 when 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 indicate that stream energy is concentrated in-channel during flood events versus having energy dissipate 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). Width/depth and entrenchment ratios were calculated for each 2011 assessment reach based on five riffle cross-section measurements.

Width/Depth Ratio Target Development

There is reference riffle width/ratio data for the KNF, KNF Libby District, and PIBO, but because the Libby District data is a subset of the KNF dataset, only the KNF and PIBO reference data were reviewed as potential targets. The 2011 sample dataset primarily comprises B and C channels, and although on average B channels tend to have a smaller width/depth ratio than C channels (Rosgen, 1996), the ratio can vary quite a bit between small and larger streams. Because the waterbodies in the 2011 Kootenai-Fisher dataset range in bankfull width (BFW) from 5 to 100 feet (median=34 ft, 75^{th}=71 ft), target values are combined for B and C channels and expressed by BFW. Both reference datasets have BFW values that range from approximately 5ft to 60ft, but the PIBO dataset has a much greater number of larger streams (KNF: median=15 ft, 75^{th}=21 ft; PIBO: median=29 ft, 75^{th}=35 ft).

The 75^{th} percentiles of width/depth ratios for both reference datasets (**Table 5-3**) are similar to targets that have been applied in TMDLs for Bobtail Creek, Prospect Creek, the Lower Clark Fork, St Regis, Grave Creek, and the Tobacco. For B and C channels with a bankfull width < 30 ft, the target will be ≤ 21 based on the 75^{th} percentile of the KNF data. For B and C channels with a bankfull width ≥ 30ft, the target will be ≤ 32 based on the 75^{th} percentile of PIBO reference, which has a much greater number of large reference streams than the KNF dataset. The streams in the PIBO dataset are not broken out by Rosgen channel type but based on a review of reference-based width/depth ratio targets ranging from 29-33 for large B/C channels in the St. Regis, Grave Creek, and Prospect Creek TMDLs, 32 is an appropriate target for larger B/C channels within the Kootenai-Fisher project area. Raven Creek downstream of Highway 2 was the only stream segment identified as a different channel type (i.e., E), and although the sample size is smaller than desired, the target for E channels will be ≤ 8 based on the 75^{th} percentile of E channel in the KNF dataset (**Table 5-3**) because the PIBO dataset is not broken out by stream type.

Table 5-3. The 75^{th} Percentiles of Reference Data used for Width/Depth Ratio Target Development

Data Source	Category	Sample Size	75th Percentile W/D
KNF Reference	B/C channels BFW < 30’	94	**21**
KNF Reference	B/C channels BFW > 30’	7	29
KNF Reference	E channels	3	**8**
PIBO Reference	BFW < 30’	61	26
PIBO Reference	BFW > 30’	48	**32**

Entrenchment Ratio Target Development

Because higher values are more desirable for entrenchment ratio, the target value for entrenchment ratio is set at greater than or equal to the 25^{th} percentile of the KNF reference data (**Table 5-4**). When comparing assessment results to target values, more weight will be given to those values that fail to satisfy the identified target and fail to meet the minimum value associated with literature values for Rosgen stream type (i.e., B=1.4-2.2 ± 0.2, C & E 2.2 ± 0.2) (Rosgen, 1996) and reaches with multiple potential channel types will be evaluated using the lowest target value (e.g., Target for B3/C3 = 1.4).

Table 5-4. Entrenchment Targets for the Kootenai-Fisher TMDL Project Area Based on the 25th Percentile of KNF Reference Data

Rosgen Stream Type	Sample Size	25th Percentile of KNF Reference Data
B	93	1.4
C	8	2.7
E	3	2.3

Channel form targets are expressed specifically for B, C, and E channels because they are either the primary existing or potential channel type in low gradient sections of the streams of concern, which is where the effects of excess sediment from human sources are most likely to be observed. For channel types not specifically mentioned above (i.e., A, F, D, G), the Rosgen delineative criteria for width/depth ratio and entrenchment apply (Rosgen, 1996). Channel types can evolve naturally or as a result of human changes to the landscape, and channel type adjustments should be evaluated in the context of the potential cause(s) and whether human sources are causing channel instability or if the channel is recovering.

5.4.1.3 Instream Habitat Measures

For all instream habitat measures (i.e., residual pool depth, pool frequency, and large woody debris frequency), there is available reference data from the Libby District of the KNF and from PIBO. All of the instream habitat measures are important indicators of sediment input and movement as well as fish and aquatic life support, but they may be given less weight in the target evaluation if they do not seem to be directly related to sediment impacts. The use of instream habitat measures in evaluating or characterizing impairment needs to be considered from the perspective of whether these measures are linked to fine, coarse, or total sediment loading.

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 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 (Bonneau, 1998; Nielson et al., 1994; Baigun, 2003). 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 impair fish condition by altering habitat, food availability, and productivity (Sullivan and Watzin, 2010; May and Lee, 2004). Residual pool depth is typically greater in larger systems.

Although the residual pool depth measure is similar between DEQ's method and both reference methods, the definition of a pool can vary between the methods. Out of both available reference datasets, the core definition of pools for the PIBO protocol is closer to the definition used for the DEQ 2011 sample dataset where 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 is at least 1.5 times the pool tail depth (Kershner et al., 2004). The Libby District dataset defines pools as slack water areas occupying at least one-third of the bankfull channel with a scour feature and hydraulic control.

DEQ further defined pools as large or small depending on the width of the pool in relation to the stream's bankfull width, whereas the PIBO protocol only counts pools greater than half the wetted channel width. In comparison to the PIBO dataset, the 2011 sample dataset could have a higher pool frequency and more pools with a smaller residual pool depth since the DEQ protocol has no minimum pool width requirement. In comparison to the Libby dataset, the 2011 sample dataset could have a lower pool frequency but more pools with a deeper residual pool depth since some slack water areas in the Libby District dataset might not meet the head crest to tail crest ratio requirement used by DEQ. However, residual pool depths in the sample dataset are not noticeably less than the PIBO depths or greater than the Libby depths, indicating the slight protocol differences are not an issue and the reference datasets are appropriate to use for setting residual pool depth targets.

The 25th percentile of the Libby reference data will be applied as residual pool depth targets for streams with a bankfull width < 35ft (**bolded** in **Table 5-5**), which is the upper limit of streams in the Libby dataset. During the field effort in 2011, the maximum depth in several pools was estimated because they were too deep to safely wade, which is supported by the 25th percentile and median of the sample dataset being greater than PIBO reference. Therefore, the residual pool depth target for streams with a bankfull width ≥35 will be 1.6 ft based on the PIBO median (**bolded** in **Table 5-5**). Although none of the channels in the PIBO reference dataset are as wide as the reaches assessed on Lake and Libby creeks, 1.6 ft should be a reasonable target based on existing conditions within the project area and because residual pool depth tends to increase with channel size. The same value was applied for larger streams in the Tobacco watershed (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011a), and values between 1.6 and 1.9 ft were applied to large streams in the Lower Clark Fork TMDLs (Montana Department of Environmental Quality, 2010).

The target values should be assessed based on the reach average residual pool depth value. Because residual pool depths can indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis using the data collected in 2011 as a baseline. Future monitoring should document an improving trend (i.e., deeper pools) at sites which fail to meet the target criteria, while a stable trend should be documented at established monitoring sites that are currently meeting the target criteria.

Table 5-5. Percentiles of Reference Data and 2011 Sample Data for Residual Pool Depth (ft)

Category	Libby Reference			PIBO Reference			2011 Sample Data			
	n	Median	25th	n	Median	25th	n	Median	25th	75th
< 20' BFW	57	0.8	**0.6**	33	0.9	0.7	137	0.8	0.6	1.0
20-35' BFW	18	1.4	**1.2**	46	1.1	0.9	107	1.1	0.8	1.7
> 35' BFW	0	--	--	29	**1.6**	1.1	60	1.9	1.3	3.0

Targets are shown in **bold**.

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 for many of the same reasons associated with the residual pool depth discussed above and also because it can be a major driver of fish density (Muhlfeld and Bennett, 2001; Muhlfeld et al., 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.

Similarly to the residual pool depth values, protocol differences did not result in noticeable differences in the pool frequency, indicating the Libby and PIBO reference datasets are suitable for setting targets. Therefore, the 25th percentile of the Libby reference data will be applied as pool frequency targets for streams with a bankfull width < 35ft (**bolded** in **Table 5-6**), which is the upper limit of streams in the Libby dataset. Since the PIBO 25th percentile is comparable to all quartiles from the sample dataset, 25 pools per mile will be applied as the pool frequency target for streams with a bankfull width ≥ 35 ft (**Table 5-6).** The pool frequency targets are similar to the Inland Native Fish Strategy (INFISH) Riparian Management Objectives (U.S. Department of Agriculture, Forest Service, 1995) as well as reference data from the Swan River and Grave Creek watersheds (Montana Department of Environmental Quality et al., 2005) (**Table 5-7**).

Because pool frequency tends to decline as stream size increases and the PIBO dataset only includes streams with a bankfull width up to 50 feet, 25 pools per mile may be too high of a target for Lake and Libby creeks, which ranged in average bankfull width from 68-87 ft. The TMDL target for the C channel reaches of lower Grave Creek (Montana Department of Environmental Quality et al., 2005) is 12-24 pools/mile based on an internal reference reach and will be applied as the target for the Libby and Lake creeks. The INFISH goal for streams with a bankfull width of 75 ft is 23 pools per mile (**Table 5-7**), and one reach on Libby Creek exceeded this value, indicating a value near the upper end of the target range is achievable and preferable. Pools per mile should be calculated based the number of measured pools per reach and then scaled up to give a frequency per mile.

Table 5-6. Percentiles of Reference Data and 2011 Sample Data for Pool Frequency (pools/mile)

Category	Libby Reference			PIBO Reference			2011 Sample Data			
	n	Median	25th	n	Median	25th	n	Median	25th	75th
< 20’ BFW	57	114	**81**	33	82	44	12	84	67	121
20-35’ BFW	18	53	**38**	46	38	32	7	63	53	98
>35’ BFW	0	--	--	29	34	**25**	10	26	26	28
Libby & Lake Creeks	Target value = **12 -24** pools/mile based on Grave Creek reference, PIBO, and INFISH									

Targets are shown in **bold**

Table 5-7. INFISH and Reference Pool Frequency Values by Channel Bankfull Width (BFW)

Comparative Data Source	Smaller Stream Values (pools/mile)	Larger Stream Values (pools/mile)
Swan River tributary reference	19-35’ BFW: 25th = 70	35-45’ BFW: 25th = 29
Grave Creek reference	10-20’ BFW: 73-118 20-35’ BFW: 47-66	40-60’ BFW: 12-24
INFISH	< 20’ BFW: 56-96 25’ BFW: 47	50’ BFW: 26 75’ BFW: 23

Large Woody Debris

Large woody debris (LWD) is a critical component of stream ecosystems, providing habitat complexity, quality 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 numbers generally are greater in smaller, low order streams. The application of a LWD target will carry very little weight for sediment impairment verification purposes, but may have significant implications as an indicator of a non-pollutant type of impairment.

For EPA sampling in 2011, wood was counted as LWD if it was greater than 9 feet long or two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton et al., 1997). The LWD count for both available reference datasets was compiled using a different definition of LWD than the 2011 sample dataset; if measurements were conducted within the same reach, the Libby District LWD count would likely be less than the 2011 LWD count because the protocol only counted wood if it was larger than 6 inches in diameter and longer than the BFW, and the PIBO LWD count would likely be greater because it includes pieces 3 feet long and 4 inches in diameter. Unlike for pool frequency and residual pool depth, the summary statistics indicate the protocol differences did result in lower numbers in the Libby dataset and greater numbers in the PIBO dataset (except for BFW < 20 ft) (**Table 5-8**).

The Libby dataset is the preferred reference dataset for setting target values; however, using the 25th percentile of the Libby dataset as a starting point, it is less than the 25th percentile of the sample dataset, indicating the effect of the protocol difference and that the potential for streams of concern in the project area is greater than the 25th percentile of the Libby dataset. Therefore, LWD target values for streams with a bankfull width <35 ft will be based on the median of the Libby reference data (**bolded** in **Table 5-8**). For streams with a BFW ≥ 35 feet, both the PIBO median and 25th percentile values are too high relative to the sample data and are not appropriate targets. Therefore, the 25th percentile of the sample data, 148 pieces of LWD per mile, will be applied as the target for all streams with a BFW ≥ 35 feet. A range of 104-210 LWD per mile was applied as a target in TMDLs for Grave Creek, Prospect Creek, St Regis, and Tobacco based on the 25th and 75th percentile of reference data from the Swan River watershed for streams with a bankfull width ≥ 35 ft (Land & Water Consulting, Inc. et al., 2004). This range indicates the 25th percentile of the sample data is an appropriate target. Due to the extent of historical timber removal or channel encroachment by the transportation network, it is acknowledged that these targets may not be achievable for all streams.

Table 5-8. Percentiles of Reference Data and 2011 Sample Data for LWD (LWD/mile)

Category	Libby Reference			PIBO Reference			2011 Sample Data			
	n	Median	25th	n	Median	25th	n	Median	25th	75th
< 20' BFW	57	**359**	183	33	244	90	12	359	206	638
20-35' BFW	18	**242**	92	46	412	243	7	285	177	330
> 35' BFW	0	--	--	29	466	298	10	321	**148**	396

Targets are shown in **bold**. Note, the minimum LWD size varies by dataset: Libby is 6 inch diameter and longer than bankfull width; PIBO is 4 inch diameter and 3 feet long; and DEQ is 4 inch diameter and 9 feet long or greater than 2/3 channel wetted width.

5.4.1.4 Riparian Health

Riparian Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies LWD that influences sediment storage and channel morphology. Riparian vegetation helps filter sediment from upland runoff, stabilize streambanks, and it can provide shading, cover, and habitat for fish. During EPA assessments conducted in 2011, ground cover, understory shrub cover and overstory vegetation were cataloged at 10 to 20 foot intervals along the greenline at the bankfull channel margin along both sides of the stream channel for each monitoring reach. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs. While shrub cover is important for stream health, not all reaches have the potential for dense shrub cover and are instead well armored with rock or have the potential for a dense riparian community of a different composition, such as wetland vegetation or mature pine forest.

There is no available understory shrub cover reference data so the target is based on the sample dataset. At the 2011 assessment sites, there was an average value of 59% understory shrub cover and a median value of 58% understory shrub cover. Based on this median value, a target value of ≥ 58% is established for understory shrub cover in the Kootenai-Fisher project area. This target value should be assessed based on the reach average greenline understory shrub cover value. Because not all reaches have the potential for dense shrub cover, for any reaches that do not meet the target value, the greenline assessment results will be more closely examined to evaluate the potential for dense riparian shrub cover and identify if the streambanks in the reach are stabilized instead by rocks, a mature pine forest, and/or wetland vegetation.

5.4.1.5 Sediment Supply and Sources

Anthropogenic Sediment Sources

The presence of anthropogenic sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified anthropogenic sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared since Montana's narrative criteria for sediment cannot be exceeded in the absence of human causes. There are no specific target values associated with sediment sources, but the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluation of human induced and natural sediment sources, along with field observations and watershed scale source assessment information obtained using aerial imagery and Geographic Information System (GIS) data layers. Because sediment transport through a system can take years or decades, and because channel form and stability can influence sediment transport and deposition, any evaluation of anthropogenic sediment impacts must consider both historical sediment loading as well as historical impacts to channel form and stability since the historical impacts still have the potential to contribute toward sediment and/or habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.5**, with additional information in **Attachment A** and **Appendices C** and **D.**

5.4.1.6 Biological Indices

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 method 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 Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities 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 western Montana streams is any O/E value < 0.90. Therefore, an O/E score of ≥ 0.90 is established as a sediment target in the Thompson Project Area. Note, the threshold for data collected prior to 2011 is 0.80 because the O/E model has been updated since that time to better reflect DEQ's current sampling protocol (i.e., MAC-R-500). The rationale and methodology for the previous O/E model and 0.80 threshold value is detailed in the previous macroinvertebrate standard operating procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006).

Unless noted otherwise, macroinvertebrate samples discussed within this document were collected according to DEQ protocols. USFS samples were collected by the KNF in both riffles and pools with either a Hess or Surber sampler. A large proportion of the USFS data had O/E scores well below 0.80, which caused DEQ to examine the data more closely. The O/E model is very sensitive to the macroinvertebrate collection method, and DEQ determined that it is not appropriate to use the O/E model to evaluate macroinvertebrate health within the Kootenai-Fisher project area using USFS samples collected by the Hess or Surber method. Instead, the taxonomic composition of each sample was evaluated and a narrative summary was added to the DEQ assessment file for each applicable stream (i.e., Bristow, Libby (above Hwy 2), Quartz, and Wolf). That summary information is discussed within this document as part of the data evaluation for each applicable stream.

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. 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 macroinvertebrate target does not necessarily indicate a waterbody is fully supporting its aquatic life beneficial use and measures that indicate an imbalance in sediment supply and/or transport capacity will also be used for TMDL development determinations.

Periphyton

Periphyton are algae that live attached to or in close proximity to the stream bottom. Algae are ubiquitous in Montana surface waters, easy to collect, and represented by large numbers of species. Measures of the structure of algal associations, such as species diversity and dominance, can be useful indicators of water quality impacts and ecological disturbance.

DEQ collected periphyton from reference streams and from streams known to have excess sediment and used statistical analysis to identify taxa that tend to increase in the presence of excess sediment (Teply, 2010b; Teply, 2010a). Algal community composition and dynamics differs geographically, and DEQ has developed ecoregion-specific periphyton sediment metrics. The rationale and methodology for the periphyton-based metrics is presented in the DEQ Periphyton Standard Operating Procedure (Montana Department of Environmental Quality, 2011b). The metric is reported as a percent probability of impairment. According to the DEQ Standard Operating Procedure (Montana Department of Environmental Quality, 2011b) a probability of impairment > 51% indicates sediment may be impairing aquatic life but should be used in conjunction with other data when assessing stream condition. Therefore, > 51% probability of impairment will be applied as a target for the Kootenai-Fisher project area, and it will be interpreted in the context of other indicators of sediment impairment for each stream.

5.4.2 Existing Conditions and Comparison to Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for each stream segment of concern in the Kootenai-Fisher project area (**Section 5.2**). The TMDL development determination is whether or not recent data supports the impairment listing and whether a TMDL will or will not be completed, but it is not a formal impairment assessment. All waterbodies reviewed in this section are listed for sediment impairment on the 2012 303(d) List. Although inclusion on the 303(d) list indicates impaired water quality, a comparison of water quality targets with existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts.

5.4.2.1 Bristow Creek (MT76D002_110)

Bristow Creek (MT76D002_110) is listed for sedimentation/siltation on the 2012 303(d) List. It was originally listed in 1992 because of excess sediment associated with timber harvest and roads. Both in the early and mid-1990s rain-on-snow events caused extensive damage to the road network and accelerated erosion, particularly in the upper watershed. In 2004, the KNF requested delisting of Bristow Creek for sediment based on improved channel stability, a low percentage of fine sediment, and the removal of 12 stream crossings. At that time, DEQ determined that the stream was recovering from historic management but still affected by siltation. Bristow Creek flows 6.4 miles from its headwaters to its mouth at Lake Koocanusa.

Physical Condition and Sediment Sources

The DEQ assessment file states that a 2002 photo from KNF monitoring site showed dense riparian vegetation, lots of LWD, a heavy cobble bedload, and stable streambanks. Additionally, pool frequency was noted to be low and it was observed that excess fine sediment was likely still moving through the system. An Environmental Assessment (EA) was completed for the Bristow Area Restoration Project (U.S. Department of Agriculture, Forest Service, 2003) which proposed timber thinning, road improvements and decommissioning, and stream habitat improvement projects. One of the goals was to make roads within the drainage hydrologically neutral (i.e., not altering natural runoff and streamflow patterns). Within the EA, the large amount of timber harvest on both private and public land was noted as well as road encroachment and undersized culverts in the lower watershed. Additionally, it was noted that macroinvertebrate samples indicated a decline in water quality between 1996 and 2002. Bristow Creek was determined to be functioning at risk. Most recently, DEQ analyzed the taxonomic composition of seven macroinvertebrate samples collected by the KNF between 2003 and 2010 at a site two miles upstream of the mouth (**Figure 5-1)** (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013). Taxa that are sensitive to water quality changes were found in all samples, but up until 2006, taxa tolerant of water quality changes were most prevalent. However, starting in 2009, the macroinvertebrate community composition shifted and samples were dominated by a stonefly very sensitive to water quality changes, indicating very good water quality.

In 2011, EPA collected sediment and habitat data at two sites on Bristow Creek (**Figure 5-1**). The upper site, BRST04-02, was located along a forested reach of Bristow Creek that did not appear to have been logged in recent history, though evidence of recent selective harvesting was observed upstream of the monitoring site and along the stream channel corridor downstream of the monitoring site. Ferns covered the forest floor and large conifers in the overstory limited the amount of understory shrub cover in this reach. Channel conditions were typical of a lower gradient mountain stream with LWD aggregates forming pools and relatively large substrate limiting potential spawning sites. Streambanks were composed of coarse material and the small amount of bank erosion observed was attributed to natural sources. The lower site, BRST04-04, was located along a forested reach of Bristow Creek downstream of the Koocanusa West Side road crossing. Similar to the upper site, the riparian corridor did not appear to have been logged in recent history, but evidence of more recent selective harvest was observed upstream of the monitoring site. Ferns covered the forest floor and large conifers in the overstory limited the amount of understory shrub cover in this reach, though some alders were present along the channel margin at the upstream end of the reach. Channel conditions were typical of a cobble and boulder dominated step-pool mountain stream with frequent small pools and large substrate that limited pool depth and spawning habitat. The streambanks were comprised of coarse material and the minor amount of streambank erosion was attributed to natural sources. Both sites were determined to be meeting their potential.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Bristow Creek are summarized in **Tables 5-9** and **5-10**. The macroinvertebrate bioassessment data are located in **Table 5-11**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-9. Existing sediment-related data for Bristow Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
BRST04-02	2011	23.1	B3	B3	8	7	3	2	18.6	2.9	**0.8**	121	375
BRST04-04	2011	21.5	B3	B3	3	2	1	**10**	15.1	2.2	**0.9**	153	343

Table 5-10. McNeil Core Results for Bristow Creek

Values that exceed the target (26%) are in bold.

Year	2003	2004	2005	2006	2007	2008	2009	2010
Ave % <6.35mm	7	20	7	20	18	24	23	16

Table 5-11. Bioassessment data for Bristow Creek

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
BRST04-02	9/8/2011	DEQ – EMAP	**0.85**	20
BRST04-04	9/8/2011	DEQ - EMAP	**0.83**	24

Summary and TMDL Development Determination

For fine sediment, the riffle pebble count and McNeil core results met the target value. All grid toss values met the target except for pools at the lower site, which were just over the target value of 9%. The channel morphology parameters also met the target values. Residual pool depths at both sites did not meet the target value, but given the large cobbles that dominate the system and predominance of step-pools, the pool depths are likely at their potential. For the biological parameters, the periphyton samples met the target but both macroinvertebrate samples were below the O/E target. Because the

KNF samples from the past five years indicate a healthy and stable macroinvertebrate community (discussed above), the periphyton samples met the target, and the McNeil core samples met the target, the O/E scores do not appear to be associated with harm from sediment.

Roads were originally identified as a substantial sediment source, and the Kootenai National Forest has made extensive road and culvert improvements since that time (discussed above). An assessment of unpaved roads was conducted for sediment TMDL support and five crossings were visited within the Bristow Creek watershed (**Appendix D**). Two of the crossings could not be accessed because the road had been closed and decommissioned, and the other three crossings had limited erosion because of water bars. It is important that the KNF continue to adequately maintain and evaluate the effectiveness of BMPs at road crossings, but field observations indicate that efforts to mitigate road-related sediment inputs have been successful. Accelerated sediment loading associated with historical rain-on-snow events also underscores the importance of continued implementation of best management practices during timber harvest and other ground-disturbing activities. Based on current land management practices that are mitigating human sources of sediment and the comparison of recent instream data to the targets, Bristow Creek is no longer impaired for sediment and a TMDL will not be written. The 303(d) listing status will be formally reevaluated by DEQ in the future.

5.4.2.2 Lake Creek (MT76D002_070)

Lake Creek (MT76D002_070) is listed for sedimentation/siltation on the 2012 303(d) List. It was originally listed in 1992 because of excess sediment associated with timber harvest, roads, grazing, mining, and residential development. Lake Creek flows 17.6 miles from its headwaters at the outlet of Bull Lake to its mouth at the Kootenai River. One-quarter mile upstream of the mouth in a canyon section with a waterfall, a hydroelectric dam was built in 1917 that is still in operation. The Lake Creek Dam is a barrier to upstream fish movement but has minimal storage capacity and minimally affects flows or the channel upstream of it (USDA Forest Service, Kootenai National Forest (KNF), 2010).

Physical Condition and Sediment Sources

As part of the Upper Kootenai Subbasin Review (U.S. Department of Agriculture, Forest Service, 2002) and the Sparring Bulls Environmental Impact Statement (USDA Forest Service, Kootenai National Forest (KNF), 2010; USDA Forest Service, Kootenai National Forest (KNF), 2012), the KNF has summarized historical sources of sediment loading, BMPs implemented, and current sediment sources along Lake Creek and its tributary watersheds. The road crossing density and equivalent clearcut area is generally low; however, roads built on sensitive land types or with undersized drainage structures were prone to road failures (U.S. Department of Agriculture, Forest Service, 2002; USDA Forest Service, 2009b). Starting in the 1960s, road development for mining, and timber harvest in the Ross Creek subwatershed caused multiple slope failures but most of the sediment is believed to have been retained in Bull Lake (U.S. Department of Agriculture, Forest Service, 2002). Other streams in the upper watershed that are believed to be more direct sediment sources are Camp and Stanley creeks because of road failure, timber harvest, and mine operations (Stanley only) (USDA Forest Service, Kootenai National Forest (KNF) and Montana Department of Environmental Quality, 2011). Lower in the watershed, Iron and Keeler creeks have altered riparian vegetation and channel stability issues (Marotz et al., 1988; USDA Forest Service, 2009a). In particular, Keeler Creek has had major problems with sediment loading from road failure, and aerial photos indicate it has contributed substantial amounts of sediment to Lake Creek since the harvest and road development activities began in the late 1940s (USDA Forest Service, 2009a). For instance, in during 1974 and 1980 flood events, there were forty document road failures (USDA Forest Service, 2009a). Although road related inputs have generally declined since the 1990s, road problems are continuing to add excess sediment to Keeler Creek, as well as other Lake Creek tributaries

(USDA Forest Service, 2009b). As a result of the 2001 Spar and Lake Subunits Forest Health Project Record of Decision, BMPs including removal of 19 crossings and decommissioning, stabilization, and improvement were applied to over 30 miles of USFS roads in the Keeler watershed between 2003 and 2008 (USDA Forest Service, 2009b; USDA Forest Service, Kootenai National Forest (KNF), 2012). Numerous road improvements were proposed in the 2009 Sparring Bulls Environmental Impact Statement (USDA Forest Service, Kootenai National Forest (KNF), 2012). Most of the BMP work for Sparring Bulls has been accomplished, but none of the road storage or decommissioning work has yet been implemented. The storage and decommissioning work is proposed in Madge (tributary to Camp) and Keeler watersheds. The work in Keeler cannot occur until all timber sale activities are completed, and the work in Madge can occur as soon as funding is secured (Newgard, Kris, personal communication 3/20/2014).

Although most of the Lake Creek watershed is managed by the USFS (~80%), the entire riparian corridor is privately owned (**Appendix A**, **Figure A-15**). The private land was historically predominantly owned by timber companies, who selectively harvested riparian vegetation, but those holdings have increasingly been divested and the land is being developed for residential and recreational uses (U.S. Department of Agriculture, Forest Service, 2002; USDA Forest Service, Kootenai National Forest (KNF), 2010). For instance, approximately 4,000 acres of Plum Creek land (mostly along Lake Creek) were sold off to individuals and developers between 2001 and 2004, and home development is ongoing on that acreage (USDA Forest Service, Kootenai National Forest (KNF), 2010). Surveys by the KNF identified moderate levels of fine sediment and a limited amount of high quality spawning habitat where gravel substrate exists (USDA Forest Service, 2009b). To help preserve the riparian corridor and upland habitat within a large portion of the remaining private timber holdings, Stimson Lumber Company sold 28,000 acres in the Kootenai valley as a conservation easement to FWP in December 2012 (Scott, 12/20/2012); this includes approximately 8,200 acres in the Lake Creek watershed (**Figure 5-2**).

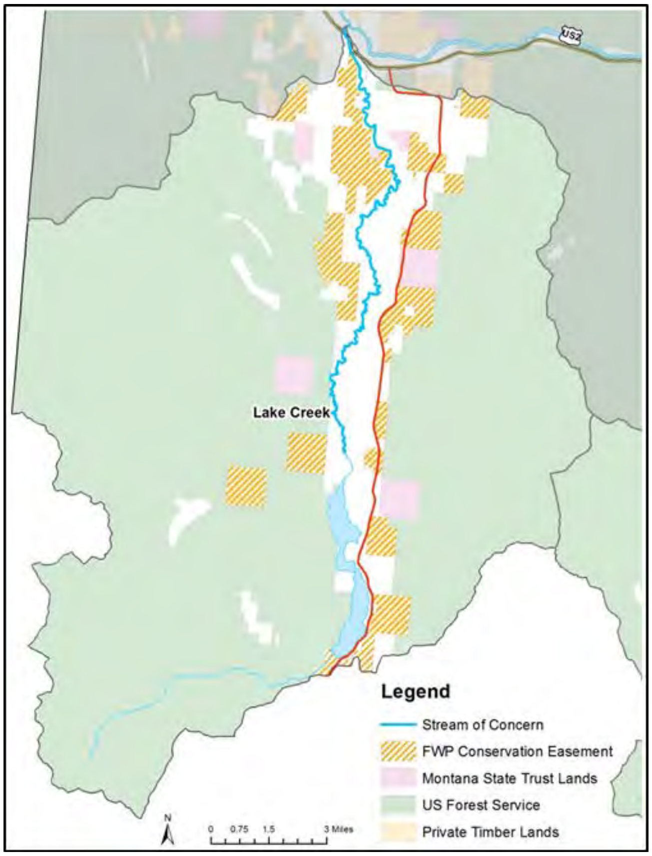

Figure 5-2. Ownership in Lake Creek watershed showing FWP conservation easement

Increasing development on private land has affected Lake Creek by the removal of riparian trees and LWD, and the placement of riprap on streambanks (USDA Forest Service, 2009a). The streambanks are fine-grained glacial till, glacial outwash, and lacustrine material that is highly erodible if not well vegetated, particularly by perennial plants and trees (U.S. Department of Agriculture, Forest Service, 2002; USDA Forest Service, Kootenai National Forest (KNF), 2010). Erosion of the fine-grained streambanks is a chronic source of sediment at high flows (Dunnigan, Jim, personal communication 10/18/2013). Even at lower flows, fine sediment can sometimes be observed in suspension for several miles (Hensler, Mike, personal communication 10/28/2013). Elevated levels of suspended sediment, particularly for an extended period of time, can harm aquatic life in a variety of ways ranging from behavioral changes and a reduction in feeding ability and reproductive success to death (Newcombe and Jensen, 1996; Suttle et al., 2004; Berry et al., 2003).

Streambank erosion that has been accelerated as a result of residential development and removal of riparian vegetation was observed at one of the 2011 monitoring sites (**Figure 5-3**, photo right, and discussed below), and also occurs between the two 2011 monitoring sites (**Figure 5-3**, photo left (courtesy of K. Newgard) (Newgard, Kris, personal communication 3/20/2014). The erosion occurring between the 2011 monitoring sites is a large unstable streambank that has been actively retreating since the early 1990s, and has progressed to become a site of mass wasting that extends several hundred feet up the hillslope (Hensler, Mike, personal communication 3/17/2014). This particular streambank is one of the sources that has caused elevated levels of suspended sediment for weeks (Newgard, Kris, personal communication 3/20/2014).

Figure 5-3. Actively eroding streambanks on Lake Creek that have worsened by removal of riparian vegetation and development. Left photo courtesy of K. Newgard, Kootenai National Forest, 2009.

In 2011, EPA collected sediment and habitat data at two sites on Lake Creek (**Figure 5-1**). The upper site, LAKE02-01, was located in an area of limited rural residential development along Lake Creek. This reach contained one very deep pool formed by large woody debris at a meander bend. The channel transitioned from a meandering channel to more of a riffle dominated channel progressing upstream through the monitoring site. Naturally eroding streambanks occurred at the outsides of meander bends, with alders along the channel margin and conifers on the floodplain. The lower site, LAKE03-03, was located upstream of the Lake Creek/Spar Lake road crossing. The road was very close to the left streambank at the downstream end of the reach and the streambank was lined with riprap. Immediately upstream of the riprap, this streambank has not been stabilized and is actively eroding. The erosion is threatening a structure on the property, and the landowner estimated the streambank has retreated 10 feet over the past 7 years. The opposite streambank progressing upstream is also riprapped along a field, likely leading to the accelerated rate of erosion at the next meander bend downstream. Lake Creek is a meandering channel with a well defined riffle-pool sequence and gravel bars at the insides of meander bends. Fine sediment was observed in the interstitial spaces of the coarse gravel substrate. This reach contained several very deep pools, which were estimated at 8-10 feet deep. These pools were typically formed by LWD accumulating at meander bends. Riparian vegetation removal for agricultural activities has occurred and the channel margin was noted to generally lack overstory vegetation at the downstream end of the reach. Progressing upstream, conifer forests occur at the outside of meander bends, with cottonwood galleries at the inside of meander bends.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Lake Creek are summarized in **Table 5-12**. The macroinvertebrate bioassessment data are located in **Table 5-13**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-12. Existing sediment-related data for Lake Creek relative to targets
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
LAKE02-01	2011	67.8	C3/C4	C4	8	4	3	0	28.6	**2.5**	3.9	16	396
LAKE03-03	2011	99.5	C4	C4	5	5	6	**11**	24.3	5.6	7.0	13	396

Table 5-13. Macroinvertebrate bioassessment data for Lake Creek
Values that do not meet the target threshold (0.90 for O/E and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
LAKE02-01	9/7/2011	DEQ – EMAP	**0.83**	17
LAKE03-03	9/7/2011	DEQ - EMAP	**0.85**	18

Summary and TMDL Development Determination
All measures of fine sediment in riffles met the target value, but the pool tail grid toss value slightly exceeded the target at the lower site. Overall, the channel morphology is stable; width/depth ratios were within the expected range and met the target at both sites, and the upper site fell slightly short of the entrenchment ratio target but still met the Rosgen criteria. Pool quality was very high at the assessment sites with pool frequency being within the expected range and residual pool depths easily meeting the target. LWD, which was the most abundant form of cover for pools, also easily met the target value at both sites. The periphyton samples from both sites met the target value, but both macroinvertebrate samples did not meet the target. The failure of the grid toss and macroinvertebrate targets, combined with the eroding streambanks that are causing extended periods of elevated turbidity indicate sediment is likely limiting its ability to fully support aquatic life. This information as well as the sensitivity of upland soils and streambanks, increasing level of development and pressure on the riparian zone along Lake Creek, and remaining road issues in tributary watersheds supports the current listing and a sediment TMDL will be developed for Lake Creek. However, because fine sediment was only slightly above the target for one metric, the extent of road mitigation work that has occurred, and the substantial amount of riparian acreage that was recently placed into a conservation easement, additional data regarding remaining human sediment sources and instream conditions should be collected prior to TMDL implementation to determine if additional restoration measures are necessary.

5.4.2.3 Libby Creek, lower segment (MT76D002_062)
The lower segment of Libby Creek (MT76D002_062) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for physical substrate alterations, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1996 because of aggradation, streambank erosion, and instability attributed to removal of riparian vegetation, channelization, and road construction. The lower segment of Libby Creek flows 14.8 miles from the Highway 2 bridge to its mouth at the Kootenai River. Note, the upper segment (MT76D002_061), which flows 11.2 miles from 1 mile upstream of Howard Creek to the Highway 2 bridge, is listed for two non-pollutant listings which may contribute excess sediment to the lower segment: alteration in streamside

or littoral vegetative covers and physical substrate habitat alterations. The portion of the watershed upstream of highway 2 is a priority watershed for the KNF.

Physical Condition and Sediment Sources

Timber harvest in the lower watershed began in the 1930s and eventually the entire valley was clearcut at least once, including riparian areas (U.S. Department of Agriculture, Forest Service, 2002; Mineau and Brundin, 1999). Grazing is now mostly on private land, but historically grazing was widespread in the watershed (Mineau and Brundin, 1999). The riparian and valley land types are severely sensitive to disturbance and erosion, and are the areas where most of the land disturbing activities have occurred (U.S. Department of Agriculture, Forest Service, 2002).

The Lincoln Conservation District conducted a walking inventory of Libby Creek in 1991 from the mouth to 22 miles upstream (Lincoln Conservation District, 1991). The inventory concluded that the creek was fairly stable upstream of Highway 2 (i.e., the upper segment) but very unstable downstream. In the lower segment, 4 to 5 miles of eroding streambanks were measured on each side of the stream channel. The report attributed channel instability largely to piecemeal attempts to stabilize streambanks and straighten the channel, but also cited road construction, removal of riparian vegetation for agriculture and development, and the high bedload as factors (Lincoln Conservation District, 1991).

A 2000 master's thesis from University of Montana evaluated natural and human sources of channel instability but focused on the upper watershed because mining, logging, and road building since the 1950s have primarily occurred in that portion of the watershed (Sato, 2000). That study concluded that excess sediment associated with riparian vegetation removal and mining are the primary sources of instability in the upper watershed and that flood events have compounded the instability and caused shifts in channel morphology.

The Draft Environmental Impact Statement for the Montanore Project (U.S. Department of Agriculture, Forest Service, Kootenai National Forest and Montana Department of Environmental Quality, 2009) discusses habitat, sediment, and fisheries information but focuses on the upper watershed because of the project area location. Since this section is focused on the condition of the lower segment and source characterization, only a brief summary of data from that report is included. McNeil core values for fine sediment <6.25 mm ranged from 15 to 29%, and riparian habitat was rated as good or excellent at all but one site near historic placer operations (U.S. Department of Agriculture, Forest Service, Kootenai National Forest and Montana Department of Environmental Quality, 2009). Based on data collected in 2005, most reaches were overwidened and pool and LWD frequency were typically below the targets being applied in this document. Macroinvertebrate community health was variable and densities appeared to be affected by high flows but generally periphyton and macroinvertebrate communities were healthy (U.S. Department of Agriculture, Forest Service, Kootenai National Forest and Montana Department of Environmental Quality, 2009). DEQ recently analyzed the taxonomic composition of 14 samples collected by the KNF from 3 sites in the upper segment (**Figure 5-1**) and had similar findings. Taxa sensitive to water quality changes were dominant at all sites but some of the samples near the headwaters and just upstream of Highway 2 also contained midges that are indicative of habitat disturbance (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013).

There is some mass wasting of streambanks in the upper watershed, but it is prevalent along the lower segment (U.S. Department of Agriculture, Forest Service, 2002; Mineau and Brundin, 1999). Several streambank stabilization projects have been completed by FWP along the upper segment (upstream of Highway 2), and in 2001 a streambank stabilization project was conducted by FWP along a 1,700 foot reach at the upper end of the lower segment (Dunnigan, Jim, personal communication 8/26/2013). A rain-on-snow event in fall 2006 damaged several of the projects in the upper segment but the project in the lower segment largely remained intact. Rain-on-snow events are common in the watershed (particularly in streams draining the Cabinet Mountains), which makes maintenance of habitat improvement projects challenging (U.S. Department of Agriculture, Forest Service, Kootenai National Forest and Montana Department of Environmental Quality, 2009). However, the stabilization project in the lower segment successfully eliminated a large actively eroding streambank that contributed an estimated 5000 cubic yards of coarse and fine sediment annually to the system (Dunnigan, Jim, personal communication 8/26/2013). FWP monitoring indicates that the stream channel dimensions remain narrower and deeper than existed prior to restoration, and fish abundance has increased at this site after restoration (Dunnigan, Jim, personal communication 8/26/2013).

According to the Upper Kootenai Subbasin Review, Libby Creek contributes thousands of tons of fine sediment to the Kootenai River annually as a result of roads, timber harvest, culverts, upland erosion, and natural properties of the watershed (U.S. Department of Agriculture, Forest Service, 2002). Overall, the report noted that Libby Creek was very unstable with a high potential for flooding and high levels of large and fine sediment. The high mobility of the bedload in the entire lower segment was noted, and that factor combined with frequent channel changes was determined to be a contributing factor in the lack of LWD and pools (U.S. Department of Agriculture, Forest Service, 2002). Overall, the Upper Kootenai Subbasin Review concluded that decades of mining, road construction, timber harvest, and land development have harmed aquatic habitat throughout the watershed and that the most severe impacts are evident along the entire lower segment (U.S. Department of Agriculture, Forest Service, 2002).

Libby Creek was channelized with riprap between 1963 and 1995 for almost 2000 feet upstream of its mouth (Zelch, 2003; Sylvester and Stephens, 2013). The channel actively migrates and is aggrading along the riprapped section (Sylvester and Stephens, 2013). Similar to Quartz Creek, Libby Creek has a delta at its mouth. The delta has been investigated in several studies (along with deltas at the mouth of other Kootenai River tributaries downstream of Libby Dam) and found to be associated with the change in the Kootenai River flow regime because of Libby Dam and not because of excess sediment supply from Libby Creek (Sylvester and Stephens, 2013; Marotz et al., 1988; Dibrani, 2003; Zelch, 2003). However, Zelch (2003) did find that Libby Creek has an excess sediment supply that is exceeding its transport capacity.

In 2011, EPA collected sediment and habitat data at two sites on Libby Creek (**Figure 5-1**). The upper site, LIBY09-03, was located downstream of the Farm to Market – Hammer Cutoff road. The Stimson Haul Road was situated along the river left bank at the upstream end of the reach, including a stretch of riprap lined streambank. Extensive mid-channel gravel bar deposits indicate Libby Creek is aggrading in this reach; 2009 color aerial imagery indicates this condition extends along the entire sediment impaired segment of Libby Creek (which extends from the Highway 2 crossing to the mouth), which is the same section that was identified as being unstable and having highly mobile bedload as part of the Kootenai Subbasin Review. The large gravel bars contained numerous pieces of LWD (**Figure 5-4**). Streambanks were primarily composed of coarse gravel and small cobbles of similar size to the stream substrate. A layer of fine sediment, likely of lacustrine origin, overlay the gravel layer in some of the eroding banks. Some bank erosion appeared natural but it was largely attributed to the removal of riparian vegetation. Fine sediment was observed in the interstitial spaces of the coarse gravel substrate found in the long glides downstream of pools (**Figure 5-4**), which typically formed at the outsides of meander bends and in association with LWD. Relatively large substrate in the pool tail-outs likely limits spawning potential for all but the largest fish, but the degree to which reproduction is currently limiting trout populations in

Libby Creek is unknown. The riparian clearcutting that once occurred is evident in the even-aged mid-seral cottonwood stands along the channel. One local resident indicated that since the large cedar trees lining the stream were logged, the stream has been actively meandering, becoming overwidened, and transporting large quantities of bedload sediment. This observation is consistent with the channel changes that were observed after riparian vegetation was clearcut in the upper watershed (Sato, 2000). Understory shrub cover was sparse and extensive patches of knapweed were observed.

The lower site, LIBY09-05, also flowed next to the Stimson Haul Road, which encroached upon the stream channel upstream of the reach, and it included a stretch of riprap-lined streambank and a flow deflection feature extending into the channel. The substrate was slightly finer than at the upstream reach, but was similar in that it had extensive mid-channel gravel bar deposits, large gravel bars with LWD, streambanks of coarse gravel and small cobbles, and even-aged mid-seral cottonwood stands with sparse understory shrub cover. However, one large eroding streambank along the river left side of the channel where Libby Creek was eroding into the terrace was a source of finer material, as well as LWD. A small side channel along this eroding terrace had a dynamic series of pools formed by recent LWD inputs. Streambank erosion at this site was attributed to a mix of natural sources, riparian vegetation removal, and the road network. At both sites, it appeared that the mobile bedload is the primary source of sediment to Libby Creek, along with additional inputs from streambank erosion as the stream actively meanders across the floodplain.

Figure 5-4. Site LIBY09-03: Mid-channel gravel bars with LWD (left) and fine sediment within pool glides (right)

Comparison with Water Quality Targets

The existing data in comparison with the targets for Libby Creek are summarized in **Tables 5-14** and **5-15**. The macroinvertebrate bioassessment data are located in **Table 5-16**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-14. Existing sediment-related data for Libby Creek relative to targets
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
LIBY09-03	2011	82.3	C/D/F 3/4	C3/C4	8	7	7	8	**41.4**	**1.9**	2.5	13	304
LIBY09-05	2011	93.0	C/D/F4	C4	9	7	7	6	**41.6**	2.7	2.3	29	409

Table 5-15. McNeil Core Results for Libby Creek below Crazyman Creek (lower end of upper segment)
Values that exceed the target (26%) are in bold.

Year	2003	2004	2005	2006	2007	2008	2009	2010
Ave % <6.35mm	11.5	20.6	12	10	6	15.8	16	6

Table 5-16. Macroinvertebrate bioassessment data for Libby Creek
Values that do not meet the target threshold of 0.90 for O/E or <51% for periphyton are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
LIBY09-03	9/6/2011	DEQ – EMAP	**0.88**	20
LIBY09-05	9/6/2011	DEQ – EMAP	**0.82**	18

Summary and TMDL Development Determination

All fine sediment targets were met for the pebble count and grid toss. The McNeil Core values are from just above the lower segment but all samples met the target. Both sites were overwidened and exceeded the target for width/depth ratio, and the upper site was slightly entrenched and did not meet the entrenchment target. The residual pool depth target was met at both sites. Pool and LWD frequency was lower at the upper site but both sites met the targets. For the biological parameters, both sites met the periphyton target but were slightly below the O/E target. Because fine sediment at that site was low and the periphyton score does not indicate a problem, the value may be associated with bedload mobility near the mouth or other stressors.

Based on the recent data, excess fine sediment is not a widespread problem in lower Libby Creek. Fine sediment accumulations were observed in some pool tails though and given the streambank material and instability of the channel and streambanks, there is likely a substantial load of fine sediment to the system that is either being flushed downstream during high flow events or not apparent because of the aggradation of larger substrate. Habitat measures were met, which indicate the habitat may be improving over conditions documented in the Upper Kootenai Subbasin Review (U.S. Department of Agriculture, Forest Service, 2002). However, the 2011 field work did not document an improvement in channel stability; the overwidened and aggrading channel conditions that have been largely attributed to historical land management practices were observed at both sample sites and throughout the lower segment. Like Zelch (2003) found, recent observations indicate the sediment supply is exceeding the transport capacity. In addition to coarse sediment aggradation, the high mobility of the bedload and overall instability of the system is impeding its ability to fully support fish and aquatic life, particularly bull trout and other native trout species (Dunnigan, Jim, personal communication 8/26/2013). Based on the overwidened channel and excess sediment and the link to human sources and limitations to the fishery, a sediment TMDL will be developed for the lower segment of Libby Creek.

5.4.2.4 Quartz Creek (MT76D002_090)
Quartz Creek (MT76D002_090) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for physical substrate alterations, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1992 because of excess sediment associated with timber harvest and roads. Quartz Creek flows 11.2 miles from its headwaters to its mouth at the Kootenai River.

Physical Condition and Sediment Sources
The Quartz Creek watershed was heavily harvested and had an extensive road network (U.S. Department of Agriculture, Forest Service, 2002). The DEQ assessment file notes logging roads, failing culverts, and erosion from channel instability as sediment sources. The file also notes a high precipitation event in 1996 that caused channel avulsion and channel braiding. The last major disturbance was a 1994 fire that burned 1,650 acres in the West Fork portion of the drainage and the subsequent timber salvage in 1995 (U.S. Department of Agriculture, Forest Service, 2002). Because it is an important spawning and rearing area for bull trout downstream of Libby Dam (Dunnigan et al., 2013), it has been the focus of extensive restoration work by the KNF since the early 1990s. The timber salvage in 1995 was conducted to be consistent with restoration goals (Wegner, 1998), which largely focused on addressing road-related issues: A large culvert was removed from the mainstem in 1995, numerous roads were recontoured, and in 1998 a road rehabilitation project was initiated that removed 9 culverts and decommissioned 11.6 miles of road in the West Fork watershed that had previously identified as sediment sources (U.S. Department of Agriculture, Forest Service, 2002). These projects reduced the road network in the West Fork portion of the drainage by 68% (Wegner, 1998). Additionally, LWD was placed in the channel, 800 feet of channel were dredged and reconstructed to address loading and channel avulsion associated with a slump on private land (Wegner, 1998), fireline fuel breaks were removed, and an additional 21.2 miles of road were removed from the system between 1995 and 1999 (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013).

Fisheries projects in the 1970s and 1980s removed LWD from the system; this affected the instream LWD, potential for recruitment, and the pool frequency (U.S. Department of Agriculture, Forest Service, 2002). However, the quality of the pools was noted to be high with several very deep pools in lower Quartz Creek. Substrate in the system is fairly unstable with significant annual bedload movement (U.S. Department of Agriculture, Forest Service, 2002) that is exacerbated by the frequency of high flow events (Dibrani, 2003). Also, there is a delta at the mouth that has caused aggradation in the lower section of the creek (U.S. Department of Agriculture, Forest Service, 2002; Dibrani, 2003). Several studies have investigated this delta (along with deltas at the mouth of other Kootenai River tributaries) and found it to be associated with the change in the Kootenai River flow regime because of Libby Dam and not because of excess sediment supply from Quartz Creek (Dibrani, 2003; Marotz et al., 1988; Sylvester and Stephens, 2013; Zelch, 2003).

Between 2003 and 2009, the KNF collected 13 macroinvertebrate samples from 4 sites (**Figure 5-1**). DEQ recently analyzed the taxonomic composition of the samples to help evaluate aquatic life beneficial-use support. Two samples collected near the mouth in 2006 and 2009 had mayflies that potentially indicate instream disturbance, but those samples and all others contained large quantities of several taxa that are very sensitive to changes in water quality (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013).

In 2011, EPA collected sediment and habitat data at two sites on Quartz Creek (**Figure 5-1**). The upper site, QRTZ03-01, was located in the upper watershed approximately five miles upstream of the West Fork Quartz Creek confluence. While a road parallels this portion of Quartz Creek, it is situated high up on the hillslope and does not appear to influence the stream channel. Timber harvest has occurred in the watershed upstream of this reach. The channel was lined by large cedar trees, with infrequent alder in the understory. The streambed was composed of gravel and small cobble substrate and most pools were formed by LWD. It appeared that the substrate size, pool frequency, and pool quality would provide ideal spawning conditions. Streambank erosion was limited and attributed to natural sources. This site appeared to be achieving its potential.

In addition to the assessment conducted on QRTZ03-01, the field crew also examined reaches QRTZ07-01 and QRTZ08-01 above and below the confluence with West Fork Quartz Creek. An erosive hillslope along river left was observed just downstream of the confluence and upstream of a small bedrock canyon. While human disturbances appeared absent along the stream channel in this area, evidence of timber harvest was observed on the adjacent hillslopes.

The lower site, QRTZ10-01, was located near the mouth of Quartz Creek. Activities that have influenced this site include timber harvest in the upper watershed, riparian harvest along the monitoring site, road encroachment, and LWD removal. This monitoring site was essentially comprised of one long riffle, with a couple of pools at the upper end of the monitoring site formed by LWD aggregates. One long eroding streambank was observed where the stream channel abuts a terrace and erosion was attributed to timber harvest and encroachment from the adjacent road. All other eroding streambanks were attributed to natural sources. Riparian vegetation along the channel margin includes conifers, cottonwoods, and alder. It appeared that a LWD aggregate at the upstream end of the reach was partially removed as evidenced by saw marks in the logs on both sides of the channel margin.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Quartz Creek are summarized in **Tables 5-17** and **5-18**. The macroinvertebrate bioassessment data are located in **Table 5-19**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-17. Existing sediment-related data for Quartz Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
QRTZ03-01	2011	18.7	B4c	B4c	13	8	3	4	17.9	2.2	1.4	90	480
QRTZ10-01	2011	38.5	B3	B3	7	4	3	3	25.7	1.5	**1.5**	26	338

Table 5-18. McNeil Core Results for Quartz Creek
Values that exceed the target (26%) are in bold.

Site/Year	2003	2004	2005	2006	2007	2008	2009	2010
Upstream of W Fork	19.3	19.5	**29**	19	16	21.6	23	21
Downstream of W Fork	26.3	19.9	21	20	17	**27.4**	**27**	20

Table 5-19. Macroinvertebrate bioassessment data for Quartz Creek
Values that do not meet the target threshold of 0.90 for O/E or <51% for periphyton are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
QRTZ03-01	9/8/2011	DEQ – EMAP	1.03	28
QRTZ10-01	9/8/2011	DEQ - EMAP	1.14	23

Summary and TMDL Development Determination
All riffle pebble count and grid toss targets were met and channel morphology parameters were within the expected range at both sites. The residual pool depth target was met at the upper site but was slightly below the target of 1.6 ft at the lower site. However, the Upper Kootenai Subbasin Review (U.S. Department of Agriculture, Forest Service, 2002) did document several very deep pools in lower Quartz Creek. Relative to the upper site, the effects of habitat disturbance on LWD and pool frequency is apparent, but both sites did meet the target for pool frequency and LWD frequency. For the biological parameters, the macroinvertebrate and periphyton samples were well within the target range at both sites.

Three of the core results exceed the 26% target, but the average since 2003 is 21% upstream of the West Fork and 22% downstream of the West Fork. Based on variability of core values in the KNF dataset, core values are naturally highly variable; therefore, more weight is given to long term trends than individual years. In a review of redd counts since 1995, the total count for all tributaries between Kootenai Falls and Libby Dam have been declining, but overall the population in Quartz Creek has been stable and not changed significantly since 1995 (Dunnigan et al., 2013). Although there is still evidence of the historical management practices, particularly in impacts to the habitat near the mouth, the restoration projects in the late 1990s and goals that continue to drive management actions in the watershed have expedited the watershed's recovery. Based on current land management practices that are mitigating human sources of sediment and the comparison of recent instream data to the targets, Quartz Creek is no longer impaired for sediment and a TMDL will not be written. The 303(d) listing status will be formally reevaluated by DEQ in the future.

5.4.2.5 Raven Creek (MT76C001_030)
Raven Creek (MT76C001_030) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1992 because of excess sediment associated with timber harvest and roads. Raven Creek flows 3 miles from its headwaters to its mouth at the Pleasant Valley Fisher River, but there is no year-round surface flow for approximately 1.25 miles in the middle portion of the waterbody segment.

Physical Condition and Sediment Sources
The Raven Creek watershed has been highly impacted by fire and also heavily used for timber harvest. A Watershed and Fishery Analysis conducted as part of the Raven Crystal Environmental Assessment in 1990 concluded that the clearcut equivalent was 52% (Altman, 1990). The report stated that harvesting was initially selective but that extensive regeneration harvest occurred after the 1984 Houghton Creek

fire and subsequent regeneration was unsuccessful. The Houghton Creek fire was severe, burning approximately 1,952 acres (88%) of the watershed (orange area in **Figure 5-5 inset**), and undoubtedly affected riparian vegetation, runoff rates, and sediment loading to Raven Creek. The disturbance caused by the fire was compounded by the post-fire harvest activities: the scale of the salvage harvest and associated road construction caused “extensive streambank cutting of 2 to 3 feet” because of increased runoff and a lack of LWD (Altman, 1990). High sediment loads were noted to be limiting the stream’s ability to support fish, and no additional harvest or road building was recommended at that time (Altman, 1990). In 1996, Plum Creek Timber Company planted ponderosa pine trees within a 100 foot buffer of each side of the channel along a 1 mile section of Raven Creek (from lower RAVN03-01 to the USFS boundary in lower RAVN05-01, **Figure 5-5**) in areas where regeneration was unsuccessful and vegetation was sparse (Sugden, Brian, personal communication 01/08/2014). KNF field forms from 2002 to 2004 also noted the extensive logging in the 1980s, and concluded it changed peak flows and increased the sediment load in Raven Creek (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013).

DEQ performed an assessment in 2004 at site K02RAVNC01 in the lower watershed approximately 0.4 miles upstream of the Highway 2 crossing (**Figure 5-5**). At the time, the substrate was dominated by large gravel but had silt at the channel margins. A pebble count was performed and fine sediment <6mm was 36% and <2mm was 31%, both of which exceed the targets being applied in this document. Woody vegetation was identified as a major factor in controlling lateral erosion. Other notes were written about the watershed conditions: Timber harvest appeared the least intense near the headwaters, the dry middle portion of the waterbody segment (which corresponded to the most intensively harvested area) was incised and resembled a gully, and downstream of Highway 2 silt deposition was noted and the channel was narrow and deep.

In 2011, EPA performed a streambank erosion assessment at one site and a full assessment at two sites (**Figure 5-5**). The bank erosion site, RAVN04-01, was located 1.6 miles from the mouth on a dry ephemeral reach upstream of a road crossing. Just upstream of the site in reach RAVN03-01 (**Figure 5-5**), surface flow was observed. Logging and fire appeared to be the primary landscape scale disturbances along this site. The low streambanks were generally armored by cobble and the relatively straight cascading stream channel appeared to limit streambank erosion. Eroding streambanks were attributed to a combination of timber harvest and natural sources. Grass, small shrubs, and knapweed lined the channel margin. Given the lack of perennial flow, the riparian potential for the site is likely limited; however, vegetation around the site has improved quite a bit over the last 15 to 20 years (**Figure 5-6)**.

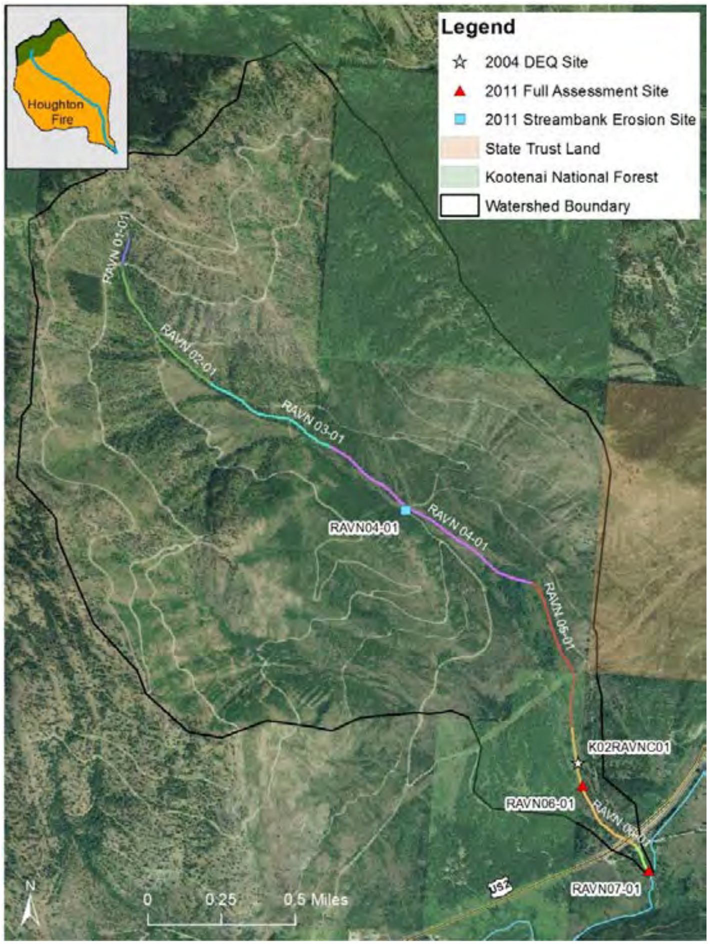

Figure 5-5. Raven watershed aerial photo (2009) showing stream reaches and sample sites. The inset shows the magnitude of the 1984 Houghton Fire

Figure 5-6. Looking downstream from the road at Raven Creek near RAVN04-01 in May 1994 (left) and July 2011 (right), photos courtesy of Plum Creek

In 2011, it appeared that Raven Creek had no perennial flow until the lower extent of reach RAVN05-01, where springs emerged and flowed into the channel (**Figure 5-5**). Because the entire stream except a reach downstream of Highway 2 was identified as having a valley gradient greater than 4%, the upper full assessment site, RAVN06-01, was slightly steeper than desired for observing the effects of excess sediment. However, the site was at almost the same location as the 2004 DEQ site (**Figure 5-5**), allowing the data and relative site conditions to be compared. The channel at RAVN06-01 was entrenched and had numerous small pools formed by small woody debris inputs. Streambank erosion was attributed to natural sources and limited by the small channel size, the degree of entrenchment, and dense woody vegetation along the stream channel margin. The substrate was comprised of gravel and small cobbles and free of fine sediment accumulations due to the high transport capacity of this reach. Alders formed a narrow band of vegetation along the channel margin, while the uplands were composed of weeds and small conifers.

RAVN07-01 was located near the mouth of Raven Creek, where it joins the Pleasant Valley Fisher River. Historic logging has occurred along this transitional reach where Raven Creek flows across the Fisher River floodplain. Stream substrate became finer in a downstream direction toward the mouth. The channel was small with grass-lined streambanks that limited streambank erosion. Alders were also present along the channel margin. The riparian vegetation was achieving its potential.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Raven Creek are summarized in **Table 5-20**. The macroinvertebrate bioassessment data are located in **Table 5-21**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-20. Existing sediment-related data for Raven Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
RAVN06-01	2011	6.8	B4/E4b	B4	10	1	7	6	6.7	2.6	0.7	211	813
RAVN07-01	2011	5.2	E4	E4	**41**	**22**	**19**	**24**	5.5	6.9	0.6	**63**	454

Table 5-21. Macroinvertebrate bioassessment data for Raven Creek

Values that do not meet the target threshold (0.80 for the 2004 O/E, 0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
K02RAVNC01	8/3/2004	Kick	0.91	--
RAVN06-01	9/5/2011	DEQ	**0.88**	44
RAVN07-01	9/5/2011	DEQ	**0.83**	43

Summary and TMDL Development Determination

All fine sediment targets were met at the upper site and all fine sediment targets were exceeded at the lower site. Compared to percent fine values for both size classes being greater than 30% in 2004, recent data from the upper site indicate a substantial improvement. Additionally, fine sediment was not observed at the channel margins as in 2004. At the lower site, all fine sediment targets were exceeded. The fine sediment targets being applied to the lower site are for an E channel, which are almost double the targets for B and C channel types, but there is some uncertainty regarding their applicability because Raven Creek downstream of the highway is in the floodplain for the Pleasant Valley Fisher River and achievable fine sediment values may differ from a typical E channel. However, some cells within the site did have pebble count and/or riffle grid toss values that met the target, indicating the targets are likely achievable. Given that reach RAVN07-01 is the only reach with a slope less than 4%, it is the most susceptible to excess sediment from the watershed and the last area where improvement is likely to be observed. Channel form parameters were within the expected range and met the target value at both sites. All instream habitat parameters met the targets at the upper site and all but the pool frequency target was met at the lower site. For the biological parameters, the periphyton samples were within the target range at both sites but two of the three macroinvertebrate samples did not meet the target.

It is unclear whether the Houghton Creek fire combined with the scale of harvest and road building caused the extent of subsurface flow that now exists, but it did increase sediment loads, destabilize streambanks, and cause channel downcutting. Although the extensive network of logging roads is still apparent (**Figure 5-5**), the roads assessment performed to support TMDL development found a high level of BMP implementation at crossings (**Appendix D**). Also, riparian vegetation throughout the stream has vastly improved and is helping stabilize streambanks and filter sediment from upland sources. Recent data and field observations indicate current management practices are facilitating the recovery of Raven Creek, but excess sediment is likely still limiting its ability to fully support aquatic life. Therefore, a sediment TMDL will be developed for Raven Creek.

5.4.2.6 Wolf Creek (MT76C001_020)

Wolf Creek (MT76C001_020) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1988 because of excess sediment associated with channelization from the relocation of the Great Northern Railroad and erosion from timber harvest and roads. Wolf Creek flows 39.3 miles from its headwaters to its mouth at the Fisher River.

Physical Condition and Sediment Sources

One of the largest changes to Wolf Creek occurred when the Great Northern Railroad was relocated through the drainage in the mid to late 1960s because of Libby Dam. Some channelization occurred upstream of Little Wolf Creek but most of it occurred downstream, with 21% (~4 miles) being reconstructed and channelized, shortening Wolf Creek by 0.75 miles (Huston and May, 1970). The railway and adjusted channel cut through the Wolf Creek valley and floodplain, which contain highly erosive glacial till and lacustrine silt (Huston and May, 1970). There were difficulties re-establishing riparian vegetation in some areas of the creek and erosion was observed following construction along the railroad right-of-way, of cut and fill material, and of streambanks, particularly from just upstream of Little Wolf Creek to the mouth (**Figure 5-6**). The changes in flow dynamics caused by channelization not only affected streambank erosion, but also channel morphology and fish habitat: there were increases in the average channel depth and width, and the amount of backwater areas, which increased the sucker [fish] population (Huston and May, 1970).

The watershed has also been affected by grazing, timber harvest, and wildfires. Grazing started in the Little Wolf drainage in the early 1900s and then spread out to other areas (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, Libby Ranger District, 1999). Near the headwaters in the Weigel drainage, road construction and timber harvest began in the 1960s and a portion of the drainage burned in 1988 (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1996) (**Figure 5-7**). Approximately 44% of the watershed was harvested and over 38 miles of road were constructed. The extent of timber harvest has caused some streambank destabilization, but the level of disturbance has also caused the KNF to be concerned about upland erosion, cutbank slumping and debris slides, and limitations on revegetation potential (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1996). Fires have also burned portions of the Dry Fork, Brush Creek, and Little Wolf subwatersheds since the 1980s (**Figure 5-7**), and Environmental Assessments conducted prior to [post-fire] salvage harvests summed up land management practices and channel conditions (USDA Forest Service, 1981; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1998; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, Libby Ranger District, 1999; Edwards, 2008). In the Dry Fork subwatershed, fire suppression, timber harvest, road and railroad construction, grazing, pine beetle, and wildfire were all noted as factors that are still affecting sediment deposition and channel conditions (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, Libby Ranger District, 1999). Between wildfire and timber harvest, the equivalent clearcut area in Dry Fork reached almost 50% at one time, and increases in runoff associated with harvest were attributed to channel filling and braiding and streambank erosion. Channel instability in Dry Creek was also associated with a loss of riparian habitat caused by timber harvest followed by a combination of wildfire, harvest, road construction, and grazing (USDA Forest Service, 1981; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, Libby Ranger District, 1999). In Brush Creek, timber harvest, overgrazing, and increased peak flows were cited as causes of bank erosion, alterations to channel morphology, and excess sedimentation (Edwards, 2008). Removal of riparian vegetation and resulting channel instability was noted in general for tributaries to Wolf Creek and in associated with streambank erosion on Wolf Creek (Edwards, 2008). Restoration projects to address runoff from the road network, add LWD, and add riparian fencing were completed in conjunction with post-fire timber salvage projects (Edwards, 2008; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, Libby Ranger District, 1999).

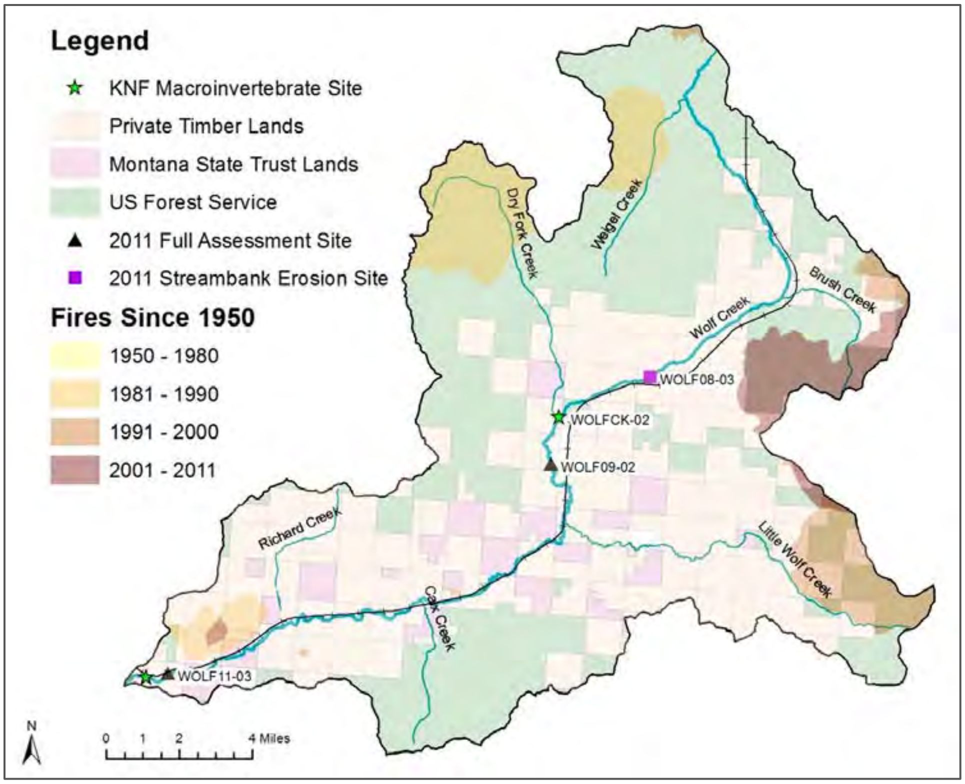

Figure 5-7. Wolf Creek watershed with sample sites, ownership, and fire history

DEQ visited three sites in 1992. At the time, the macroinvertebrates showed impairment from excess sediment. Lots of fine sediment was observed, especially near the mouth. Most of the overstory was noted to be gone from the valley and riprap was extensive, but shrub cover was good and limited grazing pressure on the stream. Extensive riprap and check dams were noted. Downstream of Little Wolf Creek, an unvegetated fire guard adjacent to the railroad track and eroding streambanks associated with channelization were noted to be the largest sources of sediment. Some beaver dams were observed near Little Wolf Creek but wetland vegetation was limited because the channel was incised. Closer to the canyon in the upper part of the watershed, channel alterations and riprap were also seen, as was evidence of historic logging, ongoing grazing, and BMP implementation at an active harvest area near the mouth of Rock Creek.

Between 2003 and 2009, the KNF collected 12 macroinvertebrate samples from 2 sites (**Figure 5-1**). DEQ recently analyzed the taxonomic composition of the samples to help evaluate aquatic life beneficial-use support. All samples at the upper site were dominated by taxa sensitive to changes in water quality, and all samples collected near the mouth contained sensitive taxa but were dominated by taxa that indicated instream habitat disturbance (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013).

In 2011, EPA performed a streambank erosion assessment at one site and a full assessment at two sites. A streambank erosion assessment was performed at WOLF08-03. Extensive logging has occurred in the Wolf Creek watershed upstream of this monitoring site. Grazing appears to be the primary land-use activity along the monitoring site, though overall grazing pressure appears relatively light. Streambanks were composed primarily of clay and silt and most streambank erosion appeared to be due to historic grazing activity and the loss of riparian vegetation, though historic logging and changes in water yield may also play a role. A fine layer of silt was observed on the streambed and the channel was slightly entrenched. The streambanks were lined with grass and the understory was dominated by alders.

The upper full assessment site, WOLF09-02, was located in a meadow area that has been grazed historically, though a recently constructed fence appeared to exclude grazing. Although the channel was entrenched, it was relatively sinuous and contained long runs and slow moving pools with an occasional short riffle. The substrate was predominantly fine material but was also covered with a layer of fine silt. Streambanks were composed primarily of clay and silt and the entrenched channel and most streambank erosion appeared to be due to historic grazing activity and the loss of riparian vegetation, though historic logging and changes in water yield may also play a role. Streambanks were lined with wetland sedges and grasses, with alders in the understory along the channel margin and very little overstory. The riparian vegetation appeared to be in a state of recovery and beaver activity was observed, though sediment contributions from eroding streambanks remain significant.

WOLF11-03 was located along the main road approximately 1.5 miles from the mouth. The monitoring site was situated so that the lower portion was located in a channelized area, while the upper portion was along a meander bend situated away from the road. As part of the channelization effort, it appeared that several grade control structures were added to Wolf Creek. During a review of 2009 color aerial imagery using GIS, 31 bridge crossings of Wolf Creek were identified, most of which were associated with the railroad. The streambed at the monitoring site was composed of large cobbles and small boulders, with riprap lining a portion of the reach, while natural streambanks generally contained large cobbles. Pools were relatively shallow and lacked spawning sized gravels. Alder and red osier dogwood lined the channel margin with conifers and a few cottonwoods in the overstory.

During field work in 2011, western pearlshell mussel shells were observed in portions of Wolf Creek. The Montana Natural Heritage Program surveyed Wolf Creek in 2007 for the mussel and conducted follow up checks in 2010 and 2012. A population with good viability was found in the lower watershed between Calx and Richard creeks, a relic shell with no live mussels was found near WOLF09-02, and several sites near and downstream of Little Wolf Creek had populations with no evidence of recent reproduction (Stagliano, David, personal communication 12/6/2012) (**Figure 5-7**). Although the mussel is sensitive to excessive siltation, the levels causing harm are unknown and its populations are also highly dependent on a salmonid host species, making it difficult to draw conclusions about the role of sediment in health of the Wolf Creek population (Stagliano, David, personal communication 12/6/2012).

Comparison with Water Quality Targets

The existing data in comparison with the targets for Wolf Creek are summarized in **Tables 5-22** and **5-23**. The macroinvertebrate bioassessment data are located in **Table 5-24**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-22. Existing sediment-related data for Wolf Creek relative to targets
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
Wolf Creek 5	2011	38.6	B4c	--	**--**	**--**	--	**--**	26.1	2.0	--	**14**	**14**
WOLF09-02	2011	29.7	B4c	C4	**16**	**16**	5	**11**	21.3	1.9	1.5	58	285
WOLF11-03	2011	45.1	F3	C3	6	5	0	--	27.2	**1.3**	1.6	**21**	**121**

Table 5-23. Average Annual McNeil Core Results for Wolf Creek
Values that do not meet the target are in bold.

Year	2003	2004	2005	2006	2007	2008	2009	2010
Upper Wolf	21.3	24.5	15	18	15	23.9	23	22
Lower Wolf	14.8	19.4	13	8	19	16.5	16	9

Table 5-24. Macroinvertebrate bioassessment data for Wolf Creek
Values that do not meet the target threshold (0.90 for O/E and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
WOLF09-02	9/6/2011	DEQ	**0.61**	24
WOLF11-03	9/5/2011	DEQ	**0.63**	25

Summary and TMDL Development Determination
The upper site exceeded the fine sediment target for both particles <6mm and <2mm in riffles by pebble count and also for particles <6mm in pool tails via grid toss. The lower site, which was mostly channelized and entrenched, met all fine sediment targets. All McNeil core samples met the target value. At all sites, the W/D ratio was within the expected range, but the entrenchment ratio was below the target at the entrenched lower site (WOLF 11-03). The residual pool depth met the target at both EPA sites, but pool and LWD frequency was below the target at the KNF site in the upper watershed and at the lower EPA site. For the biological parameters, the periphyton samples were well within the target range at both sites but both macroinvertebrate samples did not meet the target.

The highest achievable condition of the watershed is somewhat constrained by the extensive channelization and associated habitat changes caused by the railroad. However, timber harvest, roads, and grazing have also substantially altered the watershed, increased sediment loads to Wolf Creek, and caused streambank erosion and channel stability problems that persist. Although land management practices have improved, soils in the watershed are very sensitive to disturbance and field observations in combination with recent data indicate it is still recovering and excess sediment is limiting its ability to fully support aquatic life. This information supports the sediment impairment listing and a sediment TMDL will be developed for Wolf Creek.

5.5 Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and the determination of the allowable load for each source category. DEQ determines the allowable load by estimating the obtainable load reduction once all reasonable land, soil, and water conservation practices have been implemented. The reduction forms the basis of the allocations and TMDLs provided in **Section 5.6**. This section focuses on four potentially significant sediment source categories and associated controllable human loading for each of these sediment source categories:

- streambank erosion
- upland erosion and riparian health
- unpaved roads
- permitted point sources

EPA's guidance for developing sediment TMDLs states that the basic procedure for assessing sources includes compiling an inventory of all sediment sources to the waterbody. In addition, the guidance suggests using one or more methods to determine the relative magnitude of loading, focusing on the primary and controllable sources (U.S. Environmental Protection Agency, 1999b). Federal regulations allow that loadings "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR 130.2(G), 2012).

For each impaired waterbody segment, sediment loads from each source category were estimated based on field surveys, watershed modeling, and load extrapolation techniques (described below). The results include a mix of sediment sizes, particularly for bank erosion that involves both fine and coarse sediment loading to the receiving water. Conversely, loading from roads, upland erosion, and permitted point source discharges are predominately fine sediment. The complete methods and results for source assessments for streambank erosion, upland erosion, and roads are found in **Attachments A** and **Appendices C** and **D**, respectively**.**

5.5.1 Eroding Streambank Sediment Assessment

Data collected during the 2011 Kootenai-Fisher sediment and habitat field work were used to estimate the total sediment load associated with bank erosion for each watershed. Streambank erosion was assessed in 2011 at the 15 assessment reaches discussed in **Section 5.3**. Each reach was walked and measurements were collected on both streambanks where bank erosion was observed. For each eroding streambank, channel cross section measurements were collected to indicate the erosive force (i.e., Near Bank Stress) (Rosgen, 1996; 2004), and measurements of the bank height, bankfull height, root depth, root density, bank angle, and surface protection were collected as indicators each streambank's susceptibility to erosion (i.e., BEHI). This information was used to calculate an annual sediment load for each monitoring site.

Because identifying the contribution from human sources is an important part of the source assessment and TMDL allocations, the sources of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- silviculture
- natural sources
- irrigation-shifts in stream energy
- other (e.g., past sources)

Whether using field observations, aerial photography, or GIS methodology, it is difficult to discern between bank erosion influenced from current or past human practices and bank erosion as a result of natural processes. However, a simple break down of the apparent erosion sources provides a general indicator of the activities that may be affecting bank erosion, which in turn could help land managers prioritize areas for improvement. The erosion sources identified for each reach, and summarized at the watershed scale, are provided in **Attachment A**.

Streambank erosion data from each 2011 monitoring site was used to calculate an annual load for that reach (as identified during the aerial assessment and stratification process described in **Section 5.3**). Because reaches were classified by ecoregion, stream order, and valley gradient/confinement, which may affect the background streambank erosion rate, the annual load from similar reach types was averaged and extrapolated to like reach types to estimate the annual load for each stream segment of concern. Note, the average reach type loads were also grouped and extrapolated depending on whether sources were identified in the field and via the aerial assessment process (discussed in **Section 5.3**) to be predominately natural (>75%) or attributable to human causes. Using a Wilcoxon rank sum test, the average annual load was significantly different ($\alpha \leq 0.17$ for all comparisons) between reach type categories and by predominant erosion source category. A more detailed description of the bank erosion assessment can be found in **Attachment A**.

5.5.1.1 Establishing the Total Allowable Load

Streambank erosion is a natural process typically dominated by slowly eroding streambanks. Human disturbances to riparian vegetation and health and/or stream hydrology can accelerate the natural erosion rate. This commonly occurs when streambanks shift from being well vegetated and/or armored (and commonly undercut) to being largely, or entirely, unvegetated with vertical banks. As discussed above, the annual bank erosion rate in reaches predominantly influenced by natural sources was significantly less than in those influenced by human sources. Therefore, the potential for reducing sediment loading from bank erosion was estimated by applying the erosion rate for reaches predominantly influenced by natural sources to all reaches where human sources are currently accelerating bank erosion. The “natural” erosion rate applied to establish the total allowable load is intended to represent bank erosion caused by natural sources and human sources when best management practices are used.

Tributaries to the 303(d) listed streams were included in the existing load estimate; however, because little is known about them, and the lowest erosion rate was applied to them, no reductions were applied to those waterbodies in determining the total allowable load at the watershed scale. The most appropriate BMPs will vary by site, and active restoration may be necessary to address some eroding banks, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream. Therefore, the load reductions are largely anticipated to be achieved by applying riparian BMPs. DEQ acknowledges that some streams may have a higher or lower background rate of eroding streambanks; thus, although the reduction may not be achievable in all areas, greater reductions will likely be achievable in some areas.

Assessment Summary

Based on the source assessment, streambank erosion loads range from 61 tons per year in the Raven Creek watershed to 5,659 tons per year in the Wolf Creek watershed (**Table 5-25**). Significant human-caused sources of streambank erosion include transportation (i.e., generally roads but also the railroad for Wolf Creek), timber harvest, removal of riparian vegetation, residential development, and grazing. Depending on the watershed, DEQ estimated that implementing riparian BMPs could decrease the human-caused level of streambank erosion by 10% to 32%. **Attachment A** contains additional information about the streambank erosion source assessment and associated load estimates for the

303(d) listed streams in the Kootenai-Fisher project area, including a breakdown by particle size class (i.e., coarse gravel, fine gravel, and sand/silt).

Table 5-25. Existing and Reduced Sediment Load from Eroding Streambanks in the Kootenai-Fisher Project Area

Subbasin	Existing Sediment Load (tons/year)	Existing Sediment Load (tons/mile/year)	Allowable Sediment Load with Riparian BMPs (tons/year)	Percent Reduction
Lake Creek	3,218	13.9	2,731	15%
Libby Creek	4,938	17.4	3,498	29%
Raven Creek	61	8.8	55	10%
Wolf Creek	5,659	19.9	3,867	32%

5.5.1.2 Streambank Assessment Assumptions

The following is a summary of the significant assumptions used during the assessment of eroding streambanks:

- The average annual rate of bank erosion at sites with predominantly natural sources is an appropriate and achievable rate in reaches where all reasonable land, soil, and water conservation practices are applied.
- The streambank erosion data collected during 2011 represents conditions within the watershed.
- The average annual load per reach type is applicable to other reaches within the same category.
- The assignment of influence to eroding streambanks and the distinction between natural and human-caused erosion is based on best professional judgment by qualified and experienced field personnel.
- Sources of bank erosion at the assessed stream segment scale are representative of sources for that watershed.
- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies in Colorado for sedimentary and metamorphic geologies (Rosgen, 2006). The Kootenai-Fisher project area primarily has metasedimentary geology (see **Appendix A**, **Figure A-4**); therefore, the erosion rates applied to help estimate the current loading from streambank erosion and the reductions achievable by implementing riparian BMPs are applicable to the project area.

5.5.2 Upland Erosion and Riparian Buffering Capacity Assessment

Upland sediment is that which originates beyond the stream channel. The erosion rate of sediment from upland sources is influenced by land use and/or vegetative cover. Sediment loading from upland erosion was modeled using a GIS application of the Universal Soil Loss Equation (USLE).

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

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

All factors except for vegetation cover (C-factor) and field practices (P-factor) are environmental variables unaffected by management practices. Because the P-Factor generally relates to practices occurring at a finer scale than is practical for establishing TMDLs in the project area, it was set at 1 for all scenarios. To estimate the existing upland load associated with each land-use category, adjustments were made to the C-Factor, which integrates a number of variables that influence erosion, including vegetative cover, plant litter, soil surface, and land management.

The existing sediment load delivered to each 303(d) listed stream was estimated by combining the USLE model results with a sediment delivery ratio that accounts for downslope travel distance to surface water, along with a riparian buffer factor that reflects ability of buffers to filter sediment from runoff. The ability of existing riparian vegetation to reduce upland sediment loads was based on a riparian health classification performed for the left and right streambank of each 303(d) listed waterbody during the stratification process described in **Section 5.3**. Buffer health was classified into five categories, which ranged from good (i.e., a dense riparian buffer) to poor (i.e., a mix of bare ground and no woody shrubs, in areas with potential for shrub cover). Based on studies that have found that a well-vegetated riparian buffer filters 75% to 90% of incoming sediment from reaching the stream channel (Wegner, 1999; Knutson and Naef, 1997), a 75% removal efficiency was applied to good buffers; this was scaled down to 50% and 30% for fair and poor buffers, respectively.

5.5.2.1 Establishing the Total Allowable Load

The allowable load from upland erosion, which is associated with implementing BMPs, was determined by a two-fold approach: (1) C-factors for human-influenced land-use categories were modified to reflect the improvement in ground cover that is expected by implementing upland BMPs and (2) riparian health was improved to represent the additional decrease in upland sediment loading that will occur by implementing riparian BMPs.

The land-use categories with modified C-factors were grasslands/herbaceous and pasture/hay. The C-factor change equated to an approximate 10% improvement in ground cover per category. Timber harvest also has the potential to contribute upland sediment, but the C-factor was kept the same for both scenarios because upland loading from this source is mitigated by conditions specified in Montana's Streamside Management Zone law and within the Plum Creek and Department of Natural Resources & Conservation (DNRC) Habitat Conservation Plans (Montana Department of Natural Resources and Conservation, 2010; Plum Creek Timber Co., 2000). The C-factor values for both scenarios (i.e., existing and improved conditions) were based on literature values, stakeholder input, and field observations. DEQ acknowledges that C-factor values are variable within land-use categories throughout the watershed and over time; however, because of the model's scale, DEQ assumed that values for ground cover were consistent throughout each land-use category and throughout the year.

The potential for improvements in riparian health was based on the existing riparian health classification, a review of aerial imagery, and on-the-ground verification. It is important to note that under the improved-conditions scenario, a significant portion of the remaining sediment load, after BMPs are implemented in human-influenced land-use categories, is also a component of the natural background load. Additionally, the allocation to human sources includes both present and past influences and is not meant to represent only current management practices. Many of the restoration practices that address current land use will reduce pollutant loads that are influenced from historic land uses. A more detailed description of the assessment can be found in **Appendix C**.

Assessment Summary

Sediment loads from upland erosion range from 31 tons/year in the Raven Creek watershed to 1,209 tons/year in the Lake Creek watershed (**Table 5-26**). Since this assessment was conducted at the watershed scale, DEQ expects larger watersheds to have greater sediment loads. A significant portion of the sediment load from upland erosion is contributed by natural sources, but the estimated contribution by all land-use categories is provided in **Appendix C**. By implementing upland and riparian BMPs, annual loading reductions are expected to range from 10% to 19%. Improvement in riparian health comprises greater than 98% of the estimated reduction in annual loading from upland sources.

Table 5-26. Existing and Reduced Sediment Loads from Upland Erosion in the Kootenai-Fisher Project Area

Subbasin	Existing Delivered Sediment Load (tons/year)	Improved Upland and Riparian Conditions Sediment Load (tons/year)	Percent Reduction
Lake Creek	1,209	1,085	10%
Libby Creek	876	709	19%
Raven Creek	31.1	25.6	18%
Wolf Creek	807	705	13%

5.5.2.2 Upland Assessment Assumptions

As with any modeling effort, and especially when modeling at a watershed scale, a number of assumptions are made. The following is a summary of the significant assumptions used during the assessment of upland erosion:

- The USLE model is sufficiently accurate for the level of detail needed for sediment TMDLs in this project area. This empirical model was selected for this source assessment because it is well suited for large watersheds and incorporates local climate and landscape data, but it is not overly data-intensive.
- The data sources used are reasonable and appropriate to characterize the watershed and build the model.
- The input variables used in the USLE calculations represent their respective land-use conditions.
- The land management practices that define the vegetative cover throughout the year are relatively consistent and represent practices throughout the watershed.
- The riparian condition as estimated through the aerial assessment and field-verified represents on-the-ground conditions. Riparian buffer health was included to emphasize its importance in reducing upland sediment loading; however, DEQ acknowledges the classification and improvement potential was conducted at a coarse scale.
- 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.

5.5.3 Unpaved Road Sediment Assessment

Roads located near stream channels can reduce stream function by degrading riparian vegetation, encroaching on the channel, and adding sediment. The degree of harm is determined by a number of factors, including road type, construction specifications, drainage, soil type, topography, and precipitation, as well as the usage and maintenance of BMPs. Unpaved roads were identified as a potentially significant sediment source for this project area and were the primary focus of the roads source assessment. However, culverts can pose a substantial risk for sediment loading and fish passage, and were also evaluated as part of the roads source assessment.

5.5.3.1 Erosion from Unpaved Road Crossings

Sediment loading from the unpaved road network in the Kootenai-Fisher project area was assessed using GIS, field data, and modeling. Prior to field data collection, GIS tools were used to identify each road crossing and near-stream parallel road segment and assign attributes for road name, surface type (i.e., native, gravel, paved), road ownership, stream name, and subwatershed. In 2011, 47 unpaved crossings were field assessed. At almost half of the sites, there was no defined stream crossing or the road had been closed. The lack of a defined stream channel at such a high number of sites was a factor of the high resolution stream layer (1:100,000 NHD) used to initially identify road crossings. The percentage of randomly selected crossings with no defined channel (21%) was used when modeled loads for field sites were extrapolated to the watershed scale to reduce the number of GIS-identified crossings that are potentially contributing sediment.

Although the majority of the field assessed crossings were pre-selected at random with the goal of collecting data at a representative subset of crossings, some additional sites were added in the field because of the large number that were lacking a defined stream crossing or were inaccessible. Ultimately, a suite of measurements related to road composition, traffic level, and contributing distance for eroding sediment were collected at 24 sites. Additionally, the location and type of existing BMPs and potential locations for additional BMPs (if necessary) were recorded. No near-stream parallel road segments were officially assessed because parallel segments were determined to be an insignificant component of road-related sediment loading; this determination was based on no evidence of loading being observed from these road segments and the robustness of most roadside buffers in the project area.

All field measurements were input into the Water Erosion Prediction Project (WEPP): Road soil erosion model to calculate an annual sediment load per crossing. Because precipitation is a key driver of erosion and it varies largely across the project area (**Appendix A**, **Figure A-10**), the project area was divided into three precipitation zones, and crossing loads were modeled in WEPP using climate data to reflect those zones. Because of differences observed in the field and in WEPP-generated loads between Federally-managed and private/county/state managed crossings, modeled loads were grouped by ownership in addition to climate zone before being averaged. This resulted in an average annual load per Federal and non-Federal crossing in each precipitation zone that was then extrapolated to all road crossings in the watershed based on ownership and precipitation zone.

5.5.3.2 Establishing the Total Allowable Load

For unpaved road crossings, the allowable load was determined by re-entering the 2011 field data into the WEPP: Road model and reducing the contributing distance for each crossing to the length identified in the field where a BMP could potentially be added. This process was used to provide a more customized approach than using a set reduction or contributing length per crossing, however, the distances used still are not intended to be prescriptive measures. The optimal location for additional BMPs is ultimately up to the road owner. The overarching goal is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. BMPs that may be used to either reduce the contributing length, or achieve the allowable load, include installing full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc.), improving the road surface, and reducing traffic levels (seasonal or permanent road closures). Although the estimated reductions may not be possible at all locations because of site-specific conditions or existing BMPs, additional loading reductions will likely be achievable at other locations.

Assessment Summary
Based on the source assessment, the sediment load from unpaved roads ranges from 0.17 ton/year in the Raven Creek watershed to 6.9 tons/year in the Libby Creek watershed (**Table 5-27**). In general, private/county roads had a higher proportion of crossings with adequate BMPs than federal roads (i.e., 5/7 vs. 4/17, respectively). This trend is also apparent in the contributing lengths when broken down by jurisdiction: the average contributing length at all private/county crossings was 60 feet and the average contributing length at all federal crossings was 167 feet. However, conditions for unpaved roads within the project area are generally good for all ownership categories. Most loading is coming from a limited number of crossings with inadequate or improperly maintained BMPs.

At fourteen of the crossing approaches, sufficient BMPs are already in place. The most common BMPs observed were rolling dips and water bars. Both of these BMPs interrupt the flow of water, reducing the amount of road surface that water can erode as it moves towards the stream channel (i.e., the contributing length). Based on measurements taken at crossings where additional BMPs are recommended, loading reductions ranging from 32% to 51% (**Table 5-27**) are achievable. Reductions are slightly greater for federally administered roads than private/county/state roads, but because of the greater average load per crossing at federal crossings, reductions at the subwatershed scale were similar. A more detailed description of this assessment, including the loads broken down by jurisdiction, can be found in the Road Sediment Assessment report (**Appendix D**).

Table 5-27. Annual Sediment Load (tons/year) from Roads in the Kootenai-Fisher Project Area

Watershed	Total Load (tons/year)*	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application*
Lake Creek	4.8	50%	2.4
Libby Creek	6.9	51%	3.4
Raven Creek	0.172	32%	0.116
Wolf Creek	5.7	47%	3.0

*Because of rounding, differences in loads presented in this table may not correspond to the percent reduction.

5.5.3.3 Culvert Failure and Fish Passage
Undersized or improperly installed culverts may be a chronic source of sediment to streams, or a large acute source during failure. They may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for each culvert. After crossings with no culvert were excluded, the culvert analysis was performed at 21 of the 24 field assessed road crossings. The assessment incorporated bankfull width measurements taken upstream of each culvert to determine the stream discharge associated with different flood frequencies (e.g. 2, 5, 10, 25, 50, and 100 year), as well as measurements to estimate the capacity and amount of fill material of each culvert. DEQ assumed that fill above an undersized culvert will periodically erode into the channel, but the culvert will not completely fail; therefore, the annual amount of sediment at-risk was set at a 25% probability for the loading analysis.

A common BMP for culverts is designing them to accommodate 25-year storm events; this capacity is specified as a minimum in Water Quality BMPs for Montana Forests (Montana State University Extension Service, 2001), and it is typically the minimum used by the USFS. Therefore, fill was only assumed to be at-risk in culverts that cannot convey a 25-year event. However, other considerations, such as fish passage, the potential for large debris loads, and the level of development and road density upstream of the culvert, should also be considered during culvert installation and replacement. When these are factored in, larger culverts may be necessary. For instance, USFS typically designs culverts to pass the 100-year event, while also accommodating fish and aquatic organism passage on fish bearing streams (U.S. Department of Agriculture, Forest Service, 1995). Therefore, the BMP scenario for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. At a minimum, culverts should meet the 25-year event. For fish-bearing streams, or those with a high level of road development upstream, meeting the 100-year event is recommended.

Fish passage assessments were performed on 18 culverts. The majority of these culverts were located on streams containing fish as evaluated by Montana Fish, Wildlife and Parks, though this was not considered when evaluating a culvert's ability to pass fish (**Appendix D**, **Figure 3-3**). Sites where all measurements could not be collected, as well as sites lacking perennial flow, were excluded. The assessment was based on the methodology defined in **Appendix D**, which is geared toward assessing passage for juvenile salmonids. Considerations for the assessment include streamflow, culvert slope, culvert perch/outlet drop, culvert blockage, and constriction ratio (i.e., culvert width to bankfull width). The assessment is intended to be a coarse level evaluation of fish passage that quickly identifies culverts that are likely fish barriers and those that need a more in-depth analysis. The culvert assessment in **Appendix D** contains information that may help land managers focus restoration efforts on those culverts that were deemed fish barriers and/or undersized per this analysis.

Assessment Summary

Out of the 21 culverts assessed for failure risk, 19 (90%) were estimated to pass a 25-year event, and 15 (71%) were estimated to pass the 100-year event. Both crossings not passing the 25-year event and five of the six crossings not passing the 100-year event were on road crossings administered by the USFS. Considering that approximately 60% of road crossings in the project area are administered by the USFS, this is not surprising. Although we evaluated a relatively small sampling of all the culverts, these findings indicate that landowners in the project area are very aware of the importance of properly sized culverts and have been diligent about installing appropriately sized culverts and replacing inadequate ones.

The two culverts that are predicted to pass less than a 25-year recurrence interval flood appear to be at a relatively high risk of failure. Should they fail, up to 180 tons of sediment is at risk of being contributed to the road-related sediment load. However, because of the sporadic nature and uncertainty regarding timing of culvert failures, the estimated load at-risk is not included in the existing loads estimates for each impaired stream.

For the fish passage assessment, 17 of 18 culverts were determined to pose a significant passage risk to juvenile fish at all flows. The predominant reason cited as a barrier to fish was a steep culvert gradient. Recent research suggests fish can pass steeper culverts than indicated by the screening tool used for this assessment (Burford et al., 2009; Peterson et al., 2013), particularly if there is no outlet drop (Peterson et al., 2013). When gradients up to 8% are considered at culverts with no outlet perch, five additional culverts may pass some fish. As this is a very coarse assessment, additional evaluations should be conducted at any culvert that may be replaced to facilitate fish passage.

5.5.3.4 Road Assessment Assumptions

The following is a summary of the significant assumptions used during the roads assessment:

- The road crossings assessed in the field represent conditions throughout the watershed.
- The WEPP: Road model reasonably characterizes the existing sediment loads and potential for load reductions for the road and climate conditions observed in the Kootenai-Fisher project area.

- Using modeling scenarios that focus reducing the contributing length near road crossings will effectively reduce the majority of the sediment load from roads. This is an effective way to represent loading reductions associated with implementing all reasonable, land, soil, and water conservation practices.
- BMPs may have already have been implemented on many roads, and therefore the reductions necessary in some locations may be less than described in this document.

5.5.4 Permitted Point Sources

As of September 23, 2013, the Kootenai-Fisher project area had 11 Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within sediment-impaired watersheds (**Appendix A, Figure A-18**). All of the permits fall within the Libby Creek watershed; none of them are located on the lower segment but because they all have the potential to contribute sediment that could flow into the lower segment, they were all evaluated. There is one individual permit issued to the Montanore Minerals Corporation (MT0030279) for reclamation and exploration at the Montanore Mine site, but all other permits are general. Nine of the general permits are for suction dredge (MTG370000) and one is construction storm water (MTR104874). To provide the required wasteload allocation (WLA) for permitted point sources, a source assessment was performed for these point sources. Because of the conditions set within all of the applicable permits, and the nature of sediment loading associated with these permits, the WLAs are not intended to add load limits to the permits; DEQ assumed that the WLAs will be met by adhering to the permit requirements.

5.5.4.1 Montanore Minerals Corporation

Individual Permit (MT0030279)

The permit has been administratively continued since 2011 and is being evaluated for renewal by DEQ. DEQ conducted compliance inspections in August 2005 and February 2011 and found no violations during either inspection. The mine is not currently active, but the site has an exploration adit, a water treatment plant, and a percolation pond, and there are three permitted outfalls. Based on the renewal application, Montanore Minerals Corporation plans to continue using the water treatment plant, adit, and permitted outfalls and to add two new adits, a tailings storage facility, a plant/mill facility, and five stormwater outfalls. Additionally, it would like to use one of the existing outfalls (#1) for stormwater; because this outfall also receives adit discharge, it will receive water that goes to the water treatment plant and a percolation pond before being discharged to groundwater.

Only one of the currently permitted outfalls (#3) could potentially discharge directly to Libby Creek, but it has not been constructed. When it is active, it will discharge from a percolation pond and may also receive treated effluent from the water treatment plant. The effluent limit for the three permitted outfalls corresponds to the Effluent Limit Guidelines for Discharges from Active Ore (Metal) Mining and Dressing Sites: a daily maximum Total Suspended Solids (TSS) concentration of 30 mg/L and a monthly average TSS concentration of 20 mg/L (40 CFR, §440.104(a)). There is no flow limit in the permit but the permittee estimates a typical discharge from outfall #3 of 0.8021 cfs. Based on sample data collected between 2008 and 2010 from the water treatment plant, the average TSS concentration in the outfall effluent is anticipated to be 1 mg/L. Since other source water to the outfall will be from a percolation pond, which allows for solids to settle, 1 mg/L seems like a reasonable estimate for the outfall effluent. At a flow rate of 0.8021 cfs, this equates to 0.8 tons/year, which is much less than the permitted load of 15.8 tons/year (assuming a concentration of 20 mg/L and 0.8021 cfs flow rate). The median TSS concentration from samples collected quarterly from Libby Creek at the future discharge location for outfall #3 (at LB-300) between 2006 and 2010 as part of the existing permit requirements is <1 mg/L.

This indicates the typical discharge concentration will be similar to that found in Libby Creek. Alternatively, if the concentration of the outfall effluent were at the monthly permit limit of 20 mg/L during critical low flow conditions (i.e., 7Q10) of 2.22 cfs, the concentration in Libby Creek would increase from 1 mg/L to 6 mg/L TSS. Based on monitoring data at LB-300 and farther upstream (LB-200), 6 mg/L is within the concentration range that occurs near the mine site and well below that anticipated to harm aquatic life (Newcombe and Jensen, 1996).

All five of the proposed stormwater outfalls will discharge to surface water: two will discharge to Libby Creek, one will discharge to Ramsey Creek (a tributary), and two will discharge to Poorman Creek (a tributary). Since both Ramsey and Poorman are tributaries to Libby Creek, all outfalls will be considered for this evaluation. Four of the proposed stormwater outfalls will collect runoff from access/haul roads and one will collect runoff from an adit pad, but none of the stormwater from the proposed outfalls is anticipated to contact waste rock or other mining-related material. According to supporting information in the permit file, all stormwater from the site will be collected in ditches and sediment ponds, and the outfalls would only be used for stormwater that exceeds the onsite storage capacity. Ditches and ponds will be sized to contain the 10-year, 24-hour storm event. Based on PRISM data referenced in the permit application, the average annual precipitation at the site is 35 inches. The combined drainage area contributing to the five proposed stormwater outfalls is 20.7 acres. Assuming no runoff is retained and the TSS concentration is 100 mg/L (which is the benchmark value provided in the General Industrial Stormwater Permit to assess successful BMP implementation), 8.2 tons of sediment could runoff annually. Using BMPs that maximize the onsite storage capacity, as well as BMPs that minimize the contributing length along the haul roads, is expected to greatly reduce sediment loading from the stormwater outfalls. Particularly since the BMPs are being designed to retain the 10-year, 24-hour storm event, the annual load will likely be much lower than this estimate. The BMPs discussed in the renewal application will be included in the Stormwater Pollution Prevention Plan (SWPPP) that will accompany the final permit.

The WLA for permit MT0030279 will be 24 tons/year based on the sum of the permitted monthly load to outfall #3 and the estimated load from the stormwater outfalls (15.8 tons and 8.2 tons, respectively). As stated above, this WLA is not intended to add load limits to the permits. Based on the current permit conditions and stormwater BMPs discussed in the renewal application, the intent of the WLA will be met by adhering to the permit requirements.

Construction Stormwater Permit (MTR104874)

Since construction activities at a site are relatively temporary and short term in nature, the number of construction sites covered by the general permit at any given time varies. Collectively, these areas of severe ground disturbance have the potential to be significant sediment sources if proper BMPs are not implemented and maintained. Each construction stormwater permittee is required to develop a SWPPP that identifies the stormwater BMPs that will be in place during construction. Prior to permit termination, disturbed areas are required to have a vegetative density equal to or greater than 70% of the pre-disturbed level (or an equivalent permanent method of erosion prevention). Inspection and maintenance of BMPs is required, and although Montana stormwater regulations provide the authority to require stormwater monitoring, water quality sampling is typically not required (Heckenberger, Brian, personal communication 2009).

The construction stormwater permit at the Montanore Mine site is for surface construction and underground exploration. According to the permit file, the site mostly has a flat gradient and 12 acres are anticipated to be disturbed. BMPs in place include vegetative buffer zones, sediment traps, berms and ditches, a storage pond for runoff from the main adit area with no discharge, and a pond for runoff from the former waste rock storage area. Based on the site layout and BMPs in place, no discharge is anticipated to Libby Creek. Therefore, a WLA of 0 will be provided and is anticipated to be met by adherence to permit conditions. Because following permit conditions meets the intent of the WLA for construction stormwater, any future permits will meet the TMDL by following all permit conditions, including the SWPPP.

5.5.4.2 Suction Dredge Permits (MTG370000)

There are currently nine suction dredge permits in the Libby Creek watershed. The Suction Dredge General Permit describes portable suction dredges and their operation as "mechanical devices that float on the stream surface and pump stream water and stream bed material through a suction dredge intake to a sluice box, from which gold or other precious metals are recovered. Unwanted gravels and other naturally occurring stream bottom material fall off the end of the sluice box and are redeposited back onto the stream bottom. Since the discharge consists of naturally occurring stream bottom material and no chemicals are allowed to be added to enhance gold recovery, there is no additional load of pollutants to the receiving stream." The general permit has special conditions to minimize harmful conditions caused by elevated suspended sediment concentrations:

- No disturbance of the streambanks or streambank vegetation
- No visual increase in turbidity (cloudiness or muddiness) observable at the end of the mixing zone. The mixing zone is defined as 10 stream widths downstream of the suction dredge.
- No visible oil sheen caused by the suction dredge operation.
- No discharge of floating solids or visible foam in other than trace amounts.
- No added chemicals allowed in the discharge.

Additionally to protect the fishery during spawning and fry emergence, all permits are seasonally limited to dredge between July 15 and September 1.

Assessment Summary

Because only sediment within the wetted channel is permitted and no visual increase is allowed beyond the mixing zone, if the permit conditions are followed, no sediment loading is anticipated from these permits. Therefore, a composite WLA of 0 will be provided for the suction dredge permits in the Libby Creek watershed.

Because following permit conditions meets the intent of the WLA for suction dredge, any future permits will meet the TMDL by following all permit conditions.

5.5.5 Source Assessment Summary

Based on field observations and associated source assessment work, all assessed source categories represent significant controllable loads. Each source category has different seasonal loading rates, and the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, because of the coarse nature of the source assessment work, and the unique uncertainties involved with each source assessment category, the intention is to separately evaluate source effects within each assessment category (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus water quality restoration activities in the Kootenai-Fisher project area; they indicate the relative contribution of different subwatersheds or landcover types for each source category and the percent loading reductions that can be achieved with the implementation of improved management practices (**Appendix C** and **D** and **Attachment A**).

5.6 TMDL and Allocations

The sediment TMDLs for the Kootenai-Fisher project area will be based on a percent reduction approach, discussed in **Section 4.0.** This approach will apply to the loading allocated among sources as well as to the TMDL for each waterbody. Each impaired segment's TMDL consists of any upstream allocations. An implicit margin of safety will be applied, further discussed in **Section 5.7**.

5.6.1 Application of Percent Reduction and Yearly Load Approaches

Cover et al. (2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools. DEQ assumed that a decrease in sediment supply, particularly fine sediment, will correspond to a decrease in the percent fine sediment deposition within the streams of interest and result in attaining sediment-related water quality standards. A percent-reduction approach is preferable because there is no numeric standard for sediment to calculate the allowable load and because of the uncertainty associated with the loads derived from the source assessment (which are used to establish the TMDL), particularly when comparing different load categories, such as road crossings to bank erosion. Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because this approach helps focus on implementing water quality improvement practices (BMPs) versus focusing on uncertain loading values.

An annual expression of the TMDLs was determined as the most appropriate timescale because sediment generally has a cumulative effect on aquatic life and other designated uses, and all sources in the watershed are associated with periodic loading. Each sediment TMDL is stated as an overall percent reduction of the average annual sediment load that can be achieved after summing the individual annual source allocations and dividing them by the existing annual total load. EPA encourages TMDLs to be expressed in the most applicable timescale but also requires TMDLs to be presented as daily loads (Grumbles, Benjamin, personal communication 2006). Daily loads are provided in **Appendix E**.

5.6.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, roads, and permitted point sources). These BMP scenarios are discussed in **Section 5.5** and associated appendices/attachments. They reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. Sediment loading was evaluated at the watershed scale and associated sediment reductions are also applied at the watershed scale based on the fact that many sources deliver sediment to tributaries that then deliver the sediment load to the impaired waterbodies.

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

Progress toward TMDL and individual allocation achievement can be gaged by adhering to point source permits, implementing BMPs for nonpoint sources, and improving or attaining the water quality targets defined in **Section 5.4**. Any effort to calculate loads and percent reductions for comparison with TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

The following subsections present additional allocation details for each sediment source category.

5.6.2.1 Streambank Erosion

Streambank stability and erosion rates are closely linked to the health of the riparian zone. Reductions in sediment loading from bank erosion are expected to be achieved by applying BMPs within the riparian zone. Sediment loads associated with bank erosion are identified by separate source categories (e.g., transportation, grazing, natural) in **Attachment A**; however, because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding the effects of past land management activity, all sources of bank erosion were combined to express the TMDL and allocations.

DEQ acknowledges that the annual sediment loads, and the method by which to attribute human 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 but was done to direct efforts to reduce the loads toward those causes that are likely having the biggest effect on the investigated streams. Ultimately, local land owners and managers are responsible for identifying the causes of bank erosion and for adopting practices to reduce bank erosion wherever practical.

5.6.2.2 Upland Erosion

The allocation to upland sources includes application of BMPs to present land-use activities as well as recovery from past land-use influences, such as riparian harvest. No reductions were allocated to natural sources, which are a significant portion of all upland land-use categories. For all upland sources, the largest percent reduction will be achieved via riparian improvements. The anticipated loading reductions achievable by implementing upland and riparian BMPs for each land cover category are presented in **Appendix C**. For the TMDL, the allocation to upland erosion sources is presented as a single load and percent reduction.

5.6.2.3 Roads

The allocation to roads can be met by incorporating and documenting that all road crossings with potential sediment delivery to streams have the appropriate BMPs in place. Routine maintenance of the BMPs is also necessary to ensure that sediment loading remains consistent with the intent of the allocations. Although near-stream parallel road segments (i.e., within 150 feet) were excluded from the unpaved road source assessment because of the general condition and composition of the roadside vegetative buffer in the watersheds for the streams of concern, current conditions should be maintained where sediment is not a source from parallel roads and additional BMPs will be needed if there are or become parallel segments that are sources of sediment. The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culverts. At a minimum, culverts should meet the 25-year event; however, for fish-bearing streams and streams with a high level of road and impervious surface development upstream, or for culvert sites with a large amount of fill, meeting the 100-year event is recommended.

5.6.2.4 Permitted Point Sources

All WLAs are expected to be met by adhering to permit conditions and loads provided within this document are not intended to be incorporated into permit limits or added to permit conditions.

5.6.3 Allocations and TMDL for Each Stream

The following subsections present the existing quantified sediment loads, allocations, and TMDL for each waterbody (**Tables 5-28** through **5-31**). Note, sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.6.3.1 Lake Creek (MT76D002_070)

Table 5-28. Sediment Source Assessment, Allocations and TMDL for Lake Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	4.8	2.4	50%
Streambank Erosion	3,218	2,731	15%
Upland Sediment Sources	1,209	1,085	10%
Total Sediment Load	**4,432**	**3,818**	**14%**

5.6.3.2 Libby Creek, lower segment (MT76D002_062)

Table 5-29. Sediment Source Assessment, Allocations and TMDL for lower Libby Creek

<table>
<tr><th colspan="2">Sediment Sources</th><th>Current Estimated Load (Tons/Year)</th><th>Total Allowable Load (Tons/Year)</th><th>Load Allocations (% reduction)</th></tr>
<tr><td colspan="2">Roads</td><td>6.9</td><td>3.4</td><td>51%</td></tr>
<tr><td colspan="2">Streambank Erosion</td><td>4,938</td><td>3,498</td><td>29%</td></tr>
<tr><td colspan="2">Upland Sediment Sources</td><td>876</td><td>709</td><td>19%</td></tr>
<tr><td rowspan="3">Point Source</td><td>Montanore Mine (MT0030279)</td><td>0</td><td>24</td><td>0%</td></tr>
<tr><td>Suction Dredge (MTG370000)</td><td>0</td><td>0</td><td>0%</td></tr>
<tr><td>Construction Stormwater (MTR100000)</td><td>0</td><td>0</td><td>0%</td></tr>
<tr><td colspan="2">Total Sediment Load</td><td>5,821</td><td>4,234</td><td>27%</td></tr>
</table>

5.6.3.3 Raven Creek (MT76C001_030)

Table 5-30. Sediment Source Assessment, Allocations and TMDL for Raven Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	0.17	0.12	32%
Streambank Erosion	61	55	10%
Upland Sediment Sources	31	26	18%
Total Sediment Load	**92**	**81**	**12%**

5.6.3.4 Wolf Creek (MT76C001_020)

Table 5-31. Sediment Source Assessment, Allocations and TMDL for Wolf Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	5.7	3.0	47%
Streambank Erosion	5,659	3,867	32%
Upland Sediment Sources	807	705	13%
Total Sediment Load	**6,472**	**4,575**	**29%**

5.7 Seasonality and Margin of Safety

Seasonality and margin of safety are both required elements of TMDL development. This section describes how seasonality and margin of safety were applied during development of the Kootenai-Fisher project area sediment TMDLs.

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 a stream. Seasonality was addressed in several ways:

- The applicable narrative water quality standards (**Appendix B**) are not seasonally dependent, 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 project area. 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 effects, 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 (MOS) 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, 1999b). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets; as discussed for each target parameter in **Section 5.4.1**, an effort was made to select achievable water quality targets, but in all cases, the most protective statistical approach was used. **Appendix B** contains additional details about statistical approaches used by DEQ.
- The C-factor and Sediment Reduction Efficiency values used to estimate sediment loading from upland sources were based on conservative literature values (i.e., allowing for more sediment erosion and delivery).
- When reducing the number of road crossings identified in GIS for the extrapolation, only the percentage of crossings encountered in the field with no defined channel (21%) were used. The percentage of field sites that had a paved approach or were not accessible (28%) was not used to adjust the number of GIS-identified stream crossings that potentially contribute sediment from the road network.
- By developing TMDLs for streams which were close to meeting all target values. This approach addresses some of the uncertainty associated with sampling variability and site representativeness and recognizes that capabilities to reduce sediments exist throughout the watershed.
- Sediment impairment is typically identified based on excess fine sediment but the targets and TMDLs address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations (details provided in **Section 5.7.1**).
- 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 in **Sections 5.10**, **9.0**, and **10.0**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.
- By developing TMDLs at the watershed scale to address all potentially significant human-related sources beyond just the impaired waterbody segment scale. This approach should also reduce loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

5.8 TMDL Development 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 subject to periodic modification or adjustment as new information and relationships are better understood. Within the Kootenai-Fisher project area, adaptive management for sediment TMDLs relies on continued monitoring of water quality and stream habitat conditions, continued assessment of effects from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fish 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 MOS. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring, and adaptive management (**Sections 9.0** and **10.0**). 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 (a) field data and target development and (b) 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.

5.8.1 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 in **Attachment A**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for creating sediment TMDLs (Montana Department of Environmental Quality, 2011a). This procedure defines specific methods for each parameter, including sampling location and frequency, to ensure proper representation and applicability of results. Before 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 the appropriate sites were assessed and whether 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 B**. 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 recent sample data for the project area. These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the Kootenai-Fisher 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. DEQ recognizes 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. Under these conditions the goal is to ensure that management activities do not significantly delay achievement of targets compared with the time for natural recovery to occur.

Also, human activity should not significantly increase the extent of water quality effects 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 flexibility to refine targets as necessary to ensure resource protection and to adapt to new information concerning target achievability.

5.8.2 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. Because of these uncertainties, conclusions may not represent existing conditions and achievable reductions at all locations in the watershed. Uncertainties are discussed independently for the three major nonpoint source categories: bank erosion, upland erosion, and unpaved road crossings. Additional details about uncertainties associated with the source assessments are contained in the associated attachments/appendices.

<u>Bank Erosion</u>

Bank erosion loads were initially quantified using the DEQ protocols (Montana Department of Environmental Quality, 2011a) and the standard BEHI methodology, defined in **Attachment A**. Before 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 project area to provide an estimate of bank erosion loading to the stream segments of concern. 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. Because of the small sample size for each unique reach type, and even for the reach types groupings that were used for the extrapolation, there is a high degree of uncertainty in the average annual load estimates that were extrapolated to the stream segment and watershed scale. For this reason, the loads are intended to provide a relative sense of the loading associated with bank erosion from human and natural sources for each watershed.

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 identifying sources at the stream segment scale using aerial photos and also because of the heavy influence from past disturbances; it is extremely difficult to identify the level to which historical occurrences still affect 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 Kootenai-Fisher project area. Evaluating bank erosion levels, particularly where BMPs 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 effect that bank erosion has on water quality throughout the Kootenai-Fisher project area.

Upland Erosion

A professional modeler determined upland erosion loads by applying a landscape soil loss equation (USLE), defined in **Appendix C**. As with any model, there will be uncertainty in the model input parameters, including land use, land cover, and assumptions regarding existing levels of BMP application. For example, only one vegetative condition was assigned per land cover type. In other words, the model 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 potential to reduce sediment loading was based on modest land cover improvements, along with riparian improvements, to reduce the generation of eroded sediment particles. Thus, there is uncertainty regarding existing erosion prevention BMPs and the ability to reduce erosion with additional BMPs.

The upland erosion model integrates sediment delivery based on riparian health; riparian health evaluations linked to the stream stratification work are discussed in **Attachment A**. The riparian health classifications were performed using aerial imagery and a coarse classification system (i.e., poor, poor/fair, fair, fair/good, and good). This particularly introduced uncertainty in watersheds that had limited woody vegetation but that may have had a high buffering capacity from other vegetation, such as wetland grasses. However, field verification and adjustment of the original classifications as well as the potential improvement was conducted to help reduce the uncertainty.

The riparian health analysis was not performed with the expectation that it would identify specific locations for implementation of additional BMPs. Instead it was performed to simulate the buffering capacity of riparian vegetation and emphasize the importance of a healthy riparian buffer. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, and the estimated reductions are consistent with literature values for riparian buffers.

Roads

As described in **Appendix D**, the road crossings sediment load was estimated via a standardized simple yearly model developed by USFS. 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 47 sites were visited in the field, representing about 3% of the total population of roads. The results from these sites were extrapolated to the whole population of roads stratified by ownership and precipitation class. Random selection of the stratified sites was intended to capture a representative subset of the road crossings for existing conditions and level of BMP implementation. However, some uncertainty is introduced because of the small sample size relative to the total number of road crossings.

Although the culvert assessment is a coarse level assessment, there is uncertainty in the peak flow capacity that was calculated for each culvert because it is based on regional regression equations, which may substantially overestimate or underestimate peak flow. The fish passage assessment indicated most culverts are problematic for fish passage, which is a little surprising given the high percentage of culverts estimated to pass greater than a 100-year storm event. Although there is a fair amount of uncertainty with any rapid assessment tool, such as the fish passage assessment, there is uncertainty associated with the fish passage conclusion because the assessment uses criteria that differ from that found by some recent research, which means fish passage rates may be higher than indicated by this analysis. The conclusions of the analysis were not used for the TMDL and are not intended to be used for decision-making but instead to raise awareness about the importance of proper culvert installation and maintenance, and to be a general indicator of potential fish passage issues at the watershed scale.

6.0 NUTRIENTS TMDL COMPONENTS

This section focuses on nutrients (nitrate + nitrite [NO_3+NO_2], total nitrogen [TN], and total phosphorus [TP] forms) as a cause of water quality impairment in the Kootenai-Fisher project area. It includes 1) nutrient impairment of beneficial uses; 2) specific stream segments of concern; 3) currently available data on nutrient impairment assessment in the watershed, including target development and a comparison of existing water quality targets; 4) quantification/description of nutrient sources based on recent studies; and 5) identification and justification for nutrient TMDLs and TMDL allocations.

6.1 EFFECTS OF EXCESS NUTRIENTS ON BENEFICIAL USES

Nitrogen and phosphorus are natural background chemical elements required for the healthy and stable functioning of aquatic ecosystems. Streams in particular are dynamic systems that depend on a balance of nutrients, which is affected by nutrient additions, consumption by autotrophic organisms, cycling of biologically fixed nitrogen and phosphorus into higher trophic levels, and cycling of organically fixed nutrients into inorganic forms with biological decomposition. Additions from natural landscape erosion, groundwater discharge, and instream biological decomposition maintain a balance between organic and inorganic nutrient forms. Human influences may alter nutrient cycling pathways, causing damage to biological stream function and water quality degradation.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with human sources) can be toxic to aquatic life. Elevated nitrates in drinking water can inhibit normal hemoglobin function in infants. Besides the direct effects of excess nitrogen, elevated inputs of nitrogen and phosphorus from human sources can accelerate aquatic algal growth to nuisance levels. Respiration and decomposition of excessive algal biomass depletes dissolved oxygen, which can kill fish and other forms of aquatic life. Nutrient concentrations in surface water can lead to blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans.

Aside from toxicity, nuisance algae can shift the macroinvertebrate community structure, which also may affect fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

6.2 STREAM SEGMENTS OF CONCERN

There are four waterbody segments in the Kootenai-Fisher project area that are on the 2012 Montana 303(d) List for nutrient impairments – Bristow Creek, Lake Creek, Raven Creek, and Stanley Creek (**Figure 6-1**). However, recent data indicate Bristow Creek is no longer impaired for nutrients, and it will be delisted for TN on the 2014 303(d) List. **Table 6-1** summarizes the nutrient impaired stream segments addressed in this document.

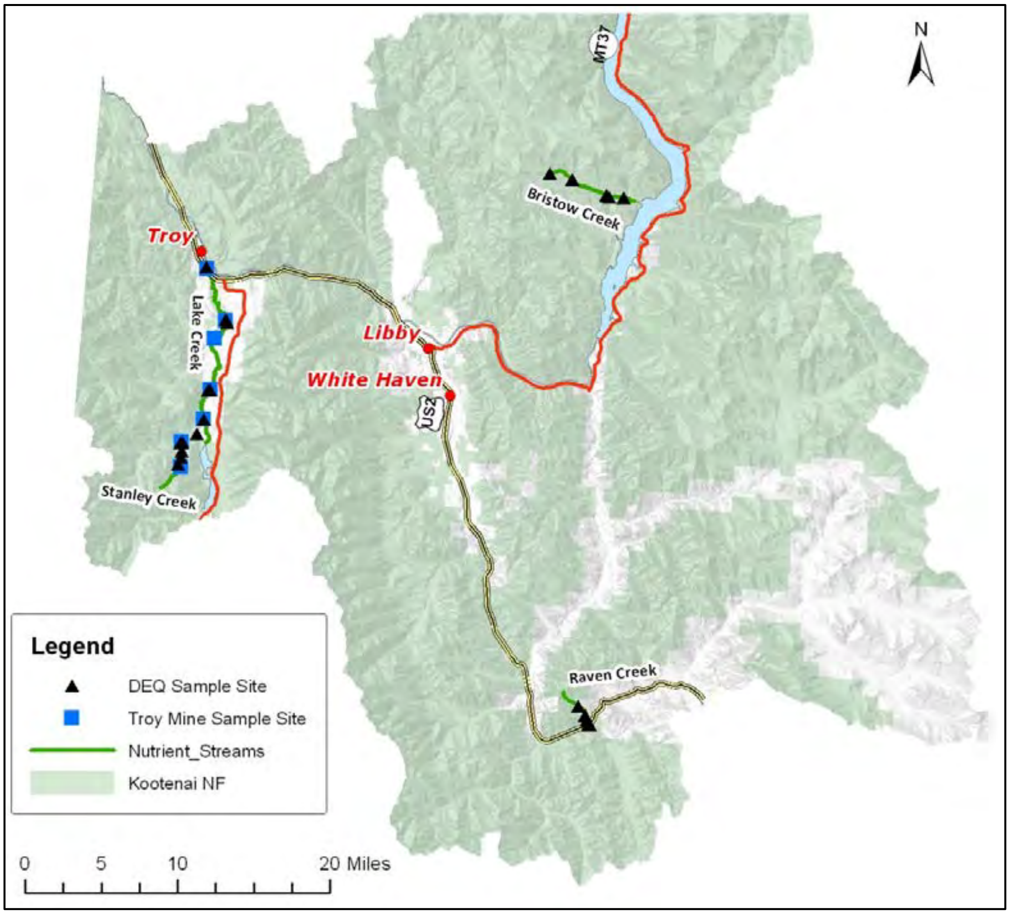

Figure 6-1. Stream segments of concern in the Kootenai-Fisher Project Area

Table 6-1. Nutrient impaired stream segments addressed in the Kootenai-Fisher Project Area

Stream Segment	Waterbody ID
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	MT76D002_070
RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030
STANLEY CREEK, Headwaters to the mouth	MT76D002_010

6.3 Information Sources and Assessment Methods

To assess nutrient conditions for TMDL development, DEQ compiled nutrient data and undertook additional monitoring. The following data sources represent the primary information used to characterize water quality.

1) **TMDL Sampling:** DEQ and EPA conducted water quality sampling from 2011 through 2013 to update impairment determinations and assist with the development of nutrient TMDLs. Sample locations were generally such that they provided a comprehensive upstream to downstream view of nutrient levels. All data used in TMDL development were collected during the growing season for the Northern Rockies Level III Ecoregion (July 1 – September 30). Benthic algae samples were collected for each stream and analyzed for chlorophyll-*a* and ash-free dry mass (AFDM). Macroinvertebrate samples were also collected in each stream.

2) **Troy Mine Data:** Water quality data were obtained from the Troy Mine for Stanley Creek and Lake Creek. Data were available from multiple sites on both streams spanning from 2003-2011 (**Figure 6-1**).

3) **DEQ Assessment Files:** These files contain information used to make the existing nutrient impairment determinations.

Nutrient data used for impairment assessment purposes and TMDL development are included in **Appendix F**. Other nutrient data from the watershed is publicly available through EPA's STORET and DEQ's EQuIS water quality databases.

Additional sources of information used to develop TMDL components include the following:
- Streamflow data
- GIS data layers
- Forest Service National Environmental Protection Act (NEPA) documents
- Land-use information

The above information and water quality data are used to compare existing conditions to waterbody restoration goals (targets), to assess nutrient pollutant sources, and to help determine TMDL allocations. Field data sheets were reviewed to rule out irregularities in collection methods or sample Quality Assurance/Quality Control (QA/QC). Laboratory methods and QA/QC criteria were also reviewed to ensure these values were accurate. Nothing was found to indicate that any results were anomalous.

6.4 Water Quality Targets

TMDL water quality targets are numeric indicator values used to evaluate whether water quality standards have been met. These are discussed further in **Section 4.0**. This section presents nutrient water quality targets and compares them with recently collected nutrient data in the Kootenai-Fisher project area following DEQ's draft assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's draft assessment methodology, and because of improvements in analytical methods, only data from the past 10 years are included in the review of existing data.

6.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous) are narrative and are addressed via narrative criteria. Narrative criteria require state surface waters to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: 1) produce conditions that create concentrations or combinations of material toxic or harmful to aquatic life, and 2) create conditions that produce undesirable aquatic life (ARM 17.30.637 (1) (d-e)). DEQ is currently developing numeric nutrient criteria for TN and TP that will be established at levels consistent with narrative criteria requirements. These draft numeric criteria are the basis for the nutrient TMDL targets and are consistent with EPA's guidance on TMDL development and federal regulations.

6.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae (a form of aquatic life that at elevated concentrations is undesirable) chlorophyll-*a* concentrations and AFDM. The target concentrations for nitrogen and phosphorus are established at levels believed to prevent the harmful growth and proliferation of excess algae. Since 2002, DEQ has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms). DEQ is developing draft numeric nutrient standards for TN, TP, chlorophyll-*a* and AFDM based on 1) public surveys defining what level of algae was perceived as “undesirable” (Suplee et al., 2009), and 2) the outcome of nutrient stressor-response studies that determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee and Watson, 2013). Although dissolved fractions of phosphorus and nitrogen do not have draft numeric nutrient criteria because uptake by aquatic organisms can make their concentrations highly variable, DEQ has determined that nitrate is an important constituent to evaluate in conjunction with TN and TP (Suplee and Watson, 2013).

Nutrient targets for TN and TP (which are also draft numeric criteria), chlorophyll-*a*, and AFDM are based on Suplee and Watson (2013) and can be found in **Table 6-2**. The NO_3+NO_2 target is based on research by DEQ (Suplee, Michael W., personal communication 11/14/2013) and can also be found in **Table 6-2**. DEQ has determined that the values for NO_3+NO_2, TN, and TP provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Kootenai-Fisher project area. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses. When the draft criteria for TN and TP become numeric standards they will be in DEQ’s DEQ-12 circular.

The nutrient target suite for streams in the Northern Rockies Level III Ecoregion also includes two biometric indicators: macroinvertebrates and diatoms. For macroinvertebrates, the Hilsenhoff Biotic Index (HBI) score) is used. The HBI value increases as the amount of pollution tolerant macroinvertebrates in a sample increases; the macroinvertebrate target is an HBI score equal to or less than 4.0 (Suplee and Sada de Suplee, 2011) (**Table 6-2**). Benthic diatoms, or periphyton, are a type of algae that grow on the stream bottom, and there are certain taxa that tend to increase as nutrient concentrations increase. The diatom target is a periphyton sample with a ≤51% probability of impairment by nutrients (Suplee and Sada de Suplee, 2011) (**Table 6-2**).

Because numeric nutrient chemistry is established to maintain algal levels below target chlorophyll-*a* concentrations and AFDM, target attainment applies and is evaluated during the summer growing season (July 1–September 30 for the Northern Rockies Level III Ecoregion) when algal growth will most likely affect beneficial uses. For data evaluation, samples collected ten days on either side of the growing season may also be included (Suplee and Watson, 2013). Targets listed here have been established specifically for nutrient TMDL development in the Kootenai-Fisher Project Area and may or may not be applicable to streams in other TMDL project areas.

Table 6-2. Nutrient Targets for the Kootenai-Fisher Project Area

Parameter	Northern Rockies Level III Ecoregion Target Value
Nitrate+Nitrite (NO_3+NO_2)[(1)]	≤ 0.10 mg/L
Total Nitrogen (TN)[(2)]	≤ 0.275 mg/L
Total Phosphorus (TP)[(2)]	≤ 0.025 mg/L
Chlorophyll-*a*[(2)]	≤ 125 mg/m2
Ash Free Dry Mass (AFDM)	≤ 35 g /m2
Hilsenhoff’s Biotic Index (HBI)[(3)]	< 4.0
Periphyton[(3)]	< 51%

(1) Value is from Suplee (11/14/2013)
(2) Value is from Suplee and Watson (2013).
(3) Value is from Suplee and Sada de Suplee (2011).

6.4.3 Existing Conditions and Comparison to Targets

To evaluate whether attainment of nutrient targets has been met, the existing water quality conditions in each waterbody segment are compared to the water quality targets in **Table 6-2** using the methodology in the DEQ draft guidance document “2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels” (Suplee and Sada de Suplee, 2011). This approach provides DEQ with updated impairment determinations used for TMDL development. Because the original impairment listings are based on old data or were listed before developing the numeric criteria, each stream segment will be evaluated for impairment from nitrate, TN, and TP using data collected within the past 10 years. Additionally, nutrient samples collected prior to 2005 were analyzed for Total Kjehldahl Nitrogen (TKN), which has since been replaced by DEQ with Total Persulfate Nitrogen as the preferred analytical method for total nitrogen; samples analyzed for TKN may have a bias and are excluded from the data review.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student’s T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, compliance with water quality targets is not attained when nutrient chemistry data shows a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry exceeds target values (Student T-test), or when a single chlorophyll-*a* value exceeds benthic algal target concentrations (125 mg/m^2 or 35 g $AFDW/m^2$). Where water chemistry and algae data do not provide a clear determination of impairment, or where other limitations exist, macroinvertebrate and periphyton biometrics are considered in further evaluating compliance with nutrient targets. Lastly, inherent to any impairment determination is the existence of human sources of pollutant loading. Human-caused sources of nutrients must be present for a stream to be considered impaired. To ensure a higher degree of certainty for removing an impairment determination and making any new impairment determination, the statistical tests are configured differently for an unlisted nutrient form than for a listed nutrient form. This can result in a different number of allowable exceedances for nutrients within a single stream segment. Such tests help assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample. When applying the T-test for assessment and sample values were below detection limits, one-half the detection limit was used.

As mentioned in **Section 6.2,** recent data from Bristow Creek showed no nutrient impairment and it will be delisted for TN on the 2014 303(d) List. It was assessed by DEQ following the same process outlined in this section, but because it does not need any nutrient TMDLs, the data are not presented within this section. Assessment information for Bristow Creek may be obtained by contacting DEQ. A summary of the existing data, comparison to water quality targets, and TMDL development determinations are presented for all other stream segments of concern. Because Stanley is within the Lake Creek watershed, they are discussed prior to Raven Creek.

6.4.3.1 Stanley Creek (MT76D002_010)

Stanley Creek is on the 2012 303(d) List as impaired for Nutrient/Eutrophication-Biological Indicators. The impaired segment of Stanley Creek begins at headwaters and flows 6.0 miles until the confluence with Lake Creek. It was originally listed in 2000 based on macroinvertebrate data indicating nutrient enrichment, but at the time the nutrient causing the impairment was unknown.

Summary nutrient data statistics and assessment method evaluation results for Stanley Creek are provided in **Tables 6-3 and 6-4**, respectively. Twenty-four NO_3+NO_2 samples were collected between

2003 and 2012; values ranged from 0.06 to 0.71 mg/L with six samples exceeding the NO_3+NO_2 target of 0.10 mg/L. Six TN samples were collected between 2011 and 2012; values ranged from < 0.1 to 0.11 mg/L with zero samples exceeding the TN target of 0.275 mg/L. Nineteen TP samples were collected between 2005 and 2012; values ranged from <0.003 to 0.04 mg/L with one sample exceeding the TP target of 0.025 mg/L.

Chlorophyll-*a* was visually estimated to be below 50 mg/m^2 at two sites in Stanley Creek in 2012. No samples were collected, and no AFDM data are available. There was one macroinvertebrate and one periphyton sample collected from Stanley Creek in 2011, and both samples met their respective target value.

Based on the assessment results (**Table 6-4)** Stanley Creek is impaired for NO_3+NO_2. The Nutrient/Eutrophication-Biological Indicators impairment cause will be refined to a NO_3+NO_2 impairment listing for the 2014 303(d) List and a nitrate + nitrite TMDL will be completed for Stanley Creek.

Table 6-3. Nutrient Data Summary for Stanley Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
NO_3+NO_2, mg/L	2003-2012	24	0.06	0.71	0.09
TN, mg/L	2011-2012	5	0.09	0.14	0.11
TP, mg/L	2005-2012	19	<0.003	0.04	0.006
Chlorophyll-*a*, mg/m^2	2012	2	<50[2]	<50[2]	<50[2]
AFDM, g/m^2	2011-2012	0	NA	NA	NA
Macroinvertebrate HBI	2011	1	2.90	2.90	2.90
Periphyton	2011	1	26.7%	26.7%	26.7%

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.
[2] Visually estimated to be less than 50 mg/m2

Table 6-4. Assessment Method Evaluation Results for Stanley Creek

Nutrient	Sample Size	Target Value (mg/L)	Target Exceed-ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	Peri-phyton	TMDL Required ?
NO_3+NO_2	24	0.10	6	**FAIL**	**FAIL**	Pass	Pass	Pass	Pass	**YES**
TN	6	0.275	0	PASS	PASS					NO
TP	19	0.025	1	PASS	PASS					NO

6.4.3.2 Lake Creek (MT76D002_061)

Lake Creek is on the 2012 303(d) List as impaired for Nitrate/Nitrite (Nitrite + Nitrate as N). The impaired segment of Lake Creek begins at the outlet of Bull Lake and flows 17.6 miles to the confluence with the Kootenai River. Lake Creek was originally identified as impaired in 2000 based on nutrient, algal, and macroinvertebrate data collected near the Troy Mine.

Summary nutrient data statistics and assessment method evaluation results for Lake Creek are provided in **Tables 6-5 and 6-6**, respectively. Fifty-two NO_3+NO_2 samples were collected between 2003 and 2012; values ranged from 0.02 to 0.14 mg/L with 7 samples exceeding the NO_3+NO_2 target of 0.10 mg/L. Sixteen TN samples were collected between 2007 and 2012; values ranged from <0.01 to 0.12 mg/L with zero samples exceeding the TN target of 0.275 mg/L. Forty-six TP samples were collected between 2005 and 2012; values ranged from <0.005 to 0.016 mg/L with zero samples exceeding the TP target of 0.025 mg/L.

Eight chlorophyll-*a* and seven AFDM samples were collected from Lake Creek between 2011 and 2012. Chlorophyll-*a* values ranged from 5.5 to 38.9 mg/m² with none exceeding the target of 125 mg/m². The AFDM samples ranged from 18.5 to 69.5 g/m² with four of the observations exceeding the target of 35 g/m². There were two macroinvertebrate and two periphyton samples collected from Lake Creek in 2011, and all samples met their respective target value. The exceedance of the AFDM target indicates nutrient impairment. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be taking up excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients to the system that is causing the biological response.

All nutrient forms passed both statistical tests, but NO_3+NO_2 was at the maximum number of allowable exceedances for the binomial test. Therefore, the assessment results (**Table 6-6)** support the existing Lake Creek impairment listing for NO_3+NO_2. Because the NO_3+NO_2 impairment is not associated with a TN impairment, only a nitrate + nitrite TMDL will be completed for Lake Creek.

Table 6-5. Nutrient Data Summary for Lake Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
NO_3+NO_2, mg/L	2003-2012	52	0.02	0.14	0.06
TN, mg/L	2007-2012	16	< 0.01	0.12	0.09
TP, mg/L	2005-2012	46	<0.005	0.016	0.006
Chlorophyll-*a*, mg/m²	2011-2012	8	5.5	38.9	14.0
AFDM, g/m²	2011-2012	7	13.5	69.5	37.3
Macroinvertebrate HBI	2011	2	3.42	3.64	3.53
Periphyton	2011	2	20.0%	29.1%	24.6%
[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.					

Table 6-6. Assessment Method Evaluation Results for Lake Creek

Nutrient	Sample Size	Target Value (mg/l)	Target Exceed -ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	Peri-phyton	TMDL Required ?
NO_3+NO_2	52	0.10	7	Pass	Pass	Pass	**FAIL**	Pass	Pass	**YES**
TN	16	0.275	0	Pass	Pass					No
TP	46	0.025	0	Pass	Pass					No

6.4.3.3 Raven Creek

Raven Creek is on the 2012 303(d) List as impaired for total phosphorus, nitrate/nitrite, total nitrogen, and chlorophyll-*a*. The impaired segment of Raven Creek begins at headwaters and flows three miles until the confluence with Pleasant Valley Fisher River. Raven Creek was originally listed in 2006 based on nutrient and algal data.

Summary nutrient data statistics and assessment method evaluation results for Raven Creek are provided in **Tables 6-7 and 6-8**, respectively. Thirteen NO_3+NO_2 samples were collected between 2004 and 2013; values ranged from 0.01 to 0.04 mg/L with no samples exceeding the NO_3+NO_2 target of 0.10 mg/L. Twelve TN samples were collected between 2004 and 2013; values ranged from < 0.05 to 0.12 mg/L with zero samples exceeding the TN target of 0.275 mg/L. Thirteen TP samples were collected between 2004 and 2013; values ranged from <0.012 to 0.055 mg/L with two samples exceeding the TP target of 0.025 mg/L.

Five chlorophyll-*a* and three AFDM samples were collected between 2011 and 2012. Chlorophyll-*a* values ranged from 7.7 to 22.4 mg/m^2 with none exceeding the target of 125 mg/m^2. Similarly, AFDM samples were all below the target of 35 g/m^2. There were four macroinvertebrate samples collected from Raven Creek and all of the values were less than the HBI target of 4.0. Two periphyton samples were collected in 2013 and both were well above the target of 51%.

The failure of the binomial test for TP combined with the exceedance of the periphyton target (**Table 6-8**) supports the existing Raven Creek impairment listing for TP. However, assessment results (**Table 6-8**) indicate that Raven Creek is not impaired for NO_3+NO_2, TN, or chlorophyll-*a* and those causes will be delisted on the 2014 303(d) List. A TP TMDL will be completed for Raven Creek.

Table 6-7. Nutrient Data Summary for Raven Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Median
NO_3+NO_2, mg/L	2004-2013	13	0.01	0.04	0.02
TN, mg/L	2004-2013	12	<0.05	0.12	0.06
TP, mg/L	2004-2013	13	<0.012	0.055	0.018
Chlorophyll-*a*, mg/m^2	2011, 2012	5	7.7	22.4	<20
AFDW, g/m^2	2011, 2012	3	4.27	6.49	5.79
Macroinvertebrate HBI	2005, 2010, 2011	4	2.45	3.96	3.75
Periphyton (%)	2013	2	70.5	72.1	71.3

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-8. Assessment Method Evaluation Results for Raven Creek

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceed -ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Macro Test Result	Peri-phyton	TMDL Required ?
NO_3+NO_2	13	0.1	0	PASS	PASS	Pass	Pass	Pass	**FAIL**	No
TN	12	0.275	0	PASS	PASS					No
TP	13	0.025	2	**FAIL**	PASS					**YES**

6.4.4 Nutrient TMDL Development Summary

Based on the assessment results, three nutrient TMDLs will be developed as summarized in **Table 6-9**.

Table 6-9. Nutrient TMDL Summary for the Kootenai-Fisher Project Area

Stream Segment	Waterbody ID	TMDL
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	MT76D002_070	Nitrate/Nitrite
RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030	Total Phosphorus
STANLEY CREEK, Headwaters to the mouth	MT76D002_010	Nitrate/Nitrite

6.5 Source Assessments, TMDLs, and Allocations

This section summarizes the approach used for the source assessment, TMDLs, and allocations, and then presents the source assessment results, TMDL, allocations, and estimated reductions necessary to meet water quality targets for each nutrient impaired stream.

6.5.1 Source Assessment Approach

Source characterization was conducted by using aerial photos, GIS analysis, field work, phone interviews, and literature reviews to determine the major sources in each of the nutrient impaired watersheds. There are no permitted point sources in the three watersheds. Therefore, nutrient loading is coming from two source types: 1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; and 2) human-caused nonpoint sources dispersed across the landscape (e.g., mining, septic, residential development, and timber harvest).

Because of human sources in the headwaters of all three nutrient impaired streams in the project area and intermittent flow in the upper watershed of Stanley and Raven creeks, no monitoring data could be used to estimate natural background nutrient loading. Natural background loading was estimated by using the median concentration from the reference nutrient dataset for each pollutant in the Level III Northern Rockies ecoregion (as described in Suplee and Watson, 2013; Suplee et al., 2008): NO_3+NO_2 = 0.009 and TP = 0.005 mg/L. A simple mass balance approach was used to quantify the load from human sources. Monitoring data collected in the project area from 2003 through 2013 were analyzed to determine existing loads at various locations throughout the impaired streams. Box plots, line graphs, and other statistical analyses helped to define the magnitude and location of nutrient loading.

6.5.2 TMDL and Allocation Summary

Nutrient TMDLs will be developed for the nutrient causes identified for each waterbody in **Table 6-9**. Because streamflow varies seasonally, TMDLs are not expressed as a static value, but as an equation of the appropriate target multiplied by flow as shown in **Equation 6-1**. As flow increases, the allowable load (TMDL) increases as shown by the nitrate TMDL example in **Figure 6-2.** Like the water quality targets, the TMDLs are applied only to the summer growing season (July 1st through Sept 30th). For each stream, a TMDL example is presented based on measured flows and the highest growing season concentration , but the range of reductions necessary based on all growing season sampling data is also discussed.

Equation 6-1*: TMDL (lbs/day) = (X) (Y) (k)*

X = water quality target in mg/L (NO_3+NO_2 = 0.1 mg/L, TP = 0.025 mg/L)
Y = streamflow in cubic feet per second (cfs)
k = conversion factor of 5.4

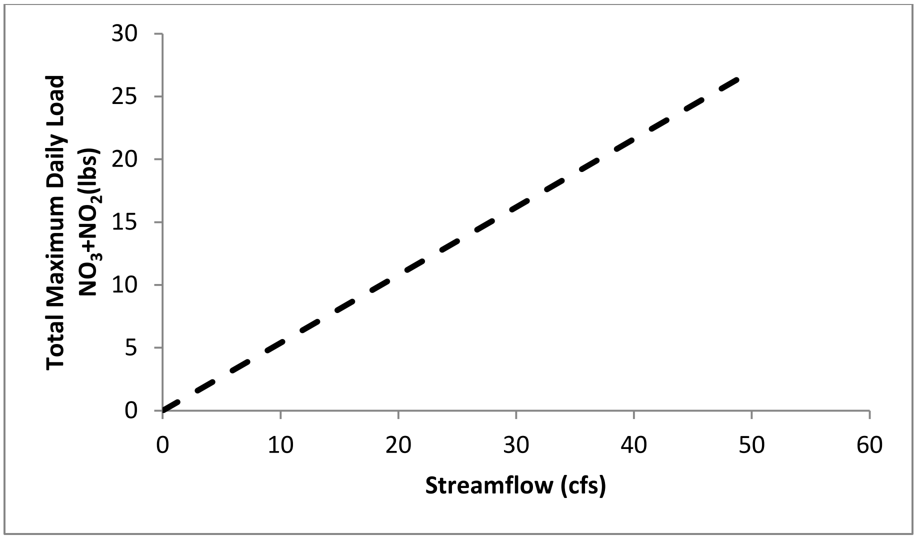

Figure 6-2. Example TMDL for NO_3+NO_2 for streamflow ranging from 0 to 50 cfs

Because a simple approach was used for the source assessment and all sources are nonpoint, the TMDL allocations for each stream are broken into a load allocation to natural background and a composite load allocation to all human-caused nonpoint sources. Therefore, the equation for all nutrient TMDLs is as follows:

$$\textbf{TMDL} = \textbf{LA}_{\text{Natural Background}} + \textbf{LA}_{\text{Human Sources}}$$

The LA $_{\text{Human Sources}}$ is calculated by subtracting the LA $_{\text{Natural Background}}$ from the TMDL. Because there are no point sources, the wasteload allocation (WLA) is 0. All nutrient TMDLs include an implicit margin of safety (MOS), which is based on conservative assumptions as described in **Section 6.6.2**.

6.5.2.1 Meeting Allocations

Allocations are intended to be met by implementation of additional BMPs. It is important to recognize that the first critical step toward meeting the nutrient allocations involves applying and/or maintaining the land management practices or BMPs that will reduce nutrient loading. Once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the nutrient allocation for that location. For many nonpoint source activities, it can take several years to achieve the full load reduction at the location of concern, even though full BMP implementation is in effect. For example, it may take several years for riparian areas to fully recover and decrease nutrient loading after implementing grazing BMPs. It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased nutrient loading.

Progress towards TMDL and individual allocation achievement can be gauged by BMP implementation and improvement in or attainment of water quality targets defined in **Section 6.4.2**. Any effort to calculate loads and percent reductions for purposes of comparison to TMDLs and allocations in this document should be accomplished via the same methodology used to develop the loads and percent reductions presented within this document.

6.5.3 Stanley Creek

6.5.3.1 Assessment of Water Quality Results

Nitrate/nitrite concentrations in Stanley Creek between 2003 and 2012 were relatively consistent over time (**Figure 6-3**), with a median value of 0.09 mg/L. There were a few very high values in 2005 but overall there does not appear to be an increasing or decreasing trend over time. Available flow data were also assessed relative to target exceedances and there were no flow-related patterns. However, when looking at box plots of individual monitoring sites over the same time period (**Figure 6-4**), NO_3+NO_2 concentrations are higher in the upstream reaches and noticeably decrease at the mouth (**Figure 6-5**).

Stanley Creek receives most of its flow from Fairway Creek and is usually intermittent upstream of the confluence during summer months. Stanley Creek upstream of Fairway Creek had zero flow during several site visits in 2012. There are four sets of synoptic samples (i.e., collected on the same day) for sites upstream and downstream of Fairway Creek which can be used to help with the source assessment. NO_3+NO_2 concentrations at the site just downstream of Fairway Creek (K01STNLC01/SC02) are typically close to those upstream of Fairway Creek, as evidenced by the median at that site and the upper site (K01STNLC05/SC15) being similar (**Figure 6-4**). Particularly given the substantial flow from Fairway Creek, this indicates Fairway Creek is also a source of NO_3+NO_2 to Stanley Creek. Fairway Creek originates from Spar Springs (which are fed by Spar Lake in the upper watershed) approximately 0.5 miles upstream of its confluence with Stanley Creek (KNF 2010).

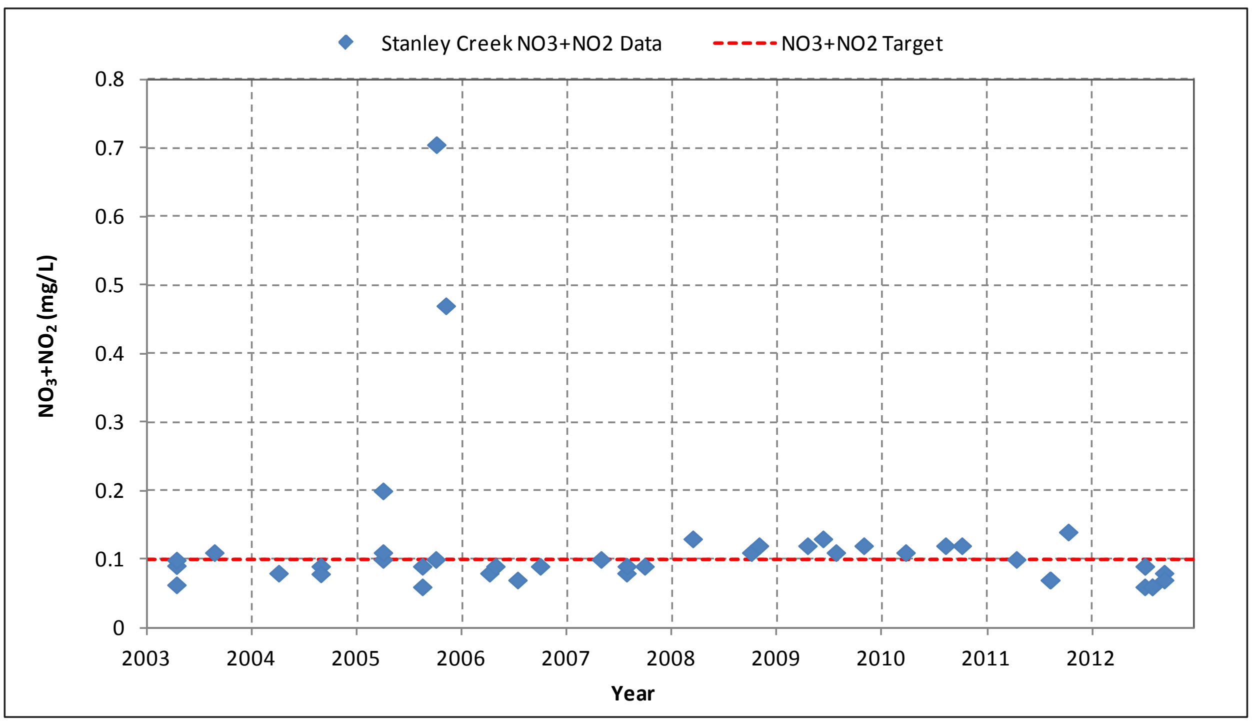

Figure 6-3. NO_3+NO_2 data collected in Stanley Creek, 2003-2012

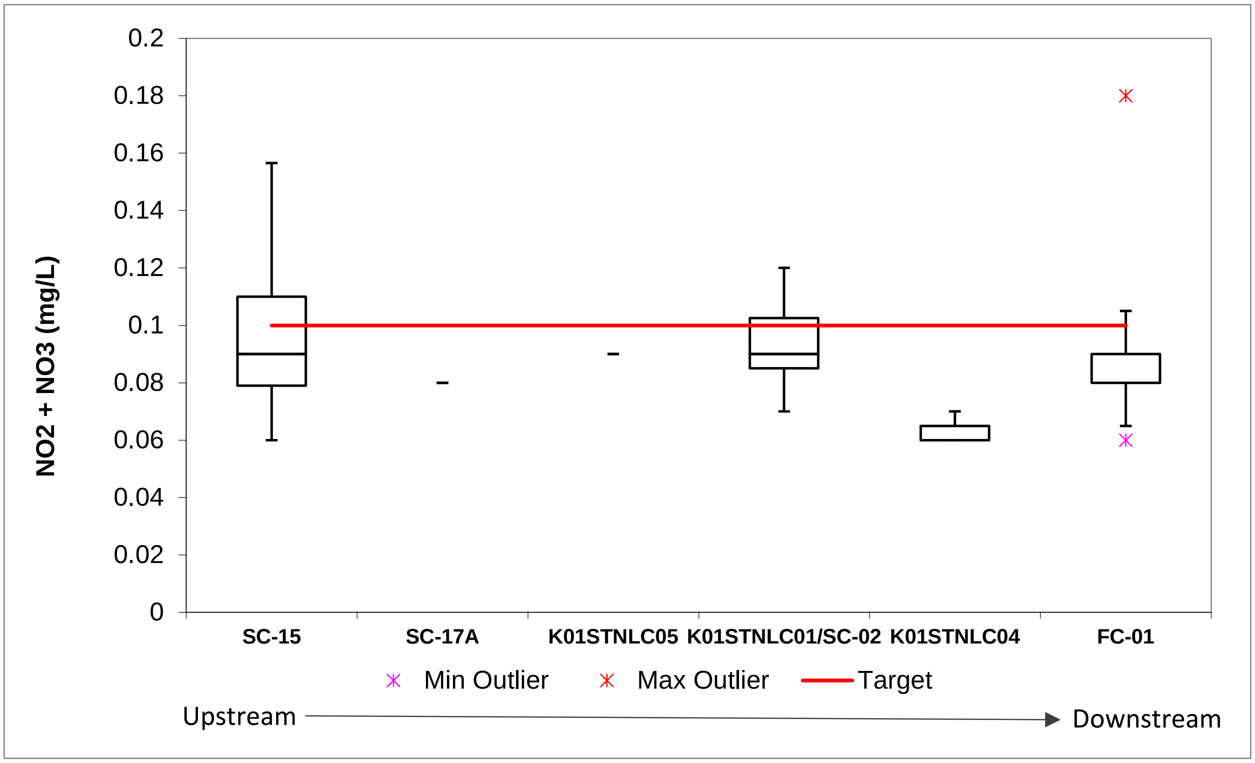

Figure 6-4. NO_3+NO_2 box plots for monitoring sites on Stanley Creek and Fairway Creek (FC-01), 2003-2012, growing season only

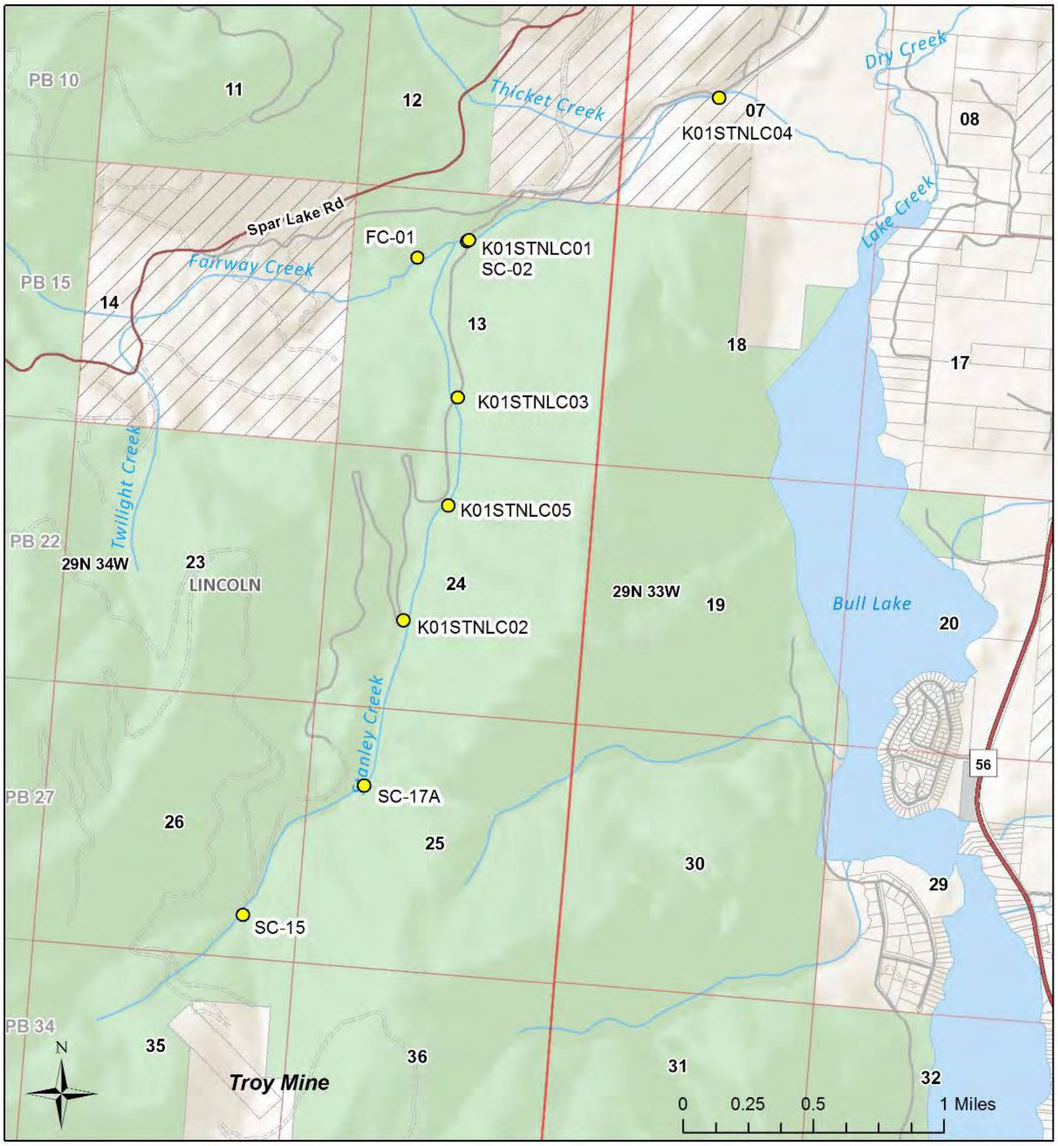

Figure 6-5. Location of the Stanley Creek monitoring stations

6.5.3.2 Source Assessment

The Stanley Creek watershed is located within the upper Lake Creek watershed just west of Bull Lake, and although it is primarily on land administered by the KNF, the Troy Mine is located near its headwaters (**Figure 6-5**). The predominant human sources that could contribute NO_3+NO_2 to Stanley Creek are timber harvest and mining. Each of the potential human sources is discussed below, followed by an analysis of the sources.

Timber Harvest

Timber harvest has the potential to affect nitrate loading because it can affect water yield and peak flows and also because it affects biological uptake and nutrient cycling in the soil. Timber harvest has long been a land use in the watershed, but since nutrient concentrations tend to return to normal within two to three years post-harvest (Feller and Kimmins, 1984; Likens et al., 1978; Martin and Harr, 1989), the assessment of the potential for harvest-related NO_3+NO_2 loading focused on recent harvest activity.

The KNF harvested timber above the headwaters near Spar Lake in 2004/2005 via helicopter. The Stimson Lumber Company selectively harvested from 129 acres in the Fairway Creek subdrainage in 2012 (USDA Forest Service, Kootenai National Forest (KNF), 2012). Timber harvest related to the Sparring Bulls timber harvest project was initiated in 2013 and will likely continue until 2015. Harvest will also be occurring in the watershed from 2013-2015 (Newgard, Kris, personal communication 3/20/2014; USDA Forest Service, Kootenai National Forest (KNF), 2012). Although the sampling conducted to support TMDL development does not overlap with the Sparring Bulls harvest, environmental analysis conducted by the KNF as part of the Sparring Bulls Final Environmental Impact Statement (EIS) concluded the project would not result in elevated nutrient concentrations in Stanley Creek because of the location and intensity of the harvest, and that the Stimson project activities would also not harm beneficial uses (USDA Forest Service, Kootenai National Forest (KNF), 2012).

Mining

Mining could be a source of NO_3+NO to Stanley Creek because it is a byproduct of explosives used during mining. With the exception of a closure between 1993 and 2004 because of metals prices and since December 2012 because of rock falls and haul route instability, Troy Mine has been active since the early 1970s (U.S. Forest Service and Montana Department of Environmental Quality, 2012; Associated Press, 10/19/2013). The mill and associated facilities, portals, and ventilation adits for Troy Mine are all in the upper Stanley Creek watershed. The creek flows just east of the mill site, which is at the entrance to the mine (USDA Forest Service, Kootenai National Forest (KNF), 2010). Although the mine does not have any direct discharges to surface water, NO_3+NO_2 from blasting could enter Stanley Creek through fractures in the bedrock in the mine void. This loading pathway as well as evidence of elevated NO_3+NO_2 concentrations in mine water are documented in the Final EIS for the Troy Mine Revised Reclamation Plan (U.S. Forest Service and Montana Department of Environmental Quality, 2012): "Nutrients, including ammonia and nitrate plus nitrite, are elevated in mine water due to residues from blasting compounds…although most water from the mine void is removed by pumping, some of it may re-enter the groundwater system, ultimately discharging to streams, seeps and springs, and to groundwater aquifers in the Stanley Creek and Ross Creek watersheds" (U.S. Forest Service and Montana Department of Environmental Quality, 2012). According to the EIS, nitrate concentrations in mine discharge water ranged from 0.7 to 13.6 mg/L, with a mean concentration of 4.88 mg/L during active mining operations from 2004-2009 (U.S. Forest Service and Montana Department of Environmental Quality, 2012).

Loading Analysis

Based on the known elevated levels of NO_3+NO_2 in mine water, fractured bedrock in upper Stanley Creek, and target exceedances in upper Stanley Creek, loading via groundwater from the mine void at Troy Mine appears to be the dominant human source of NO_3+NO_2 to upper Stanley Creek (i.e., headwaters to the confluence with Fairway Creek). Limited sampling data of headwater tributaries of Stanley Creek validate this conclusion but also indicate natural background concentrations may be contributing to the observed nitrate exceedances. Additional investigation and monitoring is recommended to refine the source assessment for upper Stanley Creek. The upper segment of Stanley Creek is often intermittent in the summer, and paired flow-nitrate data show that this segment contributes a relatively small nitrate load to the lower segment. However, due to the target exceedances observed in this segment, load reductions are still required.

Fairway Creek is a major tributary to Stanley Creek, with an average measured flow of 66 cfs (Troy Mine Data, 1985-2009). Although upper Stanley Creek tends to have higher and more frequent spikes in nitrate concentrations, Fairway Creek also has high nitrate values at times (**Figure 6-6**). Particularly given the average flow in Fairway Creek, its input dominates the nitrate load downstream of its confluence with Stanley Creek. It does not appear that the Troy Mine is directly having an impact on Fairway Creek nitrate concentrations, as there are no known fractures or faults draining from the Troy Mine vicinity to Fairway Creek (Jepson, Wayne, personal communication 11/20/2013). Other potential anthropogenic nitrate sources in Fairway Creek include timber harvest, the campground at Spar Lake, and abandoned mines. Given that the campground has light usage and toilet waste that has been contained in concrete vaults for over 20 years (Newgard, Kris, personal communication 12/2/2013) it is unlikely that it is a source of nitrate to Fairway Creek. It is possible that there are unknown human sources in Fairway Creek, or that the Fairway Creek watershed has a naturally high nitrate load. Future monitoring is recommended in this watershed to better define sources.

Downstream of the confluence with Fairway Creek, Stanley Creek is largely comprised of flow from Fairway Creek in the summer months. Potential sources in this portion of the watershed (i.e., confluence to the mouth) include timber harvest and upstream sources.

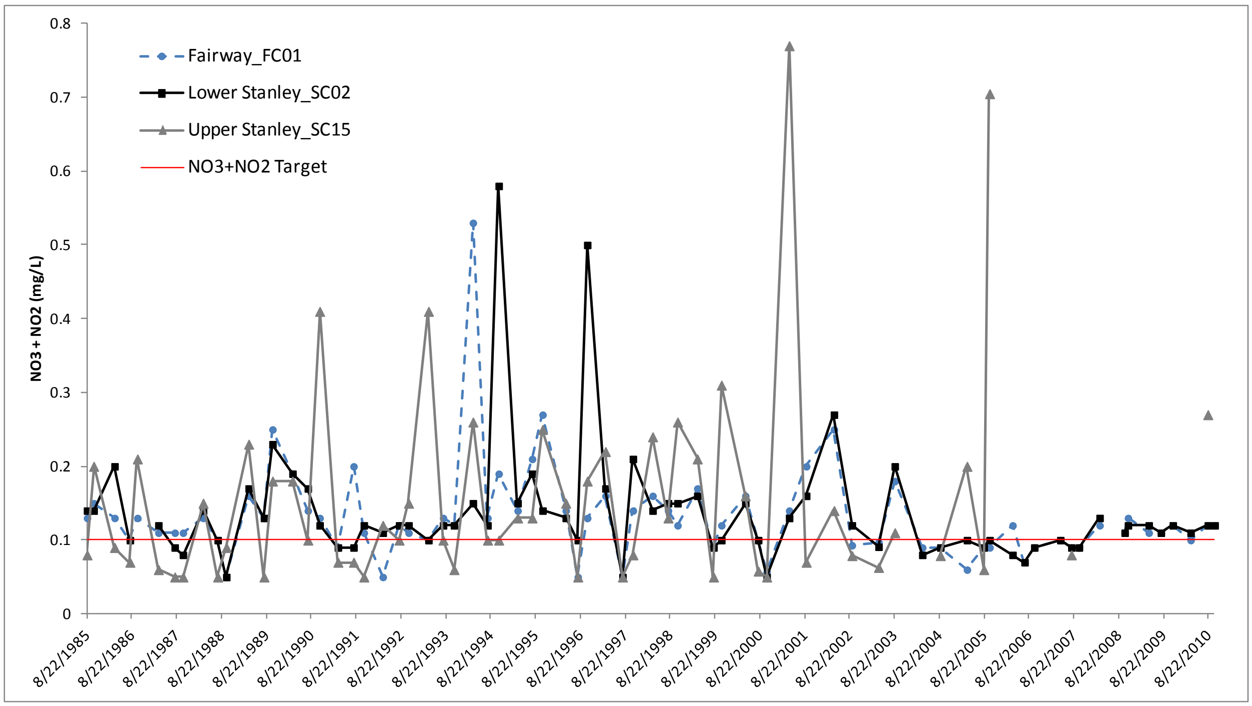

Figure 6-6. Long-term NO_3+NO_2 concentrations for upper and lower Stanley Creek and Fairway Creek

6.5.3.3 Nitrate/Nitrite TMDL, Allocations, Current Loading, and Reductions

Based on the monitoring data, NO_3+NO_2 load reductions between 0% and 86% are required. In other words, the NO_3+NO_2 concentration in the creek is sometimes below the target concentration, and no load reduction is required. At its worse, the NO_3+NO_2 concentration (and associated load) needs to be reduced by 86%. Of the 22 available growing season samples in Stanley Creek, only six of them exceed the NO_3+NO_2 target, which suggests that only minor changes in management activities are needed to meet the TMDL and water quality standard.

Because of the uncertainty regarding human caused sources other than mining, the TMDL will be composed of two load allocations: one to natural background sources and the other to all human sources (e.g., mining, timber harvest, etc.). The largest load reductions are required in the upper portion of Stanley Creek. **Table 6-10** shows an example NO_3+NO_2 TMDL for upper Stanley Creek (headwaters to the confluence with Fairway Creek). The example is presented for the worst case measured conditions in the creek during the growing season. A second TMDL example is presented for lower Stanley Creek (confluence with Fairway Creek to the mouth) (**Table 6-11**). Although examination of best management practices to reduce nitrate concentrations in mine wastewaters should be evaluated to determine if improvements can be made, particularly given the loading from Fairway creek and uncertainty regarding sources in that drainage, additional monitoring and refinement of the source assessment is recommended to better identify source loadings from both segments of the creek and the source of non-mining related loading.

Table 6-10. Example NO_3+NO_2 TMDL for Stanley Creek, headwaters to the confluence with Fairway Creek

Allocation	Source Category	Current Load (lbs/day)[1]	% Reduction	Allocation (lbs/day)	Rationale/Assumptions
Load Allocation	Natural Background	0.02	0%	0.02	Assumes a natural background concentration of 0.009 mg/L NO_3+NO_2 and a flow of 0.32 cfs measured at site SC15.
	Mining, Timber Harvest, & Other Human Sources	1.20	88%	0.15	Activities at the Troy Mine are the likely source of nitrate loading to this segment of Stanley Creek
TMDL	All Sources	1.22[1]	86%	0.17	

[1]Based on a measured concentration of 0.705 mg/L and an estimated flow of 0.32 cfs on October 7, 2005 at site SC15

Table 6-11. Example NO_3+NO_2 TMDL for Stanley Creek, confluence with Fairway Creek to the mouth.

Allocation	Source Category	Current Load (lbs/day)	% Reduction	Allocation (lbs/day)	Rationale/Assumptions
Load Allocation	Natural Background	3.61	0%	3.61	Assumes a natural background concentration of 0.009 mg/L NO_3+NO_2 and a flow of 74.32 cfs measured at site SC02.
	Mining, Timber Harvest, & Other Human Sources	76.51	52%	36.45	Fairway Creek is the major source of nitrate loading in this segment of Stanley Creek. Future work is needed to better define the anthropogenic source loads from Fairway Creek.
TMDL	All Sources	80.12[1]	50%	40.06	

[1]Based on a measured concentration of 0.20 mg/L and an estimated flow of 74.32 cfs on August 25, 2003 at site SC02

6.5.4 Lake Creek

6.5.4.1 Assessment of Water Quality Results

Figure 6-7 shows box plots of NO_3+NO_2 concentrations at selected stations on Lake Creek during the growing season, 2003-2012. **Figure 6-8** shows available synoptic NO_3+NO_2 data for Lake Creek. Both figures show that NO_3+NO_2 concentrations in the upstream portion of Lake Creek (i.e., just downstream of Bull Lake) are usually lower than the target. The data indicate there is a significant source of NO_3+NO_2 in the two mile segment between stations K01LAKEC06 and LC04 (river mile 12.5 to 10.1). This is located downstream of the Troy Mine Tailings Impoundment (**Figure 6-9**). By river mile 7.4 (Station K01LAKEC02), NO_3+NO_2 concentrations decrease to below the target concentration, and then continue to decrease moving downstream. This is likely somewhat associated with NO_3+NO_2 uptake by primary producers but also appears to be caused by dilution coming from tributaries such as Keeler Creek, Iron Creek, Copper Creek, etc. There were only three recent growing season sampling events that included synoptic samples down to the mouth of Lake Creek, and there was no trend in NO_3+NO_2 concentrations in lower Lake Creek: they increased slightly, decreased slightly, or stayed the same.

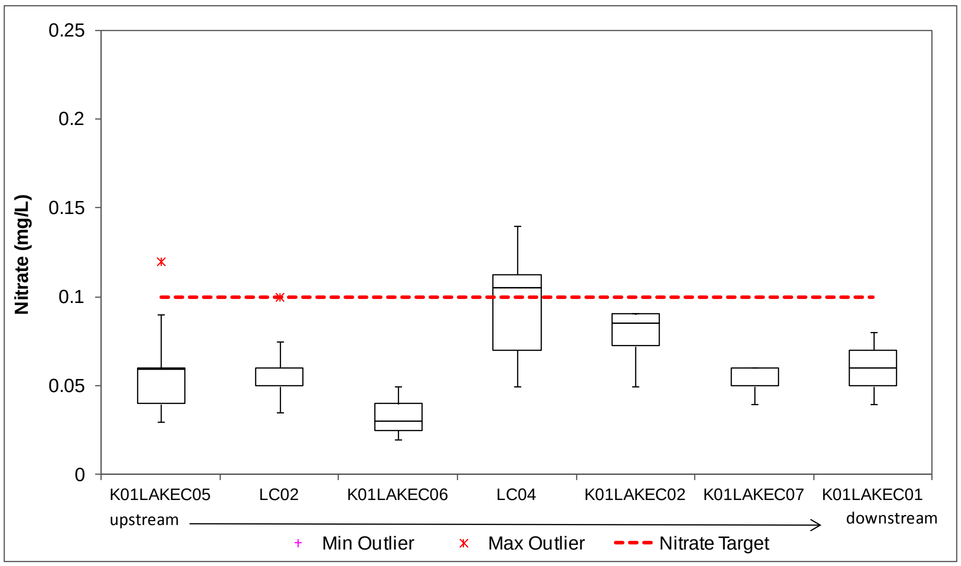

Figure 6-7. Nitrate/nitrite box plots for monitoring sites on Lake Creek, 2003-2012, growing season only[1]

[1] Some sites in the above figures are collocated including: K01LAKEC05 (LKC-280 and LC01); K01LAKEC06 (LKCA); K01LAKEC02 (LKC-279,); K01LAKEC07 (LKC-278); and K01LAKEC01 (LKC-276).

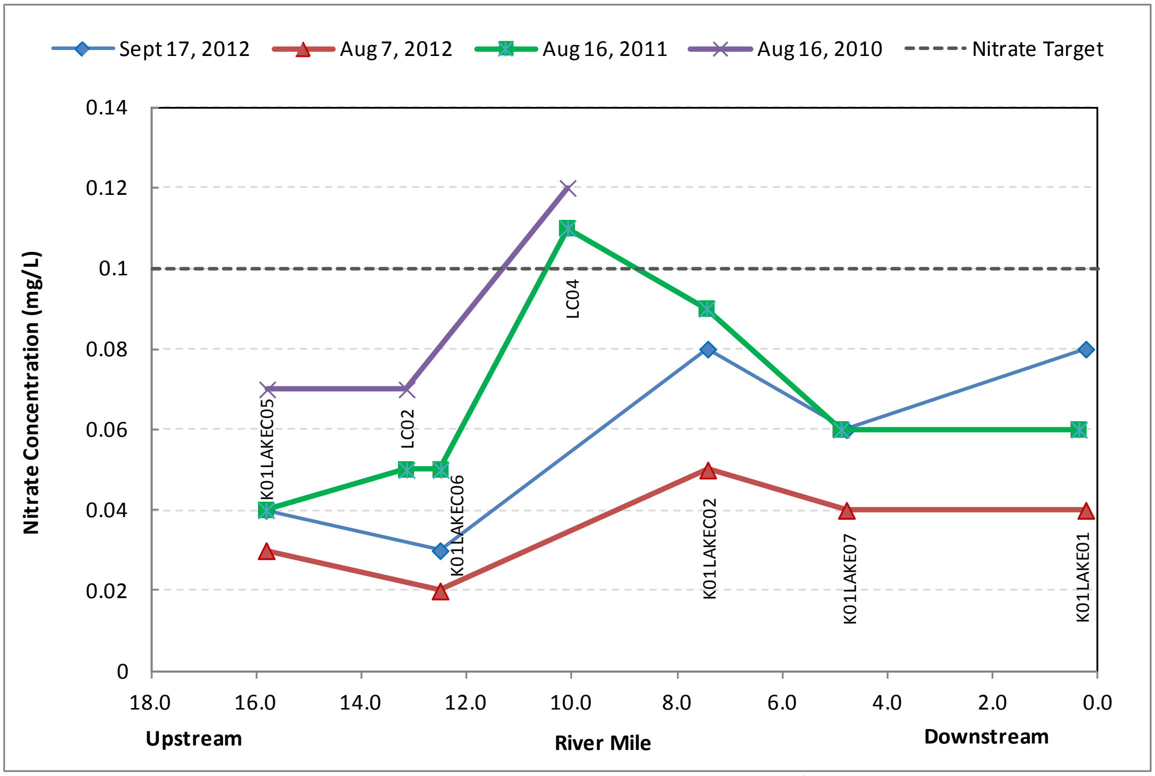

Figure 6-8. Synoptic growing season NO_3+NO_2 data for Lake Creek[1]

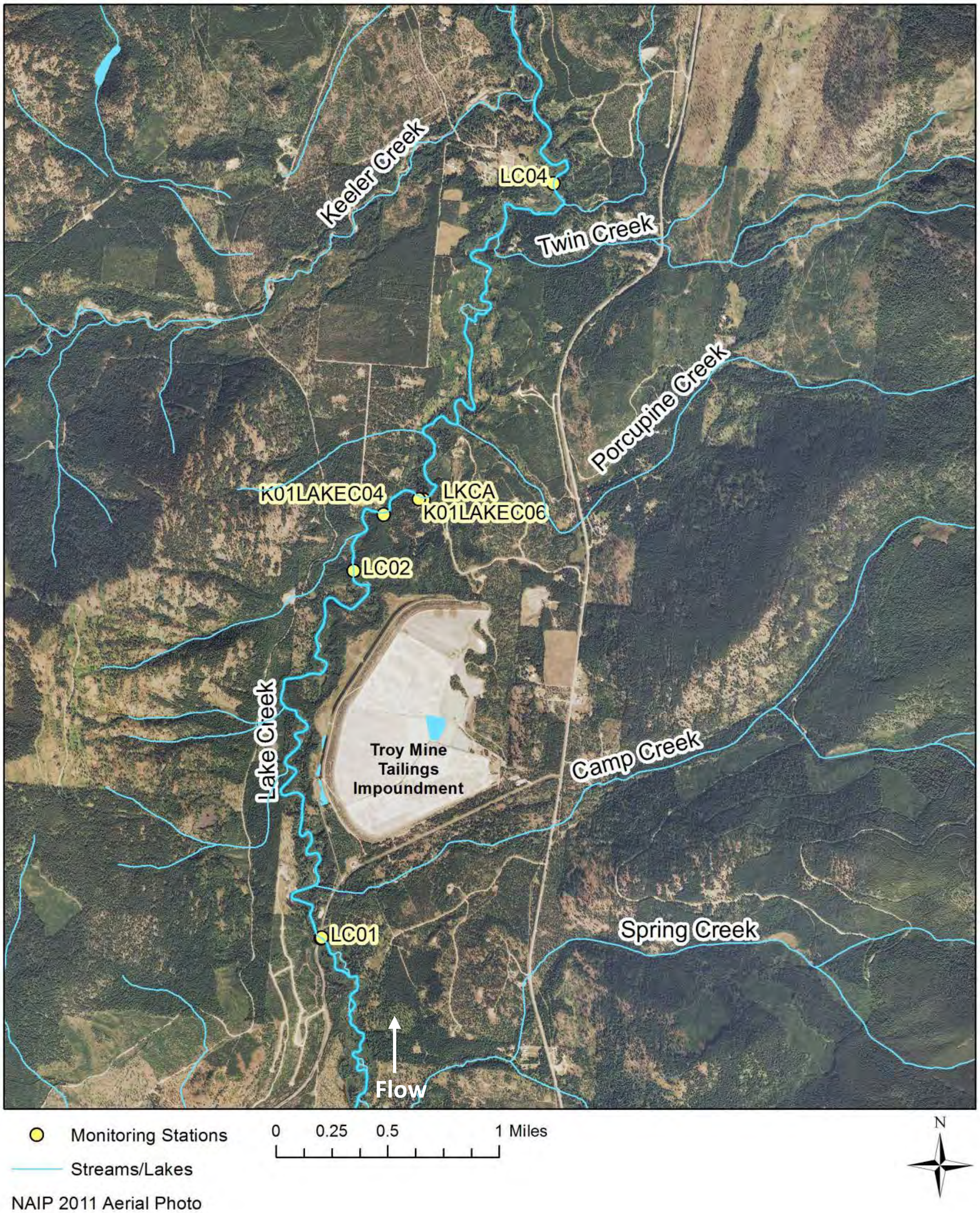

Figure 6-9. Location of monitoring sites on Lake Creek

6.5.4.2 Source Assessment

Lake Creek flows 17.6 miles from its headwaters at the outlet of Bull Lake to its mouth at the Kootenai River. There is some private development along Bull Lake and most of the riparian corridor is privately owned, but approximately 80% of the watershed is managed by the USFS (**Figure 5-2**). Potential human sources of NO_3+NO_2 in the Lake Creek watershed include mining, septic systems, and timber harvest. Each of the potential human sources is discussed below.

Mining

As described in **Section 6.6.1**, Stanley Creek is a tributary to Lake Creek, and at times contributes excess NO_3+NO_2 into Lake Creek. However, because NO_3+NO_2 concentrations are typically lower than the target at the mouth of Stanley Creek, and NO_3+NO_2 is bioavailable and tends to be consumed by primary producers quickly (Suplee, Michael W., personal communication 11/14/2013), concentrations in Lake Creek just downstream of the confluence with Stanley Creek (e.g., Stations K01LAKEC05 and LC02) rarely exceed the NO_3+NO_2 target.

In addition to Stanley Creek, the Troy Mine is partially located in the Ross Creek, Weasel Gulch, and Emma Gulch watersheds (tributaries to Bull Lake). The Troy Mine Revised Reclamation Plan Final Environmental Impact Statement states that most of the groundwater from the underground mines is pumped out and routed to the tailings pond downstream of Bull Lake. However, some of the groundwater from the mines potentially resurfaces in springs and seeps in the Ross Creek, Emma Gulch, and Weasel Gulch watersheds (tributaries to Bull Lake) (U.S. Forest Service and Montana Department of Environmental Quality, 2012). Data from Weasel Gulch and Emma Gulch do not currently exceed nitrate targets, but the limited data for Ross Creek suggests significant nitrate loadings (U.S. Forest Service and Montana Department of Environmental Quality, 2012).

Although there is no direct discharge to surface water, previous studies conclude that the Troy Mine Tailings Impoundment is a source of NO_3+NO_2 to groundwater in the Lake Creek watershed (U.S. Forest Service and Montana Department of Environmental Quality, 2012). The Final EIS for the Troy Mine Revised Reclamation Plan shows that groundwater nitrate concentrations in the vicinity of the tailings impoundment range from <0.01 to 1.19 mg/L (U.S. Forest Service and Montana Department of Environmental Quality, 2012). Mean nitrate concentrations in wells MW1 and MW95-4 (0.16 and 0.19 mg/L, respectively) are higher than the NO_3+NO_2 target of 0.10 mg/L. The Final EIS acknowledges that the tailings impoundment and toe ponds contribute excess nitrate to groundwater, and that a sump and pump system has been installed in the toe ponds to help mitigate nitrate concentrations (U.S. Forest Service and Montana Department of Environmental Quality, 2012).

Measured data show that nitrate concentrations in Lake Creek are regularly higher downstream of the tailings impoundment, which is where most of the target exceedances occurred. Because this trend has persisted for the past decade, and well before that (based on Troy Mine monitoring data), excess nitrate loading to the groundwater from the impoundment is well documented (U.S. Forest Service and Montana Department of Environmental Quality, 2012), and groundwater tends to flow towards Lake Creek (U.S. Forest Service and Montana Department of Environmental Quality, 2012), the pattern of elevated nitrate concentrations downstream of the impoundment are likely associated with groundwater loading from the impoundment. However, multiple tributaries (e.g., Camp Creek and Porcupine Creek) also flow into Lake Creek in this vicinity and may also be contributing to the nitrate load as well. Additionally, groundwater well data collected prior to the construction of the tailings impoundment show variable nitrate concentrations in the Lake Creek valley (Levings et al., 1984), and the cause of that and the relationship to concentrations today is uncertain. Future additional monitoring should be conducted to (1) determine the groundwater flow path and extent of nitrate loading from the tailings impoundment to Lake Creek, and (2) determine the nitrate contribution from any other localized sources, and (3) determine natural background levels of nitrate in localized groundwater.

Septic Systems

Septic systems, even when operating as designed can contribute nutrients to surface water through subsurface pathways. The amount of nutrients that a given septic system contributes to a waterbody is dependent upon its discharge, soils, and distance from the waterbody. The number and location of septic systems in the Lake Creek watershed was determined by downloading the Montana Structures Framework GIS layer (Montana State Library, 2012). The data layer indicates that there are approximately 585 structures in the watershed that potentially have septic systems. Most of the systems are located along the Lake Creek valley bottom, around Bull Lake, and in the Falls Creek watershed (**Figure 6-10**). There may be some localized excess loading from failing septic systems, but based on the low NO_3+NO_2 concentrations coming out of Bull Lake and near the mouth, where most of the septic systems are concentrated, NO_3+NO_2 loading to Lake Creek from septic systems is likely minimal.

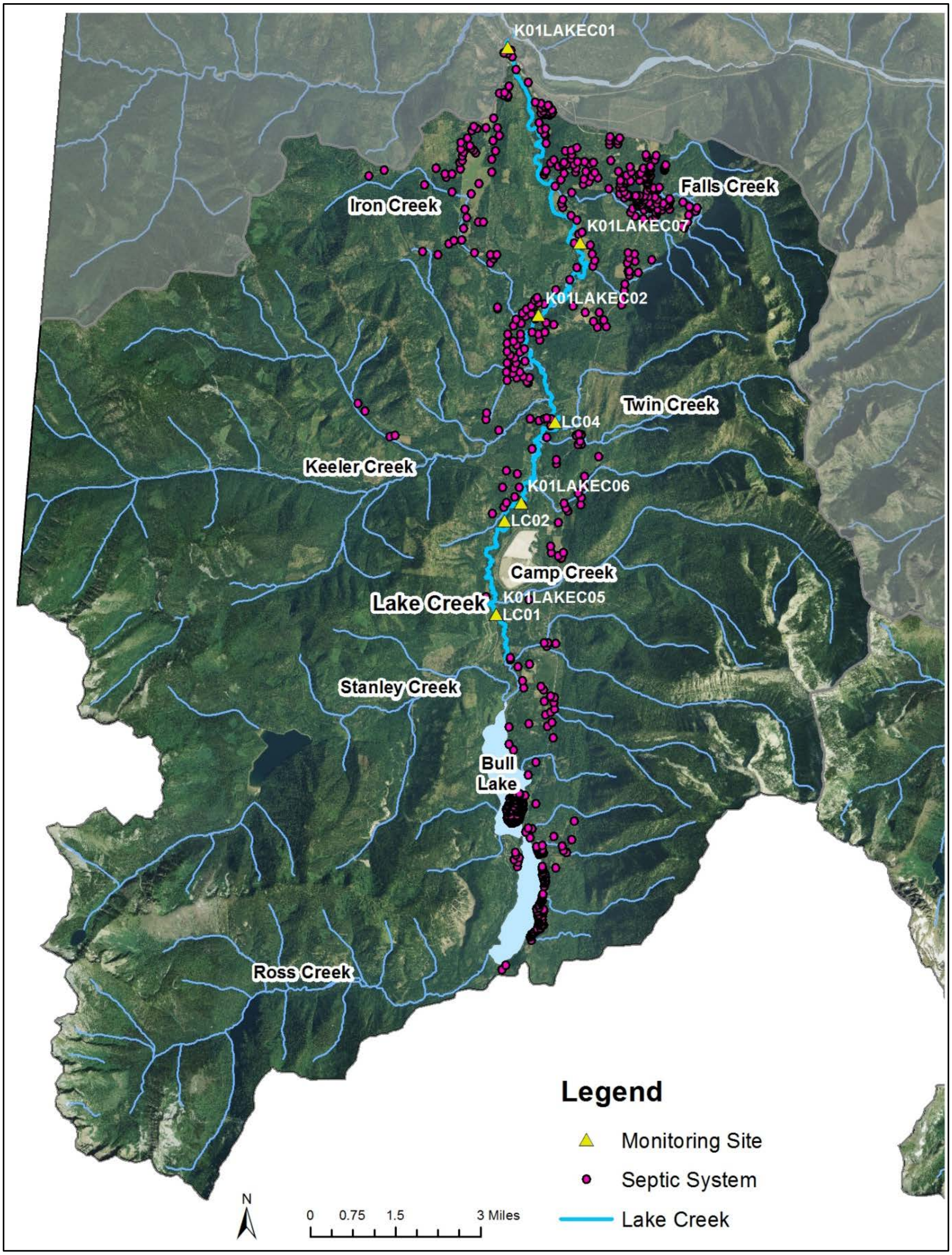

Figure 6-10. Distribution of septic systems in the Lake Creek watershed

Timber Harvest

Timber harvest has the potential to affect nitrate loading because it can affect water yield and peak flows and also because it affects biological uptake and nutrient cycling in the soil. Timber harvest is pervasive throughout the Lake Creek watershed, but since nutrient concentrations tend to return to normal within two to three years post-harvest (Feller and Kimmins, 1984; Likens et al., 1978; Martin and Harr, 1989), the assessment of the potential for harvest-related NO_3+NO_2 loading focused on recent harvest activity. As discussed in the source assessment for Stanley Creek (**Section 6.5.3.2**), some timber harvest occurred in the Stanley Creek watershed. However, no large scale timber harvest is known to have occurred in the Lake Creek watershed during the past several years when monitoring was being conducted to support TMDL development. The most recent harvests occurred in 2013 as part of the Sparring Bulls Timber Sale, which is ongoing through 2015.

Since 1994, riparian harvest has been limited or absent because the KNF has Riparian Habitat Conservation Areas that restrict harvest related activities on USFS land from a minimum of 50 to a minimum of 300 feet from streams and wetlands (distance is dependent on the waterbody type) and the Streamside Management Zone law that restricts commercial harvest-related activities by all landowners within 50 feet of streams. Based on the restrictions placed on riparian harvest, BMPs used during timber harvest, and the rapid decline in harvest-related nutrient loading following harvest activities, timber harvest is likely a minimal source of NO_3+NO_2 to Lake Creek.

6.5.4.3 Nitrate/Nitrite TMDL, Allocations, Current Loading, and Reductions

Based on the measured growing season concentrations, NO_3+NO_2 load reductions between 0% and 28% are required. In other words, NO_3+NO_2 concentrations in the creek are sometimes below the target concentration, and no load reduction is required. At its worse, the NO_3+NO_2 concentration (and associated load) needs to be reduced by 28%. Of the 52 available growing season samples in Lake Creek, only seven of them exceed the NO_3+NO_2 target, which suggests that only minor changes in management activities are needed to meet the TMDL and water quality standard. The largest load reductions are required near monitoring site LC04 and just downstream of the tailings impoundment. Based on monitoring data near the mouth, little to no reduction in NO_3+NO_2 loads are necessary downstream of site LC04 (near Twin Creek) to the mouth.

The TMDL will be composed of two load allocations: one to natural background sources and the other to all human sources (e.g., mining, timber harvest, septic systems, etc.). The largest load reductions are required near monitoring site LC04 (just downstream of the tailings impoundment and near the confluence with Twin Creek). **Table 6-11** shows an example NO_3+NO_2 TMDL with allocations based on sample data for Lake Creek. The example TMDL is presented for the worst case measured condition during the growing season. Although the source assessment indicates the tailings impoundment is the likely source of nitrate in the portion of Lake Creek needing the largest load reductions, target exceedances were sporadic and typically not much above the target value. Although examination of best management practices to reduce nitrate concentrations in mine wastewater should be evaluated to determine if improvements can be made, additional monitoring and refinement of the source assessment and loading pathways is also recommended.

Table 6-11. Example NO_3+NO_2 TMDL and allocations for Lake Creek

Allocation	Source Category	Current Load (lbs/day)	% Reduction	Allocation (lbs/day)	Rationale/Assumptions
Load Allocation	Natural Background	4.0	0%	4.0	Assumes a natural background concentration of 0.009 mg/L NO_3+NO_2 and a flow of 81.4 cfs measured at site LC04
	Mining, harvest, septics, and other human caused sources	57.5	30%	40.0	The existing load was calculated by subtracting the natural background load and the load from the impoundment from the existing calculated load.
	Troy Mine Tailings Impoundment	40.8	43%	23.3	The Troy Mine tailings impoundment is the major source of nitrate in Lake Creek. The existing load from the tailings impoundment was calculated based on the average increase in load from 8 synoptic samples collected at sites LC02 and LC04. This assumes that the loading increase between these two sites is solely due to the impoundment.
TMDL	**All Sources**	**61.5**[1]	**28%**	**44.0**	

[1]Based on a measured concentration of 0.14 mg/L and a measured flow of 81.4 cfs on August 19, 2005 at site LC04

6.5.5 Raven Creek

6.5.5.1 Assessment of Water Quality Results

Figure 6-11 shows the available TP data for Raven Creek from 2004-2013 (all stations). Overall, the data are limited and do not show any increasing or decreasing trends in time. **Figure 6-12** shows box plots of TP concentrations (growing season only) on Raven Creek, 2004-2013. There does not appear to be a strong trend in the data moving upstream to downstream **(Figure 6-13** shows station locations**)**. The 2004 sample was collected in the rain and the total suspended sediment concentration was 7mg/L – all other suspended sediment concentrations were close to or below the detection limit (i.e., 4 or 1 mg/L), indicating the elevated TP concentration in 2004 may be associated with sediment. However, there was no precipitation and the suspended sediment concentration was <1mg/L for the sample that exceeded the TP target in 2013. Both target exceedances occurred in the lower watershed upstream of Highway 2. It should be noted that upper Raven Creek typically has no surface flow, and it had no flow during several site visits in 2011 and 2012.

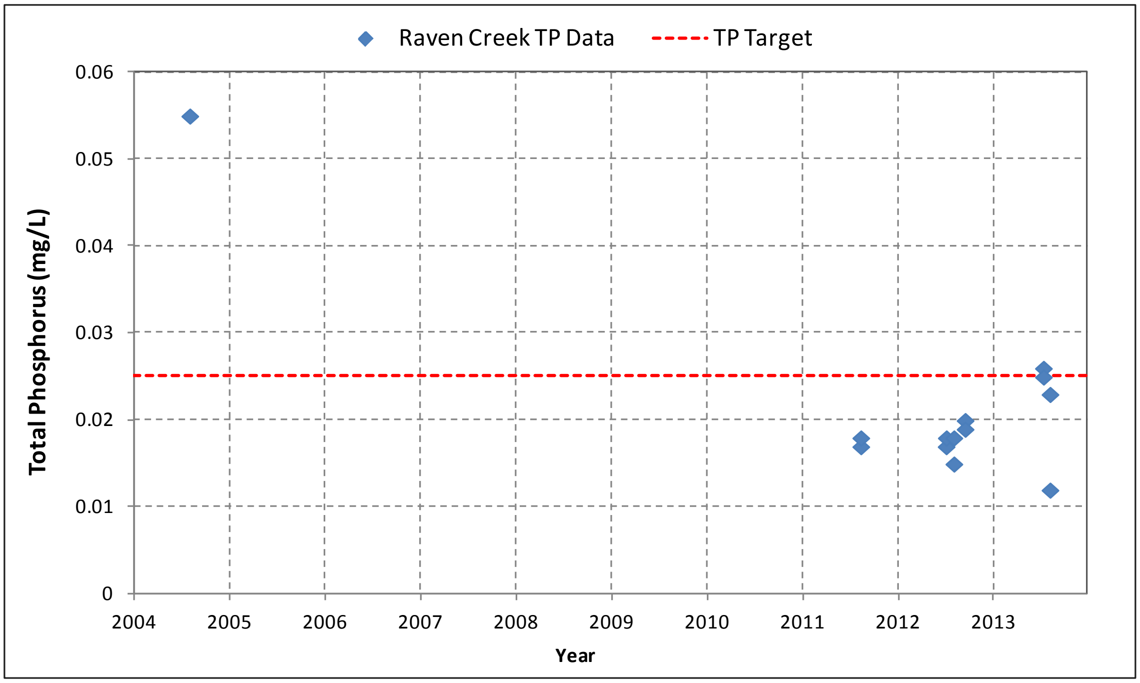

Figure 6-11. Total phosphorus data collected in Raven Creek, 2004-2013

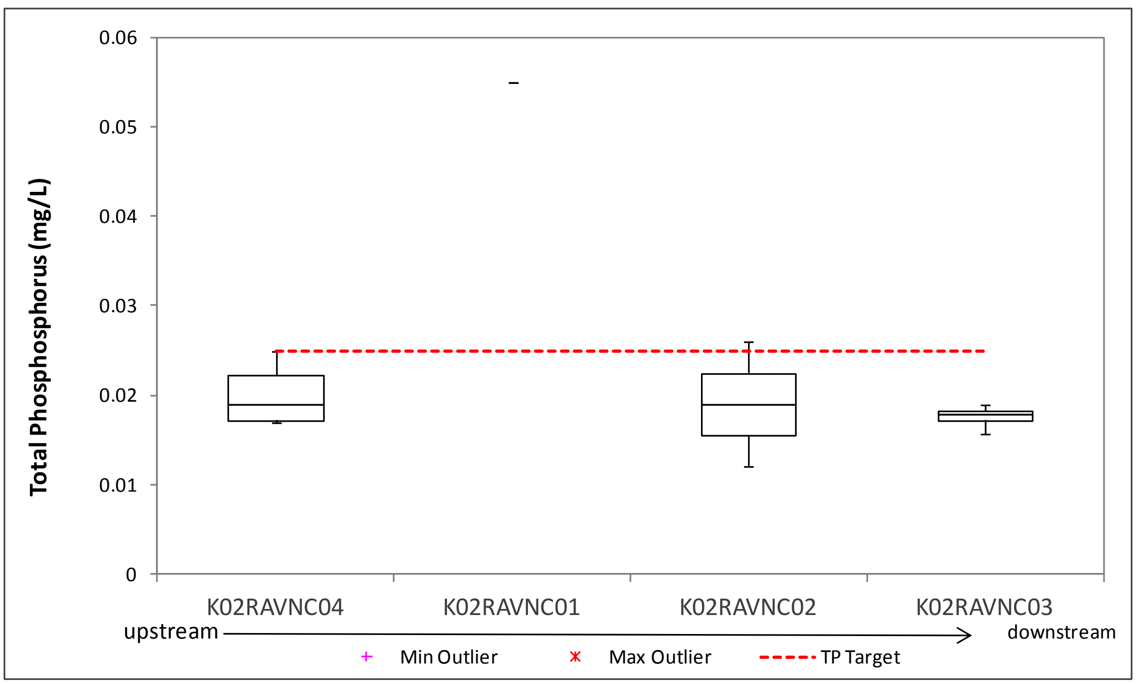

Figure 6-12. Total phosphorus box plots for sites on Raven Creek, 2004-2013, growing season only

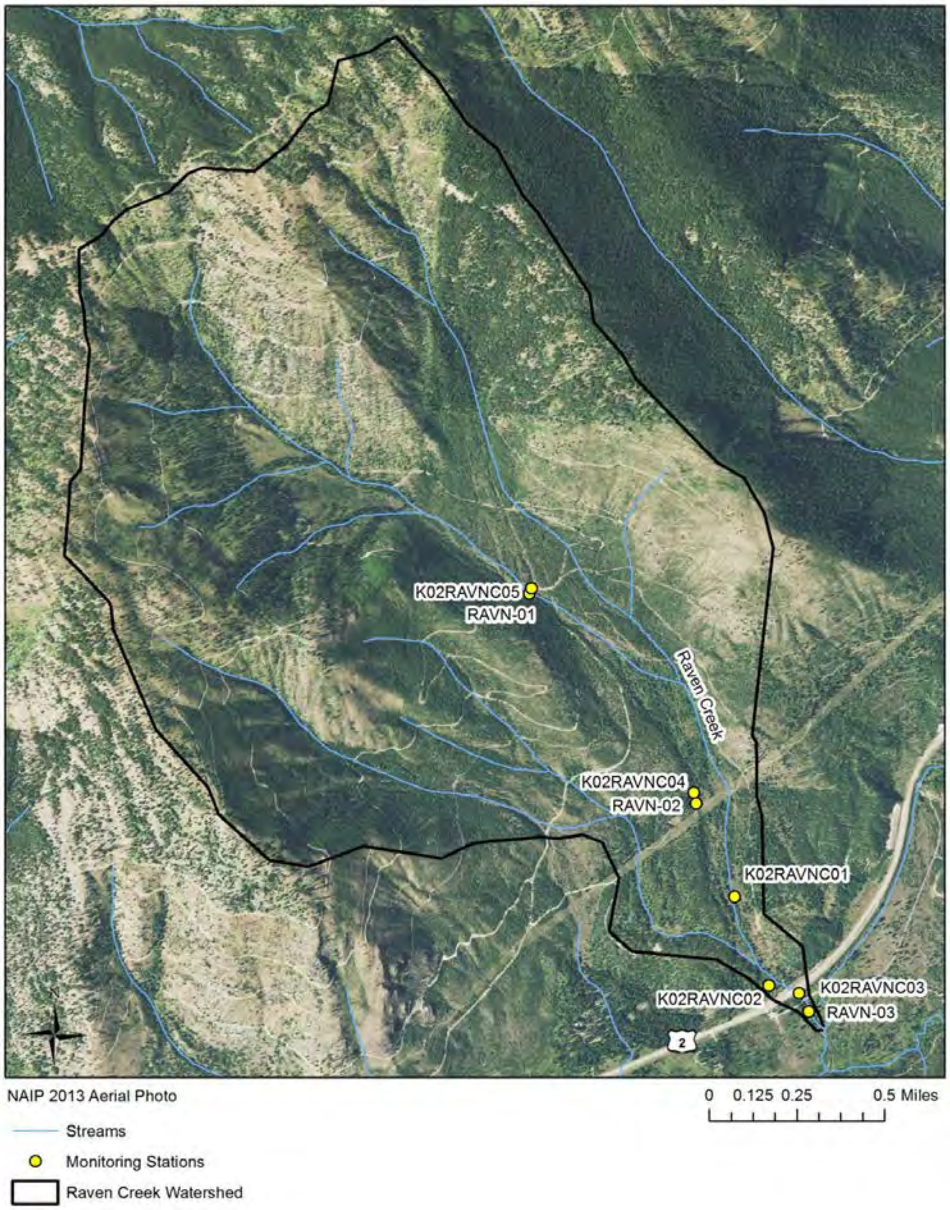

Figure 6-13. Location of the Raven Creek watershed and nutrient monitoring stations

6.5.5.2 Assessment of Loading by Source Categories

At this time, there is uncertainty regarding the sources of phosphorus in the Raven Creek watershed. There are currently no septic systems, point sources, or agriculture in the watershed. As shown in **Figure 5-4**, the watershed is largely forested, and is largely owned by Plum Creek Timber Company. The only known potential human sources of phosphorus are timber harvest and associated land disturbing activities (**see Section 5.5.4**).

Nutrient water quality for Raven Creek is very similar to sediment (see **Section 5.5.4**) in that it is very close to meeting the water quality standard. The elevated sample in 2004 suggests the nutrient impairment may be associated with sediment, although suspended sediment concentrations during growing season sampling were typically very low. The phosphorus could be associated with sediment that enters the stream during higher flows from eroding streambanks, unpaved roads, and/or upland sources (as discussed in **Section 5.6**). Additional monitoring and source assessment work is recommended for Raven Creek but based on the existing sediment impairment and the fact that phosphorus is commonly bound to soil particles, excess phosphorus loading is likely linked to sediment loading. The sediment source assessment concluded that historical harvest practices combined with the Houghton Creek fire (1984) led to excess sediment loading and impairment (**Section 5.5.4**).

6.5.5.3 TP TMDL, Allocations, Current Loading, and Reductions

Based on the measured growing season concentrations, TP load reductions between 0% and 55% are required. In other words, the TP concentration in the creek is sometimes below the target concentration, and no load reduction is required. At its worse, the TP concentration (and associated load) needs to be reduced by 55%. Of the 13 available growing season samples in Raven Creek, only two of them exceed the TP target, which suggests that only minor changes in management activities are needed to meet the TMDL and water quality standard. With the likely connection between the TP and sediment impairment, the conclusion from the sediment source assessment (**Section 5.5.4**) also applies to nutrients – current management practices are facilitating the recovery of Raven Creek but additional time is needed to meet the TMDL.

Table 6-12 shows an example TP TMDL with allocations based on sample data for Raven Creek. The example is presented for the worst case measured conditions in the creek during the growing season (where there is a paired TP and flow measurement). In this case, the example is provided for site K02RAVNC02, which is just upstream of the Highway 2 crossing (**Figure 6-13**).

Table 6-12. Example TP TMDL and allocations for Raven Creek

Allocation	Source Category	Current Load (lbs/day)[1]	% Reduction	Allocation (lbs/day)	Rationale/Assumptions
Load Allocation	Natural Background	0.023	0%	0.023	Assumes a natural background concentration of 0.005 mg/L TP, which is the median TP concentration from the reference dataset for the Northern Rockies ecoregion
	All other nonpoint sources (e.g., roads, timber harvest)	0.095	2%	0.093	The load was calculated by subtracting the natural background load from the measured load.
TMDL	**All Sources**	**0.118**	**2%**	**0.116**	

[1]Based on a measured concentration of 0.026 mg/L and a measured flow of 0.84 cfs on July 18, 2013 at site K02RAVNC02

6.6 Seasonality and Margin of Safety

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses.

6.6.1 Seasonality

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan seasonality is an integral consideration. Specific examples of how seasonality has been addressed within this document include:

- Water quality targets and subsequent allocations are applicable for the summer-time growing season (July 1st – Sept 30th), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads was collected during the summer-time period to coincide with applicable nutrient targets.

6.6.2 Margin of Safety

A margin of safety is a required component of TMDL development. The margin of safety accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a). This plan addresses MOS implicitly in a variety of ways:

- Static nutrient target values (e.g., 0.100 mg/L NO_3+NO_2 and 0.025 mg/L TP) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses.
- By considering seasonality (discussed above) and variability in nutrient loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

6.7 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in both the water quality-based and model-based modes of assessing nutrient sources and needed reductions.

For all three streams, there is uncertainty associated with the source assessment and additional monitoring is recommended to refine the source assessment. For Stanley Creek, additional monitoring should be conducted to determine natural background concentrations and to determine potential sources in the Fairway Creek watershed. In Lake Creek, uncertainties exist around groundwater source loading and contributions from tributaries. For Raven Creek, monitoring data indicate borderline nutrient impairment, so there is also uncertainty regarding the degree of impairment; additional monitoring to help with source assessment should also help refine the impairment status.

7.0 TEMPERATURE TMDL COMPONENTS

This portion of the document focuses on temperature as an identified cause of water quality impairment in the Kootenai-Fisher TMDL Project Area. It describes: (1) the mechanisms by which temperature affects beneficial uses of streams; (2) the stream segment of concern; (3) information sources used for temperature TMDL development; (4) temperature target development; (5) assessment of sources contributing to excess thermal loading; (6) the temperature TMDL and allocations; (7) seasonality and margin of safety; and (8) uncertainty and adaptive management.

7.1 TEMPERATURE (THERMAL) EFFECTS ON BENEFICIAL USES

Human influences that reduce stream shade, increase stream channel width, add heated water, or decrease the capacity of the stream to buffer incoming solar radiation all increase stream temperatures. Warmer temperatures can negatively affect aquatic life that depend upon cool water for survival. Coldwater fish species are more stressed in warmer water temperatures, which increases metabolism and reduces the amount of available oxygen in the water. Coldwater fish and other aquatic life may feed less frequently and use more energy to survive in thermal conditions above their tolerance range, which can result in fish kills. Also, elevated temperatures can boost the ability of non-native fish to outcompete native fish if the latter are less able to adapt to warmer water conditions (Bear et al., 2007). Although the TMDL will address increased summer temperatures as the most likely to cause detrimental effects on fish and aquatic life, human influences on stream temperature, such as those that reduce shade, can lead to lower minimum temperatures during the winter (Hewlett and Fortson, 1982). Lower winter temperatures can lead to the formation of anchor and frazzle ice which can harm aquatic life by causing changes in movement patterns (Brown, 1999; Jakober et al., 1998), reducing available habitat, and inducing physiological stress (Brown et al., 1993). Addressing the issues associated with increased summer maximum temperatures will also address these potential winter problems. Assessing thermal effects upon a beneficial use is an important initial consideration when interpreting Montana's water quality standard (**Appendix B**) and subsequently developing temperature TMDLs.

7.2 STREAM SEGMENTS OF CONCERN

One waterbody segment in the Kootenai-Fisher project area appeared on the 2012 Montana impaired waters list as having temperature limiting a beneficial use: Wolf Creek (**Appendix A**, **Figure A-8**).To help put sampling data into perspective and understand how elevated stream temperatures may affect aquatic life, information on fish presence in Wolf Creek and temperature preferences for the most sensitive species are described below.

7.2.1 Fish Presence in Wolf Creek

Because different fish species have varying optimal temperature ranges for survival and some are more sensitive than others to elevated stream temperatures, it is important to identify the fish species within each stream segment of concern. Based on a query of the Montana Fisheries Information System (MFISH), brook trout, Columbia basin redband trout, largescale sucker, longnnose dace, redside shiner, sculpin, and westslope cutthroat/rainbow trout hybrids are all common in Wolf Creek, and mountain whitefish are rare (Montana Department of Fish, Wildlife and Parks, 2013). Although Wolf Creek is a tributary to the Fisher River, which is used rarely by migrating bull trout (Montana Department of Fish, Wildlife and Parks, 2013), Wolf Creek is not currently or potentially suitable for bull trout (Dunnigan, Jim, personal communication 04/02/2012). According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, Wolf Creek is considered "High-Value" (rating score 2) from river mile 20.8 to 35 (most of the creek upstream of Dry Fork Creek) and the rest of it is "Moderate" (rating score 4) (Montana Department of Fish, Wildlife and Parks, 2013).

Although not a fish, the western pearlshell mussel is a Montana species of concern that inhabits the Wolf Creek watershed (Stagliano and Montana Natural Heritage Program, 2010). Its larvae rely on a fish host for dispersal, and its native host species is westlope cutthroat, but other trout such as those listed above could also serve as a host (Stagliano and Montana Natural Heritage Program, 2010).

7.2.1.1 Temperature Levels of Concern

Special temperature considerations are warranted for the westslope cutthroat trout and Columbia basin redband trout, which are identified in Montana as species of concern. Research by Bear et al. (2007) found that westslope cutthroat maximum growth occurs around 56.5°F, with an optimum growth range (based on 95% confidence intervals) from 50.5–62.6°F. Columbia basin redband trout are a type of rainbow trout, which have a similar optimum growth temperature to westslope cutthroat trout; however, rainbow trout have the ability to grow better over a wider range of temperatures than cutthroat trout, with growth significantly better at temperatures below 44.2° F and above 69.4°F (Bear et al., 2007).

The ultimate upper incipient lethal temperature (UUILT) is the temperature considered to be survivable by 50% of the population over a specified time period. Bear et al. (2007) found the 60-day UUILT for westslope cutthroat trout to be 67.3°F and the 7-day UUILT to be 75.4°F. In contrast they observed that rainbow trout had a 60-day UUILT of 75.7°F and a 7-day UUILT of 78.8°F. Considering a higher level of survival, the lethal temperature dose for westslope cutthroat that will kill 10% of the population in a 24-hour period is 73.0°F (Liknes and Graham, 1988).

The western pearlshell mussel is known to be sensitive to elevated temperatures but less information about optimal growth and lethal temperatures is known about it than its host species (i.e., salmonids); in statewide monitoring of its populations, the mussel has been observed in streams with water temperatures over 77°F (Stagliano, David, personal communication 12/6/2012). This indicates temperature levels of concern for salmonids are lower than for the western pearlshell mussel and that maintaining temperatures that are protective of salmonids will also be protective of the mussel.

7.3 Information Sources and Data Collection

As part of this TMDL project, DEQ used several information and data sources to assess temperature conditions in Wolf Creek:

- DEQ assessment file information
- Temperature Related Data Collection
    - 2012 DEQ/EPA stream temperature, flow, riparian shade, and channel geometry data
    - 2012 Plum Creek temperature data

As discussed in **Appendix B** and **Section 7.4.1**, Montana defines temperature impairment as occurring when human sources cause a certain degree of change over the water temperature that occurs as a result of natural sources and human sources that are implementing all reasonable land, soil, and water conservation practices. Because interpreting the standard is more complex than just comparing measured temperatures to the temperature levels of concern discussed above, a QUAL2K water quality model was needed to determine if human sources are causing the allowable temperature change to be exceeded. Model details are presented in **Appendix G** but the model summary and outcome is provided in **Section 7.5**, **Source Assessment**. To assist with model development and assessment of temperature conditions in Wolf Creek, two other categories of data were needed:

- Climate Data
- Montana Department of Natural Resources and Conservation (DNRC) water usage data

7.3.1 DEQ Assessment Files

DEQ maintains assessment files that provide a summary of available water quality and other existing condition information, along with a justification for impairment determinations.

7.3.2 Temperature Related Data Collection

In summer 2012 DEQ and EPA collected temperature data, along with measurements of streamflow, riparian shade, and channel geometry. This information is collectively used within the QUAL2K model to evaluate impairment and the potential for improvement associated with the implementation of all reasonable land, soil, and water conservation practices. The following sections describe the data collected in Wolf Creek for temperature assessment.

7.3.2.1 Temperature Monitoring

In summer 2012 EPA deployed seven temperature loggers in Wolf Creek and five temperature loggers at the mouth of tributaries (**Figure 7-3**). All tributary loggers were deployed in late June but loggers were not deployed in Wolf Creek until mid-July because of high flows in June. All loggers recorded temperatures every 30 minutes until they were retrieved in mid-September. Water temperature data were collected when streamflow tends to be the lowest and air temperatures the highest because that is when aquatic life are exposed to the highest water temperatures of the year. Temperature monitoring sites on Wolf Creek were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width. Tributary loggers were deployed in the largest tributaries (based on stream order) to help with model development and to identify if those tributaries are having a warming or cooling effect on Wolf Creek. Loggers were deployed following DEQ protocols and a Quality Assurance Project Plan (Montana Department of Environmental Quality, 2005b; Montana Department of Environmental Quality, 2005a; ATKINS, 2012). Temperature data can be obtained by contacting DEQ but are summarized within this document and **Attachment A** of **Appendix G**.

Plum Creek Timber Company, Inc. (Plum Creek), which owns much of the Wolf Creek valley bottom (**Attachment A** of **Appendix G**, **Figure 3**), deployed three temperature loggers in summer 2012, and those data were also used for TMDL development. Like the EPA loggers, the Plum Creek loggers recorded water temperature every 30 minutes. Two temperature loggers were deployed on Wolf Creek and one was deployed midway up the tributary Little Wolf Creek (**Figure 7-1**). The Plum Creek loggers were deployed from late June to early December 2012.

7.3.2.2 Streamflow

Streamflow measurements were collected following DEQ protocols at all temperature monitoring sites (**Figure 7-1**) during logger deployment (June/July), mid-season (August) and logger retrieval (September). There was no streamflow at the uppermost site (WLFC-T0.1) during logger retrieval and there was no streamflow at the mouths of Dry Fork Creek (DRFKC) and Calx Creek (CALXC) during August and September monitoring (**Figure 7-1**).

7.3.2.3 Riparian Shading

Characterization of riparian shade was based on a combination of field data and aerial imagery analysis. EPA and DEQ used a Solar Pathfinder to measure effective shade in September 2012 at seven locations on Wolf Creek near the temperature logger sites (**Figure 7-1**). Effective shade is the percent reduction of incoming solar radiation that reaches the stream because of riparian vegetation and topography. Because of the variability in riparian cover and topography throughout the watershed, a GIS-based model called TTools (v.3.0) (Oregon Department of Environmental Quality, 2001) was used along with field measurements for trees, shrubs, and herbaceous vegetation and a spreadsheet tool (Shadev3.0.xls) (Pelletier, 2012) to estimate the hourly effective shade approximately every 100 feet along the entire stream. The analysis was performed using August 2012 Google Earth aerial imagery to classify vegetation into broad categories (i.e., bare ground/road, herbaceous, shrub, and trees). The 2001 National Land Cover Database identified percent canopy cover for trees, and that information was used to classify trees as sparse, low, medium, or high density. Although the seven Solar Pathfinder measurements were sparse compared to the Shade model output, they indicate the model reasonably approximated effective shade along Wolf Creek; the average error between the field measurements and model output was 3%. Additional details regarding the shade assessment are contained in **Attachment A** of **Appendix G**.

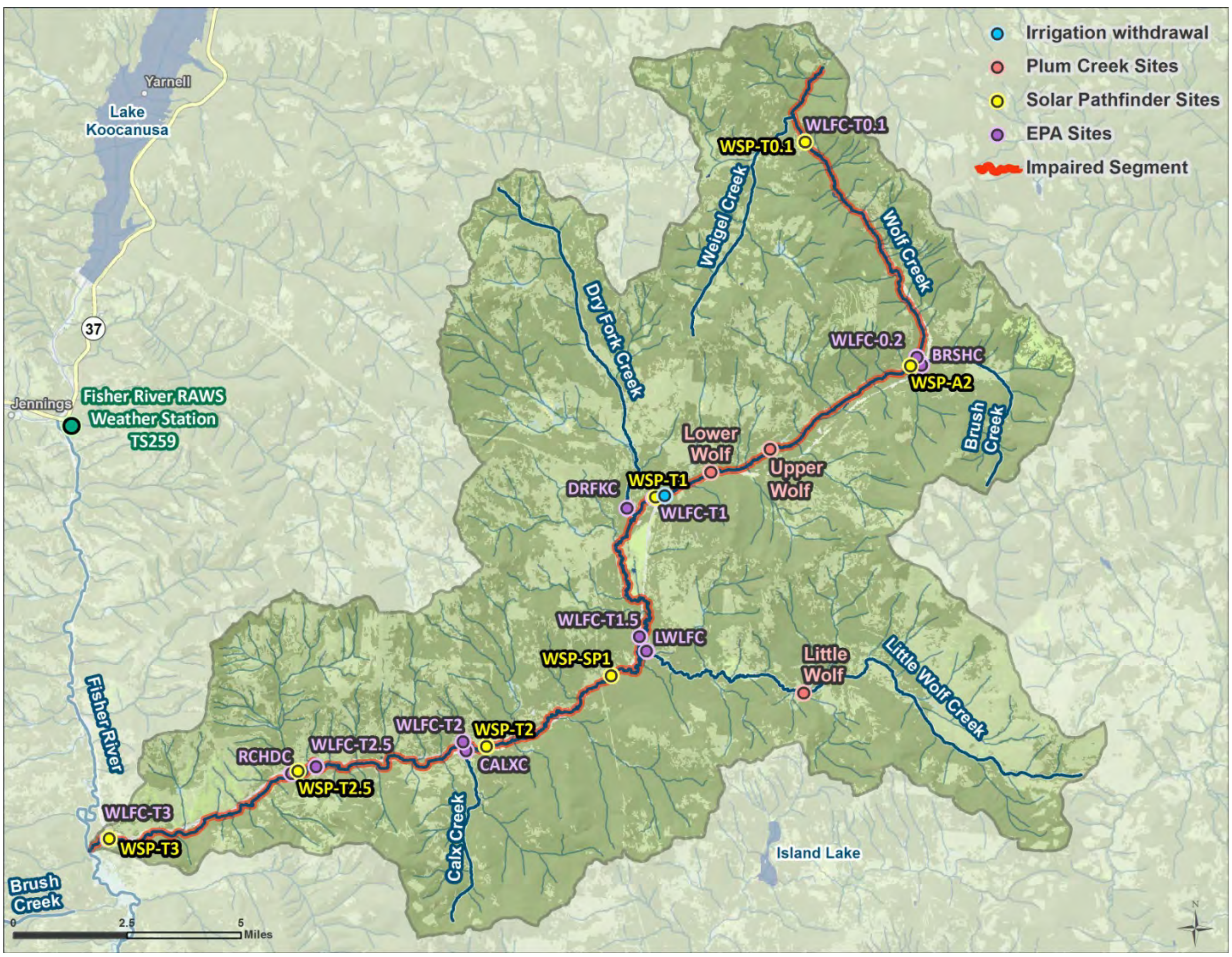

Figure 7-1. Temperature data logger sampling sites on Wolf Creek

7.3.2.4 Channel Geometry

Channel geometry (i.e., width and depth) can influence the rate of thermal loading and is a necessary input for the QUAL2K model. Wide, shallow streams transfer heat energy faster than narrow, deep streams. Human activities that alter peak flows or disturb the riparian vegetation, streambanks, and/or stream channel have the potential to alter channel geometry. Therefore, channel geometry can be used to identify areas that may be destabilized and more prone to rapid thermal loading, particularly in locations where shading is minimal. Channel width (wetted and bankfull) was collected at each of the Wolf Creek shade sites in 2012 (**Figure 7-1**) and [bankfull] width/depth ratios were measured at one site by the KNF in 2011 and at two sites by DEQ and EPA in 2011 (**Figure 5-1**).

7.3.3 Climate Data

Climate data, including air temperature, dew point temperature, wind speed, and cloud cover, are major inputs to the QUAL2K model and are also drivers for stream temperature. Climatic data inputs, including hourly air temperature, were obtained from the nearby Fisher Remote Automatic Weather Station, which is 8 miles from the mouth of Wolf Creek (**Figure 7-1**).

7.3.4 DRNC Water Usage Data

Spatial DNRC water usage data that includes identification of active points of diversion and places of use was obtained from the Natural Resources Information System (Natural Resources Information System, 2012). This information was necessary because streamflow is an important input for the QUAL2K model and irrigation withdrawals have the potential to influence stream temperatures.

7.4 Target Development

The following section describes 1) the framework for interpreting Montana's temperature standard; 2) the selection of target parameters and values used for TMDL development; and 3) a summary of the temperature target values for Wolf Creek.

7.4.1 Framework for Interpreting Montana's Temperature Standard

Montana's water quality standard for temperature is narrative in that it specifies a maximum allowable increase above the naturally occurring temperature to protect fish and aquatic life. Under Montana water quality law, naturally occurring temperatures incorporate natural sources and human sources that are applying all reasonable land, soil, and water conservation practices. Naturally occurring temperatures can be estimated for a given set of conditions using QUAL2K or other modeling approaches, but because water temperature changes daily and seasonally, no single temperature value can be identified to represent standards attainment. Therefore, in addition to evaluating if human sources are causing the allowable temperature change to be exceeded, a suite of temperature TMDL targets were developed to translate the narrative temperature standard into measurable parameters that collectively represent attainment of applicable water quality standards at all times. The goal is to set the target values at levels that occur under naturally occurring conditions but are conservatively selected to incorporate an implicit margin of safety that helps account for uncertainty and natural variability. The target values are protective of the use most sensitive to elevated temperatures, aquatic life; as such, the targets are protective of all designated uses for the applicable waterbody segments.

For Wolf Creek a QUAL2K model was used to estimate the extent of human influence on temperature by evaluating the temperature change between existing conditions and naturally occurring conditions. The model used the data described in **Section 7.3** to simulate existing conditions, and then the model was re-run with riparian shade and water use altered to reflect naturally occurring conditions. If the modeled temperature change between the two scenarios (i.e., existing and naturally occurring) is greater than allowed by the water quality standard (i.e., 0.5-1.0°F, depending on the naturally occurring temperature), this verifies the existing temperature impairment for Wolf Creek. This section discusses whether the model outcome supports the existing impairment listing, but model scenario details are presented in **Section 7.5**, **Source Assessment,** and **Appendix G.**

7.4.2 Temperature Target Parameters and Values

The primary temperature target is the allowable human-caused temperature change (i.e., 0.5-1.0°F, depending on the naturally occurring temperature), and the other targets are those parameters that influence temperature and can be linked to human causes. The other targets are riparian shade, channel geometry, and improved streamflow conditions, where applicable. All targets are described in more detail below.

7.4.2.1 Allowable Human-Caused Temperature Change

The target for allowable human-caused temperature change for Wolf Creek links directly to the numeric portion of Montana's temperature standard for B-1 streams [**ARM 17.30.623(e)**]: When the naturally occurring temperature is less than 66^{o}F, the maximum allowable increase is 1^{o}F. Within the naturally occurring temperature range of 66–66.5^{o}F, the allowable increase cannot exceed 67^{o}F. If the naturally occurring temperature is greater than 66.5^{o}F, the maximum allowable increase is 0.5^{o}F. As stated above, naturally occurring temperatures incorporate natural sources, yet also include human sources that are applying all reasonable land, soil, and water conservation practices.

7.4.2.2 Riparian Shade

Increased shading from riparian vegetation reduces sunlight hitting the stream and, thus, reduces the heat load to the stream. Riparian vegetation also reduces near-stream wind speed and traps air against the water surface, which reduces heat exchange with the atmosphere (Poole and Berman, 2001). In addition, lack of established riparian areas can lead to bank instability, which can result in an overwidened channel.

To help minimize the influence of upland activities on stream temperature, a riparian buffer close to 100 feet is commonly recommended (Ledwith, 1996; Knutson and Naef, 1997; Ellis, 2008). However, several studies have shown that most (85-90%) of the maximum shade potential is obtained within the first 50 feet (Brazier and Brown, 1973; Broderson, 1973; Steinblums et al., 1984) or 75 feet of the channel (CH2M, 2000; Castelle and Johnson, 2000; Christensen, 2000). The Natural Resources Conservation Service (NRCS) Conservation Practice Standard recommends a minimum buffer width of 35 feet, and also includes recommendations to use species with a medium or high shade value and to meet the minimum habitat requirements of aquatic species of concern (Natural Resource Conservation Service, 2011a; 2011b). Based on several literature sources finding that most shade is obtained within a buffer width of 50 feet and that 50 feet is the minimum buffer width for the Montana Streamside Management Zone (Montana Department of Natural Resources and Conservation, 2006), the target is a buffer width of 50 feet. Based on areas of reference riparian health in the upper watershed and documented removal of much of the overstory trees in the valley (see **Section 5.5.5**), as well as the NRCS recommendation for buffers with medium to high shade value, this 50 foot buffer should consist of medium density trees or any vegetation providing equivalent effective shade. The target does not apply to portions where the riparian zone is already at potential or is dominated by vegetation not likely to attain great heights at maturity (e.g., wetland shrub community).

Although the target is 50 feet, the USFS abides by Inland Native Fish Strategy standards in the Wolf Creek watershed for Riparian Habitat Conservation Areas, which sets a buffer ranging from a minimum of 50 feet for seasonally flowing streams to a minimum of 300 feet for fish-bearing streams (U.S. Department of Agriculture, Forest Service, 1995).

DEQ realizes most healthy riparian buffers are comprised of more than a single category of vegetation, but a buffer of medium density trees was used as a shade target throughout Wolf Creek for two reasons: 1) the actual composition of the riparian zone under target shade conditions will vary over time and is too complex to model with QUAL2K, and 2) based on existing vegetation in the watershed and what is known of historical conditions, the effective shade provided by medium density trees was determined to be a reasonable target. Considering the variability in potential vegetation and shade, medium density trees was used as a surrogate to represent the average achievable shade condition; effective shade is the result of topography and vegetative height and density, so the target shade condition could be achieved by a large combination of vegetation types and densities. Additionally, the effective shade potential at any given location may be lower or higher than the target depending on natural factors such as fire history, soil, topography, and aspect but also because of human alterations to the near-stream landscape including roads, the railroad, and riprap that may not feasibly be modified or relocated. The target is provided as a quantitative guide for meeting the standard but since it is intended to represent all reasonable land, soil, and water conservation practices, if those are being implemented, then Wolf Creek will be meeting the riparian shade target.

7.4.2.3 Width/Depth Ratio

A narrower channel with a lower width-to-depth ratio results in a smaller contact area with warm afternoon air and is slower to absorb heat (Poole and Berman, 2001). Also, a narrower channel increases the effectiveness of shading produced by the riparian canopy. A target for width/depth ratio was developed for the sediment TMDLs using reference data (**Section 5.4.1**), and will also apply for temperature: ≤ 21 for sections with a bankfull width less than 30 feet and ≤ 32 for sections with a bankfull width greater than 30 feet. The target is not intended to be specific to every given point on the stream but to maintain current conditions where the target is generally being met. In areas where the target is not being met, actions to improve riparian shade are also anticipated to lower width/depth ratios.

7.4.2.4 Instream Flow (Water Use)

Because larger volumes of water take longer to heat up during the day, the ability of a stream to buffer incoming solar radiation is reduced as instream water volume decreases. In other words, a channel with little water will heat up faster than an identical channel full of water, even if they have identical shading and are exposed to the same daily air temperatures.

Human-caused sedimentation, which is a process than can lower the summer base flow of a stream by reducing groundwater inputs (May and Lee, 2004; Sullivan and Watzin, 2010), is widespread in tributaries to Wolf Creek (USDA Forest Service, 1981; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1996; 1998; 1999; Edwards, 2008); however, field observations indicate that small tributaries and particularly those on the south-facing side of the drainage tend to naturally go dry in the summer. Reductions in streamflow because of direct withdrawals of water from Wolf Creek are very limited. DNRC water use data indicates there is only one irrigation withdrawal from Wolf Creek, and it is estimated to withdraw 1.78 cfs daily for flood irrigation (**Attachment A** of **Appendix G, Table A-8**). Given this very limited amount of consumptive water use, there is no water use target.

7.4.3 Target Values Summary

The allowable human-caused temperature change is the primary target that must be achieved to meet the standard. Alternatively, compliance with the temperature standard can be attained by meeting the two temperature-influencing targets (i.e., riparian shade and width/depth ratio). In this approach, if all reasonable land, soil, and water conservation practices are installed or practiced, water quality standards will be met. **Table 7-1** summarizes the temperatures targets for Wolf Creek.

Table 7-1. Temperature Targets for Wolf Creek

Target Parameter	Target Value
Primary Target	
Allowable Human-Caused Temperature Change	If the naturally occurring temperature is less than 66°F, the maximum allowable increase is 1°F. Within the naturally occurring temperature range of 66–66.5°F, the allowable increase cannot exceed 67°F. If the naturally occurring temperature is greater than 66.5°F, the maximum allowable increase is 0.5°F.
Temperature-Influencing Targets: Meeting both will meet the primary target	
Riparian Health - Shade	50 foot buffer with medium density trees, or vegetation providing equivalent effective shade
Width/Depth Ratio	B & C stream types with bankfull width < 30ft: $\leq$ 21 B & C stream types with bankfull width > 30ft: $\leq$ 32

7.4.4 Wolf Creek Existing Conditions and Comparison to Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for Wolf Creek. QUAL2K model results will be compared to the allowable human-caused temperature change to determine if the target is being exceeded, but most model details will be presented in **Section 7.5**, **Source Assessment**.

Wolf Creek (MT76C001_020) was initially listed for temperature impairment in 1990 because of an instantaneous water temperature of 69°F. The assessment file also documents changes to channel form and shade, both of which could influence water temperatures. Because of the railroad construction in the 1970s, large extents of the stream were channelized and riprapped. During visits at three sites in 1992, dense shrub cover was generally observed, but extensive historic logging that included the removal of overstory in the valley was noted. Overall, human-influenced factors that could increase temperatures in Wolf Creek include the railroad, road network, present and historic agricultural activities (mostly grazing), and timber harvest.

Data Summary and Comparison with Water Quality Targets

To help evaluate the extent and implications of impairment it is useful to evaluate the degree to which existing temperatures may harm fish or other aquatic life. Measured temperatures were warmest for the longest period of time near the mouth (WLFC-T3), where the water temperature on 21 days exceeded 70°F. These temperatures are not in the lethal range discussed in **Section 7.2.1.1**, but maximum daily temperatures throughout Wolf Creek (**Figure 7-2**) were commonly outside of the optimal growth range for both westslope cutthroat trout and Columbia redband trout (i.e., 62.6°F). For tributaries, Dry Fork Creek and Little Wolf Creek were the warmest, with Little Wolf Creek temperatures exceeding 75°F.

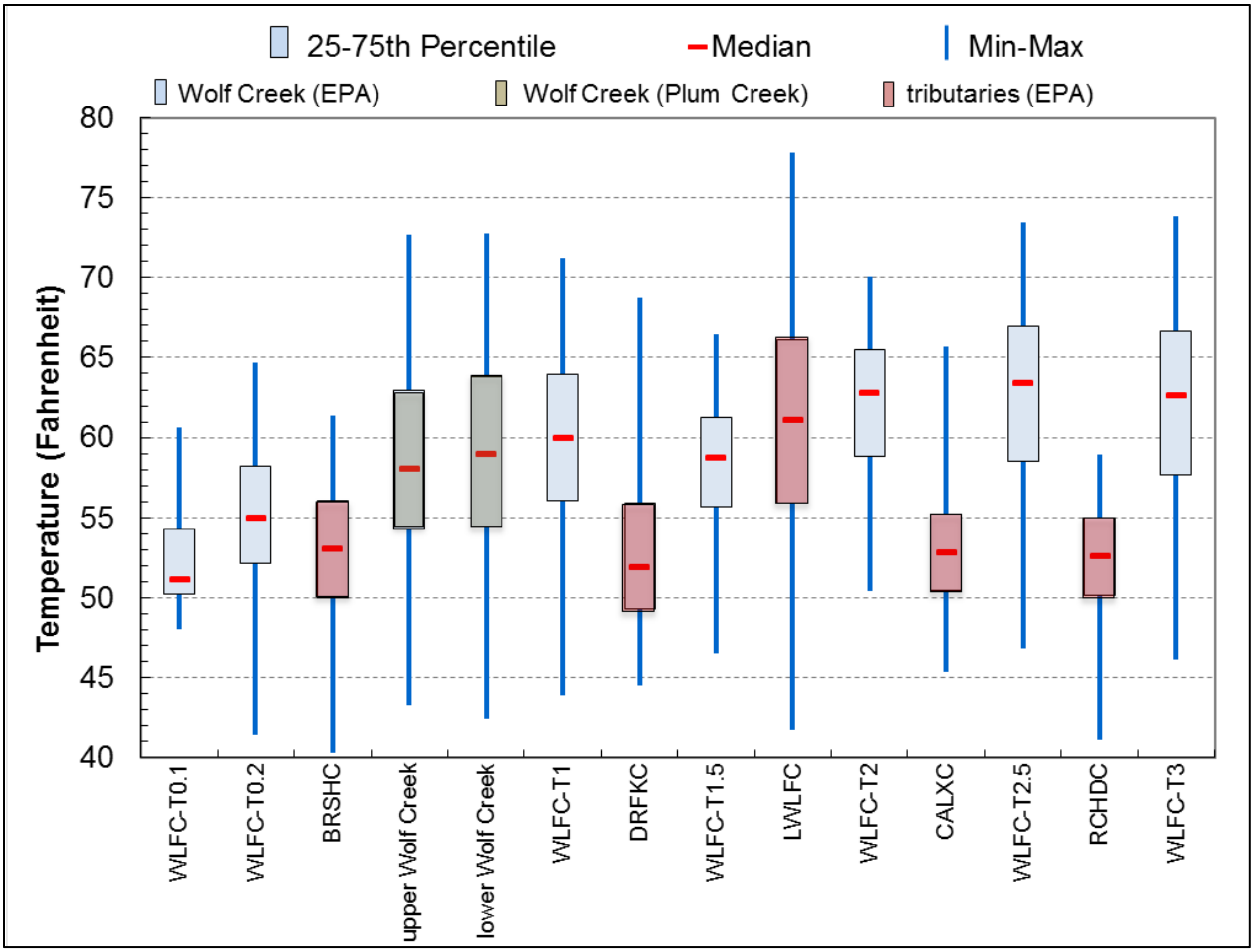

Figure 7-2. 2012 temperature logger monitoring data for Wolf Creek and several tributaries

The QUAL2K model results indicate that the maximum naturally occurring summer temperatures in Wolf Creek are greater than 66.5°F downstream of Dry Fork Creek, meaning human sources cannot cause the temperature to be exceeded by more than 1.0°F upstream of Dry Fork Creek and by more than 0.5°F downstream. Based on the model and temperature data, human sources have caused the allowable change target to be exceeded throughout Wolf Creek, with the increase ranging from 0.6°F to 7.8°F and averaging 4.6°F. There is only a 1 mile section of stream just upstream from site WLFC-T2 where human sources are causing less than a 1.0°F increase.

The existing riparian buffer is predominantly herbaceous ground cover and shrubs, followed by medium and high density trees (**Table 7-2**). Much of the riparian vegetation upstream of Dry Fork Creek (**Figure 7-1**) is a mix of shrubs (primarily alder and dogwood) and conifers. Riparian vegetation in the lower watershed is dominated by the same shrubs as the upper watershed and has interspersed conifers and deciduous trees. Much of the riparian shrubs are dense, but the lack of overstory vegetation reduces the effective shade well below the target. **Figure 7-3** shows the percent difference between the existing effective shade and the target effective shade (based on the Shade Model results). Note, the dark blue section near site WLFC-T1.5 represents a sinuous 6 mile stretch inhabited by beavers. Because there is extensive wetland habitat in that section, the target does not apply and it was excluded from the Shade Model; however, the riparian zone is generally dominated by dense willows and at its potential.

Table 7-2. Composition of the existing riparian buffer 50 feet on both sides of Wolf Creek

Land cover type	Relative area (percent)
Bare ground/road	3.4%
Herbaceous	27.9%
Shrub	34.2%
Sparse trees	2.6%
Low density trees	5.9%
Medium density trees	16.6%
High density trees	9.4%

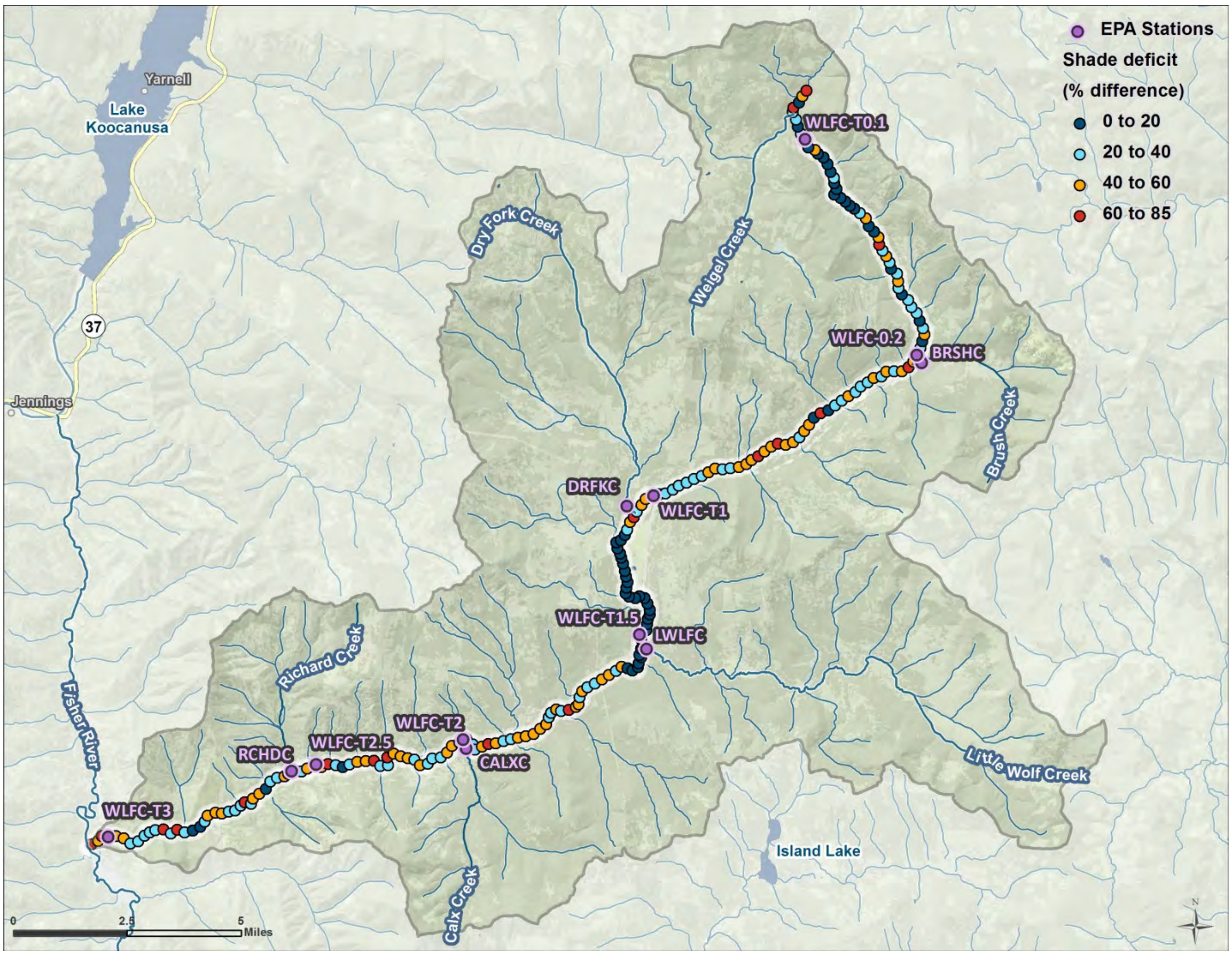

Figure 7-3. The percent of additional effective shade needed to meet the target along Wolf Creek.

The width/depth ratios measured at three sites in 2011 to support sediment TMDL development (**Section 5.5.5**) all met the target value. Channel widths at all shade sites visited in 2012 were similar to those measured in 2011, indicating Wolf Creek is meeting the target for width/depth ratio. Although the channel is not overwidened, which is good for water temperatures, actions such as channel hardening and realignment, which were extensively done in Wolf Creek, can alter a stream's ability to access its floodplain (i.e., entrenchment) and increase stream temperatures by reducing the stream's interaction with groundwater (Poole and Berman, 2001).

Summary and TMDL Development Determination
The human-influenced allowable temperature change target is being exceeded throughout Wolf Creek. Additionally, although width/depth ratios are meeting the target, the riparian vegetation is generally well under the shade target. The dense shrubs present in much of the Wolf Creek riparian zone as well as observations made during the assessment of sediment and habitat data (see **Section 5.5.5**) indicate it is recovering from historical practices but the removal of much of the overstory vegetation in the riparian zone continues to limit shade and contribute to elevated water temperatures that are likely limiting its ability to fully support aquatic life. This information supports the existing impairment listing and a temperature TMDL will be developed for Wolf Creek.

7.5 Source Assessment

As discussed above, the source assessment for Wolf Creek largely involved QUAL2K temperature modeling. There are no permitted point sources in the watershed. The watershed has been affected by the railroad, road network, present and historic agricultural activities (mostly grazing), and timber harvest. Instead of focusing on the potential contribution of these sources, the source assessment focused on two factors that can be influenced by human activities and are drivers of stream temperature: instream flow and riparian shade.

7.5.1 Wolf Creek Assessment Using QUAL2K

A QUAL2K model was used to determine the extent that human-caused disturbances within the Wolf Creek watershed have increased the water temperature above the naturally occurring level. The evaluation of model results focuses on the maximum daily water temperatures in Wolf Creek during the summer because those are conditions mostly likely to harm aquatic life, the most sensitive beneficial use.

QUAL2K is a one-dimensional river and stream water quality model that assumes the channel is well-mixed vertically and laterally. The QUAL2K model uses steady state hydraulics that simulates non-uniform steady flow. Within the model, water temperatures are estimated based on climate data, riparian shading, and channel conditions. Each stream is segmented into reaches within the model that are assigned the same channel and shade characteristics. Segmentation is largely based on the location of field data, tributaries, irrigation withdrawal/returns, and changes in channel conditions or shading.

Within the model, Wolf Creek was segmented into reach lengths of 0.93 miles. The water temperature and flow data collected from Wolf Creek and five tributaries in 2012, along with channel measurements, irrigation data, and climate data (**Section 7.3**), were used to calibrate and validate the model. Both Dry Fork Creek and Calx Creek were dry at the mouth in August and September, when the model was calibrated and validated, so they had no flow contributing to Wolf Creek within the model. Error rates for the maximum stream temperatures for the calibration and validation were 2.6% and 3.1%, respectively, indicating the model provides a reasonable approximation of maximum daily temperatures in Wolf Creek. While temperatures were monitored at the mouth of the largest tributaries to evaluate if and how they are affecting temperatures in Wolf Creek, due to time and resource constraints measuring effective shade and identifying human influences on tributary water temperatures was outside of the scope of this project.

Flow data at the USGS gage on the nearby Fisher River (#12301990) were evaluated to determine how August streamflow in 2012 (when data were collected) compared to the average August streamflow; flows were at the 77th percentile, indicating they were higher than average.

A baseline scenario and three additional scenarios were modeled to investigate the potential influences of human activities on temperatures in Wolf Creek. The following sections describe those modeling scenarios. Although channel width and depth can influence stream temperatures, the existing channel dimensions were not changed for any of the scenarios because Wolf Creek is meeting the channel width/depth target. A more detailed report of the development and results of the QUAL2K model are included in **Appendix G**.

7.5.1.1 Baseline Scenario (Critical Existing Conditions)

The baseline scenario represents stream temperatures under existing shade and channel conditions in August on a hot, dry year and is the scenario that all others are compared against to evaluate the influence of human sources. The calibrated and validated model was set up entirely on measured conditions and corresponding weather data, but because long-term flow data at the nearby Fisher River gage indicated Wolf Creek summer flows were likely higher than usual (which could result in cooler water temperatures), flow and climate data were adjusted to represent more critical (i.e., hotter and drier) conditions for the baseline scenario. Flow inputs in the model were decreased to represent the 25th percentile flow conditions for August. Climate inputs reflect the median of the warmest four consecutive days in August for the period of record at the Fisher RAWS climate station (2004-2013).

Under the baseline scenario, maximum daily temperatures range from 52.4°F near the headwaters to 74.2°F at the mouth (**Figure 7-4**). Temperatures generally increase in a downstream direction but reset somewhat by decreasing by 2 or more degrees Fahrenheit near river mile 20, which is just upstream of Little Wolf Creek at site WLFCT1.5. The area where temperatures decrease is within the sinuous section of channel with extensive beaver habitat and is also one of the few areas of the creek where it is not adjacent to the railroad (**Figure 5-6**).

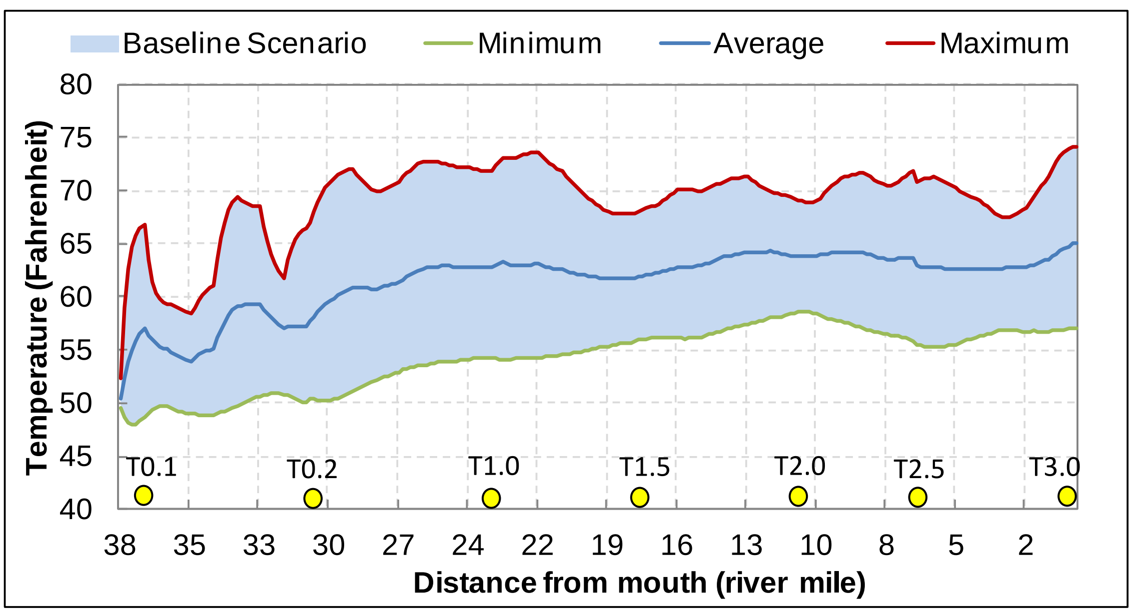

Figure 7-4. Modeled temperatures for the Wolf Creek baseline scenario

7.5.1.2 Water Use Scenario

Although there is no formal target for consumptive water use relative to instream flow because of the limited amount of water withdrawn for irrigation, the naturally occurring condition referenced in the temperature standard includes the use of all reasonable water conservation practices (ARM 17.30.602(17)). Therefore, a water use scenario was conducted to evaluate the effect that water conservation measures resulting in more instream flow would have on temperatures.

In this scenario, the single irrigation withdrawal that is used for flood irrigation (which was estimated at 1.78 cfs daily, see **Appendix G)** is reduced by 15% within the model and that savings of 0.27 cfs (1.78 * 0.15 = 0.27) is allowed to remain in the stream. The Natural Resources Conservation Service Irrigation Guide (Natural Resources Conservation Service, 1997) states that improving an existing irrigation system often increases water application efficiency by more than 30% and installing a new system typically adds an additional 5% to 10% savings. These improvements in efficiency could be used to grow different crops, expand production, or withdraw less water from the stream. Since leaving additional water instream could lower the maximum daily temperature, converting efficiency savings to a lower amount of water usage is the focus of this scenario.

However, per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-705, State of Montana, 2011), so any voluntary water savings and subsequent instream flow augmentation must be done in a way that protects water rights. In the water use scenario, a 15% reduction in withdrawal volume was used to simulate the outcome of leaving some of the water saved by implementing improvements to the irrigation network instream. Considering the statistics presented above from the NRCS Irrigation Guide and other sources that evaluated efficiency improvements for different irrigation practices (Negri et al., 1989; Negri et al., 1989; Howell and Stewart, 2003; Osteen et al., 2012) and savings left instream (Kannan et al., 2011), using efficiency gains to reduce withdrawal volume by 15% was selected for the water use scenario. Fifteen percent was chosen to be a reasonable starting point, but as no detailed analysis was conducted of the irrigation network in the Wolf Creek watershed, this scenario is not a formal efficiency improvement goal; it is an example intended to represent the application of water conservation practices for water withdrawals.

The withdrawal occurs at river mile 23.8, which is just upstream of monitoring site WLFC-T1.0 (**Figure 7-1**). Under the water use scenario, improving water use efficiency and withdrawing 15% less water has a minimal effect on temperatures in Wolf Creek. Starting at the withdrawal location and extending to the mouth, maximum daily temperatures averaged 0.06°F less than the baseline scenario, and the largest decrease in maximum daily temperature was 0.21°F. Therefore, consumptive water usage is not causing the allowable temperature change target to be exceeded.

7.5.1.3 Shade Scenario

For the shade scenario, the effective shade inputs to the model were set to represent the target shade condition. Since the target is a 50 foot buffer of medium density trees or any vegetation providing equivalent effective shade, the effective shade generated by a 50 foot buffer of medium density trees along Wolf Creek was calculated using the Shade Model (discussed in **Section 7.3.2.3**) and averaged for each model segment (approximately 1 mile). Based on this scenario, the maximum daily stream temperature is very sensitive to improvements in riparian shade. This scenario resulted in maximum daily temperatures ranging from 52.4°F to 70.2°F, which is decrease from the baseline scenario of 0.63°F to 7.82°F (**Figure 7-5**). Meeting the shade target caused an average decrease in the maximum daily temperature of 4.55°F from the baseline scenario. The maximum decrease was in the upper watershed slightly downstream of Brush Creek and sample site WLFC-T0.2 (river mile 29.9) and the smallest change was in the sinuous section of beaver habitat near site T1.5, where temperatures already decrease in the baseline scenario. The shade scenario indicates that human changes to the riparian vegetation are the primary source of temperature impairment. To illustrate how this scenario relates to current conditions, the average daily effective shade for segments with similar vegetation is presented in **Table 7-3** for the baseline scenario and shade scenario.

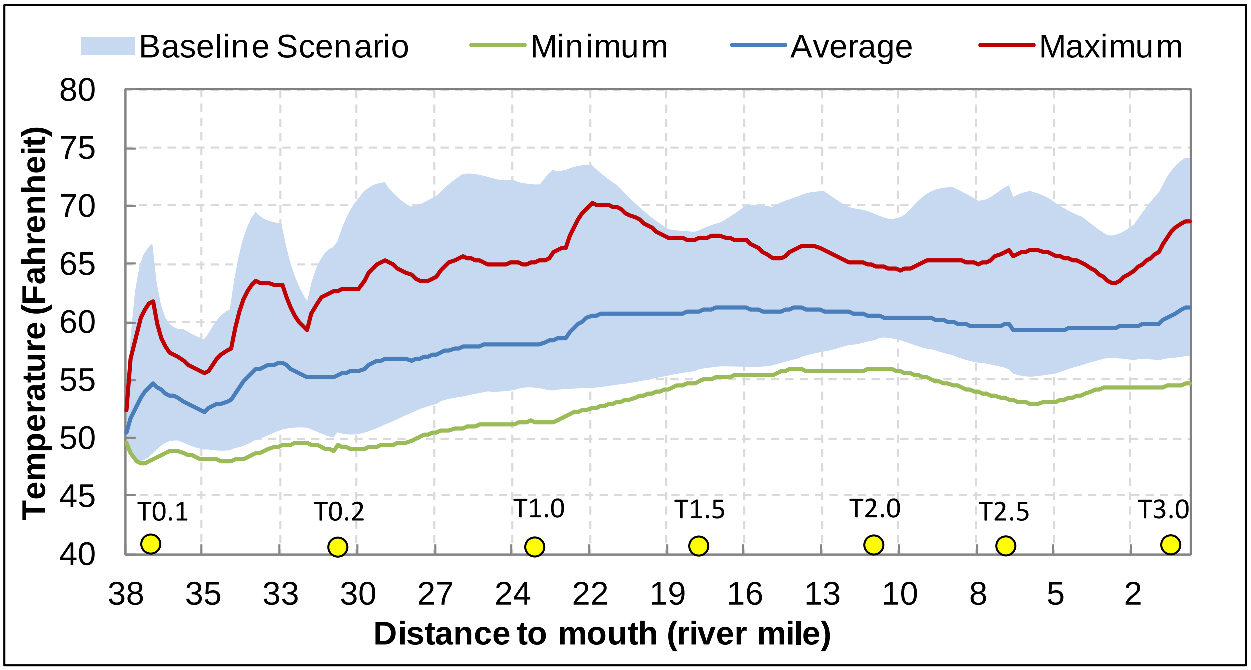

Figure 7-5. Comparison of modeled temperatures between the shade and baseline scenarios

Table 7-3. Comparison of effective shade between the existing condition and shade scenario

Segment (river mile)	Current Conditions, Baseline Scenario	Shade Scenario
37.8 - 30.6	72%	82%
30.6 - 26.6	55%	72%
26.6 - 25.0	48%	69%
25.0 - 22.9	50%	67%
22.9 - 17.7[1]	47%	47%
17.7 - 11.0	50%	63%
11.0 - 6.5	52%	65%
6.5 - 0	52%	63%

[1]Section containing wetland shrubs that were not adjusted for the shade scenario

7.5.1.4 Naturally Occurring Scenario (Full Application of BMPs with Current Land Use)

The naturally occurring scenario represents Wolf Creek water temperatures when all reasonable land, soil, and water conservation practices are implemented (**ARM 17.30.602**). Since the current width/depth ratios are meeting the target and reflected in the baseline scenario, the naturally occurring scenario is a combination of the shade and water use scenarios. Although water conservation measures resulting in additional instream flow will only cause a slight decrease in maximum daily stream temperatures (**Section 7.5.1.2**), the conditions applied in the water use scenario were included because water conservation is a component of the naturally occurring condition. Water users in the Wolf Creek watershed are encouraged to work with the USDA Natural Resource Conservation Service, the Montana Department of Natural Resources and Conservation, the local conservation district, and other local land management agencies to review their irrigation systems, practices, and the variables that may affect overall irrigation efficiency (Negri and Brooks, 1990; Natural Resources Conservation Service, 1997). If warranted and practical, users may consider changes that increase instream flows, and/or reduce warm water return flows in Wolf Creek.

Given the small influence of water withdrawals, the target for maximum allowable human-influenced temperature change could be achieved entirely by increasing the effective shade. However, water conservation measures resulting in more instream flow would slightly decrease temperatures, meaning slightly less improvement in effective shade would be necessary to meet the water quality standard. The naturally occurring scenario maximum daily temperatures ranged from 52.36°F to 69.96°F, with an average of 64.59°F. Based on these results, the naturally occurring temperature is less than 66.0°F until approximately 0.15 miles downstream of Dry Fork Creek (river mile 22.76), and an increase of 1°F is allowed from human sources, but downstream of that location, human sources are not allowed to increase stream temperatures by more than 0.5°F (**Figure 7-6**).

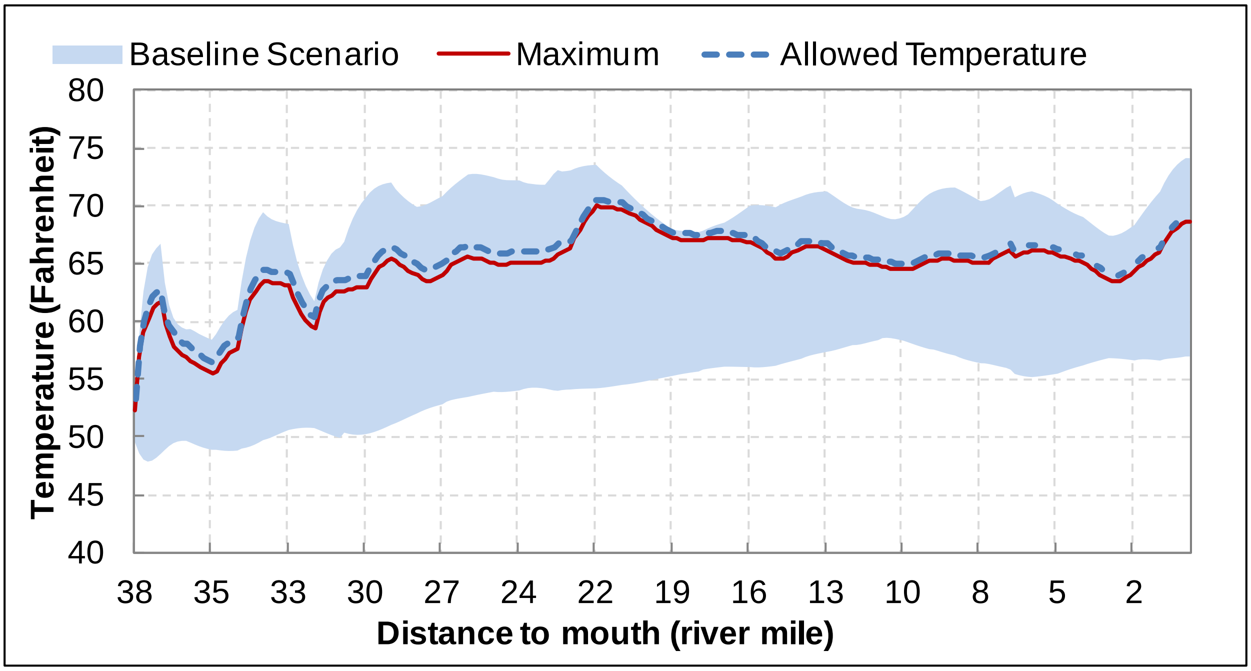

Figure 7-6. The maximum naturally occurring temperature relative to the existing condition (baseline scenario) and the allowed temperature

The naturally occurring scenario results indicate there is the potential for significant reductions in stream temperatures relative to the existing condition (baseline scenario): the potential temperature decreases from this scenario as compared to the baseline scenario ranged from 0.72°F to 7.82°F, with an average decrease of 4.60°F (**Figure 7-7**). Like the shade scenario, the maximum decrease was in the upper watershed slightly downstream of sample site WLFC-T0.2 and the smallest change was near site T1.5 (**Figure 7-8**).

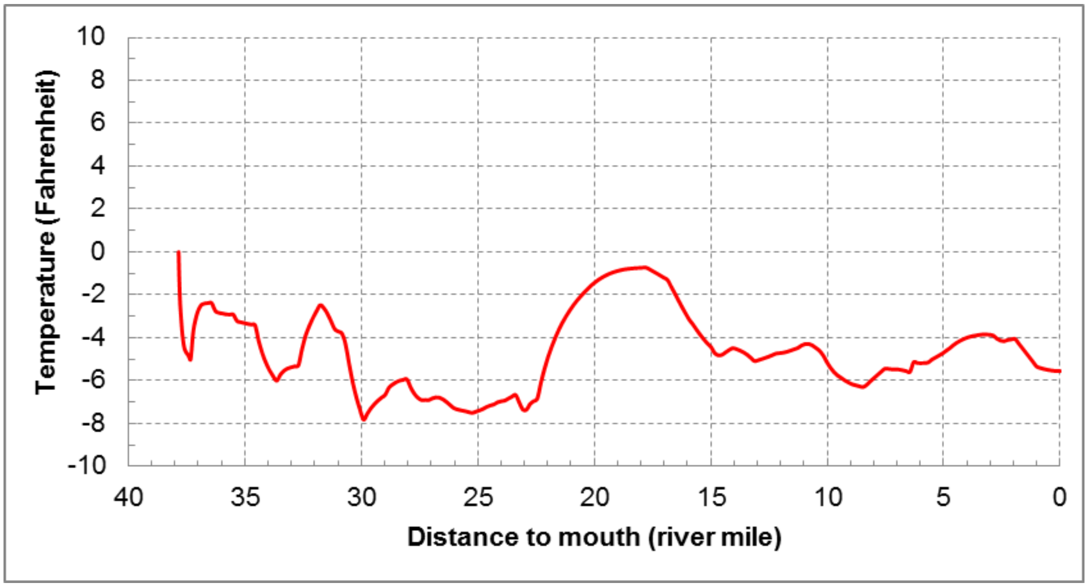

Figure 7-7. Temperature difference between the baseline and naturally occurring scenario

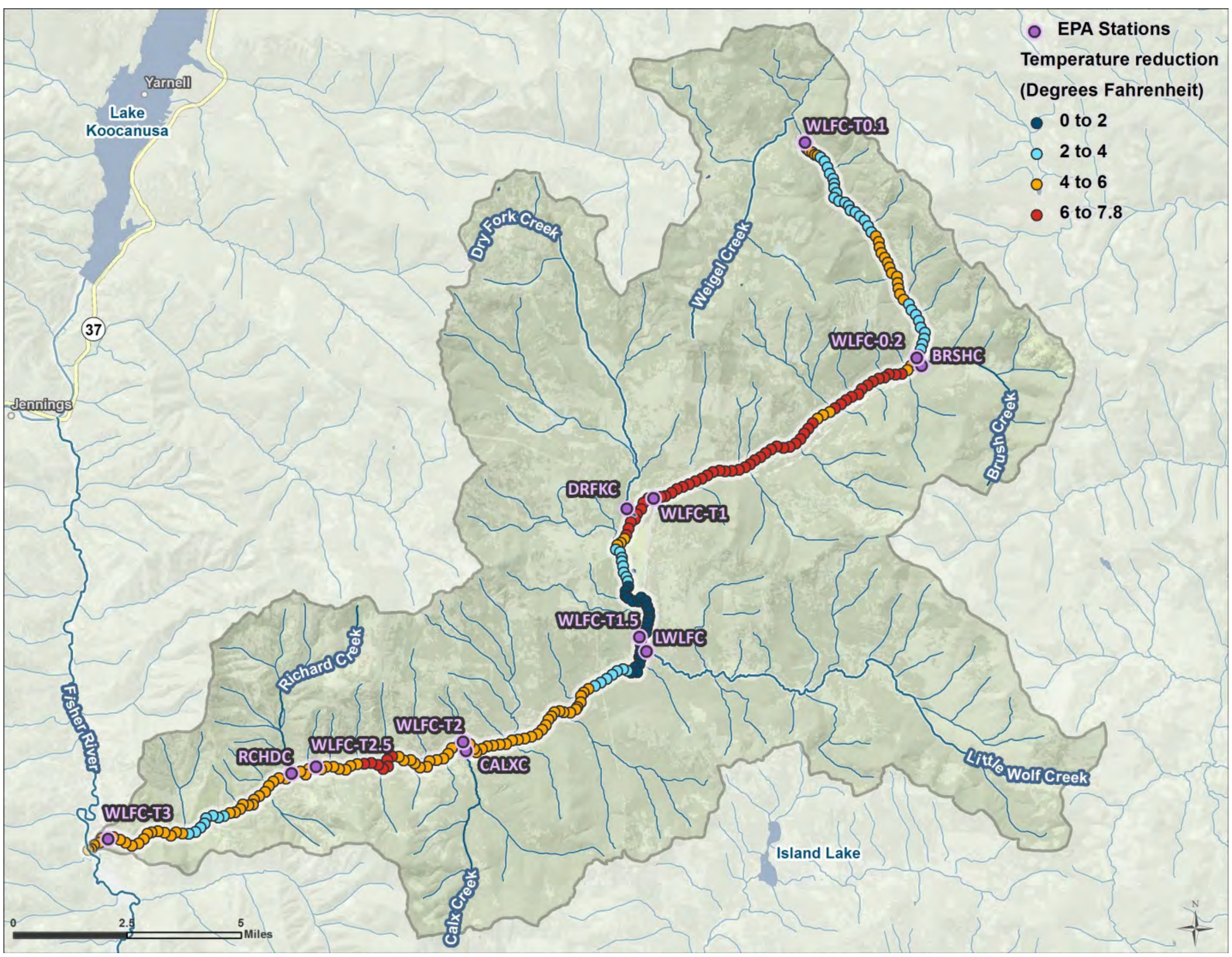

Figure 7-8. Temperature reductions that can be obtained under naturally occurring conditions (relative to the baseline scenario)

7.5.2 QUAL2K Model Assumptions

The following is a summary of the significant assumptions used during the QUAL2K model development:

- Wolf Creek can be divided into distinct segments, each considered homogeneous for shade, flow, and channel geometry characteristics. Monitoring site locations were selected to be representative of segments of Wolf Creek.
- Stream meander and subsurface flow paths (both of which may affect depth-velocity and temperature) are inherently represented during the estimation of various parameters (e.g., stream slope, channel geometry, and Manning's roughness coefficient) for each segment.
- Weather conditions at the Fisher River RAWS, which were elevation-corrected, are representative of local weather conditions along Wolf Creek. Adjustments made to streamflow and climate for the baseline scenario adequately represent existing conditions on a hot, dry summer.
- Shade Model results are representative of riparian shading along segments of Wolf Creek.
- All of the cropland associated with water rights is fully irrigated. No field measurements of irrigation withdrawals or returns were available. Application of some water conservation measures resulting in a 15% decrease in water withdrawn is reasonable and consistent with the definition of the naturally occurring condition.
- The effective shade provided by a 50 foot buffer of medium density trees is achievable and consistent with the definition of the naturally occurring condition.

7.6 Temperature TMDLs and Allocations

Total maximum daily loads (TMDLs) are a measure of the maximum load of a pollutant a particular waterbody can receive and still maintain water quality standards (**Section 4.0**). A TMDL is the sum of wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. A TMDL includes a margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. Allocations represent the distribution of allowable load applied to those factors that influence loading to the stream. In the case of temperature, thermal loading is assessed.

7.6.1. Temperature TMDL and Allocation Framework

Because stream temperatures change throughout the course of a day, the temperature TMDL is expressed as the instantaneous thermal load associated with the stream temperature when in compliance with Montana's water quality standards. As stated earlier, the temperature standard for Wolf Creek is defined as follows: The maximum allowable increase over the naturally occurring temperature is 1°F, when the naturally occurring temperature is less than 66°F. Within the naturally occurring temperature range of 66–66.5°F, the allowable increase cannot exceed 67°F. If the naturally occurring temperature is greater than 66.5°F, the maximum allowable increase is 0.5°F. Montana's temperature standard that applies to Wolf Creek relative to naturally occurring temperatures is depicted in **Figure 7-9**. As stated in **Section 7.4.4**, maximum daily temperatures in Wolf Creek during the baseline scenario are typically greater than 66.5°F for the lower half of the watershed (downstream of Dry Fork Creek), which means the allowable increase caused by human sources during the hottest part of the summer is typically 0.5°F in the lower watershed and 1.0°F in the upper watershed.

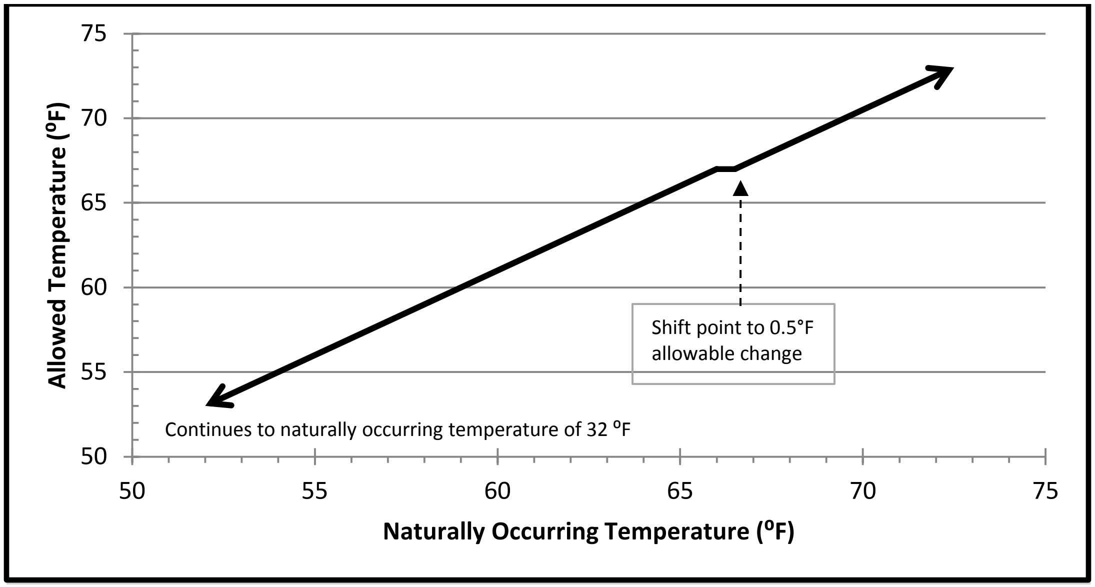

Figure 7-9. Line graph of the temperature standard that applies to Wolf Creek

For any naturally occurring temperature over 32°F (i.e., water's freezing point), the allowable instantaneous thermal total maximum load (kcal/per second) can be calculated using the standard to identify the allowable human-caused increase (stated above and shown in **Figure 7-9**) and **Equation 7-1.**

Equation 7-1: $TMDL = (((T_{NO} + \Delta) - 32) * 5/9) * Q * 28.3$

Where:

TMDL = allowable thermal load (kcal/s) above 32°F
T_{NO} = naturally occurring water temperature (°F)
Δ = allowable increase above naturally occurring temperature (°F)
Q = streamflow (cfs)
28.3 = conversion factor

The instantaneous load is most appropriate expression for a temperature TMDL because water temperatures fluctuate throughout the day and an instantaneous load allows for evaluation of human caused thermal loading during the daytime when fish are most distressed by elevated water temperatures and when human-caused thermal loading would have the most effect. Although EPA encourages TMDLs to be expressed in the most applicable timescale, it also requires TMDLs to be presented as daily loads (Grumbles, Benjamin, personal communication 2006). Any instantaneous TMDL calculated using **Equation 7-1**, which provides a load per second, can be converted to a daily load (kcal/day) by multiplying by 86,400 (which is the number of seconds in a day).

Because calculation of the TMDL on any timescale relies on the identification of the naturally occurring condition, which fluctuates over time and within a stream, it generally requires a water quality model. However, the shade and width/depth targets that will be met when all reasonable land, soil, and water conservation practices are applied and the water conservation efforts that fall under the definition of naturally occurring are also measurable components of meeting the TMDL and water quality standard. Meeting targets for effective shade and width/depth ratio, and applying all reasonable water conservation measures collectively provide an alternative method for meeting and evaluating the TMDL that more directly translates to implementation than an instantaneous or daily thermal load.

Therefore, these temperature-influencing measures are being provided as a surrogate TMDL. An example instantaneous TMDL will also be provided. Conceptually, the allocations for the surrogate TMDL and numeric TMDL are the same: the entire load is allocated to natural sources and nonpoint human sources that influence temperature (by altering effective shade, width/depth ratio, and instream flow). Human sources should follow all reasonable land, soil, and water conservation practices.

7.6.2 Temperature TMDL and Allocations for Wolf Creek

The example TMDL expressed as an instantaneous load is presented in **Table 7-4** and the surrogate TMDL and allocations are presented in **Table 7-5**. The example TMDL is a direct translation of the water quality standard into a thermal load. There are no point sources and the entire allowable load is allocated to natural and human sources that influence temperature. The example TMDL is based on the modeled naturally occurring maximum daily temperature at the mouth during a hot summer with low flow (9.4 cfs). The naturally occurring temperature used in the example is 68.60°F, which means there is an allowable increase of 0.5°F and the allowable temperature would be 69.1°F. The maximum daily temperature at the mouth under the baseline scenario representing critical existing conditions was 74.15°F (which is only 0.25°F above the measured maximum daily temperature in 2012). The calculation for the example TMDL following E**quation 7-1** is shown below:

$$TMDL = ((68.6 + 0.5) - 32) * 5/9) * 9.4 * 28.3 = 5{,}483 \text{ kcal/second}$$

The surrogate TMDL contains allocations to temperature-influencing factors that will result in standards attainment when met. Because there are no point sources, there is no wasteload allocation. There is an implicit margin of safety (MOS); the main factor in the MOS is that although there is an allowable increase over the naturally occurring condition, when implementing the TMDL, human sources should follow all reasonable land, soil, and water conservation practices. Additional details about the MOS are described in **Section 7.7**.

Table 7-4. Example Instantaneous Temperature TMDL and Allocation for Wolf Creek

Source Type	Modeled Existing Load (kcal/sec)	TMDL/Load Allocation (kcal/sec)	Percent Reduction Needed
Natural and human sources that influence temperature	6,229	5,483	12%

Table 7-5. Surrogate Temperature TMDL and Allocations for Wolf Creek

Source Type	Surrogate Allocation
Land uses and practices that reduce riparian health and shade provided by near-stream vegetation along Wolf Creek.	• Improve to and maintain a 50 foot buffer with medium density trees or any vegetation providing equivalent effective shade
Land uses and practices that result in the overwidening of the stream channel such that widths are increased, depths are decreased, and thermal loading is accelerated	No increase in average width or width/depth ratios due to human-caused sources • Where bankfull width < 30ft, a width/depth ratio $\leq$ 21 • Where bankfull width > 30ft: a width/depth ratio $\leq$ 32
Inefficient consumptive water use	• Application of all reasonable water conservation practices
Surrogate TMDL	**Application of all reasonable land, soil, and water conservation practices for human sources that could influence stream temperatures. This primarily includes those affecting riparian shade, channel width, and instream flow.**

7.6.2.1 Meeting Temperature Allocations

Since riparian shade is the primary source of the impairment, improving the effective shade will be the primary mechanism for implementing and achieving the TMDL. DEQ realizes that re-establishment of a riparian overstory and meeting the effective shade target will likely take a long time. In most instances, current management practices are meeting the intent of the allocations, and the commitment to improving water quality needs to be maintained so that the existing riparian vegetation can continue to mature. The targets and allocations represent the desired conditions that would be expected in most areas along the stream, but as discussed relative to shade, width/depth ratios, and water conservation in the target and source assessment sections (**Sections 7.4.2** and **7.5**), DEQ acknowledges that the allocations may not be achievable at all locations along the stream. The surrogate TMDL provides a measure of conditions that equate to meeting the temperature standard, but the intent and measure of success for all allocations is to follow all reasonable land, soil, and water conservation practices. Future evaluations of TMDL implementation and impairment status will not only assess conservation practices in the watershed but will also use adaptive management (as described in **Section 7.8** and **11.2**) to determine if targets applied within this document are still appropriate.

7.7 Seasonality and Margin of Safety

Seasonality and margin of safety are both required elements of TMDL development. This section describes how seasonality and margin of safety (MOS) were applied during development of the Wolf Creek temperature TMDL.

Seasonality addresses the need to ensure year-round beneficial-use support. Seasonality is addressed for temperature in this TMDL document as follows:

- Temperature monitoring and modeling occurred during the summer, which is the warmest time of the year and when instream temperatures are most stressful to aquatic life.
- Effective shade for Wolf Creek was based on the August solar path, which is typically the hottest month of the year.
- Although the maximum daily temperature was focused on for the source assessment and impairment characterization because it is mostly likely to stress aquatic life, sources affecting maximum stream temperatures can also alter daily minimum temperatures year-round.
- Addressing the sources causing elevated summer stream temperatures will also address sources that could lower the minimum temperature at other times of the year.
- Temperature targets, the TMDL, and load allocations apply year round, but it is likely that exceedances occur mostly during summer conditions.

The MOS is included 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. The MOS is addressed in several ways for temperature as part of this document:

- Although there is an allowable increase from human sources beyond those applying all reasonable land, soil, and water conservation practices, the surrogate allocations are expressed so human sources must apply all reasonable land, soil, and water conservation practices.
- Montana's water quality standards are applicable to any timeframe and any season. The temperature modeling analysis for Wolf Creek investigated stream temperatures during summer when effects of increased water temperatures are most likely to have a detrimental effect on aquatic life. Additionally, flow and climatic conditions were slightly adjusted from the

sampling year to represent stream temperatures under more critical conditions than those observed in 2012.

- Despite the limited amount of irrigation in the watershed and modest improvement in stream temperature that could be obtained by implementing conservation measures to leave additional water instream, the source assessment and allocations address consumptive use as a potential human source and recommend the use of all reasonable water conservation measures.
- Compliance with targets and refinement of load allocations are all based on an adaptive management approach (**Section 7.8**) that relies on future monitoring and assessment for updating planning and implementation efforts.

7.8 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, source assessments, water quality models, loading calculations and other considerations are inherent when evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainty through adaptive management approaches is a key component of ongoing TMDL implementation activities. Uncertainties, assumptions and considerations are applied throughout this document and point to the need for refining analyses when needed.

The process of adaptive management is predicated on the premise that TMDLs, allocations and their supporting analyses are not static, but are processes which are subject to periodic modification and adjustment as new information and relationships are better understood. As further monitoring and assessment is conducted, uncertainties with present assumptions and consideration may be mitigated via periodic revision or review of the assessment which occurred for this document. As part of the adaptive management approach, changes in land and water management that affect temperature should be tracked. As implementation of restoration projects which reduce thermal input or new sources that increase thermal loading arise, tracking should occur. Known changes in management should be the basis for building future monitoring plans to determine if the thermal conditions meet state standards.

Uncertainty was minimized during data collection because EPA temperature and field data were collected following a Quality Assurance Project Plan (QAPP) (ATKINS, 2012) and adhering to DEQ sampling protocols (Montana Department of Environmental Quality, 2005b; Montana Department of Environmental Quality, 2005a). A QAPP was also completed for the QUAL2K model (Tetra Tech, Inc., 2012), but there was more uncertainty associated with the model than with the field data because numerous assumptions had to be made to help simulate existing and naturally occurring conditions. Modeling assumptions are briefly described in **Section 7.5.2** but are further detailed within the model report in **Appendix G**.

The largest source of uncertainty is regarding the targets and conditions used to represent the naturally occurring condition. The target for width/depth ratio was developed as part of the sediment TMDL process (**Section 5**) and is based on reference data. The target for effective shade from riparian vegetation is intended to represent the reference condition (i.e., highest achievable) and is based on field observations, communication with stakeholders, and best professional judgment. It was selected to be conservative yet achievable, and as discussed in the target and source assessment sections (**Sections 7.4** and **7.5**), the ultimate goal and measure of success is implementation of all reasonable land, soil, and water conservation practices. Since no information is known regarding current irrigation practices within the watershed, there is also uncertainty regarding current conservation practices and the potential for improvement. This uncertainty is the reason there is no set target for improving instream flow or numeric allocation. Literature values were used to estimate the potential for additional instream flow if additional water conservation measures are necessary and implemented. Other areas of uncertainty related to the model are associated with assumptions regarding channel dimensions and groundwater temperatures; limited information for those sources was used and applied throughout the watershed. Riparian shade is highly variable in the watershed but a comparison between the field measured effective shade values and values simulated via the Shade Model indicate the model reasonably approximated existing shade conditions within the watershed. Although this uncertainty within the model results in error bars around the modeled temperatures for each scenario, the magnitude of temperature increase caused by human sources still exceeds the allowable change for most of Wolf Creek. Additional details regarding uncertainty associated with the model are contained in **Appendix G**.

The TMDLs and allocations established in this section are meant to apply to recent conditions of natural background and natural disturbance. Under some periodic natural conditions, such as fire, it may not be possible to satisfy all targets, loads, and allocations because of natural short-term affects to temperature. Additionally, fire has the potential to alter the long-term vegetative potential. The goal is to ensure that management activities are undertaken to achieve loading approximate to the TMDL within a reasonable time frame and to prevent significant long-term excess loading during recovery from significant natural events.

Any factors that increase water temperatures, including global climate change, could impact thermally sensitive fish species in Montana. The assessments and technical analysis for the temperature TMDL considered a worst case scenario reflective of current weather conditions, which inherently accounts for any global climate change to date. Allocations to future changes in global climate are outside the scope of this project but could be considered during the adaptive management process if necessary.

8.0 METALS TMDL COMPONENTS

This portion of the document addresses metals water quality impairments in the Kootenai-Fisher TMDL project area. It includes:

- Metals designated 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 source assessments
- Metals total maximum daily loads and allocations
- Seasonality and margin of safety
- Uncertainty and adaptive management

8.1 EFFECTS OF METALS ON DESIGNATED BENEFICIAL USES

Metals concentrations exceeding the aquatic life and/or human health standards can impair support of numerous designated beneficial uses including: aquatic life, drinking water, and agriculture. Within aquatic ecosystems, metals can have a toxic, carcinogenic, or bioconcentrating effect on biota. Likewise, humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. High metals concentrations can be toxic to plants and animals and therefore can affect irrigation. Although arsenic and antimony are metalloids, they are treated as metals for TMDL development due to the similarity in sources, environmental effects and restoration strategies.

8.2 STREAM SEGMENTS OF CONCERN

Six waterbody segments in the Kootenai-Fisher TMDL Project Area are listed as impaired due to metals in the most recent (2012) 303(d) List and associated 2012 Water Quality Integrated Report. These waterbodies include Stanley Creek, Snowshoe Creek, Fisher River, Lake Creek, Big Cherry Creek and Libby Creek. Additional information regarding the specific metals impairments identified on the 2012 303(d) List is contained within **Table 1-1.**

The DEQ performed updated assessments on all six of these waterbodies using the data sources defined below in **Section 8.3**. The updated assessments confirmed metals impairment conditions for Stanley Creek, Snowshoe Creek, Lake Creek and Big Cherry Creek (**Figure 8-1**). The metals assessment results for these four streams are included within **Section 8.4.3**. No metals impairment conditions were identified for Libby Creek and the Fisher River. DEQ also sampled and assessed Bear Creek for metals impairment. No metals impairment conditions were identified for Bear Creek. All updated assessment results, including removal of all metals impairment causes for Libby Creek and the Fisher River, will be captured within Montana's 2014 303(d) List.

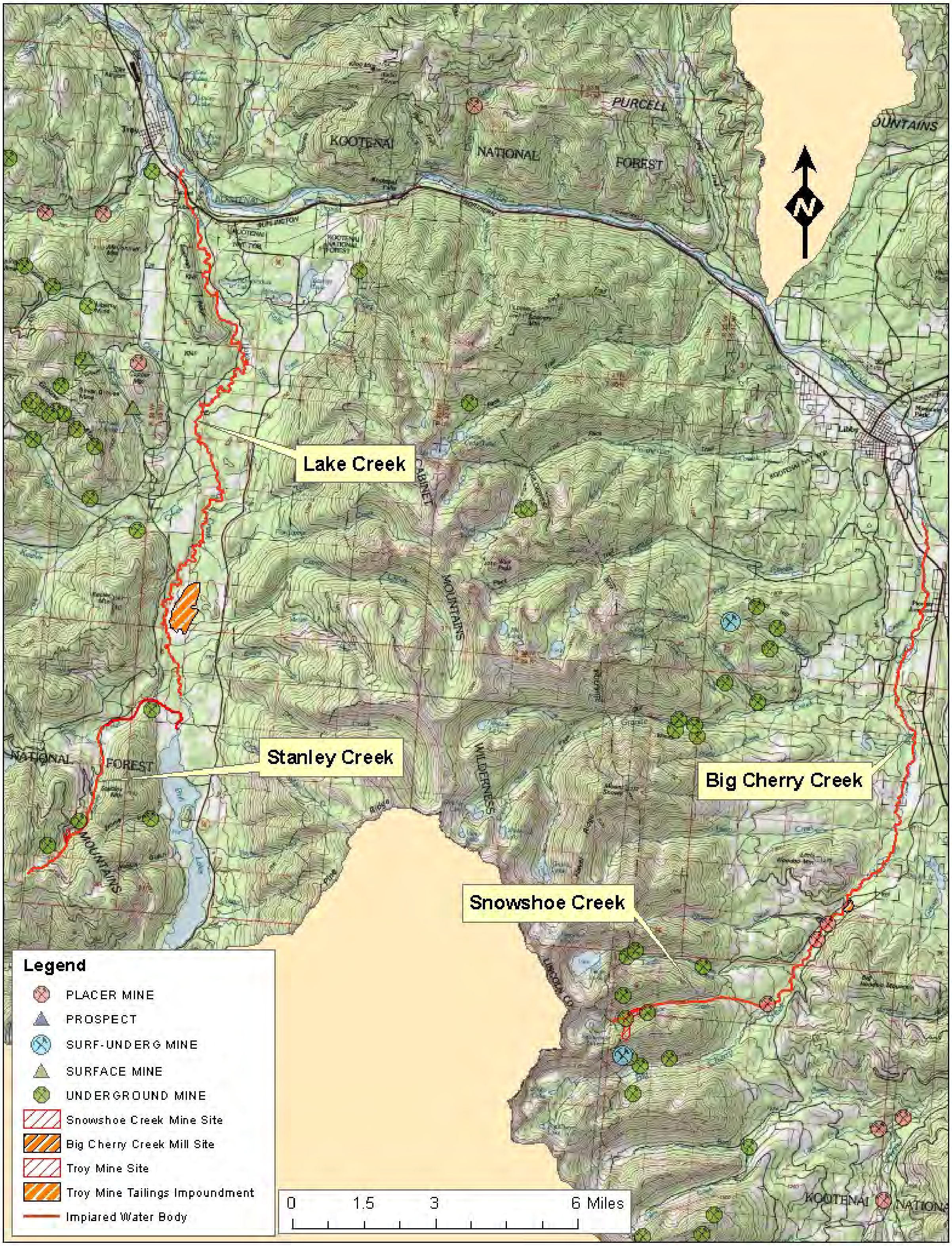

Figure 8-1. Metals Impaired Waterbodies in the Kootenai-Fisher TMDL Project Area

8.3 Water Quality Data and Information Sources

The data and information used in this report was obtained from the DEQ Abandoned Mines Program, Montana Bureau of Mines and Geology, U.S.D.A Forest Service, Troy Mine, and DEQ water and sediment quality sampling from 2009-2012.

In accordance with DEQ's data quality objectives guidance (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2013) the data used for impairment assessment and target evaluation are no older than 10 years. Older data are considered descriptive and may be used for source characterization, loading analysis and trend evaluation. In cases where there has been significant cleanup action, data predating the cleanup was not considered.

The DEQ data is the most recent, and provides the basis for the existing condition analyses, TMDLs and allocations in this document. The water and sediment metals data used for analysis in this report is attached in **Appendix F**. Data summaries of relevant water quality and sediment quality parameters for each metals-impaired waterbody segment are provided in **Section 8.4**.

8.4 Water Quality Targets and Comparison to Existing Conditions

DEQ compiled the water quality data described in **Section 8.2** for comparison to water quality targets. These targets are established using the most stringent water quality standard, in order to protect all designated uses. **Section 8.4.1** presents the evaluation framework, the metals water quality targets used in the evaluation, and the results of these evaluations for each impaired waterbody.

8.4.1 Metals Evaluation Framework

The metals evaluation process includes:

1. Evaluation of metals sources.
   Metals sources may be both naturally occurring and anthropogenic (i.e. human-caused). TMDLs are developed for waterbodies that do not meet standards, at least in part, due to anthropogenic sources.

2. Development of numeric water quality targets that represent unimpaired water quality (**Section 8.4.2**).
   TMDL plans must include 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. They may be used separately or in combination with other targets to represent water quality conditions that comply with Montana's water quality standards (both narrative and numeric). Metals water quality targets are presented in **Section 8.4.2**.

3. Comparison of water quality with water quality targets to determine whether a TMDL is necessary.
   DEQ determines whether a TMDL is required by comparing recent water quality data to metals water quality targets. In cases where one or more targets are not met, a TMDL is developed. If data demonstrates no impairment, each waterbody – impairment cause combination is subsequently removed from the 303(d) list.

8.4.2 Metals Water Quality Targets

Water quality targets for metals-related impairments in the Kootenai-Fisher TMDL Project Area include both water chemistry targets and sediment chemistry targets. The water chemistry targets are based on numeric human health standards and both chronic and acute aquatic life standards as defined in DEQ Circular DEQ-7. Sediment chemistry targets are adopted from numeric screening values for metals in freshwater sediment established by the National Oceanographic and Atmospheric Administration (NOAA).

8.4.2.1 Water Chemistry Targets

Most metals pollutants have numeric water quality criteria defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2008a). These criteria include values for protecting human health and for protecting aquatic life, and apply as water quality standards for all stream segments addressed within this document due to their B-1 classification **(Appendix B)**. Aquatic life criteria include values for both acute and chronic effects. For any given pollutant, the most stringent of these criteria is adopted as the water quality target. Throughout this document, the terms “standard”, “criteria” and “target” are used somewhat interchangeably.

The aquatic life criteria for most metals are dependent upon water hardness values: usually increasing as the hardness increases. Water quality criteria (acute and chronic aquatic life, human health) for each parameter of concern at water hardness values of 25 milligrams per liter (mg/L) and 400 mg/L are shown in **Table 8-1**. These criteria translate into the applicable water quality targets and are expressed in micrograms per liter (ug/L), equivalent to parts per billion. Acute and chronic toxicity aquatic life criteria are intended to protect aquatic life uses, while the human health criteria is intended to protect drinking water uses. Note that arsenic and mercury do not have variable criteria. The acute and chronic criteria are fixed and do not fluctuate with changes in hardness. The chronic and acute aquatic life criteria for zinc are identical for hardness values of 25 mg/L and 400 mg/L and all hardness values in-between.

The evaluation process summarized below is derived from DEQ’s Monitoring and Assessment program guidance for metals assessment methods (Drygas, 2012).

- A waterbody is considered impaired if a single sample exceeds the human health target.
- If more than 10% of the samples exceed the acute or chronic aquatic life target, then the waterbody is considered impaired for that pollutant.
- If both the acute and chronic aquatic life target exceedance rates are equal to or less than 10%, for a given metal, then it is not considered a cause of aquatic life impairment to the waterbody. A minimum 8 samples are required, and samples must represent both high and low flow conditions.
- There are two exceptions to the 10% aquatic life exceedance rate rule: a) if a single sample exceeds the acute aquatic life target by more than a factor of two, the waterbody is considered impaired regardless of the remaining data set; and b) if the exceedance rate is greater than 10% but no anthropogenic metals sources are identified, management is consulted for a case-by-case review.

Table 8-1. Metals numeric water chemistry targets applicable to the Kootenai-Fisher TMDL Project Area

Metal of Concern	Aquatic Life Criteria (µg/L) at 25 mg/L Hardness		Aquatic Life Criteria (µg/L) at 400 mg/L Hardness		Human Health Criteria (ug/L)
	Acute	Chronic	Acute	Chronic	
Arsenic, TR*	340.00	150.00	340.00	150.00	10
Cadmium, TR	0.52	0.10	8.73	0.76	5
Copper, TR	3.79	2.85	51.7	30.5	1,300
Lead, TR	14.0	0.54	477	18.5	15
Mercury, TR	1.70	0.91	1.70	0.91	0.05
Zinc, TR	37.0	37.0	388	388	2,000

*TR = total recoverable

8.4.2.2 Metals Sediment Chemistry Targets

Montana does not currently have numeric water quality criteria for metals in stream sediment, although general water quality prohibitions (ARM 17.30.637) 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".* Stream sediment metals concentrations are used as supplementary indicators of impairment. In addition to directly impairing aquatic life in contact with stream sediments, high metals values in sediment commonly correspond to elevated concentrations of metals in water during high flow conditions. Where instream water quality data exceeds water quality targets, sediment quality data provide supporting information, but is not necessary to verify impairment.

In the absence of numeric criteria for metals in stream sediment, DEQ bases sediment quality targets on values established by the National Oceanic and Atmospheric Administration (NOAA). NOAA has developed Screening Quick Reference Tables for stream sediment quality, including concentration guidelines for metals in freshwater sediments. These criteria come from numerous studies and investigations, and are expressed in Probable Effects Levels (PEL). PELs represent the sediment concentration above which toxic effects to aquatic life frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects data set and the 85th percentile of the no-effect data set (Buchman, 2008). PEL values are therefore used by DEQ as supplemental targets to evaluate whether streams are "*free from substances…that will…create concentrations or combinations of materials that are toxic or harmful to aquatic life."* If the water quality targets are met but a sediment concentration is more than double the PEL (100% exceedance magnitude), then this result can be used as an indication of a water quality problem and additional sampling may be necessary to fully evaluate target compliance.

Table 8-2 contains the PEL values (in parts per million) for metals of concern in the Kootenai-Fisher TMDL Planning Area.

Table 8-2. Screening level criteria for sediment metals concentrations

Metal of Concern	PEL (mg/kg or parts per million)
Arsenic	17.0
Cadmium	3.53
Copper	197
Lead	91.3
Mercury	0.486
Zinc	315

8.4.3 Existing Conditions and Comparison with Water Quality Targets

For each waterbody segment included in the 2012 Integrated Report for metals (**Table A-1**), DEQ evaluates recent water quality and sediment data relative to the water quality targets to make a TMDL development determination. Many metals impairment determinations were initially based on data collected by the DEQ Abandoned Mines Bureau in the 1990s and may not reflect current conditions. DEQ has recently completed several years of water and stream sediment sampling in the Kootenai-Fisher TMDL project area for the purpose of reassessing the metals impairment determinations. This data provides the basis for the metals target evaluations below.

8.4.3.1 Big Cherry Creek MT76D002_050

Big Cherry Creek is listed in the 2012 Integrated Report as being impaired for zinc. Data compilation, collection and analysis confirm the need for a zinc TMDL and demonstrate the need for cadmium, and lead TMDLs.

Available Water Quality Data

DEQ used recent metals water quality and sediment data to evaluate current conditions relative to water quality targets. Due to the availability of recently-collected water quality data in the watershed, data used were recent 2006 and 2011-2012 synoptic high and low flow sampling data collected by DEQ for subsequent TMDL development support. The water and sediment sample results for those metals exhibiting impairment are compared to water chemistry and sediment targets in **Tables 8-3** and **8-4**.

Table 8-3. Big Cherry Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Cadmium	Lead	Zinc
# Samples	14	14	14
Minimum values (ug/L)	0.29	<0.5	12.8
Maximum Values (ug/L)	01.12	4.2	61.7
# Acute Exceedances	9	0	7
Acute Exceedance Rate	64.3%	0.0%	50.0%
# Chronic Exceedances	14	6	7
Chronic Exceedance Rate	100%	42.9%	50.%
# Human Health Exceedances	0	0	0
Human Health Standard Exceedance Rate	0.0%	0.0%	0.0%

*all units in µg/L are total recoverable fraction

Table 8-4. Big Cherry Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Cadmium	Lead	Zinc
# Samples	2	2	2
Minimum (mg/kg)	2.03	78.9	173
Maximum (mg/kg)	17.8	903	1280
PEL Value (mg/kg)	3.53	91.3	315
# Samples>PEL	1	1	1
PEL Exceedance Rate	50.0%	50.0%	50.0%

*All units in mg/kg are dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Each pollutant is discussed individually. The discussions are summarized below in **Table 8-5**.

Cadmium

Big Cherry Creek was not listed as impaired by cadmium in the 2012 Integrated Report. Recent data collected in 2006 and 2011-2012 established acute and chronic aquatic life (AL) target exceedance rates of 64.3 and 100% respectively. Additionally, one of two sediment samples (50%) was above the PEL. As a result of these exceedances DEQ will add cadmium as a cause of impairment and develop a TMDL for it.

Lead

Big Cherry Creek was not listed as impaired by lead in the 2012 Integrated Report. Recent data collected in 2006 and 2011-2012 indicated that six of 14 water quality samples exceeded the chronic target. The chronic exceedance rate for lead was 42.9%. Additionally, one of two sediment samples (50%) was above the PEL. As a result of these exceedances DEQ will add lead as a cause of impairment and develop a TMDL for it.

Zinc

Big Cherry Creek was listed as impaired by zinc in the 2012 Integrated Report. Data collected in 2006 and 2011-2012 indicated that seven of 14 samples (50%) exceeded both the acute and chronic targets. Additionally, one of two sediment samples (50%) was above the PEL. Because zinc targets were exceeded zinc will remain listed as a cause of impairment to Big Cherry Creek and a TMDL will be developed.

Big Cherry Creek TMDL Development Summary

As discussed above and summarized in **Table 8-5**, cadmium, lead and zinc TMDLs are developed for Big Cherry Creek. These impairment conditions are summarized in **Table 8-5**, and are documented within DEQ's assessment files and will be included in the 2014 Integrated Report.

Table 8-5. Big Cherry Creek Metals TMDL Decision Factors

Parameter	Cadmium	Lead	Zinc
Number of Samples	14	14	14
Chronic AL exceedance rate >10%?	Yes	Yes	Yes
Greater than 2x acute AL target exceeded?	No	No	No
Human Health target exceeded?	No	No	No
2x NOAA PEL exceeded?	Yes	Yes	Yes
Human-caused sources present?	Yes	Yes	Yes
2012 303(d) listed?	No	No	Yes
TMDL developed?	**Yes**	**Yes**	**Yes**

8.4.3.2 Stanley Creek MT76D002_010

Stanley Creek is in the 2012 Integrated Report as impaired by copper. Data compilation, collection and analysis confirm the need for a copper TMDL and demonstrate the need for lead and zinc TMDLs.

Available Water Quality Data

Metals water and sediment quality data were used to compare current conditions to water quality targets. Due to the availability of water quality data in Stanley Creek, data used includes 2005-2012 synoptic high and low flow sampling data collected by the Troy Mine and DEQ for TMDL development support. The water and sediment sample results for those metals exhibiting impairment are compared to water chemistry and sediment targets in **Tables 8-6** and **8-7**.

Table 8-6. Stanley Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Copper	Lead	Zinc
# Samples	38	19	34
Minimum values (ug/L)	<0.5	<0.10	<0.21
Maximum Values (ug/L)	25	10	230
# Acute Exceedances	10	0	1
Acute Exceedance Rate	26.3%	0.00%	2.94%
# Chronic Exceedances	11	3	1
Chronic Exceedance Rate	28.9%	15.8%	2.94%
# Samples >2X the Acute Standard	6	0	1
# Human Health Exceedances	0	0	0
Human Health Standard Exceedance Rate	0.0%	0.0%	0.0%

*all units in µg/L are total recoverable fraction

Table 8-7. Stanley Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Copper	Lead	Zinc
# Samples	1	1	1
Minimum (mg/kg)	215	75	69
Maximum (mg/kg)	215	75	69
PEL Value (mg/kg)	197	91.3	310
# Samples>PEL	1	0	0
PEL Exceedance Rate	100%	0%	0%

*All units in mg/kg are dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Each pollutant is discussed individually. The discussions are summarized below in **Table 8-8**.

<u>Copper</u>

Stanley Creek was listed as impaired by copper in the 2012 Integrated Report. This impairment was originally based upon older sampling from the 1980s and 1990s. Recent (2005-2012) water chemistry data exceeded the acute and chronic aquatic life targets in approximately 26% and 29% of the samples respectively. One sediment sample was collected by DEQ in Stanley Creek and this sample was above the PEL. The copper impairment is retained and a copper TMDL is developed for Stanley Creek.

<u>Lead</u>

Stanley Creek was not listed as impaired by lead in the 2012 Integrated Report. Recent (2005-2012) water chemistry data exceeded the chronic aquatic life target in more than 15% of the samples. Metals concentrations for lead in sediment samples were not above PELs. As a result of the exceedances, DEQ will develop a TMDL for lead and add lead as a cause of impairment to Stanley Creek. DEQ could not use 19 of the samples reported in **Table F-2** in **Appendix F**. These samples were reported as non-detect, with reporting limits that were above the acute aquatic life (AAL), chronic aquatic life (CAL) or Human Health standard. Samples that are reported in this fashion, cannot be accurately compared to a standard, and were therefore left out of the assessment.

<u>Zinc</u>

Stanley Creek was not listed as impaired by Zinc in the 2012 Integrated Report. Recent (2005-2012) water chemistry data exceeded the acute and chronic aquatic life targets in approximately 3% the samples. While these percent exceedances do not typically mandate an impairment listing, one sample was greater than twice the acute aquatic life target. DEQ considered a waterbody impaired if one single sample exceeds the acute aquatic life target (see **Section 8.4.2.1**). Metals concentrations for zinc in sediment samples were not above PELs. As a result of the magnitude of the acute exceedance, DEQ will develop a zinc TMDL and add zinc as a cause of impairment to Stanley Creek.

Stanley Creek TMDL Development Summary
As discussed above and summarized in **Table 8-8**, copper, lead and zinc TMDLs are developed for Stanley Creek.

Table 8-8. Stanley Creek Metals TMDL Decision Factors

Parameter	Copper	Lead	Zinc
Number of Samples	38	19	34
Chronic AL exceedance rate >10%?	Yes	Yes	No
Greater than 2x acute AL target exceeded?	Yes	No	Yes
Human Health target exceeded?	No	No	No
2x NOAA PEL exceeded?	No	No	No
Human-caused sources present?	Yes	Yes	Yes
2012 303(d) listed?	Yes	No	No
TMDL developed?	**Yes**	**Yes**	**Yes**

8.4.3.3. Lake Creek MT76D002_070
Lake Creek is in the 2012 Integrated Report as impaired by metals for cadmium, copper, lead, mercury and zinc. Data compilation, collection and analysis demonstrate the need for copper and lead TMDLs.

Available Water Quality Data
Metals water and sediment quality data were used to compare current conditions to water quality targets. Available water quality data in the Lake Creek watershed includes recent (2011-2012) synoptic high and low flow sampling data collected by DEQ for subsequent TMDL development support as well as data from the Troy Mine from 2005 through 2011. The water and sediment sample results for those metals exhibiting impairment as well as those no longer found to be causing impairment are compared to water chemistry and sediment targets in **Tables 8-9** and **8-10**.

Table 8-9. Lake Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Cadmium	Copper	Lead	Mercury	Zinc
# Samples	24	77	43	12	71
Minimum values (ug/L)	<0.08	<0.5	<0.5	<0.005	<5
Maximum Values (ug/L)	<0.1	49	6	0.0152	10
# Acute Exceedances	0	2	0	0	0
Acute Exceedance Rate	0.00%	2.60	0.00%	0.00%	0.00%
# Chronic Exceedances	0	4	7	0	0
Chronic Exceedance Rate	0.0%	5.19%	16.3%	0.0%	0.0%
# Human Health Exceedance	0	0	0	0	0
Human Health Exceedance Rate	0.0%	0.0%	0.0%	0.0%	0.0%

*all units in µg/L are total recoverable fraction

Table 8-10. Lake Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Cadmium	Copper	Lead	Mercury	Zinc
# Samples	3	3	3	3	3
Minimum (mg/kg)	<0.2	<20	8	<0.05	26
Maximum (mg/kg)	<0.2	21	19	<0.05	52

Table 8-10. Lake Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Cadmium	Copper	Lead	Mercury	Zinc
PEL Value (mg/kg)	3.53	197	91.3	0.486	315
# Samples>PEL	0	0	0	0	0
PEL Exceedance Rate	0.0%	0.0%	0.0%	0.0%	0.0%

*all units in mg/kg are dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Each pollutant is discussed individually. The discussions are summarized below in **Table 8-11**.

<u>Cadmium</u>

Lake Creek was listed as impaired by cadmium in the 2012 Integrated Report. This impairment was originally based upon older sampling from the 1980s and 1990s. Cadmium concentrations in samples recently collected (2005-2012) from Lake Creek did not exceeded the human health, acute or chronic aquatic life targets. Cadmium concentrations in sediment samples were not above PELs. Therefore, DEQ determined that cadmium is not a cause of impairment to Lake Creek, and a TMDL will not be developed for cadmium. Cadmium as a cause of impairment will be removed from the 2014 Integrated Report.

<u>Copper</u>

Lake Creek was listed as impaired by copper in the 2012 Integrated Report. A copper concentration in a sample recently collected (low flow, 2008) from Lake Creek exceeded twice the acute aquatic life target. Therefore, DEQ determined that copper is retained as a cause of impairment to Lake Creek, and a TMDL is developed for copper.

<u>Lead</u>

Lake Creek was listed as impaired by lead in the 2012 Integrated Report. Lead concentrations in samples recently collected (2005-2012) from Lake Creek exceeded the chronic aquatic life target in 16.28% of the samples. Therefore, DEQ determined that lead is retained as a cause of impairment to Lake Creek, and a TMDL is developed for lead.

<u>Mercury</u>

Lake Creek was listed as impaired by mercury in the 2012 Integrated Report. This impairment was originally based upon older sampling from the 1980s and 1990s. Mercury concentrations in samples recently collected (2011-2012) from Lake Creek did not exceeded the human health, acute or chronic aquatic life target. Mercury concentrations in sediment samples were not above PELs. Therefore, DEQ determined that mercury is not a cause of impairment to Lake Creek, and a TMDL will not be developed for mercury. Mercury as a cause of impairment will be removed from the 2014 Integrated Report.

<u>Zinc</u>

Lake Creek was listed as impaired by zinc in the 2012 Integrated Report. This impairment was originally based upon older sampling from the 1980s and 1990s. Zinc concentrations in samples recently collected (2005-2012) from Lake Creek did not exceeded the human health, acute or chronic aquatic life target. Zinc concentrations in sediment samples were not above PELs. Therefore, DEQ determined that zinc is not a cause of impairment to Lake Creek, and a TMDL will not be developed for zinc. Zinc as a cause of impairment will be removed from the 2014 Integrated Report.

Lake Creek TMDL Development Summary

As discussed above and summarized in **Table 8-11**, copper and lead TMDLs are developed for Lake Creek. DEQ concluded that cadmium, mercury and zinc no longer contribute to impairment on Lake Creek. This non-impairment condition, also summarized in **Table 8-11**, is documented within DEQ's assessment files and will be included in the 2014 Integrated Report.

Table 8-11. Lake Creek Metals TMDL Decision Factors

Parameter	Cadmium	Copper	Lead	Mercury	Zinc
Number of Samples	24	77	43	12	71
Chronic AL exceedance rate >10%?	No	No	Yes	No	No
Greater than 2x acute AL target exceeded?	No	Yes	No	No	No
Human Health target exceeded?	No	No	No	No	No
2x NOAA PEL exceeded?	No	No	No	No	No
Human-caused sources present?	Yes	Yes	Yes	Yes	Yes
2012 303(d) listed?	Yes	Yes	Yes	Yes	Yes
TMDL developed?	**No**	**Yes**	**Yes**	**No**	**No**

8.4.3.4. Snowshoe Creek MT76D002_040

Snowshoe Creek is in the 2012 Integrated Report as impaired by metals for cadmium and zinc. Data compilation, collection and analysis confirm the need for arsenic and lead TMDLs as well as demonstrate the need for cadmium and zinc TMDLs.

Available Water Quality Data

DEQ used recent metals water quality to evaluate current conditions relative to water quality targets. Due to the availability of recently-collected water quality data in the watershed, data used were recent 2011-2012 synoptic high and low flow sampling data collected by DEQ for subsequent TMDL development support. The water sample results are compared to water chemistry targets in **Tables 8-12**. No sediment samples were collected in Snowshoe Creek.

Table 8-12. Snowshoe Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Lead	Zinc
# Samples	9	9	9	9
Minimum values (ug/L)	<3	<0.08	<0.5	<10
Maximum Values (ug/L)	13	7.03	27.9	480
# Acute Exceedances	0	7	2	7
Acute Exceedance Rate	0.00%	77.8%	22.2%	77.8%
# Chronic Exceedances	0	7	8	7
Chronic Exceedance Rate	0.0%	77.8%	88.9%	77.8%
# Human Health Exceedance	1	3	3	0
Human Health Exceedance Rate	11.1%	33.3%	33.3%	0.0%

*all units in µg/L; total recoverable fraction

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Each pollutant is discussed individually. The discussions are summarized below in **Table 8-13**.

<u>Arsenic</u>

Arsenic concentrations in samples recently collected (2011-2012) from Snowshoe Creek exceeded the human health target in one water sample. DEQ considers a waterbody impaired if one single sample exceeds the human health target (see **Section 8.4.2.1**). Therefore, DEQ determined that arsenic will be addressed as a cause of impairment to Snowshoe Creek, and a TMDL is developed for arsenic.

Cadmium
Snowshoe Creek was listed as impaired by cadmium in the 2012 Integrated Report. Cadmium concentrations in samples recently collected (2011-2012) from Snowshoe Creek exceeded the acute and chronic aquatic life target in 77.8% of the samples for each target. Cadmium concentrations were also above the human health target in 33.3% of the samples. Therefore, DEQ determined that cadmium is a cause of impairment to Snowshoe Creek, and a TMDL is developed for cadmium.

Lead
Snowshoe Creek was listed as impaired by lead in the 2012 Integrated Report. Lead concentrations in samples recently collected (2011-2012) from Snowshoe Creek exceeded the acute and chronic aquatic life target in 22.2% and 88.9% of the samples respectively. Lead concentrations were also above the human health target in 33.3% of the samples. Therefore, DEQ determined that lead is retained as a cause of impairment to Snowshoe Creek, and a TMDL is developed for lead.

Zinc
Zinc concentrations in samples recently collected (2011-2012) from Snowshoe Creek exceeded the acute and chronic aquatic life target in 77.8% of the samples for each target. Therefore, DEQ determined that zinc is added as a cause of impairment to Snowshoe Creek, and a TMDL is developed for zinc.

Snowshoe Creek TMDL Development Summary
As discussed above and summarized in **Table 8-13**, arsenic, cadmium, lead and zinc TMDLs are developed for Snowshoe Creek.. These impairment conditions, also summarized in **Table 8-13**, are documented within DEQ's assessment files and will be included in the 2014 Integrated Report.

Table 8-13. Snowshoe Creek Metals TMDL Decision Factors

Parameter	Arsenic	Cadmium	Lead	Zinc
Number of Samples	9	9	9	9
Chronic AL exceedance rate >10%?	No	Yes	Yes	Yes
Greater than 2x acute AL target exceeded?	No	Yes	No	Yes
Human Health target exceeded?	Yes	Yes	Yes	No
2x NOAA PEL exceeded*	N/A	N/A	N/A	N/A
Human-caused sources present?	Yes	Yes	Yes	Yes
2012 303(d) listed?	No	Yes	No	Yes
TMDL developed?	**Yes**	**Yes**	**Yes**	**Yes**

* No metals data collected in Snowshoe Creek

8.4.4 Metals Target Comparison and TMDL Development Summary

Based on the updated metals assessment and target comparison results summarized above, 12 metals TMDLs will be developed for four waterbodies in the Kootenai – Fisher project area. These are identified in **Table 8-14**. **Table 8-14** also identifies those metals impairment causes identified on the 2012 303(d) List but subsequently concluded as not causing impairment based on the updated assessments. As previously noted, no TMDLs are required for Libby Creek and the Fisher River because the updated assessment information revealed no metals impairment conditions. All updated assessment results captured within **Table 8-14** will be incorporated within the 2014 303(d) List and associated 2014 Integrated Report.

Reassessment of metals impairment causes in Libby Creek, Fisher River and Lake Creek found that concentrations are within target values for the majority of the metals impairment causes identified in the 2012 Integrated Report. There are two exceptions: copper and lead in Lake Creek. These impairment causes were confirmed and will be retained for the 2014 Integrated Report. The impairment causes for the Fisher River (lead), Libby Creek (mercury) and Lake Creek (cadmium, mercury and zinc) will be removed from the 2014 Integrated Report.

Reassessment of metals impairment causes in Big Cherry, Snowshoe and Stanley Creek confirmed all of the metals impairments on the 2012 Integrated Report. In addition to these confirmations several additional pollutants were identified. In Big Cherry Creek cadmium and lead were identified as impairments, in Snowshoe Creek arsenic and lead were identified, and in Stanley Creek lead and zinc were identified as impairments.

During the recent sampling and analysis process, DEQ sampled Bear Creek for the first time. During this assessment, DEQ sampled for a full metals suite, and determined that Bear Creek was not impaired for any of the metals sampled.

Table 8-14. Updated Metals Assessment Results and TMDLs Developed for the Kootenai - Fisher TMDL Project Area

Waterbody & Location Description	Waterbody ID	Metal Pollutant	Listed as Impaired on 2012 303(d) List	Updated Impairment Determination	TMDL Developed
Fisher River, (Silver Butte/Pleasant Valley Junction to Kootenai River)	MT76C001_010	Lead	Yes	Not Impaired	No
Lake Creek, (Bull Lake outlet to Kootenai River)	MT76D002_070	Cadmium	Yes	Not Impaired	No
		Copper	Yes	Impaired	Yes
		Lead	Yes	Impaired	Yes
		Mercury	Yes	Not Impaired	No
		Zinc	Yes	Not Impaired	No
Big Cherry Creek, (Snowshoe Creek to Libby Creek)	MT76D002_050	Cadmium	No	Impaired	Yes
		Lead	No	Impaired	Yes
		Zinc	Yes	Impaired	Yes
Libby Creek,(1 mile above Howard Creek to HWY 2 bridge)	MT76D002_061	Mercury	Yes	Not Impaired	No
Snowshoe Creek, (Cabinet Wilderness Boundary to Big Cherry Creek)	MT76D002_040	Arsenic	No	Impaired	Yes
		Cadmium	Yes	Impaired	Yes
		Lead	No	Impaired	Yes
		Zinc	Yes	Impaired	Yes
Stanley Creek, (Headwaters to mouth, (Lake Creek))	MT76D002_010	Copper	Yes	Impaired	Yes
		Lead	No	Impaired	Yes
		Zinc	No	Impaired	Yes

8.5 Metals Source Assessments

Identified metals sources linked to human activity are primarily related to Montana's mining legacy: abandoned and inactive hard rock mines. These metals sources include adits and seeps, metals-laden floodplain deposits, waste rock and tailings, and other features associated with abandoned and inactive mining operations. There is also MPDES-permitted storm water discharges in the Kootenai-Fisher project area. Permitted storm water discharges are those that discharge stormwater runoff to a state waterbody. The specific sources identified in each watershed are described below.

8.5.1 Big Cherry Creek MT76D002_050

The major metals source identified in the Big Cherry Creek watershed is an abandoned/inactive mill site on Montana's list of priority abandoned mine cleanup sites. This site is known as the Big Cherry Creek mill site. Waste rock, tailings and by-products of the mining and milling processes are present in and around the mill site. The volume of tailing associated with this site has been estimated to be approximately 4,540 cubic yards. Tailings have been reclaimed, and are mostly vegetated (**Section 2.3.5**). Site investigations in the early 1990s discovered levels of metals in onsite tailings that were three times background concentrations. Metals parameters that were above background include arsenic, cadmium, copper, lead, antimony, zinc and mercury (Pioneer Technical Services, Inc., 1995).

Other potential contributing sources include abandoned mines identified by DEQ and the Montana Bureau of Mines and Geology (MBMG). These include the underground lode mines of the Copper Reward, Seattle, Silver Tip and Fairbault Mines. These mines are located in the headwaters of Big Cherry Creek. Additional contributing sources include the Leigh Creek, Big Sky and Missouri lode mines. These mines are in the Leigh Creek watershed. Leigh Creek flows into Big Cherry downstream of the confluence with Snowshoe Creek. DEQ and MBMG also identified a number of small scale placer operations on Big Cherry Creek up stream of the mill site.

The original metals impairment listings for Big Cherry Creek were based primarily on water quality samples collected in 1999 for the DEQ Water Quality Standards Attainment Record. DEQ completed additional stream sampling in 2006 and from 2011-2012 to use for updated assessment and to support subsequent TMDL development (**Appendix F**).

Figure 8-2 shows the location of the Big Cherry Creek mill site, the placer operations and DEQ's sample locations.

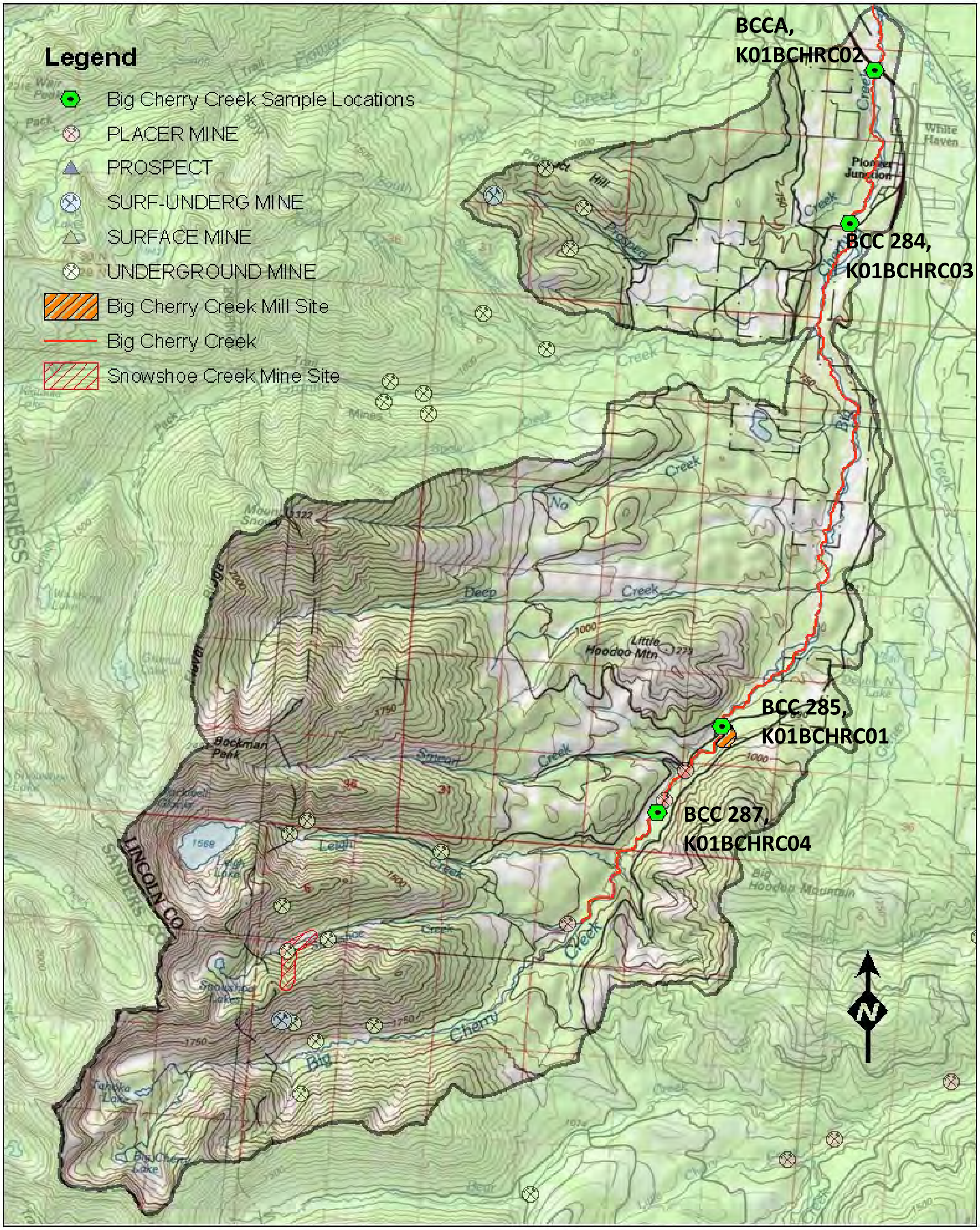

Figure 8-2. Metals sources and sample locations in the Big Cherry Creek watershed

Cadmium, concentrations were consistently above acute aquatic life (AAL) and chronic aquatic life (CAL) criteria in water samples collected above and below the Big Cherry Creek Mill site. Cadmium exceeded the CAL in 100% of the samples collected. The AAL value was exceeded in 64.3% of the samples. Lead was detected above and below the Mill site as well. The lead CAL was exceeded in 42.9% of the samples. No AAL was exceeded. Zinc was in exceedance for both the AAL and CAL. As the AAL and CAL criteria for zinc are the same, exceedance rates are the same. Both the AAL and CAL were exceeded in 50.0% of the samples collected **(Appendix F).**The aforementioned exceedance rates are for all sampling locations upstream and downstream of the Big Cherry Creek Mill site.

While the Mill site is the most probable source of pollution in the lower segments of the watershed, concentrations of all impaired metals (Cd, Pb, Zn) were significantly higher at upstream sample locations. This suggests significant metals loading from those sources above the Mill site. This includes tributary loading from the head waters of Snowshoe Creek, Leigh Creek and Snowshoe Creek. The tributary of Snow shoe Creek is a significant source, loading metals associated with the Snowshoe Mine and Snowshoe Mine tailings deposits in Snowshoe Creek. While concentrations remain highest at the sampling locations above and immediately downstream of the Mill site, they gradually decrease at downstream monitoring sites.

8.5.2 Stanley Creek MT76D002_010

The major metals source identified in the Stanley Creek watershed are most likely those associated the active Troy Mine and with other historical mining activities.

The highest water quality metals concentrations observed were associated with high flow samples, suggesting that metals are bound in the sediment and only become mobile when there is a significant disturbance (high flow events). As such, metals pollution in Stanley Creek is likely associated with sediment production. There are a number of events that have taken place in the last 10-20 years that have contributed metals laden sediment to Stanley Creek.

The upper Stanley Creek watershed has three tributary streams. Below Troy Mine's west ventilation adit, the middle tributary of Stanley Creek was once partially buried by coarse rock, which was sidecast during the initial mine development. Stanley Creek now flows through a culvert onto the talus slope and flows about 200 feet down to the original stream channel. The stream channel area is unvegetated for approximately another 200 feet below the toe of the sidecast material. While some erosion may be occurring along the unvegetated steep slope adjacent to the sidecast area, this site overall is probably a minor source of sediment to Stanley Creek (U.S. Forest Service and Montana Department of Environmental Quality, 2012). That being said, water quality samples collected upstream and downstream of the sidecast area during a July 2012 Hard Rock Program Operating Permit field inspection showed elevated copper concentration. The upstream sample was reported as 0.004 mg/L, and increased to 0.006 mg/L downstream of the sidecast area. Both samples were above the chronic aquatic life standard. Soils samples collected during the inspection from the sidecasting area contained elevated concentrations of copper, lead, and antimony.

In 1996, a slump occurred in the fillslope on NFSR 4626 between the mill site and the North Portal area resulting in a debris avalanche that buried approximately 200 feet of upper Stanley Creek with landslide debris. After reaching Stanley Creek, the slide became a debris torrent that caused major scour and sediment deposition down to the Creek's confluence with Fairway Creek. Sediment deposited during this event is still evident throughout upper Stanley Creek and is a chronic source of sediment during peak flow events. It is likely that much of the sediment resulting from the 1996 slope failure is now deposited in lower Stanley Creek (U.S. Forest Service and Montana Department of Environmental Quality, 2012).

In October of 2009, a leak in a tailings pipeline spilled tailings into Thicket Creek (a tributary to Stanley Creek) about 150 feet above its confluence with lower Stanley Creek. Approximately 40 tons of tailings solids flowed out of the pipeline during the course of the spill and much of this material settled in Thicket and Stanley Creeks as a layer of cohesive silt. Some of the material was suspended in the stream and carried down to Lake Creek. Cleanup operations removed most of the tailings from Thicket Creek. Difficult access and high water velocities made it impossible to remove most of the tailings that had reached Stanley Creek. Tailings are presently visible in the slower water areas downstream from the confluence with Thicket Creek (U.S. Forest Service and Montana Department of Environmental Quality, 2012). In October of 2011 another tailings pipeline spill occurred in Thicket Creek. Again tailings flowed down Thicket Creek and were deposited in Stanley Creek. Tailings deposits in Stanley Creek were visibly larger than those observed during the 2009 spill, as noted in the October 26, 2011 DEQ Hard Rock Program Operating Permit Field Inspection Report. Water quality data collected at the time of the inspection indicated levels of copper in exceedance of the chronic aquatic life standard. Total recoverable copper was reported at 0.017 mg/L, at a hardness of 86 mg/L.

There are also two underground lode mines that are within the Stanley Creek watershed. These are the Daniel Lee Lode Mine, Blue Bird Mine. USFS forest maps indicate unnamed mines on Mount Vernon within the Stanley Creek watershed. **Figure 8-3** shows the spatial extent of historic mining activity and mine wastes in the Stanley Creek watershed.

The only active MPDES surface water permit (permit # MTB004212) is issued to Troy Mine Inc. This permit is a temporary permit issued to control turbidity only. There is no anticipated discharge of metals polluted wastewater associated with this permit, as such no wasteload allocations (WLA) will be assigned to the discharge associated with this permit.

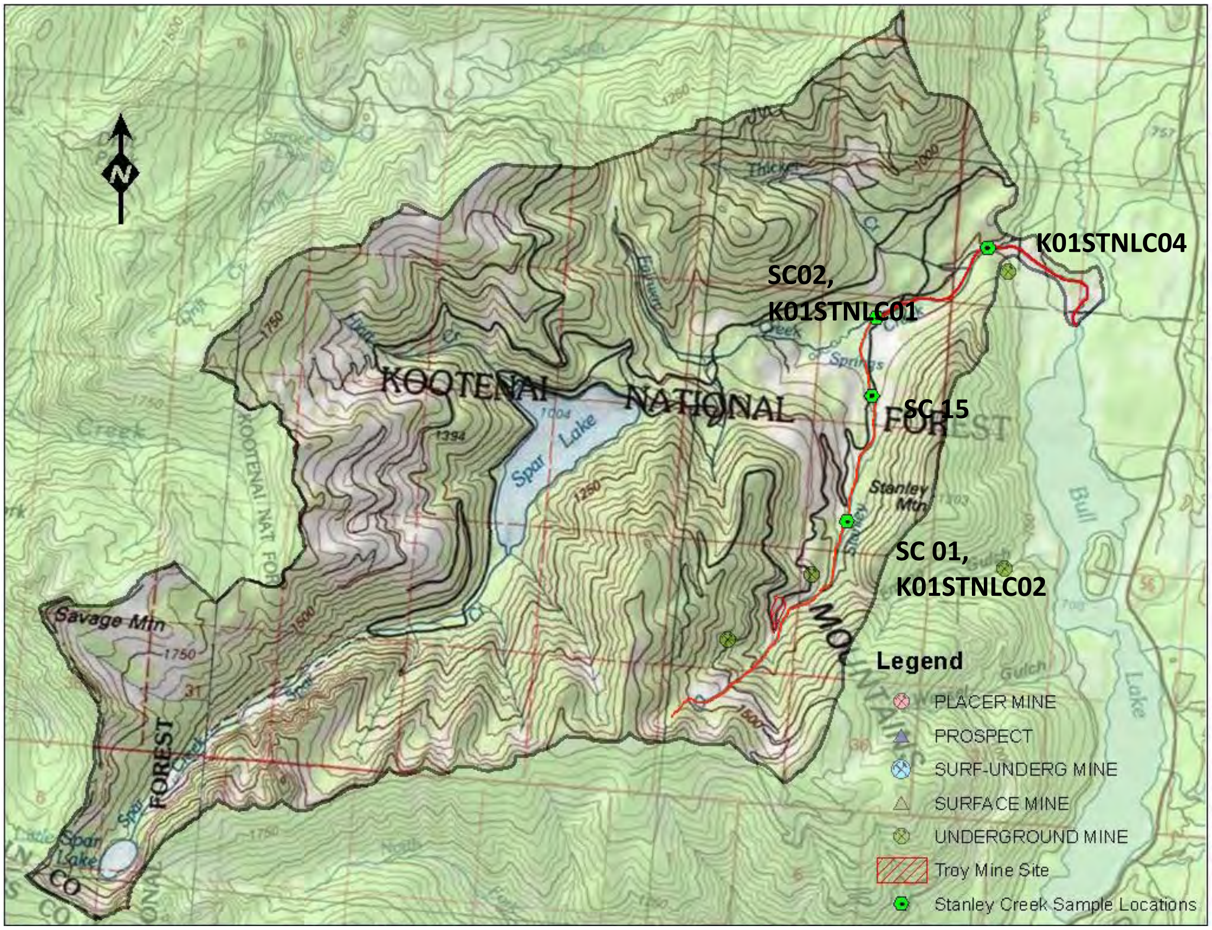

Figure 8-3. Metals sources and sample locations in the Stanley Creek watershed

The Troy Mine water quality data from 2005-2011, and DEQ stream sampling data from 2011-2012 was used for an updated assessment and to support subsequent TMDL development **(Appendix F)**. Copper, concentrations were consistently above acute aquatic life (AAL) and chronic aquatic life (CAL) criteria in water samples collected in Stanley Creek. Copper exceeded the AAL in 26% of the samples collected. The CAL value was exceeded in 29% of the samples. Lead was also a cause of impairment. The CAL for lead was exceeded in 16% of the samples. No AAL was exceeded for lead.

The Troy mine submitted data from several sampling locations. The data submitted by the mine was used in TMDL development however the data did not include latitude and longitude data. As a result the monitoring locations could not be mapped. This includes monitoring locations SC15, SC15-B, SC17-A and SC02. These monitoring locations are included in **Appendix F**, but not included in **Figure 8-3**.

8.5.3 Lake Creek MT76D002_070

Figure 8-4 shows the spatial extent of historic mining activity and mine wastes in the Lake Creek watershed. Mining-related metals sources were studied in a variety of investigation and remediation activities. These projects documented metals contamination of soil, surface water and stream sediments. Most of this work was completed by the Troy Mine (or its consultants) at the request of DEQ. Of particular interest, is the mine related investigation completed for the Troy Mine tailings impoundment adjacent to Lake Creek (U.S. Forest Service and Montana Department of Environmental Quality, 2012; Genesis, Inc., 2006; Summit Envirosolutions, 1996; 1999). Potential sources of metals pollution to Lake Creek include the aforementioned tailings pond adjacent to Lake Creek, contributions from tributaries to Lake Creek that have seen historical mining, as well as historical and active mining in Stanley Creek.

MBMG and DEQ have identified a number of abandoned underground lode mines in various states of operation (past producing mines, developed deposits and prospects) in some of the tributaries to Lake Creek. One sub-watershed with a particularly high density of mining activity is the North Fork of Keeler Creek. The North Fork of Keeler Creek flows into Keeler Creek which in turn flows into Lake Creek. MBMG and DEQ has identified operations including the Grouse Mountain, Silver Strike, Little Spokane, Silver King, Cabinet Queen Prospect, Hiawatha, Universal, Iron Mask, Bimetalic/Black Horse and Last Chance mining operations.

Another tributary to Lake Creek that has had a significant mining presence includes Copper Creek. Past mining operations on Copper Creek include the underground lode mines of: Giant Sunrise, Crescent Tunnel, Liberty Metals, American Eagle, Montana Morning and Lost Cause. Surface mining operations include the Barite Prospect and the Montana Premier Mine. Placer mining operations include the Kotschevar Barite mine. Copper Creek is a direct tributary to Lake Creek and joins the mainstem of Lake Creek approximately 5 miles upstream of the confluence with the Kootenai River. Along with these identified abandoned mines, there are likely other unidentified abandoned mines and waste rock piles acting as contributing sources.

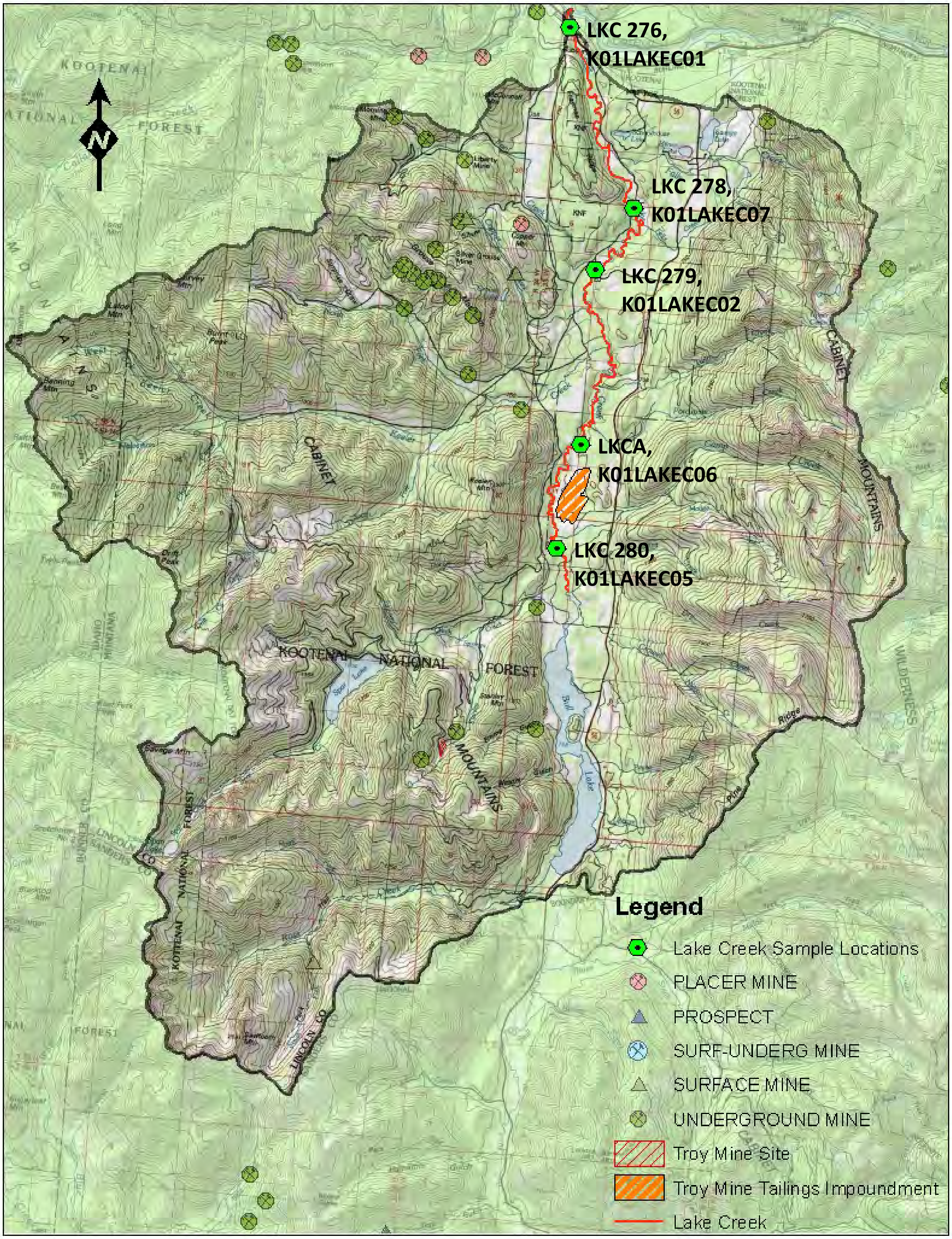

Figure 8-4. Metals sources and sampling locations in the Lake Creek watershed

The Troy Mine maintains a large tailings impoundment that is adjacent to Lake Creek, and Camp Creek, about 1000 feet downstream of the confluence of the two. The tailings impoundment is approximately 430 acres of disturbed area (Genesis, Inc., 2006). The impoundments receive several tons of slurried mine tailings daily when the mine is in operation (Jepson, Wayne, personal communication 04/15/2013). The tailings impoundment is comprised of 3 unlined cells. The tailing site incorporates several toe ponds that collect seepage from the impoundments. Water in the toe ponds is a mixture of groundwater, impoundment seepage, and surface runoff. Standing water from these ponds is periodically pumped back into the impoundments. There are also several smaller decant ponds that receive stormwater runoff from the impoundment site. The mine observes natural attenuation of copper and other metals through natural geochemical processes within the impoundments (Hydrometrics, Inc., 2010). Groundwater data from monitoring wells indicate limited metals pollution as a result of tailings pond seepage.

Troy Mine data from 2005-2011 and DEQ stream sampling from 2009-2011 were used for an updated assessment and to support subsequent TMDL development (**Appendix F**). Copper concentrations in a low-flow, sample collected at monitoring location LC02 exceeded twice the AAL standard. Lead concentrations in samples from Lake Creek exceeded the CAL standard in 16% of the samples. While the concentrations of copper and lead sample results indicate continued impairment, cadmium and zinc sample results indicated continued listing of these metals was not necessary.

The majority of the water quality data from Lake Creek was reported as non-detect. However there were exceedances of target values for both copper and lead as previously indicated. There were no lead or copper concentrations above non-detect in the sample location upstream of the tailings impoundment. Copper had one sample that was in exceedance of the target and one at the detection limit at the sampling locations downstream of the tailings impoundment.

The highest concentrations of metals occurred at those sampling sites downstream of the tailing impoundment, during high runoff events. These high concentrations are an effect of metals entrainment during high runoff events. The entrainment and resulting metals loading to Stanley Creek is related to the ongoing and historical mining activity that has taken place throughout the watershed.

The Troy mine submitted data from several sampling locations. The data submitted by the mine was used in TMDL development however the data did not include latitude and longitude data. As a result the monitoring locations could not be mapped. This includes monitoring locations LC01, LC02, LC03 and LC04. These monitoring location are included in **Appendix F** and not identified on **Figure 8-4**.

8.5.4 Snowshoe Creek MT76D002_040

Several agencies, including DEQ, MBMG, and the USFS, have studied mining-related metals sources in the Snowshoe Creek watershed (Maxim Technologies, Inc., 2004; Pioneer Technical Services, Inc., 1994; Hargrave et al., 1999b; Pioneer Technical Services, Inc., 2010). These projects documented metals contamination of soil, groundwater, surface water and stream sediments. **Figure 8-5** shows the spatial extent of historic mining activity and mine wastes in the watershed. DEQ completed additional stream sampling from 2011-2012. This data was used to update the stream assessment and to support subsequent TMDL development (**Appendix F**).

Anthropogenic metals sources in the Snowshoe Creek watershed are related primarily to the reclaimed Snowshoe Mine and Mill Site (collectively referred to as the Snowshoe Mine) and associated workings, as well as intact, instream tailing deposits downstream of the mine site. Other potential contributing sources include those abandoned mines identified by DEQ and the Montana Bureau of Mines and Geology (MBMG). These include the underground lode mines of the Texas Ranger and St. Paul Mines. These mines are located in the headwaters of Snowshoe Creek.

The Snowshoe Mine site was identified on the Montana list of priority abandoned mine cleanup sites. Reclamation activities started in 2007 and were completed in 2012. Reclamation activities were focused on U.S Department of Agriculture Forest Service (USFS) land which comprises the mine and mill sites. No reclamation efforts were directed to in stream mine tailings deposits downstream of the mine and mill sites.

The major source of metals in Snowshoe Creek is mine waste in the stream bed and in the floodplain. Maxim 2004 describes a stream reach downstream of the reclaimed mine site that contained a very long stretch of mine tailing deposits (8 feet high by 300 feet long) consisting of loose crushed ore that makes up the streambank. Streambank soil samples exhibited arsenic, cadmium, lead and zinc concentrations three orders of magnitude higher than PELs, although the PELs do not apply as TMDL targets for streambank soils. Also cadmium, lead and zinc concentrations two orders of magnitude higher than CAL standards in water quality samples.

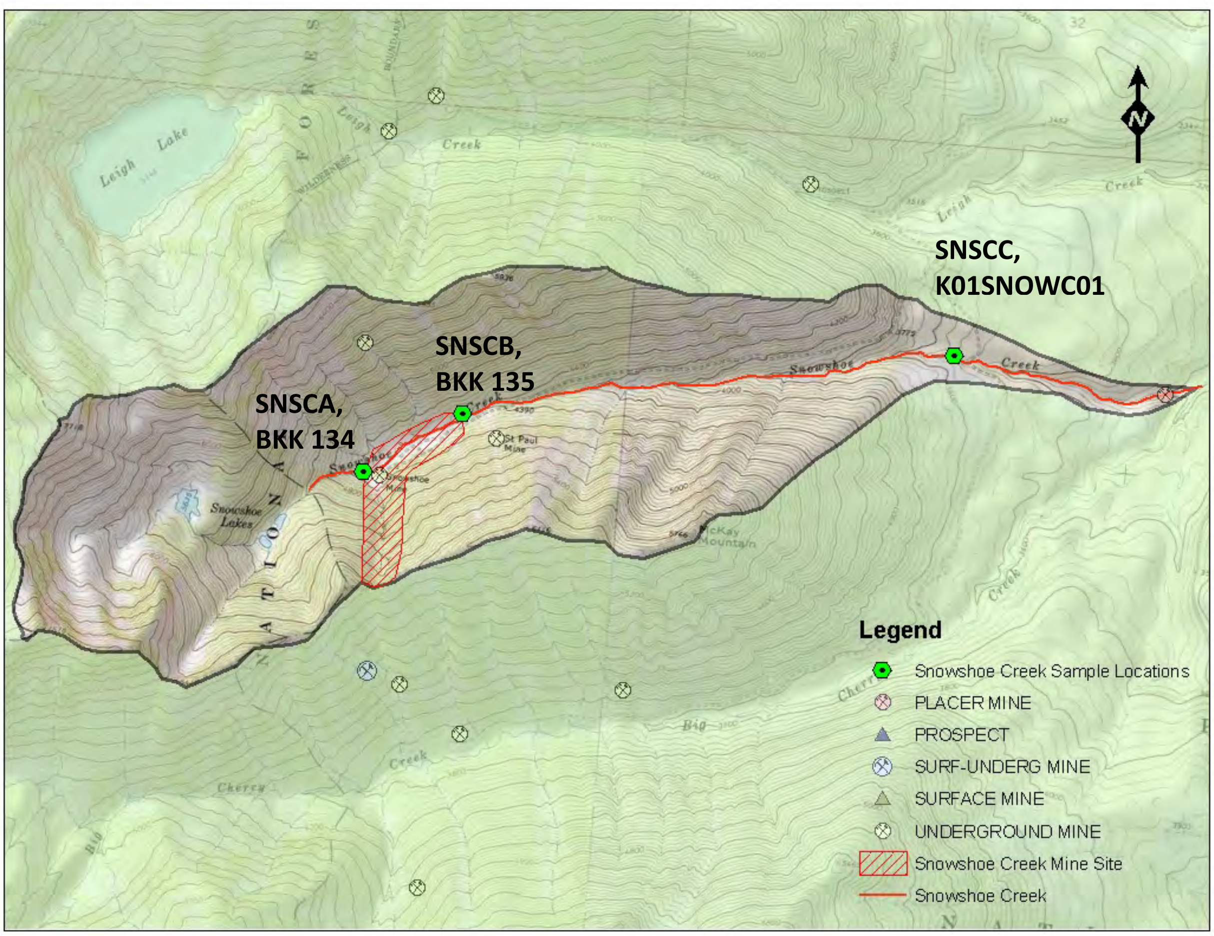

Figure 8-5. Metals sources and sampling locations in the Snowshoe Creek watershed

DEQ collected water samples from Snowshoe Creek from 2011-2012. Data from these samples is provided in **Appendix F**. The highest metals concentrations in Snowshoe Creek occur at monitoring locations SNSCB, BKK 135, SNSCC and K01SNOWC01. The highest concentrations for all metals occur at monitoring location SNSCC and K01SNOWC01. The mine waste in the stream bed and in the floodplain occurs between monitoring locations SNSCB, BKK 135 (immediately downstream of the mine site) and monitoring locations SNSCC and K01SNOWC01 (Downstream of the streamside tailings). Given these high concentrations at these locations, it is likely the source of metals is the Snowshoe Mine site and the existing streamside tailings deposits.

8.6 Metals TMDLs and Allocations

8.6.1 Metals TMDLs

This section presents metals TMDLs for impaired waterbodies in the Kootenai-Fisher TMDL Project Area. TMDLs are based on the most stringent water quality criteria or the water quality target, the water hardness if applicable, and the streamflow. Target development is discussed in detail above, in **Section 8.4.2.1**.

Because streamflow and hardness vary seasonally, the TMDL is not expressed as a static value, but as an equation of the appropriate target multiplied by flow. These equations are illustrated below in **Figures 8-6** through **8-10**. 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 µg/L
Y= streamflow in cubic feet per second
k = conversion factor of 0.0054

Four metals impairment causes in the Kootenai -Fisher project area have standards for protection of aquatic life that vary according to water hardness as defined within DEQ-7 (Montana Department of Environmental Quality, 2012a). Generally aquatic life standards become more stringent as water hardness decreases. Water hardness may vary seasonally, and instream water hardness is commonly higher under low flow conditions. For calculating example TMDLs in this section, the lowest applicable metals water quality target is based upon the measured hardness corresponding to that sample. In those cases where the human health standard is the lowest target, those values are used. This is the case with arsenic in Snowshoe Creek.

Figure 8-6 is a plot showing TMDLs versus flow for impairment causes that are not influenced by hardness. **Figures 8-7** through **8-10** show TMDLs versus flow for the hardness-dependent impairment causes at hardness conditions of 25mg/L and 400/mg/L. These values represent the complete range of variability of hardness per DEQ-7, as well as the naturally occurring conditions in the Kootenai-Fisher project area (**Appendix F**). Although a 10% target exceedance rate is allowed for aquatic life targets, the TMDLs are set so that these targets are satisfied 100% of the time. This provides a margin of safety by focusing remediation and restoration efforts toward 100% compliance to the extent practical.

The TMDL equation and curves apply to all metals TMDLs within this document and describe TMDLs for each metal under variable flow and hardness conditions. Metals TMDLs apply to any point along the waterbody and therefore protect uses along the entire stream. An exception may be found in a mixing zone established for a National Pollutant Discharge Elimination System (NPDES) permitted discharge.

However this does not apply within the Kootenai-Fisher TMDL project area since there are no permitted discharges with mixing zones.

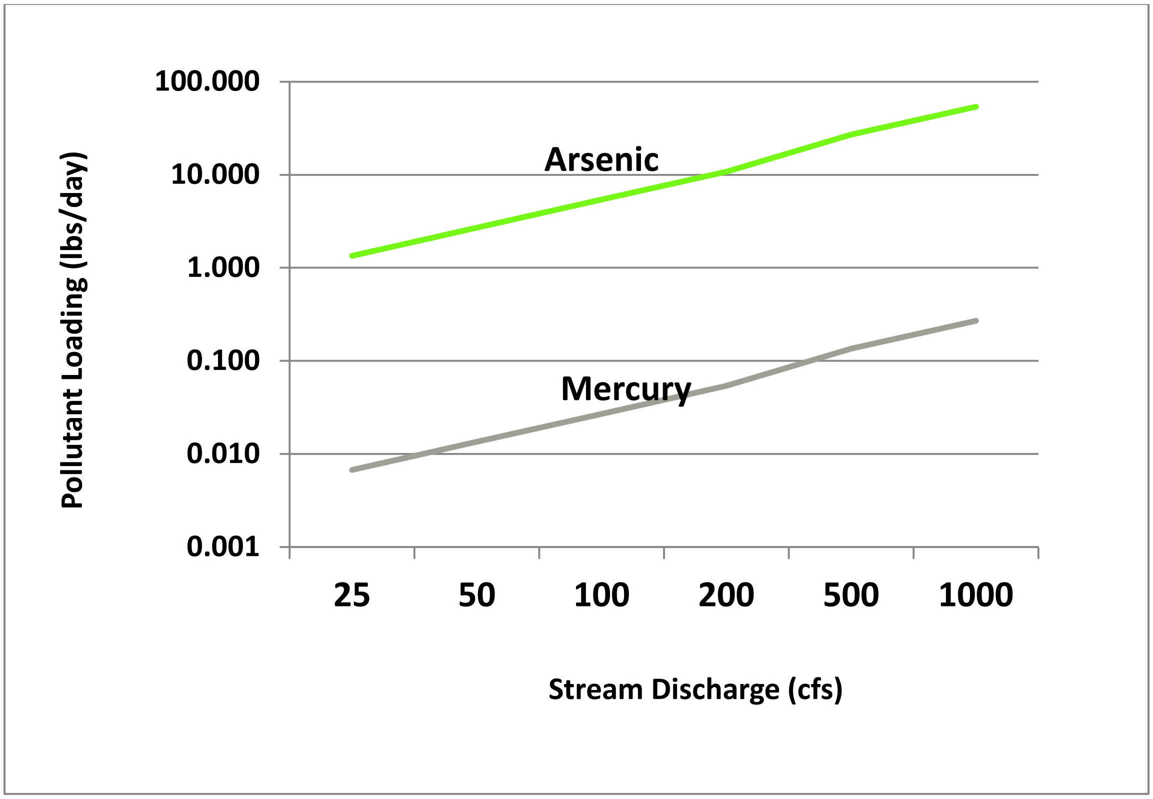

Figure 8-6. Hardness-independent metals TMDLs as functions of flow

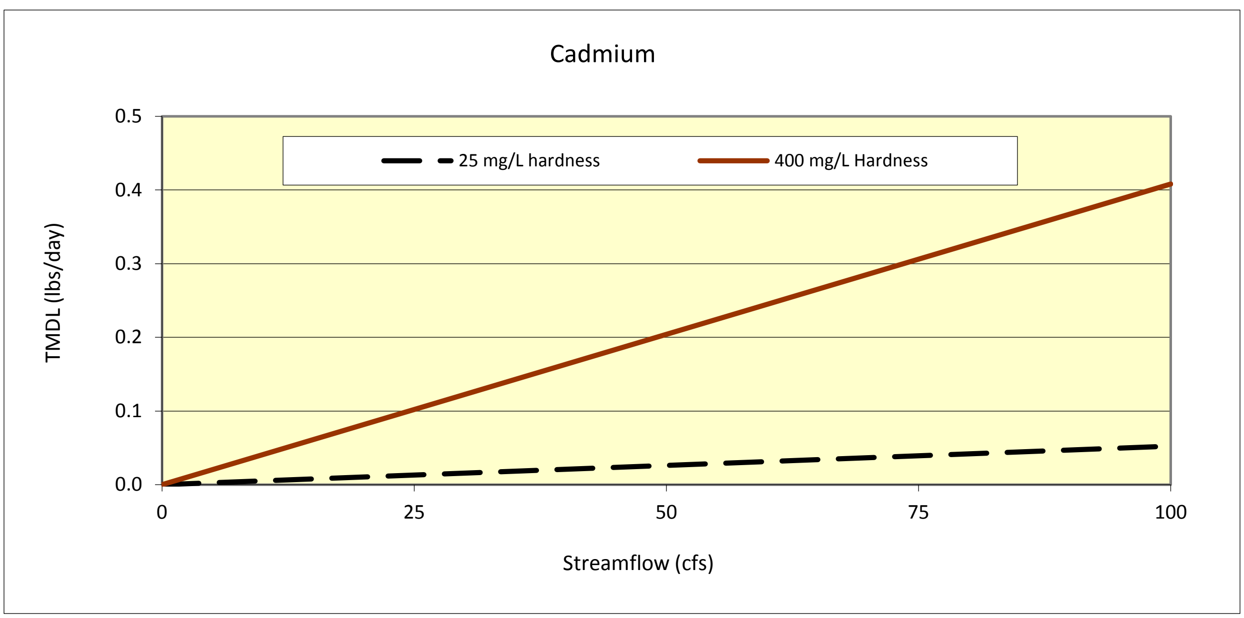

Figure 8-7. Cadmium TMDL as a function of flow

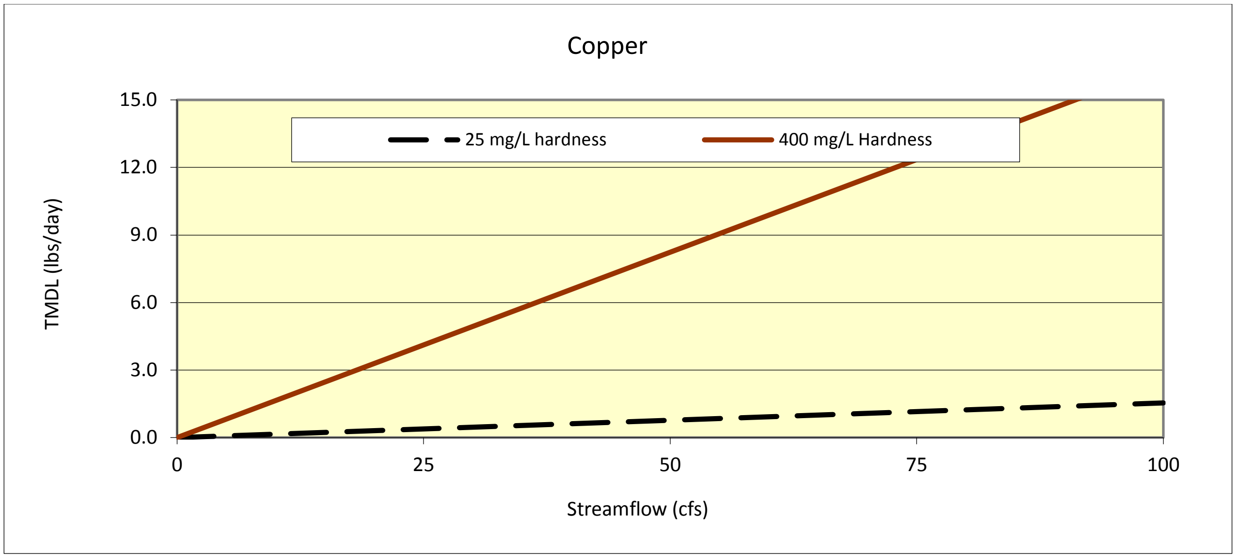

Figure 8-8. Copper TMDL as a function of flow

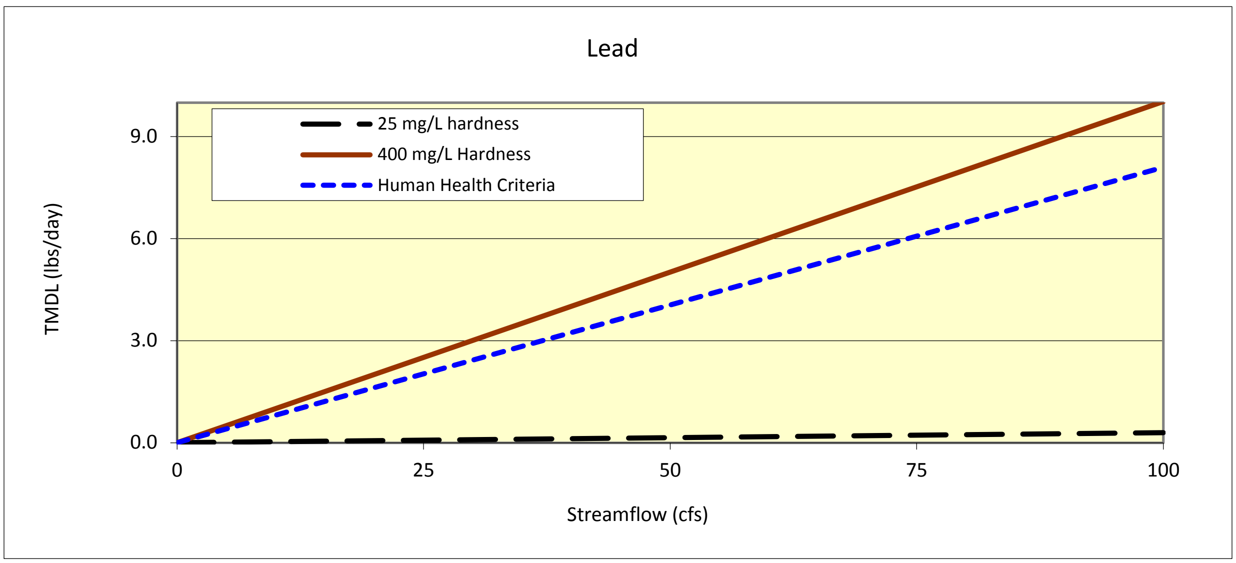

Figure 8-9. Lead TMDL as a function of flow

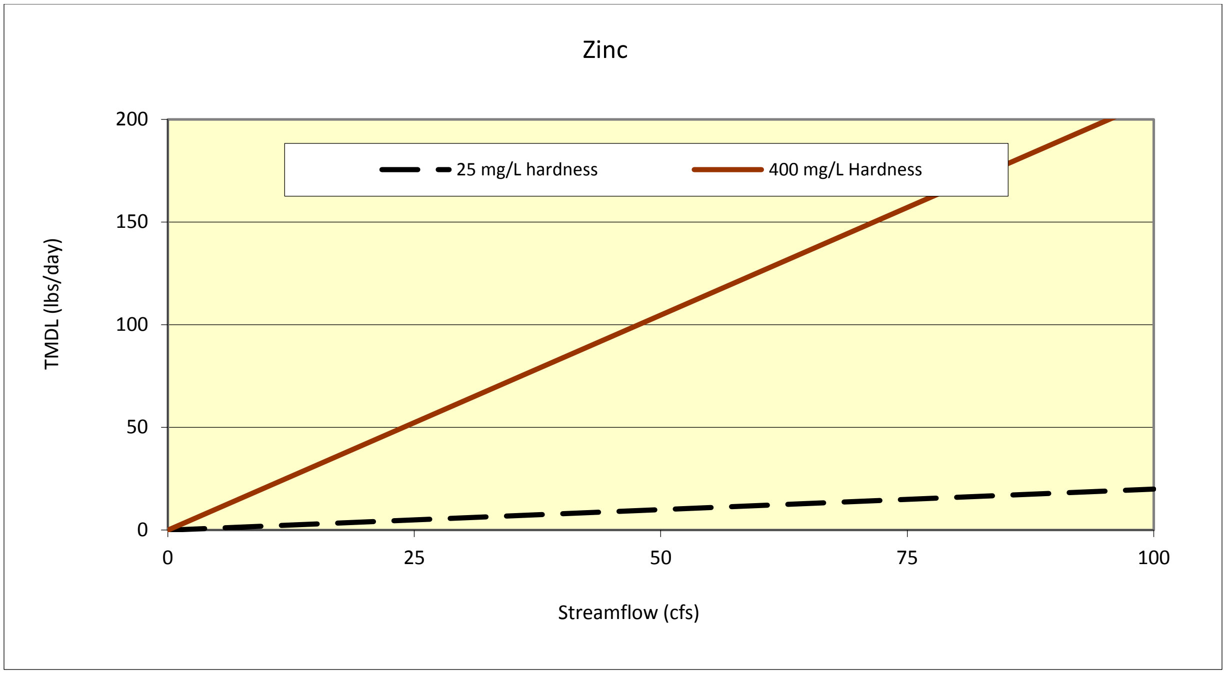

Figure 8-10. Zinc TMDL as a function of flow

Table 8-15 provides example TMDLs for each of the waterbody – impairment cause combinations in the Kootenai - Fisher project area. DEQ chose the data in **Table 8-15** by selecting the highest measured concentration for a given impairment cause for each flow regime. This accounts for seasonal variability by providing the full range of streamflow and water hardness for each waterbody –impairment cause combination (**Appendix F**). The TMDLs in **Table 8-15** are calculated according to the TMDL equation provided above.

Table 8-16 provides the calculated load reduction requirements necessary to meet each TMDL. High and low flow load reductions were calculated using the highest concentration value for a given high or low flow event and the corresponding hardness dependent target value for that given event. The required percent reduction in total load is calculated by subtracting the target value from the highest measured concentration and dividing the difference by the high concentration value. In those cases where the highest concentration was the detection limit, a zero percent reduction was assigned to that metal parameter. DEQ has chosen this approach because values below the detection limits applicable to the **Appendix F** data could not exceed a target value. This is the case for the high flow load reductions in Stanley Creek. There were also cases were the highest concentrations for a particular flow regime were identical at multiple locations (Zinc in Big Cherry Creek). In these cases the lowest hardness dependent target value was chosen to calculate the percent reduction. In the case of arsenic in Snowshoe Creek, the human health target was exceeded, and as a result, the human health value was use as the target. Those values used to calculate percent reductions are bolded in **Appendix F.**

In some cases the required percent reduction is quite high. This is based on the examples being chosen to demonstrate the highest detected metals concentrations. This may provide a somewhat misleading idea of the magnitude of the impairments, and should be considered in conjunction with the percentage of samples that exceed the lowest applicable water quality target (e.g., “exceedance rates” in **Section 8.4.3**).

In some cases the required percent reduction is zero for either high or low flow events, although in all situations there is a required percent reduction for a high and/or low flow event. The **Table 8-16** results indicate that Lake Creek impairment is a concern during high flow or runoff, although there is also low or base flow copper loading concerns. The Big Cherry Creek results suggest mainly high flow loading concerns for lead and zinc, and a combination of high and low flow concerns for cadmium. Snowshoe Creek results show a combination of high and low flow loading concerns for cadmium, lead and zinc, and a low flow loading concern for arsenic. The Stanley Creek data suggests a low flow loading concern for copper, lead and zinc.

Table 8-15. Detailed inputs for example TMDLs in the Kootenai-Fisher TMDL project area

Stream	Discharge (cfs)		Hardness (mg/L)		Metal	Target Conc. (µg/L)		TMDL (lbs/day)	
	High Flow	Low Flow	High Flow	Low Flow		High Flow	Low Flow	High Flow	Low Flow
Lake Creek MT76D002_061	285	75	40	40	Lead	0.99	0.99	1.54	0.40
					Copper	4.26	4.26	6.62	1.73
Big Cherry Creek MT76D002_050	75.0	8.3	25	33	Cadmium	0.10	0.12	0.04	0.005
					Lead	0.54	0.78	0.219	0.035
					Zinc	37.0	46.83	14.99	2.10
Snowshoe Creek MT76D002_040	40.0	0.11	NA	NA	Arsenic	10	10	2.16	0.006
			25	43	Cadmium	0.10	0.14	0.0216	0.0001
					Lead	0.54	1.09	0.117	0.0006
					Zinc	37.0	58.61	7.99	0.035
Stanley Creek *MT76D002_010*	133.7	0.32	29	25	Copper	3.24	2.85	2.34	0.005
					Lead	0.66	0.54	0.48	0.001
					Zinc	42.0	37.0	30.30	0.064

Table 8-16. High and Low Flow Load Reductions

Stream	Parameter	% Load Reduction To Meet TMDL	
		High Flow	Low Flow
Lake Creek MT76D002_061	Lead	93	0
	Copper	88	20
Big Cherry Creek MT76D002_050	Cadmium	87	86
	Lead	87	0
	Zinc	38	6
Snowshoe Creek MT76D002_040	Arsenic	0	23
	Cadmium	97	98
	Lead	98	94
	Zinc	84	91
Stanley Creek *MT76D002_010*	Copper	*0*	*68*
	Lead	*0*	*39*
	Zinc	*0*	*84*

8.6.2 Metals Allocations: Basic Approach

As discussed in **Section 4.0**, a TMDL equals the sum of all the wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS). WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. Mining-related waste sources (e.g. adit discharges, tailings accumulations, and waste rock deposits) may represent non-permitted point sources subject to WLAs. LAs are allowable pollutant loads assigned to nonpoint sources and may include the pollutant load from naturally occurring sources, as well as human-caused nonpoint loading. Where practical, LAs to human sources are provided separately from naturally occurring sources. All mining related sources are provided WLAs unless the allocation is for a mine-related source where it is know that the source loading is consistent with the definition of a nonpoint source, thus leading to the use of one or more LAs for those specific mining related sources.

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 naturally occurring background
MOS = Margin of Safety or an accounting of uncertainty about the relationship between metals loads and receiving water quality.

Metals allocations in the Kootenai-Fisher TMDL project areas are provided for the following source categories:

- Mining sources (WLA_{MS})
- Naturally occurring metals sources (LA_{NAT})

DEQ provides an implicit MOS by using assumptions known to be conservative, discussed further in **Section 8.7.2**. Because an implicit MOS is applied, the MOS in the TMDL equation above is equal to zero and is not included in the equation provided below.

The resulting TMDL equation is therefore:

$$TMDL = LA_{nat} + WLA_{MS}$$

There are no MPDES-permitted discharges to surface water that require WLA development in the project area; therefore the above WLA_{MS} does not incorporate MPDES-permitted surface water discharges

Mining sources wasteload allocation (WLA_{MS})

Within the Kootenai -Fisher TMDL Planning Area, the major metals sources are related to active, inactive and abandoned mining. Although prominent abandoned/inactive mines have been investigated in each of the watersheds (**Section 8.5**), data describing individual loading contributions from historical mining is typically insufficient to guide allocations for each individual abandoned mine feature. The nature of Montana's mining legacy is such that many small non-permitted point sources (adits, seeps, tailings piles, etc.) may be scattered throughout a watershed and pass undetected. Therefore a composite wasteload allocation (WLA_{MS}) for mining sources is provided in pounds/day to any and all metals sources related to active, inactive and abandoned mines. This composite wasteload allocation approach recognizes that abandoned mine remediation is best pursued in an adaptive manner that balances remediation costs with achievable load reductions within each watershed. The WLA_{MS} is calculated for each TMDL as the difference between the TMDL and the load allocation to naturally-occurring sources (described in the following section).

Naturally occurring metals sources

Naturally occurring loading is assumed to be a result of local geology, with minimal influence from human-caused sources. Metal loading to surface water is strongly influenced by geology and streamflow rate. Bedrock composition commonly affects sediment mineralogy and surface water concentrations of many elements, including metals. Higher suspended sediment concentrations usually increase the water column solids concentration of metals and other constituents during seasonal high flows. The local bedrock geology consists of a thick series of metasedimentary rocks known as the Belt Supergroup. This geology contains metal ores, and the potential to leach metals to surface waters.

The sampling and analysis conducted by DEQ for stream assessments in the Kootenai - Fisher TMDL Project area identify eight sampling sites remote from mining and other human-caused sources. There are a few upstream monitoring sites that were not included in this data set due to their proximity to historical mining disturbances. The eight sites were located in the upper reaches of Snowshoe Creek, Libby Creek and Bear Creek. The Snowshoe Creek sites consist of SNSCA and BKK134. The Libby Creek site is K01LIBYCO3 and K01LIBYCO5. The Bear Creek sites consist of KO1BEARCO1, KO1BEARCO2, KO1BEARCO3 and KO1BEARCO4. **Table 8-17**contains measured high and low-flow values and median values for metal pollutant parameters in samples from the eight sites representing naturally occurring conditions.

In many cases, non-detects were recorded at all the monitoring sites upstream of mining sources; for purposes of load allocations to naturally-occurring metals, half the lowest detection limit is substituted for the non-detect result value (**Table 8-17**). In some cases a combination of non-detects and reported values were recorded; for the purpose of load allocation, a median of these values will be used. The median values in the shaded rows in **Table 8-17** are used to calculate the load allocations to naturally occurring sources of metals loading in the Kootenai – Fisher project area.

Table 8-17. Median High and Low Flow Metals Background Concentrations

Flow	Site ID	**As** (ug/L) **TR**	**Cd** (ug/L) **TR**	**Cu** (ug/L) **TR**	**Pb** (ug/L) **TR**	**Hg** (ug/L) **T**	**Zn** (ug/L) **TR**
High Flow	BKK134	<3	1.18	<1	2.9	---	110
	K01LIBYC03	<3	0.08	<1	0.5	<0.005	<10
	K01LIBYC05	<3	<0.08	1	<0.5	<0.005	<10
High Flow Medians		1.5	0.08	1	0.5	0.0025	10
Low Flow	K01BEARC01	<3	<0.08	<1	<0.5	<0.005	<10
	K01BEARC02	<3	<0.08	<1	<0.5	<0.005	<10
	K01BEARC03	<3	<0.08	<1	<0.5	<0.005	<10
	K01BEARC04	<3	<0.08	<1	<0.5	<0.005	<10
	SNSCA	<3	<0.08	<1	<0.5	---	<10
	BKK134	<3	<0.08	<1	1.6	---	<10
	K01LIBYC03	<3	<0.08	<1	<0.5	---	<10
Low Flow Medians		1.5	0.04	0.5	0.25	0.0025	5

The data set contains 10 sampling results for most metal parameters. The high-flow data consists of water chemistry from the upper reaches of Snowshoe Creek and Libby Creek. These samples were collected during the high flow season (May 30 and May 23, 2012 respectively). The remaining 7 low flow samples were collected during low flows in 2011 and 2012. Complete water column chemistry results for the selected background sites are included with data contained in **Table F-4** in **Appendix F**.

The sites occur in headwater reaches that are generally upstream of mining sources. Additional surface water monitoring is recommended to better define naturally occurring levels of metals loading.
When possible, background loading is accounted for separately from human-caused sources. However, the effects of past metal mining are localized within the planning area and load allocations to naturally occurring sources cannot always be expressed separately from human-caused sources. Regardless of the allocation scheme, the underlying assumption is that, naturally occurring sources alone would not exceed the target metals concentrations in the water column, or the PELs in sediment. If future monitoring disproves this assumption, metals loading analyses may need revision per the adaptive management strategy described in **Section 8.8.**

8.6.3 Allocations by Waterbody Segment

In the sections that follow, load and wasteload allocations are provided for each pollutant-waterbody combination for which a TMDL is prepared (see **Table 8-15**). 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 TMDL and allocation tables in the following sections give example TMDLs for each metal pollutant parameter under both high- flow and low-flow conditions for each stream segment. The TMDLs are calculated according to the TMDL formula provided in **Section 8.6.1**.

Additionally, example loading values are calculated for reference purposes only. Due to the limited number of samples, examples are based on the highest detected pollutant concentration for each flow regime and the corresponding flow from that sampling event (**Table 8-15**).

8.6.3.1 Calculating Example TMDL, Load and Wasteload Allocations

Below is an example TMDL calculation for Zinc during high flow conditions. This calculation uses the lowest water quality target concentration (in this case 37.02 ug/L zinc, at 25 mg/L hardness) multiplied by the flow (the highest measured), multiplied by a unit conversion factor of 0.0054, to arrive at units of lbs/day. For example, the zinc TMDL in Big Cherry Creek under high flow conditions is 14.99 pounds per day (lbs/day). The flow values used to calculate TMDLs are marked by an asterisk in **Appendix F.** In the case of arsenic, there is no hardness specific standard and the human health standard was used.

High flow zinc TMDL: [37.02 µg/L X 75 cfs X 0.0054 = 14.99 lbs/day]

The load allocation to natural sources (LA_{nat}) is the same as the estimated naturally occurring load. In the case of Big Cherry Creek, the naturally occurring zinc load (LA_{nat}) is estimated as the median value of metals concentrations from streams representing background conditions, or 10 µg/L (**Table 8-18**). The high flow zinc load is calculated using the median background value (10 ug/L), multiplied by the flow (the highest measured), multiplied by a unit conversion factor of 0.0054. For a high flow of 75 cfs, natural background is 4.05 lbs/day.

High flow naturally occurring zinc load: [10.0 µg/L X 75 cfs X 0.0054 = 4.05 lbs/day]

The wasteload contributed by mining sources (WLA_{MS}) is calculated by subtracting the naturally occurring load (LA_{nat}) from the TMDL. The WLA_{MS} for every TMDL in this document may be calculated by this formula:

$$WLA_{MS} = TMDL - LA_{nat}$$

For zinc in Big Cherry Creek under high flow conditions, this is calculated as 14.99 lbs/day minus 4.05 lbs/day, resulting in a WLA_{MS} equal to 10.94 lbs/day under the example high flow conditions.

8.6.3.2 Calculating Existing Load Examples

The existing high and low flow loads are calculated using the lowest flow and highest flow values from the water quality monitoring data for each flow condition. For high flow in Big Cherry Creek this is calculated by multiplying the highest measured zinc concentration during high flows (60.0 µg/L) by the corresponding observed high flow in Big Cherry Creek of 75 cfs. The product of concentration multiplied by flow is multiplied by the conversion factor of 0.0054, giving an existing high flow zinc load of 24.3 lbs/day. For example, **Table 8-18** for Big Cherry Creek gives values of 24.3 lbs/day for existing high-flow zinc loads. The data used to calculate existing loads in all stream is shaded grey in **Appendix F.** In those cases where a concentration was reported as non-detect, half the detection limit was used.

Target exceedances are variable for each metal based on flow conditions and locations within the watershed. Therefore, example high and low flow events may or may not include target exceedances for each individual metals impairment cause. For this reason, percent reductions are not provided in the example allocation tables, and are instead provided above within **Table 8-16** of **Section 8.6.1.**

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

1. The hardness values used for determining hardness-based standards and associated TMDLs, LAs, and WLAs are the values recorded with the corresponding metals sample.
2. Example TMDLs are based on the maximum and minimum flows and are the same as those presented within **Table 8-15**.
3. Existing condition load summaries are based on the maximum and minimum flows and associated concentration data.

8.6.3.3 Big Cherry Creek MT76D002_050

All example Metals TMDLs for Big Cherry Creek are expressed by the following formula:

$$TMDL_{BigCherryCreek} = LA_{nat} + WLA_{MS}$$

Table 8-18. Big Cherry Creek: Example Metals TMDLs and Allocation

Metal	Flow	TMDL	LA_{nat}	WLA_{MS}	Existing Load
Cadmium	High flow	0.0405	0.0324	0.0081	0.320
	Low flow	0.0054	0.0018	0.0036	0.038
Lead	High flow	0.219	0.203	0.016	1.701
	Low flow	0.035	0.011	0.024	0.031
Zinc	High flow	14.99	4.05	10.94	24.30
	Low flow	2.10	0.22	1.88	2.24

Units are lbs/day

Some of the existing loads in Big Cherry Creek are less than the TMDLs for this waterbody segment. This is consistent with **Table 8-16** where the low flow lead data indicate a 0% reduction, although the purpose of this table is not to provide percent reduction values. The target exceedances for specific metals parameters in Big Cherry Creek are identified in **Section 8.4.3.1.** High and low flow load reductions were calculated using the highest concentration value for a given high or low flow event and the corresponding hardness dependent target value for that given event. **Table 8-16** shows the percent reductions for metals loads measured in Big Cherry Creek based on this approach.

Reductions to metals loading will be necessary to achieve the targets and thus the TMDLs for Big Cherry Creek. The source assessment for the Big Cherry Creek watershed indicates that historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources. Meeting load allocations for Big Cherry Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Sections 10.0** and **11.0**.

8.6.3.4 Stanley Creek MT76D002_010

All the example metals TMDLs for Stanley Creek are expressed by the following formula:

$$TMDL_{Stanley} = LA_{nat} + WLA_{MS}$$

Table 8-19. Stanley Creek: Example Metals TMDLs and Allocation

Metal	Flow	TMDL	LA_{nat}	WLA_{MS}	Existing Load
Copper	High flow	2.339	0.722	1.617	0.361
	Low flow	0.005	0.001	0.004	0.009
Lead	High flow	0.476	0.361	0.115	0.180
	Low flow	0.001	0.0004	0.001	0.0004
Zinc	High flow	30.3	7.218	23.082	3.609
	Low flow	0.064	0.009	0.055	0.009

Units are lbs/day

Most of the existing loads in Stanley Creek are less than the TMDLs for this waterbody segment (**Table 8-19**). This is because metals concentrations at the highest and lowest flow conditions used for the example loads were mostly below target values. That being said, the concentration data for Stanley Creek shows that there are times when the targets are exceeded and reductions are necessary. The target exceedances for specific metals parameters in Stanley Creek are identified in **Section 8.4.3.2.** High and low flow load reductions were calculated using the highest concentration value for a given high or low flow event and the corresponding hardness dependent target value for that given event. **Table 8-16** shows the percent reductions for metals loads measured in Stanley Creek based on this approach.

Reductions to metals loading will be necessary to achieve the targets and thus the TMDLs for Stanley Creek. The source assessment for the Stanley Creek watershed indicates that active and historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources. Meeting load allocations for Stanley Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Sections 10.0** and **11.0**.

8.6.3.5 Lake Creek MT76D002_070

All the example metals TMDLs for Lake Creek are expressed by the following formula:

$$TMDL_{lake} = LA_{nat} + WLA_{MS}$$

Table 8-20. Lake Creek: Example Metals TMDLs and Allocation

Metal	Flow	TMDL	LA_{nat}	WLA_{MS}	Existing Load
Copper	High flow	6.617	1.553	5.064	0.777
	Low flow	1.725	0.203	1.523	0.203

Table 8-20. Lake Creek: Example Metals TMDLs and Allocation

Metal	Flow	TMDL	LA_{nat}	WLA_{MS}	Existing Load
Lead	High flow	1.538	0.777	0.761	0.388
	Low flow	0.401	0.101	0.300	0.608

Most of the existing loads in Lake Creek are less than the TMDLs for this waterbody segment (low flow copper and high flow lead) (**Table 8-20**). This is because metals concentrations at the highest and lowest flow conditions for the example TMDL load were mostly below target values, and the purpose of this table is not to provide percent reduction values. That being said, the concentration data for Lake Creek shows that there are times when the targets are exceeded and reductions are necessary. The target exceedances for specific metals parameters in Lake Creek are identified in **Section 8.4.3.3.** High and low flow load reductions were calculated using the highest concentration value for a given high or low flow event and the corresponding hardness dependent target value for that given event. **Table 8-16** shows the percent reductions for metals loads measured in Lake Creek based on this approach.

Reductions to metals loading will be necessary to achieve the targets and thus the TMDLs for Lake Creek. The source assessment for the Lake Creek watershed indicates that active and historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources. Meeting load allocations for Lake Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Sections 10.0** and **11.0**.

8.6.3.6 Snowshoe Creek MT76D002_040

The copper example TMDL for Snowshoe Creek is expressed by the following formula:

$$TMDL_{SnowshoeCreek} = LA_{nat} + WLA_{MS}$$

Table 8-21. Snowshoe Creek: Example Metals TMDLs and Allocation

Metal	Flow	TMDL	LA_{nat}	WLA_{MS}	Existing Load
Arsenic	High flow	2.160	0.324	1.836	0.648
	Low flow	0.006	0.001	0.005	0.001
Cadmium	High flow	0.0216	0.017	0.0046	0.632
	Low flow	0.0001	0.00002	0.0001	0.000024
Lead	High flow	0.1166	0.1080	0.0086	6.0264
	Low flow	0.0006	0.0001	0.0005	0.0010
Zinc	High flow	7.996	2.160	5.836	49.680
	Low flow	0.035	0.003	0.032	0.003

Most of the existing loads in Snowshoe Creek are less than the TMDLs for this waterbody segment (high and low flow arsenic, low flow cadmium, and low flow zinc) (**Table 8-21**). This is because metals concentrations at the highest and lowest flow conditions used for the example loads were mostly below target values, and the purpose of this table is not to provide percent reduction values. That being said, the concentration data for Snowshoe Creek show that there are times when the targets are exceeded and reductions are necessary. The target exceedances for specific metals parameters in Snowshoe Creek are identified in **Section 8.4.3.4.** High and low flow load reductions were calculated using the highest concentration value for a given high or low flow event and the corresponding hardness dependent target value for that given event. **Table 8-16** shows the percent reductions for metals loads measured in Snowshoe Creek based on this approach.

Reductions to metals loading will be necessary to achieve the targets and thus the TMDLs for Snowshoe Creek. The source assessment for the Snowshoe Creek watershed indicates that historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources. Meeting load allocations for Snowshoe Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Sections 10.0** and **11.0**.

8.7 Seasonality and Margin of Safety

Streamflow, water hardness, and climate vary seasonally. All TMDL documents must consider the effects of this variability 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 designated uses. This section describes the considerations of seasonality and a margin of safety (MOS) in the Kootenai-Fisher metals TMDL development process.

8.7.1 Seasonality

Seasonality addresses the need to ensure year round designated use support. Seasonality is considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is important because metals loading pathways and water hardness change from high to low flow conditions. During high flows, loading associated with overland flow and erosion of metals-contaminated soils and mine wastes tend to be the major cause of elevated metals concentrations. During low flow, groundwater transport and/or adit discharges tend to be the major source of elevated metals concentrations. Hardness tends to be lower during higher flow conditions, which leads to more stringent water quality standards for hardness-dependent 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. DEQ's assessment method requires a combination of both high and low flow sampling for target evaluation since abandoned mines and other metals sources can lead to elevated metals loading during high and/or low flow conditions.
- Metals TMDLs incorporate streamflow as part of the TMDL equation.
- Metals concentration targets apply year round, with monitoring criteria for target attainment developed to address seasonal water quality extremes associated with loading and hardness variations.
- A sediment chemistry target is applied as a supplemental indicator to help capture impacts from episodic metals loading events that could be attributed to high flow seasonal runoff conditions.
- Example targets, TMDLs and load reduction needs are developed for high and low flow conditions. The TMDL equation incorporates all potential flow conditions that may occur during any season.

8.7.2 Margin of Safety

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

- DEQ's assessment process includes a mix of high and low flow sampling since abandoned mines and other metals sources can lead to elevated metals loading during high and/or low flow stream conditions. The seasonality considerations help identify the low range of hardness values and thus the lower range of applicable TMDL values shown within the TMDL curves and captured within the example TMDLs.
- 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.
- Although a 10% exceedance rate is allowed for chronic and acute based aquatic life targets, the TMDLs are set so the lowest applicable target is satisfied 100% of the time. This focuses remediation and restoration efforts toward 100% compliance with all targets, thereby providing a margin of safety for the majority of conditions where the most protective (lowest) target value is linked to the numeric aquatic life standard. As part of this, the existing water quality conditions and needed load reductions are based on the highest measured value for a given flow conditions in order to consistently achieve the TMDL.
- The monitoring results used to estimate existing water quality conditions are instantaneous measurement used to estimate a daily load, whereas chronic aquatic life standards are based on average conditions over a 96-hour period. This provides a margin of safety since a four-day loading limit could potentially allow higher daily loads in practice.
- The lowest or most stringent numeric water quality standard was used for TMDL target and impairment determination for all waterbody – pollutant combinations. This ensures protection of all designated beneficial uses.
- Sediment metals concentration criteria were used as a supplemental indicator target. This helps ensure that episodic loading events were not missed as part of the sampling and assessment activity.
- The TMDLs are based on numeric water quality standards developed at the national level via EPA and incorporate a margin of safety necessary for the protection of human health and aquatic life.

8.8 Uncertainty and Adaptive Management

The environmental studies required for TMDL development include inherent uncertainties: accuracy of field and laboratory data, for example. Data concerns are managed by DEQ's data quality objective (DQO) process. The use of DQOs ensures that the data is of known (and acceptable) quality. The DQO process develops criteria for data performance and acceptance that clarify study intent, define the appropriate type of data, and establish minimum standards for the quality and quantity of data.

The accuracy of source assessments and loading analyses is another source of uncertainty. An adaptive management approach that revisits, confirms, or updates loading assumptions is vital to maintaining stakeholder confidence and participation in water quality improvement. Adaptive management uses updated monitoring results to refine loading analysis, to further customize monitoring strategies and to develop a better understanding of impairment conditions and the processes that affect impairment. Adaptive management recognizes the dynamic nature of pollutant loading and water quality response to remediation.

Adaptive management also allows for continual feedback on the progress of restoration and the status of beneficial uses. Additional monitoring and resulting refinements to loading can improve t achieving and measuring success. A remediation and monitoring framework is closely linked to the adaptive management process, and is addressed in **Section 11.0**.

The metals TMDLs developed for the Kootenai –Fisher TMDL Project Area are based on future attainment of water quality standards. In order to achieve this, all significant sources of metals loading must be addressed via all reasonable land, soil, and water conservation practices. DEQ recognizes however, that in spite of all reasonable efforts, this may not be possible due to natural background conditions and/or the potential presence of unalterable human-caused sources that cannot be fully addressed via reasonable remediation approaches. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals impairments that required TMDLs will ultimately fall into one of the categories identified below:

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

The Abandoned Mines Section of DEQ’s Remediation Division will lead abandoned mine restoration projects funded by provisions of the Surface Mine Reclamation and Control Act of 1977. DEQ’s Federal Superfund Bureau (also in the Remediation Division) will provide technical and management assistance to EPA for remedial investigations and cleanup actions at national priority listed mine sites in federal-lead status.

Monitoring and restoration conducted by other parties (e.g. USFS, the Montana Department of Natural Resources and Conservation’s Trust Lands Management Division, Montana bureau of Mines and Geology) should be incorporated into the target attainment and review process as well. Cooperation among agency land managers in the adaptive management process for metals TMDLs will help identify further cleanup and load reduction needs, evaluate monitoring results, and identify water quality trends.

9.0 NON-POLLUTANT IMPAIRMENTS

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 water quality assessment process and do not appear on Montana's list of impaired waters, even though they may not be fully supporting all of their beneficial uses. In other cases, a stream may listed as impaired, but does not require TMDL development because it is determined not to be impaired for a pollutant, but for a non-pollutant (TMDLs are only required for pollutant causes of impairment). Non-pollutant causes of impairment such as "alteration in streamside or littoral vegetative covers" are often associated with sediment, nutrient, or temperature issues, but may be having a deleterious effect on beneficial uses without a clearly defined quantitative measurement or direct linkage to a pollutant.

Non-pollutant impairments have been recognized by DEQ as limiting their ability to fully support all beneficial uses and are important to consider when improving water quality conditions in individual streams, and the project area as a whole. **Table 9-1** presents the non-pollutant impairments in the Kootenai-Fisher project area and indicates those streams that either do not have any associated pollutant listings or do not have a TMDL in this document. Non-pollutant causes of impairment were not investigated for streams that do not have a TMDL in this document. They are being summarized in this section to increase awareness of the non-pollutant impairment definitions and typical sources. Additionally, the restoration strategies discussed in **Section 10.0** inherently address some or all of the non-pollutant impairments, and many of the BMPs necessary to meet TMDLs will also address non-pollutant sources of impairment. As mentioned above, these impairment causes should be considered during planning of watershed scale restoration efforts.

Table 9-1. Waterbody segments with non-pollutant impairments in the 2012 Water Quality Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause
BIG CHERRY CREEK, Snowshoe Creek to mouth (Libby Creek)	MT76D002_050	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations
[1]**CRIPPLE HORSE CREEK**, Headwaters to mouth (Lake Koocanusa)	MT76D002_100	Low flow alterations; Physical substrate habitat alterations
[1]**DRY CREEK,** 1 mile upstream from State Highway 56 to mouth (Lake Creek)	MT76D002_020	Other flow regime alterations; Physical substrate habitat alterations
[1]**FISHER RIVER**, Silver Butte / Pleasant Valley junction to mouth (Kootenai River)	MT76C001_010	High Flow Regime
[1]**KEELER CREEK**, Headwaters to Lake Creek	MT76D002_030	Low flow alterations; Physical substrate habitat alterations
[2]**KOOTENAI RIVER**, Libby Dam to Yaak River	MT76D001_010	Other flow regime alterations
[2]**KOOTENAI RIVER**, Confluence with Yaak River to Idaho border	MT76A001_010	Other flow regime alterations
[2]**LAKE KOOCANUSA**	MT76D003_010	Other flow regime alterations
LIBBY CREEK, 1 mile above Howard Creek to Highway 2 bridge	MT76D002_061	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations
LIBBY CREEK, Highway 2 bridge to mouth (Kootenai River)	MT76D002_062	Physical substrate habitat alterations

Table 9-1. Waterbody segments with non-pollutant impairments in the 2012 Water Quality Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause
RAVEN CREEK, Headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030	Alteration in streamside or littoral vegetative covers
[3]**QUARTZ CREEK**, Headwaters to confluence with Kootenai River	MT76D002_090	Physical substrate habitat alterations
SNOWSHOE CREEK, Cabinet Wilderness boundary to mouth (Big Cherry Creek)	MT76D002_040	Alteration in streamside or littoral vegetative covers
WOLF CREEK, Headwaters to mouth (Fisher River)	MT76C001_020	Alteration in streamside or littoral vegetative covers

[1] Streams listed for non-pollutant cause(s) only, with no pollutant listings or no TMDL in this document.
[2] Waterbody that is outside the scope of this document but is included for informational purposes.
[3] This cause is being removed for the 2014 303(d) List (along with sedimentation).

9.1 Non-Pollutant Impairment Causes Descriptions

Non-pollutants are often used as a probable cause of impairment when available data at the time of a water quality assessment does not provide a direct, quantifiable linkage to a specific pollutant. In some cases, the pollutant and non-pollutant categories are linked and appear together in the list of impairment causes for a waterbody; however a non-pollutant impairment cause may appear independently of a pollutant cause. The following discussion provides some rationale for the application of the identified non-pollutant causes to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation 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 and/or nutrient loads, and the resultant lack of canopy cover can lead to increased water temperatures.

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 human-influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

High Flow Regime or Other Flow Alterations
Flow alteration refers to a change in the flow characteristics of a waterbody relative to natural conditions. An impairment listing caused by high flow regime or other flow alterations could be associated with changes in runoff and streamflow due to activities such as urban development, road construction, or timber harvest. Changes in runoff are commonly linked to elevated peak flows, which can also cause excess sedimentation by increasing streambank erosion and channel scour. Road

crossings, particularly where culverts are undersized or inadequately maintained, can also alter flows by causing water to back up upstream of the culvert. An impairment listing for other flow alterations can also be associated with human sources that cause a reduction in surface flow because of excessive sedimentation or channel modifications. Lastly, an impairment listing for other flow alterations may be associated with an impoundment or dam. Flow modifications caused by a dam can affect fish spawning, dissolved gas concentrations, water temperatures, channel form, and suspended and bottom sediment concentrations. Note: under Montana's Administrative Rules (ARM 17.30.602(17)), dams that have been in existence since at least July 1, 1971, and are being operated reasonably, are considered natural.

Low Flow Alterations

Streams are typically listed as impaired for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. 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 any state or federal regulations or guidance related to stream assessment and beneficial use determination. Subsequent to the identification of this as a probable cause of impairment, it is up to local users, agencies, and entities to improve flows through water and land management.

9.2 Monitoring and BMPs for Non-Pollutant Affected Streams

Habitat alteration impairments (i.e., alteration in streamside or littoral vegetative covers and physical substrate habitat alterations) can be linked to sediment TMDL development for lower Libby, Raven, and Wolf creeks. It is likely that meeting the sediment TMDL targets will also equate to addressing the habitat impairment conditions in each of these streams. For streams with habitat alteration impairments that do not have a sediment TMDL, meeting the sediment targets applied to streams of similar size will likely equate to addressing the habitat impairment condition for each stream.

Streams listed for non-pollutant impairments should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and temperature information where data is minimal and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses is not well defined. The monitoring and restoration strategies that follow in **Sections 10.0** and **11.0** are presented to address both pollutant and non-pollutant issues for streams in the Kootenai-Fisher project area with TMDLs in this document, and they are equally applicable to streams listed for the above non-pollutant impairment causes.

10.0 WATER QUALITY IMPROVEMENT PLAN

10.1 PURPOSE OF IMPROVEMENT STRATEGY

This section describes an overall strategy and specific on-the-ground measures designed to restore water quality beneficial uses and attain water quality standards in Kootenai-Fisher TMDL project area streams. The strategy includes general measures for reducing loading from each identified significant pollutant source.

This section should assist stakeholders in developing a watershed restoration plan (WRP) that will provide more detailed information about restoration goals within the watershed. The WRP may also encompass broader goals than the water quality improvement strategy outlined in this document. The intent of the WRP is to serve as a locally organized "road map" for watershed activities, prioritizing types of projects, sequences of projects, and funding sources towards achieving local watershed goals. Within the WRP, local stakeholders identify and prioritize streams, tasks, resources, and schedules for applying best management practices (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.

10.2 ROLE OF DEQ, OTHER AGENCIES, AND STAKEHOLDERS

The Montana Department of Environmental Quality (DEQ) does not implement TMDL pollutant-reduction projects for nonpoint source activities, but may provide technical and financial assistance for stakeholders interested in improving their water quality. Successful implementation of TMDL pollutant-reduction projects requires collaboration among private landowners, land management agencies, and other stakeholders. DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help support water quality improvement and pollution prevention projects, and help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers work collaboratively with local and state agencies to achieve water quality restoration goals and to meet TMDL targets and load reductions. Specific stakeholders and agencies that will likely be vital to restoration efforts for streams discussed in this document include:

- Lincoln Conservation District
- Kootenai River Network (KRN)
- U.S. Forest Service (USFS)
- Natural Resources and Conservation Service (NRCS)
- U.S. Fish & Wildlife Service (USFWS)
- U.S. Environmental Protection Agency (EPA)
- Montana Department of Natural Resources and Conservation (DNRC)
- Montana Fish, Wildlife and Parks (FWP)
- Montana Department of Environmental Quality (DEQ)
- Kootenai Tribe of Idaho
- Plum Creek Timber Company
- Revett Minerals, Inc.
- Mines Management Inc.

Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include:

- Flathead Conservation District
- Montana Trout Unlimited
- U.S. Army Corp of Engineers
- Montana Department of Transportation
- Montana Bureau of Mines and Geology
- Montana Water Center (at Montana State University)
- University of Montana Watershed Health Clinic
- Montana Aquatic Resources Services
- Montana State University Extension Water Quality Program

10.3 Water Quality Restoration Objectives

The water quality restoration objective for the Kootenai-Fisher Project Area is to reduce pollutant loads as identified throughout this document in order to meet the water quality standards and TMDL targets for full recovery of beneficial uses for all impaired streams. Meeting the TMDLs provided in this document will achieve this objective for all identified pollutant-impaired streams. Based on the assessment provided in this document, the TMDLs can be achieved through proper implementation of appropriate BMPs.

A WRP can provide a framework strategy for water quality restoration and monitoring in the Kootenai-Fisher TMDL Project Area, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. WRPs identify considerations that should be addressed during TMDL implementation and should assist stakeholders in developing a more detailed adaptive plan in the future. A locally developed WRP will likely provide more detailed information about restoration goals and spatial considerations but may also encompass more broad goals than this framework includes. A WRP would serve as a locally organized “road map” for watershed activities, sequences of projects, prioritizing of projects, and funding sources for achieving local watershed goals, including water quality improvements. The WRP is intended to be a living document that can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities.

The EPA requires nine minimum elements for a WRP, summarized here:

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected based on implemented management measures
3. Description of needed nonpoint source management measures
4. Estimate of the amounts of technical and financial assistance needed
5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time
9. A monitoring component to evaluate effectiveness of the implementation efforts over time

This document provides, or can serve as an outline, for many of the required elements. Water quality goals for sediment, nutrients, temperature, and metals pollutants are detailed in **Sections 5, 6, 7, and 8**, respectively. These goals include water quality and habitat targets as measures for long-term effectiveness monitoring. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Kootenai-Fisher TMDL Project Area. It is presumed that meeting all water quality and habitat targets will achieve the water quality goals for each impaired waterbody. **Section 11** identifies a general monitoring strategy and recommendations to track post-implementation water quality conditions and measure restoration successes.

In 2010, the USFWS approved a Native Fish Habitat Conservation Plan (NHCP) developed by Plum Creek Timber Company, Inc. (Plum Creek) for approximately 900,000 acres of company land. Habitat Conservation Plans are long-term management plans developed under authorization of the Endangered Species Act and directed toward conservation of key species such as the Bull Trout. Plum Creek is the largest private landowner within the Kootenai-Fisher TMDL Project Area. The NHCP contains mitigation measures to protect coldwater fisheries and includes detailed management prescriptions for grazing, timber harvest, and road construction and maintenance activities. The NHCP can serve as a model for WRPs developed in the Kootenai-Fisher TMDL Project Area.

10.4 Overview of Management Recommendations

TMDLs were completed for four waterbody segments for sediment, one waterbody segment for temperature, three waterbody segments for nutrients, and four waterbody segments for metals. Other streams in the project area may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL development at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDLs. Details specific to each stream, and therefore which of the following strategies may be most appropriate, are found within **Section 5.0, 6.0, 7.0** and **8.0**.

In general, restoration activities can be separated into two categories: active and passive. Passive restoration allows natural succession to occur within an ecosystem by removing a source of disturbance. Fencing off riparian areas from cattle grazing is a good example of passive restoration. Active restoration, on the other hand involves accelerating natural processes or changing the trajectory of succession. For example, historic placer mining often resulted in the straightening of stream channels and piling of processed rock on the streambank. These impacts would take so long to recover passively that active restoration methods involving removal of waste rock and rerouting of the stream channel would likely be necessary to improve stream and water quality conditions. In general, passive restoration is preferable for sediment, temperature, and nutrient problems because it is generally more cost effective, less labor intensive, and will not result in short term increase of pollutant loads as active restoration activities may. However, in some cases active restoration is the only feasible mechanism for achieving desired goals; these activities must be assessed on a case by case basis (Nature Education, 2013).

10.4.1 Sediment Restoration Approach

The goal of the sediment restoration strategy is to limit the availability, transport, and delivery of excess sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Monitoring data used to develop targets and determine impairments are described in **Section 5.0** and in **Appendices C and D** and **Attachment A**. Sediment restoration activities on impaired stream segments will help reduce the amount of fine sediment, reduce width/depth ratio, increase residual pool depth, increase pool frequency, increase the amount of large woody debris (LWD), increase riparian understory shrub cover, reduce impacts of human-caused sediment sources, and restore appropriate macroinvertebrate assemblages. These are indicators of successful restoration activities targeted toward sediment reduction and need to be considered together and within the context of stream potential in comparison to appropriate reference sites. For example, LWD and pool frequency tend to decline as stream size increases; therefore, indicators for these parameters will vary. General targets for these indicators are summarized in **Table 5-2**.

Streamside riparian and wetland vegetation restoration and long term management are crucial to achieving the sediment TMDLs. Native streamside riparian and wetland vegetation provides root mass which hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian and wetland vegetation 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. Suspended sediment is also deposited more effectively in healthy riparian zones and wetland areas during flooding because water velocities slow in these areas enough for excess sediment to settle out. Restoration recommendations involve the promotion of riparian and wetland recovery through improved grazing and land management (including the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas), application of timber harvest best management practices, restoration of streams affected by mining activity, floodplain and streambank stabilization, revegetation efforts, and instream channel and habitat restoration where necessary. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g., WRP).

Unpaved roads are a small source of sediment at the watershed scale; however, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams primarily include measures that divert water to ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. In addition, routine maintenance of unpaved roads (particularly near stream crossings) and proper sizing and maintenance of culverts, are crucial components to limiting sediment production from roads.

Mining was not specifically discussed in the source assessment, but waste materials can be a component of upland and in-channel sediment loading. The goal of the sediment restoration strategy is to limit the input of sediment to stream channels from abandoned mine sites and other mining-related sources. Goals and objectives for future restoration work include the following:

- Prevent waste rock and tailings materials/sediments from migrating into adjacent surface waters, to the extent practicable.
- Reduce or eliminate concentrated runoff and discharges that transport sediment to adjacent surface waters, to the extent practicable.
- Identify, prioritize, and select response and restoration actions of areas affected by historical mining, based on a comprehensive source assessment and risk analysis.

10.4.2 Temperature Restoration Approach

The goal of the temperature restoration approach is to reduce water temperatures where possible to be consistent with naturally occurring conditions. The most significant mechanism for reducing water temperature in Wolf Creek is increasing riparian shade. Other factors that will help are: using water conservation measures to maximize water left in the stream, improving overwidened portions of the stream, and maintaining conditions where Wolf Creek is currently meeting the target.

Increases in shade can be accomplished through the restoration and protection of shade-providing vegetation within the riparian corridor. This type of vegetation can also have the added benefit of improving streambank stabilization to reduce bank erosion, slowing lateral river migration, and providing a buffer to prevent pollutants from upland sources from entering the stream. In some cases, this can be achieved by limiting the frequency and duration of livestock access to the riparian corridor, or through other grazing related BMPs such as installing water gaps or off-site watering. Other areas may require planting, active bank restoration, and protection from browse to establish vegetation.

Given the limited amount of consumptive water use in the Wolf Creek watershed, it is unknown to what extent instream flow could be increased, if at all. If increases in instream summer flows are possible, they can be achieved through a thorough investigation of water use practices and water conveyance infrastructure, and a willingness and ability of local water users to keep more water in the stream. This TMDL document cannot, nor is it intended to, prescribe limitations on individual water rights owners and users. Local water users should work collectively and with local, state, and federal resource management professionals to review water use options and available assistance programs.

Recovery of stream channel morphology in most cases will occur slowly over time and follow the improvement of riparian condition, stabilization of streambanks, and reduction in overall sediment load. For smaller streams, there may be discrete locations or portions of reaches that demand a more rapid intervention through active physical restoration, but size, scale, and cost of restoration in most cases are limiting factors to applying this type of remedy.

The above approaches give only the broadest description of activities to help reduce water temperatures. The temperature assessment described in **Section 7.0** looked at possible scenarios based on limited information at the watershed scale. Those scenarios showed that improvements in stream temperatures can primarily be made by improvements to riparian shade. It is strongly encouraged that resource managers and land owners continue to work to identify all potential areas of improvement and develop projects and practices to reduce stream temperatures in Wolf Creek.

10.4.3 Nutrients Restoration Approach

The goal of the nutrient restoration strategy is to reduce nutrient input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, and limiting the transport of nutrients from rangeland, cropland and mined areas (including impoundments and other storage facilities).

Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for agricultural areas. Grazing systems with the explicit goal of increased vegetative post-grazing ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

- The timing, frequency, and duration of near-stream grazing
- The spacing and exposure duration of on-stream watering locations
- Provision of off-stream watering areas to minimize near-stream damage and allow impoundment operations that minimize salt accumulations
- Active reseeding and rest rotation of locally damaged vegetation stands
- Improved management of irrigation systems

- Incorporation of streamside vegetation buffer to irrigated croplands and animal feeding areas

In general, these are sustainable grazing and cropping practices that can reduce nutrient inputs while meeting production goals. The appropriate combination of BMPs will differ according to landowner preferences and equipment but are recommended as components of a comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in Montana. The local USDA Service Center and county conservation district offices are geared to offer both planning and implementation assistance.

In addition to the agricultural-related BMPs, a reduction of sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan, particularly where excess phosphorus is a problem. Additional sediment-related BMPs are presented in **Section 10.5.**

Source assessment work during this project indicated mining activities are a source of nitrate loading to Lake and Stanley creeks. Since nitrate is a byproduct of blasting explosives used during mining, the explosives are the most likely source of nitrogen associated with mining. It could be transferred to surface water via groundwater from the mine void migrating through fractured bedrock, from unlined waste impoundments, discharging mine adits, and mine wastes on-site or in-channel. The goal of the nutrient restoration strategy is to limit the input of nutrients to stream channels from active and abandoned mine sites. The source assessment conducted to support TMDL development (**Section 6.5**) can help provide a starting point for where most loading is occurring, but for most of the mining-related sources, additional analysis and identification will likely be required to identify site-specific delivery pathways and to develop mitigation plans.

10.4.4 Metals Restoration Approach

Metal mining is the principal human-caused source of excess metals loading in the project area. To date, federal and state government agencies have funded and completed reclamation projects associated with past mining. Statutory mechanisms and corresponding government agency programs will continue to have the leading role for future restoration. Restoration of metals sources is typically conducted under state and federal cleanup programs. Rather than a detailed discussion of specific BMPs, general restoration programs and funding sources applicable to mining sources of metals loading are provided in **Section 10.5.7** and **Appendix H.** Past efforts have produced abandoned mine site inventories with enough descriptive detail to prioritize the properties contributing the largest metals loads. Additional monitoring needed to further describe impairment conditions and loading sources is addressed in **Section 11.3.1**

10.4.5 Non-Pollutant Restoration Approach

Although TMDL development is not required for non-pollutant listings, they are frequently linked to pollutants, and addressing non-pollutant causes, such as flow and habitat alterations, is an important component of TMDL implementation. Non-pollutant listings within the Kootenai-Fisher TMDL Project Area are described in **Section 9.0**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Kootenai-Fisher TMDL Project Area are not also addressing non-pollutant impairments, additional non-pollutant related BMP implementation should be considered.

10.5 Restoration Approaches by Source

General management recommendations are outlined below for the major sources of human caused pollutant loads in the Kootenai-Fisher TMDL Project Area: agricultural sources, residential development, forestry and timber harvest, riparian and wetland vegetation removal, roads, and mining. Applying BMPs is the core of the nonpoint source pollutant reduction strategy, but BMPs are only part of a watershed restoration strategy. For each major source, BMPs will be most effective as part of a comprehensive management strategy. The WRP developed by local watershed groups should contain more detailed information on restoration goals and specific management recommendations that may be required to address key pollutant sources. BMPs are usually identified as a first effort and further monitoring and evaluation of activities and outcomes, as part of an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is an important part of the restoration process, and monitoring recommendations are outlined in **Section 11.0**.

10.5.1 Agriculture Sources

Reduction of pollutants from upland agricultural sources can be accomplished by limiting the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil and runoff before it enters a waterbody. The main BMP recommendations for the Kootenai-Fisher TMDL Project Area are riparian buffers, wetland restoration, and vegetated filter strips, where appropriate. These methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept pollutants. Filter strips and buffers are even more effective for reducing upland agricultural related sediment when used in conjunction with BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, and strip-cropping (although currently there is very little cropping activity that occurs in the Kootenai-Fisher TMDL Project Area). Additional BMP information, design standards and effectiveness, and details on the suggested BMPs can be obtained from your local USDA Agricultural Service Center and in Montana’s Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

An additional benefit of reducing sediment input to the stream is a decrease in sediment-bound nutrients. Reductions in sediment loads may help address some nutrient related problems. Nutrient management considers the amount, source, placement, form, and timing of plant nutrients and soil amendments. Conservation plans should include the following information (NRCS Conservation Practice Standard 590 and 590-1, Nutrient Management) (United States Department of Agriculture, Natural Resources Conservation Service, 2005):

- 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 environmentally sensitive areas, including streams, wetlands, springs, or other locations that deliver surface runoff to groundwater or surface water
- Guidelines for operation and maintenance

10.5.1.1 Grazing

Grazing has the potential to increase sediment and nutrient loads, as well as stream temperatures (by altering channel width and riparian vegetation), but these effects can be mitigated with appropriate management. Development of riparian grazing management plans should be a goal for any landowner 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 necessarily eliminate all grazing in riparian corridors. In some areas however, a more limited management strategy may be necessary for a period of time in order to accelerate reestablishment of a riparian community with the most desirable species composition and structure.

Every livestock grazing operation should have a grazing management plan. The NRCS Prescribed Grazing Conservation Practice Standard (Code 528) recommends the plan include the following elements (Natural Resource Conservation Service, 2010):

- A map of the operation showing fields, riparian and wetland areas, winter feeding areas, water sources, animal shelters, etc.
- The number and type of livestock
- Realistic estimates of forage needs and forage availability
- The size and productivity of each grazing unit (pasture/field/allotment)
- The duration and time of grazing
- Practices that will prevent overgrazing and allow for appropriate regrowth
- Practices that will protect riparian and wetland areas and associated water quality
- Procedures for monitoring forage use on an ongoing basis
- Development plan for off-site watering areas

Reducing grazing pressure in riparian and wetland areas and improving forage stand health are the two keys to preventing nonpoint source pollution from grazing. Grazing operations should use some or all of the following practices:

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent 'loafing' in wet areas
- Managing riparian pastures separately from upland pastures
- Installing salt licks, feeding stations, and shelter fences in areas that prevent 'loafing' in riparian areas and help distribute animals
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management that takes season, frequency, and duration into consideration

The following resources provide guidance to help prevent pollution and maximize productivity from grazing operations:

- Plum Creek Timber Company's Native Fish Habitat Conservation Plan (http://www.plumcreek.com/Environment/nbspSustainableForestrySFI/nbspSFIImplementation/HabitatConservationPlans/tabid/153/Default.aspx)
- USDA, Natural Resources Conservation Service
  Offices serving Lincoln County are located in Eureka and Kalispell (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): Nonpoint Source Management Plan (http://deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram.mcpx)

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 Kootenai-Fisher TMDL Project Area are limiting livestock access to streams and stabilizing the stream at access points, providing off-site watering sources when and where appropriate, planting native stabilizing vegetation along streambanks, and establishing and maintaining riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation.

10.5.1.2 Flow and 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 flush sediment and attenuate other 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 water quality 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 coldwater fishery conservation and TMDL goals. Understanding irrigation water, groundwater, and surface water interactions is an important part of understanding how irrigation practices will affect streamflow during specific seasons.

Some irrigation practices in western Montana are based on flood irrigation methods. Occasionally head gates and ditches leak, which can decrease the amount of water in diversion flows. The following recommended activities could potentially result in notable water savings:
- Install upgraded head gates for more exact control of diversion flow and to minimize leakage when not in operation
- Develop more efficient means to supply water to livestock
- Determine necessary diversion flows and timeframes that would reduce over watering and improve forage quality and production
- Where appropriate, redesign or reconfigure irrigation systems
- Upgrade ditches (including possible lining, if appropriate) to increase ditch conveyance efficiency

Some water from spring and early summer flood irrigation likely returns as cool groundwater to the streams during the heat of the summer. These critical areas could be identified so that they can be preserved as flood irrigation areas. Other irrigated areas which do not contribute to summer groundwater returns to the river should be identified as areas where year round irrigation efficiencies could be more beneficial than seasonal management practices. Winter baseflow should also be considered during these investigations.

10.5.1.3 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment inputs. The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendations for the Kootenai-Fisher TMDL Project Area are vegetated filter strips and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70% for the filter strips and 50% for the buffers (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

10.5.2 Forestry and Timber Harvest

The Kootenai-Fisher TMDL Project Area is part of one of the best timber growing regions in Montana. As a result it has been impacted by historical timber harvest activities. Future harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 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.

The SMZ Law protects against excessive erosion and therefore is appropriate for helping meet sediment load allocations. USFS INFISH Riparian Habitat Conservation Area guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade. This guidance improves upon Montana's SMZ law and includes an undisturbed 300 foot buffer on each side of fish bearing streams and 150 foot buffer on each side of non-fish bearing streams with limited exclusions and BMP guidance for timber harvest, roads, grazing, recreation and other human sources (U.S. Department of Agriculture, Forest Service, 1995). The Kootenai National Forest adheres to these guidelines. The Native Fish Habitat Conservation Plan developed by Plum Creek Timber includes a riparian management section that supplements the SMZ riparian buffer rules to help Plum Creek minimizes impacts from timber harvest in riparian areas. It includes specific commitments to leave more trees in locations that provide the maximum benefit, such as channel migration zones and provide for an additional caution area outside of the SMZ.

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Water yield and peak flow increases should be modeled in areas of continued timber harvest and potential effects should be evaluated. Furthermore, increased use, construction, and maintenance of unpaved roads associated with forestry and timber harvest activities should be addressed with appropriate BMPs discussed in **Section 10.5.5**. Finally, noxious weed control should be actively pursued in all harvest areas and along all forest roads.

10.5.3 Riparian Areas, Wetlands, and Floodplains

Healthy and functioning riparian areas, wetlands, and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. The performance of the above named functions is dependent on the connectivity of riparian areas, wetlands, and floodplains to both the stream channel and upland areas. Human activities affecting the quality of these transitional habitats or their connectivity can alter their performance and greatly affect the transport of water, sediments, and contaminants (e.g., channelization, increased stream power, bank erosion, and habitat loss or degradation). Therefore, restoring, maintaining, and protecting riparian areas, wetlands, and floodplains within the watershed should be a priority of TMDL implementation in the Kootenai-Fisher TMDL Project Area.

Reduction of riparian and wetland vegetative cover by various land management activities is a principal cause of water quality and habitat degradation in watersheds throughout Montana. Although implementation 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.

Factors influencing the appropriate riparian and wetland restoration would include severity of degradation, site-potential for various species, and availability of local sources for native transplant materials. In general, riparian and wetland plantings would promote establishment of functioning stands of native species. The following recommended restoration measures would allow for stabilization of the soil, decrease sediment delivery to the stream, and increase absorption of nutrients from overland runoff:

- Harvesting and transplanting locally available sod mats with an existing dense root mass provides immediate promotion of bank stability and filtering nutrients and sediments
- Seeding with native graminoids (grasses and sedges) and forbs is a low cost activity at locations where lower bank shear stresses would be unlikely to cause erosion
- Willow sprigging expedites vegetative recovery, but involves harvest of dormant willow stakes from local sources
- 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

Note: Before transplanting *Salix* from one location to another it is important to determine the exact species so that we do not propagate the spread of non-native species. There are several non-native willow species that are similar to our native species and commonly present in Montana watersheds.

In addition to the benefits described above, it should be noted that in some cases, wetlands act as areas of shallow subsurface groundwater recharge and/or storage areas. The captured water via wetlands is then generally discharged to the stream later in the season and contributes to the maintenance of base flows and stream temperatures. Restoring ditched or drained wetlands can have a substantial effect on the quantity, temperature, and timing of water returning to a stream, as well as the pollutant filtering capacity that improved riparian and wetlands provide.

10.5.4 Residential/Urban Development

There are multiple sources and pathways of pollution to consider in residential and urban areas. Destruction of riparian areas, pollutants from both functioning and failing septic systems, and stormwater generated from impervious areas and construction sites are discussed below.

10.5.4.1 Riparian Degradation

Residential development adjacent to streams can affect the amount and health of riparian vegetation, the amount of large woody debris available in the stream, and might result in placement of riprap on streambanks (see **Section 10.5.5**). As discussed in the above section on riparian areas, wetlands, and floodplains, substantially degraded riparian areas do not effectively filter pollutants from upland runoff. Riparian areas that have been converted to lawns or small acreage pastures for domestic livestock may suffer from increased contributions of nutrients, sediment, and bacteria, as well as increased summer stream temperatures, increased channel erosion, and greater damage to property from flooding (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

Some of these effects are apparent within the Lake Creek watershed, where residential development has caused the erosion of fine-grained sediment from streambanks resulting in sedimentation and degradation of spawning habitat. FWP has recently purchased land for a conservation easement to help reduce residential development within the Lake Creek watershed. For landowners, conservation easements can be a viable alternative to subdividing land and can be facilitated through several organizations such as The Nature Conservancy, the Trust for Public Land, and FWP. Further information on conservation easements and other landowner programs can be obtained from FWP (http://fwp.mt.gov/fishAndWildlife/habitat/wildlife/programs/landownersGuide.html).

DEQ encourages the consideration of adopting local zoning or regulations that protect the functions of floodplains and riparian and wetland areas where future growth may occur. Requirements for protecting native vegetation riparian buffers can be an effective mechanism for maintaining or improving stream health. Local outreach activities to inform new residential property owners of the effects of riparian degradation may also prevent such activities from occurring, including providing information on: appropriate fertilizer application rates to lawns and gardens, regular septic system maintenance, preserving existing riparian vegetation, native vegetation for landscaping, maintaining a buffer to protect riparian and wetland areas, and practices to reduce the amount of stormwater originating from developed property. Montana’s Nonpoint Source Management Plan contains suggested BMPs to address the effects of residential and urban development, and also contains an appendix of setback regulations that have been adopted by various cities and counties in Montana (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). Planning guides and informational publications related to wetlands and native plant species in Montana can be found on DEQ’s Wetlands Conservation website at: http://deq.mt.gov/wqinfo/Wetlands/default.mcpx.

10.5.4.2 Septic

There are approximately 585 structures in the Lake Creek watershed that potentially have septic systems. This number is likely to increase with future residential development in the Lake Creek watershed and other watersheds within the Kootenai-Fisher TMDL Project Area. Nutrient loading values for septic systems vary depending on soil type and distance to the nearest stream, but typical values for nitrogen and phosphorous loads from individual septic systems are 30.5 lbs/yr and 6.44 lbs/yr, respectively. However, septic systems should already have minimum design/installation requirements, which should serve as a basic BMP. Older systems should be upgraded and all new systems should meet these minimum requirements.

10.5.4.3 Stormwater

Where precipitation from rain or snowmelt events does not infiltrate soils in urban areas and at construction sites, it drains off the landscape as stormwater, which can carry pollutants into waterways. As the percentage of impervious surfaces (e.g., streets, parking lots, roofs) increases, so does the volume of stormwater and pollutant loads delivered to waterbodies. Although stormwater is not currently identified as a significant source of pollutant contributions for the streams discussed in this document, stormwater management could be a consideration when identifying water quality improvement objectives within the watershed restoration plan. The primary method to control stormwater discharges is the use of BMPs. Additional information can be found in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). A guide to stormwater BMPs can be found on EPA's National Menu of Stormwater Best Management Practices at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm. The Montana Water Center also has a website dedicated to stormwater control for construction activities: http://stormwater.montana.edu/.

10.5.5 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 local land use planning initiatives.

Bank stabilization using natural channel design techniques can provide both bank stability and aquatic habitat potential. The primary recommended structures include natural or "natural-like" structures, such as large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent cottonwood-dominated riparian community types. When used together, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to fillslopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

10.5.6 Unpaved Roads and Culverts

Unpaved roads contribute sediment (as well as nutrients and other pollutants) to streams in the Kootenai-Fisher TMDL Project Area. The road sediment reductions provided in this document, and detailed in **Appendix D**, represent an estimation of the sediment load that would remain once additional road BMPs are applied. The main focus of the BMPs used to estimate reduction in loading was to reduce the contributing length to the maximum extent practicable at each crossing. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). Examples include:

- Providing adequate ditch relief up-grade of stream crossings
- Constructing waterbars, where appropriate, and up-grade of stream crossings
- Using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch
- Insloping roads along steep banks with the use of cross slopes and cross culverts
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches
- For maintenance, grading materials to the center of the road and avoid removing the toe of the cutslope
- Preventing disturbance to vulnerable slopes
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters
- Where possible, limiting road access during wet periods when drainage features could be damaged

Undersized and improperly installed and maintained culverts can be a substantial source of sediment to streams, and a barrier to fish and other aquatic organisms. Although there are a lot of factors associated with culvert failure and it is difficult to estimate the true at-risk load, the culvert analysis (**Appendix D**) found that approximately 90% of the culverts pass the discharge of a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 21 culverts in the watershed, which is a small percentage of the total culverts, and it is recommended that the remaining culverts be assessed so that a priority list may be developed for culvert replacement. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non-fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

Another consideration for culvert upgrades should be fish and aquatic organism passage. In a coarse assessment of fish passage, 96% of assessed culverts were determined to have a high certainty of not providing juvenile fish passage at all flows; this suggests that a large percentage of culverts in the watershed are barriers to fish passage. 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, can aid in culvert design.

10.5.7 Mining

The Kootenai-Fisher TMDL Project Area and Montana more broadly, have a legacy of mining which continues today. Mining activities may have impacts that extend beyond increased metal concentrations in the water. Channel alteration, riparian degradation, and runoff and erosion associated with mining can lead to sediment, habitat, nutrient, and temperature impacts as well. The need for further characterization of impairment conditions and loading sources is addressed through the monitoring plan in **Section 11.3**.

A number of state and federal regulatory programs have been developed over the years to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches that may be applicable to the Kootenai-Fisher TMDL Project Area include:

- 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).
- The federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

More detailed information is included in **Appendix H**.

10.5.7.1 The Surface Mining Control and Reclamation Act (SMCRA)

DEQ's Abandoned Mines Bureau (AMB) is responsible for reclamation of abandoned mines in Montana. The AMB reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA funding is collected as a per ton fee on coal production that is then distributed to states by the federal Office of Surface Mining Reclamation and Enforcement. Funding eligibility is based on land ownership and date of mining disturbance. Eligible abandoned coal mine sites have a priority for reclamation construction funding over eligible non-coal sites. Areas within federal Superfund sites and areas where there is a reclamation obligation under state or federal laws are not eligible for expenditures from the abandoned mine reclamation program. **Table 10-1** lists the priority abandoned mines in the Kootenai-Fisher TMDL Project Area.

Table 10-1. Priority Abandoned Mine Sites in the Kootenai-Fisher TMDL Project Area

Site Name	Receiving Stream	Original AIMSS Ranking Score*
Snowshoe Mine	Snowshoe Creek	69.39
Cherry Creek Millsite	Cherry Creek	100

* AIMSS = Abandoned and Inactive Mines Scoring System

10.5.7.2 Other Historical Mine Remediation Programs

Appendix H provides a summary of mining remediation programs and approaches that can be or may currently be applied within the Kootenai-Fisher TMDL Project Area. The extent that these programs may be necessary will depend on the level of stakeholder involvement and initiative throughout the watersheds with metals impairment causes.

10.6 Potential Funding and Technical Assistance Sources

Prioritization and funding of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project successes and failures. Several government agencies and also a few non-governmental organizations fund or can provide assistance with watershed or water quality improvement projects or wetlands restoration projects. Below is a brief summary of potential funding sources and organizations to assist with TMDL implementation. **Appendix H** of this document outlines funding sources to assist with mining related TMDL implementation.

10.6.1 Section 319 Nonpoint Source Grant Program

DEQ issues a call for proposals every year to award Section 319 grant funds administered under the federal Clean Water Act. The primary goal of the 319 program is to restore water quality in waterbodies whose beneficial uses are impaired by nonpoint source pollution and whose water quality does not meet state standards. 319 funds are distributed competitively to support the most effective and highest priority projects. In order to receive funding, projects must directly implement a DEQ-accepted watershed restoration plan and funds may either be used for the education and outreach component of the WRP or for implementing restoration projects. The recommended range for 319 funds per project proposal is $10,000 to $30,000 for education and outreach activities and $50,000 to $300,000 for implementation projects. All funding has a 40% cost share requirement, and projects must be administered through a governmental entity such as a conservation district or county, or a nonprofit organization. For information about past grant awards and how to apply, please visit http://deq.mt.gov/wqinfo/nonpoint/319GrantInfo.mcpx.

10.6.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for projects that focus on habitat restoration to benefit wild and native fish. Anyone ranging from a landowner or community-based group to a state or local agency is eligible to apply. Applications are reviewed annually in December and June. Projects that may be applicable to the Kootenai-Fisher Project Area include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats. For additional information about the program and how to apply, please visit http://fwp.mt.gov/fishAndWildlife/habitat/fish/futureFisheries/.

10.6.3 Watershed Planning and Assistance Grants

The DNRC administers Watershed Planning and Assistance Grants to watershed groups that are sponsored by a conservation district. Funding is capped at $10,000 per project and the application cycle is quarterly. The grant focuses on locally developed watershed planning activities; eligible activities include developing a watershed plan, group coordination costs, data collection, and educational activities. For additional information about the program and how to apply, please visit http://dnrc.mt.gov/cardd/LoansGrants/WatershedPlanningAssistance.asp.

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

10.6.4 Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is administered by NRCS and offers financial (i.e., incentive payments and cost-share grants) and technical assistance to farmers and ranchers to help plan and implement conservation practices that improve soil, water, air and other natural resources on their land. The program is based on the concept of balancing agricultural production and forest management with environmental quality, and is also used to help producers meet environmental regulations. EQIP offers contracts with a minimum length of one year after project implementation to a maximum of 10 years. Each county receives an annual EQIP allocation and applications are accepted continually during the year; payments may not exceed $300,000 within a six-year period. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

10.6.5 Resource Indemnity Trust/Reclamation and Development Grants Program

The Resource Indemnity Trust / Reclamation and Development Grants Program (RIT/RDG) is an annual program administered by DNRC that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the DEQ Abandoned Mine Lands (AML) priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDG program funds can also be used for conducting site assessment/characterization activities such as identifying specific sources of water quality impairment. RIT/RDG 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. For additional information about the program and how to apply, please visit http://dnrc.mt.gov/cardd/ResourceDevelopment/rdgp/ReclamationDevelopmentGrantsProgram.asp.

10.6.6 Montana Partners for Fish and Wildlife

Montana Partners for Fish and Wildlife is a program under the U.S. Fish & Wildlife Service that assists private landowners to restore wetlands and riparian habitat by offering technical and financial assistance. For additional information about the program and to find your local contact for the Kootenai River watershed, please visit: http://www.fws.gov/mountain-prairie/pfw/montana/.

10.6.7 Wetlands Reserve Program

The Wetlands Reserve Program is a voluntary conservation program administered by the NRCS that offers landowners the means to restore, enhance, and protect wetlands on their property through permanent easements, 30 year easements, or Land Treatment Contracts. The NRCS seeks sites on agricultural land where former wetlands have been drained, altered, or manipulated by man. The landowner must be interested in restoring the wetland and subsequently protecting the restored site. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/main/mt/programs/easements/wetlands/

10.6.8 Montana Wetland Council

The Montana Wetland Council is an active network of diverse interests that works cooperatively to conserve and restore Montana's wetland and riparian ecosystems. Please visit their website to find dates and locations of upcoming meetings, wetland program contacts, and additional information on potential grants and funding opportunities: http://deq.mt.gov/wqinfo/wetlands/wetlandscouncil.mcpx.

10.6.9 Montana Natural Heritage Program

The Montana Natural Heritage Program is a valuable resource for restoration and implementation information including maps. Wetlands and riparian areas are one of the 14 themes in the Montana Spatial Data Infrastructure. The Montana Wetland and Riparian Mapping Center (found at: http://mtnhp.org/nwi/) is creating a statewide digital wetland and riparian layer as a resource for management, planning, and restoration efforts.

10.6.10 Montana Aquatic Resources Services, Inc.

Montana Aquatic Resources Services, Inc. (MARS) is a nonprofit organization focused on restoring and protecting Montana's rivers, streams and wetlands. MARS identifies and implements stream, lake, and wetland restoration projects, collaborating with private landowners, local watershed groups and conservation districts, state and federal agencies, and tribes. For additional information about the program, please visit http://montanaaquaticresources.org/.

11.0 MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

11.1 MONITORING PURPOSE

The monitoring strategies discussed in this section are an important component of watershed restoration, and a requirement of TMDL implementation under the Montana Water Quality Act (MCA 75-5-703(7)), 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. The scale of the watershed analysis, coupled with constraints on time and resources, often result in necessary compromises that include estimations, extrapolation, and a level of uncertainty in TMDLs. The margin of safety (MOS) (**Section 4.4**) is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities, the amount of reduction of instream pollutants (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

The monitoring strategy presented in this section provides a starting point for the development of more detailed planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet the water quality improvement goals outlined in this document. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on funding opportunities and stakeholder priorities for restoration. Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, DEQ will conduct a formal evaluation of the waterbody's impairment status and whether TMDL targets and water quality standards are being met.

11.2 ADAPTIVE MANAGEMENT AND UNCERTAINTY

In accordance with the Montana Water Quality Act (MCA 75-5-703 (7) and (9)), DEQ is required to assess the waters for which TMDLs have been completed and restoration measures, or best management practices (BMPs), have been applied to determine whether compliance with water quality standards has been attained. This aligns with an adaptive management approach that is incorporated into DEQ's assessment and water quality impairment determination process.

Adaptive management as discussed throughout this document is a systematic approach for improving resource management by learning from management outcomes, and allows for flexible decision making. There is an inherent amount of uncertainty involved in the TMDL process, including: establishing water quality targets, calculating existing pollutant loads and necessary load allocations, and determining effects of BMP implementation. Use of an adaptive management approach based on continued monitoring of project implementation helps manage resource commitments as well as achieve success in meeting the water quality standards and supporting all water quality beneficial uses. This approach further allows for adjustments to restoration goals, TMDLs, and/or allocations, as necessary.

For an in-depth look at the adaptive management approach, view the U.S. Department of the Interior's (DOI) technical guide and description of the process at:

http://www.doi.gov/archive/initiatives/AdaptiveManagement/. DOI includes **Figure 11-1** below in their technical guide as a visual explanation of the cyclic process of adaptive management (Williams et al., 2009).

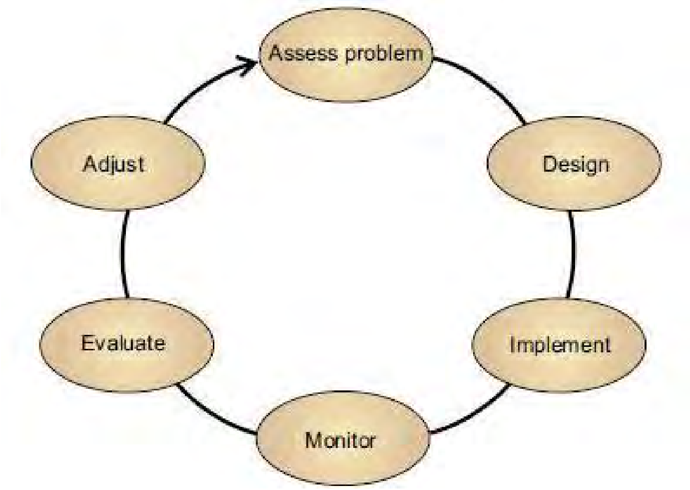

Figure 11-1. Diagram of the adaptive management process

11.3 Future Monitoring Guidance

The objectives for future monitoring in the Kootenai-Fisher TMDL Project Area include:

- Strengthen the spatial understanding of sources for future restoration work, which will also improve source assessment analysis for future TMDL review
- Gather additional data to supplement target analysis, better characterize existing conditions, and improve or refine assumptions made in TMDL development
- Gather consistent information among agencies and watershed groups that is comparable to the established water quality targets and allows for common threads in discussion and analysis
- Expand the understanding of streams throughout the Kootenai-Fisher TMDL Project Area beyond those where TMDL have been developed and address issues
- Track restoration projects as they are implemented and assess their effectiveness

11.3.1 Strengthening Source Assessment

In the Kootenai-Fisher TMDL Project Area, the identification of pollutant sources was conducted largely through tours of the watershed, assessments of aerial photographs, the incorporation of geographic information system information, reviewing and analyzing available data, and the review of published scientific studies. Limited field-verification of the available data was able to be conducted. In many cases, assumptions were made based on known watershed conditions and extrapolated throughout the project area. As a result, the level of detail often does not provide specific areas on which to focus restoration efforts, only broad source categories to reduce pollutant loads from each of the discussed streams and subwatersheds. Strategies for strengthening source assessments for each of the pollutant categories are outlined below.

Sediment

- Field surveys of roads and road crossings to identify specific contributing segments and crossings, their associated loads, and prioritize those road segments/crossings of most concern.

- Reviews of land use practices within the specific 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 streambank erosion conditions and investigation of related contributing factors for each subwatershed of concern through site visits and subwatershed-scale bank erosion hazard index (BEHI) assessments. Additionally, the development of bank erosion retreat rates specific to the Kootenai-Fisher TMDL Project Area 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 landscape settings 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.

Temperature

- Field surveys to better identify and characterize riparian area conditions and potential for improvement
- Identification of possible areas for improvement in shading along major tributaries, particularly in the mid to upper Wolf Creek watershed where past management has degraded riparian vegetation
- Collection of flow measurements at all temperature monitoring locations during the time of data collection
- Investigation of groundwater influence on instream temperatures, and relationships between groundwater availability and water use in the Wolf Creek watershed and the entire Kootenai-Fisher project area
- Assessment of irrigation practices (though limited) and other water use in Wolf Creek watershed and Kootenai-Fisher project area and potential for improvements in water use that would result in increased instream flows
- Use additional collected data to evaluate and refine the temperature targets

Nutrients

- A better understanding of nutrient concentrations in groundwater (as well as the sources) and the spatial variability of groundwater with high nutrient concentrations
- A better understanding of cattle grazing practices and the number of animals grazed in the Kootenai-Fisher TMDL Project Area
- A better understanding of natural background concentrations in Stanley Creek, including a more focused source assessment for Fairway Creek
- A more detailed understanding of nutrient contributions from historical and current mining within the watershed, particularly the Troy Mine tailings impoundment
- A better understanding of septic system contributions to nutrient loads
- A review of land management practices specific to subwatersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories
- Evaluation of didymo in Lake Creek and if it is contributing to elevated AFDM values
- Additional sampling in streams that have limited data

Metals

The level of detail of the source assessment for this project allowed allocations to broad source categories and geographic areas. Therefore, additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources. The following is recommended:

- Refinement of the sampling approach and locations at individual mine sites to better partition pollutant loading from discrete sources within the broader mine site. This may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to locate stream segments that represent background loading.
- In Big Cherry Creek, the inability to distinguish background aluminum loading from human-caused aluminum loading led to use of a broad composite allocation. Further sampling would allow better delineation of aluminum and other metal sources.
- DEQ recommends additional monitoring of all metals parameters in the upstream sections of Stanley Creek, as there were limited upstream data from above the Troy Mine in Stanley Creek.
- DEQ recommends additional monitoring of all metals parameters in all sections of Lake Creek. Additional monitoring of metals water quality data will yield a better understanding of metals source locations in the watershed.

The descriptions of several of the priority abandoned mines are based on information collected during early 1990s site inventories. Additional site reconnaissance and monitoring of discrete sources is needed to better understand sources of metals loading and develop remediation strategies. The following bulleted items describe source assessment information that could improve our understanding of loading at the priority mine sites.

- A more detailed characterization of mine tailings in the streambanks of Snowshoe Creek and their impacts on water quality.
- A more detailed surface water monitoring regime directed at defining sources of metals pollution from the Cherry Creek Mill site.

11.3.2 Increasing Available Data

While the Kootenai-Fisher TMDL Project Area has undergone significant remediation and restoration activities, data are 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 Kootenai-Fisher TMDL Project Area, each of the streams of interest was stratified into unique reaches based on physical characteristics and human-caused influences. A total of 15 sites were sampled throughout the watershed, which is 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. It would also provide more specific information on a per-stream basis and for the Kootenai-Fisher TMDL Project Area as a whole, and can be used for reach by reach comparisons and assessing potential influencing factors and resultant outcomes that exist throughout the project area.

Temperature
Temperature investigation for Wolf Creek included 12 data loggers that were deployed throughout the stream. Increasing the number of data logger locations and the number of years of data, including collection of associated flow data, would improve our understanding of instream temperature changes and better identify influencing factors on those changes. Collecting additional stream temperature data in sections with the most significant temperature changes and/or largest spatial gaps between loggers will also help refine the characterization of temperature conditions in Wolf Creek. In addition, since shade is the major focus of the allocations, a more detailed assessment of existing vegetation, limitation, and identification of areas for passive and active restoration of riparian vegetation on Wolf Creek and major tributaries is recommended.

Nutrients
Water quality sampling locations for nutrients were distributed spatially along each stream in order to best delineate nutrient sources. Over multiple sample seasons, sampling locations were refined to better quantify loading sources to the impaired waterbodies. However, due to the limited amount of surface flow in Raven Creek, sampling locations were restricted to the lower section of the stream. Available data indicate borderline impairment for Raven Creek, and additional data collection is recommended to strengthen the impairment determination. To better evaluate nutrient loading, source refinement will continue to be necessary on all streams with nutrient TMDLs and those that have not yet been assessed in the project area. With changing land uses and/or new permitted discharges to surface waters, it will be important to continually assess nutrient sources in a watershed.

Metals
Additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources, such as those having discrete adit discharges versus more diffuse runoff from mine waste accumulations. The needed refinements may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to better locate stream segments representing background loading. Additional data collection is recommended for:

- The Snowshoe Mine section of Snowshoe Creek that was restored between 2007 and 2010. Future monitoring should be planned to track arsenic, cadmium, lead and zinc concentrations in Snowshoe Creek as well as antimony, copper, mercury and silver concentrations, with attention to any soil and land conservation BMPs that may be implemented to meet the sediment TMDL .
- Copper concentrations in Lake Creek. The copper impairment determination was based on the detected concentration exceeding the twice the acute aquatic life standard. Future reassessment based on a larger sample population may conclude that copper is no longer an impairment cause to Lake Creek.
- All metals parameters that were listed for impairment in the upstream sections of Stanley Creek. There was limited upstream data from above the Troy Mine in Stanley Creek.

Table 11-1 lists the waterbodies, pollutants, and flow conditions where additional data is needed.

Table 11-1. Waterbodies, metal pollutants, and flow conditions for which additional data is needed

Stream Segment	Pollutant(s)	Flow Condition
Snowshoe Creek	Arsenic	High and Low
	Cadmium	High and Low
	Lead	High and Low
	Zinc	High and Low
Stanley Creek	Cadmium	High and Low
	Copper	High and Low
	Lead	High and Low
	Zinc	High and Low
Lake Creek	Copper	High and Low

For the pollutant-waterbody combinations in **Table 11-1**, follow up monitoring should focus on defining the contribution from sources in Snowshoe and Lake Creeks, as well as defining background water quality conditions in Stanley Creek. As this information becomes available, TMDL allocations may be modified to include load allocations to background sources, as opposed to the current composite wasteload allocations.

11.3.3 Consistent Data Collection and Methodologies

Data has been collected throughout the Kootenai-Fisher TMDL Project Area for many years and by many different agencies and entities; however, the type and quality of information is often variable. Wherever 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.

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. Water quality impairment determinations are made by DEQ, but data collected by other sources can be used in the impairment determination process. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking. Future monitoring efforts should consult DEQ on updated monitoring protocols. Improved communication between agencies and stakeholders will further improve accurate and efficient data collection.

It is important to note that monitoring recommendations are based on TMDL related efforts to protect water quality 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 the DEQ field methodologies that serve as the basis for sediment targets and assessments within this TMDL document 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, 2012b). 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 Kootenai-Fisher TMDL Project Area 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

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 that were not developed as targets but were reviewed where available during the development of these TMDLs.

Temperature

Consistency in temperature data collection is not as significant for what is collected as much as how and where it is collected. Data loggers should be deployed at the same locations through the years to accurately represent the site-specific conditions over time, and recorded temperatures should at a minimum represent the hottest part of the summer when aquatic life is most sensitive to warmer temperatures. Data loggers should be deployed in the same manner at each location and during each sampling event, and follow a consistent process for calibration and installation. Any modeling that is used should refer to previous modeling efforts (such as the QUAL2K analysis used in this document) for consistency in model development to ensure comparability. In addition, flow measurements should also be conducted using consistent locations and methodology.

Nutrients

For those watershed groups and/or government agencies that monitor water quality, it is recommended that the same analytical procedures and reporting limits are used so that water quality data may be compared to TMDL targets (**Table 11-2**). In addition, stream discharge should be measured at time of sampling.

Table 11-2. DEQ Nutrient Monitoring Parameter Requirements

Parameter*	Preferred method	Alternate method	Required reporting limit (ppb)	Holding time (days)	Bottle	Preservative
Total Persulfate Nitrogen (TPN)	A4500-NC	A4500-N B	40	28	250mL HDPE	≤6°C (7d HT); Freeze (28d HT)
Total Phosphorus as P	EPA-365.1	A4500-P F	3			H2S04, ≤6°C of Freeze
Nitrate-Nitrite as N	EPA-353.2	A4500-N03 F	10			

*Preferred analytical methods and required reporting limits may change in the future (e.g., become more stringent); consult with DEQ prior to any monitoring effort in order to ensure you use the most current methods.
HT = Holding Time

Metals

Metals monitoring should include analysis of a suite of total recoverable metals (e.g., As, Cu, Cd, Pb, Zn), sediment samples, hardness, pH, discharge, and total suspended solids (TSS). **Table 11-3** identifies the current DEQ metals sampling methodologies and reporting limits for the standard metals suite (water and sediment).

Table 11-3. DEQ Metals Monitoring Parameter Requirements

Parameter*	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
Water Sample - Physical Parameters and Calculated Results						
Total Hardness as $CaCO_3$	A2340 B (Calc)		1000			
Total Suspended Solids	A2540D		4000	7	1000 ml HDPE/500 mlHDPE	≤6oC
Water Sample - Dissolved Metals (0.45 um filtered)						
Aluminum	EPA 200.7	EPA 200.8	9	180	250 ml HDPE	Filt 0.45 um, HNO_3
Water Sample - Total Recoverable Metals						
Total Recoverable Metals Digestion	EPA 200.2	APHA3030F (b)	N/A	180	500 ml HDPE/ 250 ml HDPE	HNO_3
Arsenic	EPA 200.8		1			
Cadmium	EPA 200.8		0.03			
Calcium	EPA 200.7		1000			
Chromium	EPA 200.8	EPA 200.7	1			
Copper	EPA 200.8	EPA 200.7	1			
Iron	EPA 200.7		20			
Lead	EPA 200.8		0.3			
Magnesium	EPA 200.7		1000			
Potassium	EPA 200.7		1000			
Selenium	EPA 200.8		1			
Silver	EPA 200.8	EPA 200.7/200.9	0.2			
Sodium	EPA 200.7		1000			
Zinc	EPA 200.7	EPA 200.8	8			
Antimony	EPA 200.8		0.5			
Barium	EPA 200.7	EPA 200.8	3			
Beryllium	EPA 200.7	EPA 200.8	0.8			
Boron	EPA 200.7	EPA 200.8	10			
Manganese	EPA 200.7	EPA 200.8	5			
Nickel	EPA 200.7	EPA 200.8	2			
Thallium	EPA 200.8		0.2			
Uranium, Natural	EPA 200.8		0.2			
Parameter	**Preferred Method**	**Alternate Method**	**Req. Report Limit mg/kg (dry weight)**	**Holding Time Days**	**Bottle**	**Preservative**
Sediment Sample - Total Recoverable Metals						
Total Recoverable Metals Digestion	EPA 200.2		N/A	180	2000 ml HDPE Widemouth	
Arsenic	EPA 200.8	EPA 200.9	1			
Cadmium	EPA 200.8	EPA 200.9	0.2			
Chromium	EPA 200.8	EPA 200.7	9			
Copper	EPA 200.8	EPA 200.7	15			
Iron	EPA 200.7	EPA 200.7	10			
Lead	EPA 200.8	EPA 200.9	5			
Zinc	EPA 200.7	EPA 200.7	20			

Table 11-3. DEQ Metals Monitoring Parameter Requirements

Parameter*	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
Sediment Sample - Total Metals						
Mercury	EPA 7471B		0.05	28	2000 ml HDPE Widemouth	

*Preferred analytical methods and required reporting limits may change in the future (e.g., become more stringent); consult with DEQ prior to any monitoring effort in order to ensure you use the most current methods

11.3.4 Effectiveness Monitoring for Restoration Activities

As restoration activities are implemented, monitoring is valuable to determine if restoration activities are improving water quality, instream flow, and aquatic habitat and communities. Monitoring can help attribute water quality improvements to restoration activities and ensure that restoration activities are functioning effectively. Restoration projects will often require additional maintenance after initial implementation to ensure functionality. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is often also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in 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 project area, pre and post monitoring to understand the change that follows implementation will be necessary to track the effectiveness of specific projects. Monitoring activities should be selected such that they directly investigate those subjects that the project is intended to effect, and when possible, linked to targets and allocations in the TMDL. For example, as bank erosion is addressed, pre and post bank erosion hazard index (BEHI) analysis on the subject banks will be valuable to understand the extent of improvement and the amount of sediment reduced.

11.3.5 Watershed Wide Analyses

Recommendations for monitoring in the Kootenai-Fisher TMDL Project Area should not be confined to only those streams addressed within this document. The water quality targets presented in this document are applicable to all streams in the watershed, and the absence of a stream from the state's impaired waters list does not necessarily imply that the stream 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.

12.0 Stakeholder and Public Participation

Stakeholder and public involvement is a component of TMDL planning supported by EPA guidelines and required by Montana state law (MCA 75-5-703, 75-5-704) which directs DEQ to consult with watershed advisory groups and local conservation districts during the TMDL development process. Technical advisors, stakeholders and interested parties, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process in the Kootenai-Fisher TMDL Project Area.

12.1 Participants and Roles

Throughout completion of the Kootenai-Fisher TMDL Project Area TMDLs, DEQ worked to keep stakeholders apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of the TMDLs in the Kootenai-Fisher TMDL Project Area and their roles is contained below.

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

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for final TMDL approval. Additionally, partial project management was provided by the EPA Regional Office in Helena, MT.

Conservation Districts
The majority of the Kootenai-Fisher TMDL Project Area falls within Lincoln County, and a very small portion in Flathead County. DEQ provided both the Lincoln Conservation District and Flathead Conservation District with consultation opportunity during development of TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

TMDL Advisory Group
The Kootenai-Fisher TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Kootenai-Fisher TMDL Project Area, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included municipalities and county representatives; livestock-oriented and farming-oriented agriculture representatives; timber and mining industry representatives; watershed groups; state and federal land management agencies, tribal representatives; and representatives of fishing-related business, recreation, and tourism interests. The advisory group also

included additional stakeholders with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Communications with the group members was typically conducted through e-mail and draft documents were made available through DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

12.2 Response To Public Comments

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

The public review period for the draft Kootenai-Fisher TMDL document was initiated on February 3, 2014 and ended on March 4, 2014. During this timeframe, a public meeting was held in Libby, MT on February 13, 2014. At the meeting, DEQ and EPA project team members provided an overview of the TMDLs for metals, nutrients, sediment, and temperature in the Kootenai-Fisher project area, made copies of the document available, and solicited input and comment on the document. Both the public comment period and public meeting were announced in a February 3, 2014 press release from DEQ which was published on DEQ's website and distributed to multiple media outlets across Montana. A public notice advertising the public comment period and public meeting was published in the following newspapers: Daily Inter Lake, Missoulian, Western News, and the Kootenai Valley Record. Additionally, the announcement was distributed to the Kootenai-Fisher TMDL Watershed Advisory Group.

DEQ received public comments from multiple entities during the public comment period. **Appendix I** contains excerpts and summaries of the comments, along with DEQ and EPA's responses (joint comment responses were prepared with the EPA Region 8 Montana Office). Original comment letters and submissions are held on file at DEQ and may be viewed upon request.

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Jepson, Wayne. 04/15/2013. Phone call from Wayne Jepson, DEQ. Volpe, Lou.

Sugden, Brian. 01/08/2014. Phone call from Brian Sugden, Plum Creek Timber Company. Kusnierz, Lisa.

Appendix A – Table of Waterbody Impairments and Project Area Description Maps

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Table A-1. Status of Waterbody Impairments in the Kootenai-Fisher TMDL Project Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status[1]
BIG CHERRY CREEK, Snowshoe Creek to mouth (Libby Creek)	MT76D002_050	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
		Zinc	Metals	Zinc TMDL contained in this document
BRISTOW CREEK, headwaters to mouth at Lake Koocanusa	MT76D002_110	Nitrogen (Total)	Nutrients	Not impaired based on updated assessment
		Sedimentation / Siltation	Sediment	Not impaired based on updated assessment
CRIPPLE HORSE CREEK, Headwaters to mouth (Lake Koocanusa)	MT76D002_100	Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
DRY CREEK, 1 mile upstream from State Highway 56 to mouth (Lake Creek)	MT76D002_020	Other flow regime alterations	Not Applicable; Non-Pollutant	Not yet addressed
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
FISHER RIVER, Silver Butte / Pleasant Valley junction to mouth (Kootenai River)	MT76C001_010	High Flow Regime	Not Applicable; Non-Pollutant	Not yet addressed
		Lead	Metals	Not impaired based on updated assessment
KEELER CREEK, Headwaters to Lake Creek	MT76D002_030	Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
KOOTENAI RIVER, Libby Dam to Yaak River	MT76D001_010	Other flow regime alterations	Not Applicable; Non-Pollutant	Not yet addressed
		Temperature, water	Temperature	To be completed in a future project
KOOTENAI RIVER, Confluence with Yaak River to Idaho border	MT76A001_010	Other flow regime alterations	Not Applicable; Non-Pollutant	Not yet addressed
		Temperature, water	Temperature	To be completed in a future project

Table A-1. Status of Waterbody Impairments in the Kootenai-Fisher TMDL Project Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status[1]
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	MT76D002_070	Cadmium	Metals	Not impaired based on updated assessment
		Copper	Metals	Copper TMDL contained in this document
		Lead	Metals	Lead TMDL contained in this document
		Mercury in water column	Metals	Not impaired based on updated assessment
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	NO_2 + NO_3 TMDL contained in this document
		Sedimentation / Siltation	Sediment	Sediment TMDL contained in this document
		Zinc	Metals	Not impaired based on updated assessment
LAKE KOOCANUSA	MT76D003_010	Other flow regime alterations	Not Applicable; Non-Pollutant	Not yet addressed
		Selenium	Metals	To be completed in a future project
LIBBY CREEK, from 1 mile above Howard Creek to Highway 2 bridge	MT76D002_061	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
		Mercury	Metals	Not impaired based on updated assessment
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
LIBBY CREEK, Highway 2 bridge to mouth (Kootenai River)	MT76D002_062	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by sediment TMDL contained in this document
		Sedimentation / Siltation	Sediment	Sediment TMDL contained in this document
QUARTZ CREEK, Headwaters to confluence with Kootenai River	MT76D002_090	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Not impaired based on updated assessment
		Sedimentation / Siltation	Sediment	Not impaired based on updated assessment

Table A-1. Status of Waterbody Impairments in the Kootenai-Fisher TMDL Project Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status[1]
RAVEN CREEK, Headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL contained in this document
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by TP TMDL contained in this document
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Not impaired based on updated assessment
		Nitrogen (Total)	Nutrients	Not impaired based on updated assessment
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation / Siltation	Sediment	Sediment TMDL contained in this document
SNOWSHOE CREEK, Cabinet Wilderness boundary to mouth (Big Cherry Creek)	MT76D002_040	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (**Sections 9** and **10**); not linked to a TMDL
		Cadmium	Metals	Cadmium TMDL contained in this document
		Zinc	Metals	Zinc TMDL contained in this document
STANLEY CREEK,[2] Headwaters to confluence with Fairway Creek	MT76D002_010	Copper	Metals	Copper TMDL contained in this document
		Nutrient / Eutrophication Biological Indicators	Nutrients	Impairment cause removed and replaced by NO_2 + NO_3
WOLF CREEK, Headwaters to mouth (Fisher River)	MT76C001_020	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL contained in this document
		Sedimentation / Siltation	Sediment	Sediment TMDL contained in this document
		Temperature, water	Temperature	Temperature TMDL contained in this document

[1] TN = Total Nitrogen, TP = Total Phosphorus, NO_2+NO_3 = Nitrite + Nitrate

[2] The Stanley Creek waterbody segment is being extended to the confluence of Lake Creek and the location description will be changed in the "2014 Water Quality Integrated Report" to read: Stanley Creek, headwaters to mouth (Lake Creek)

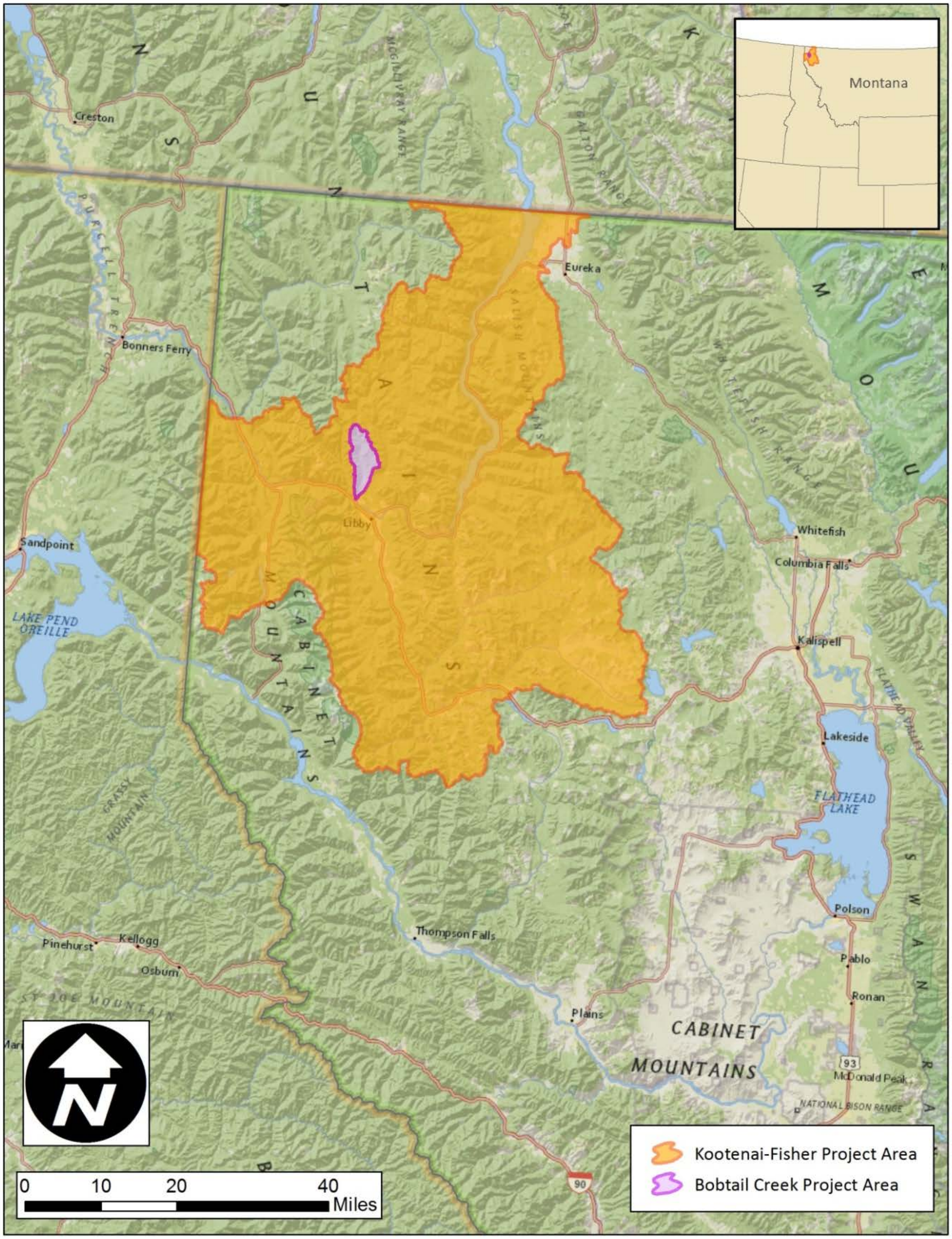


Figure A-1. Location of Kootenai-Fisher Project Area

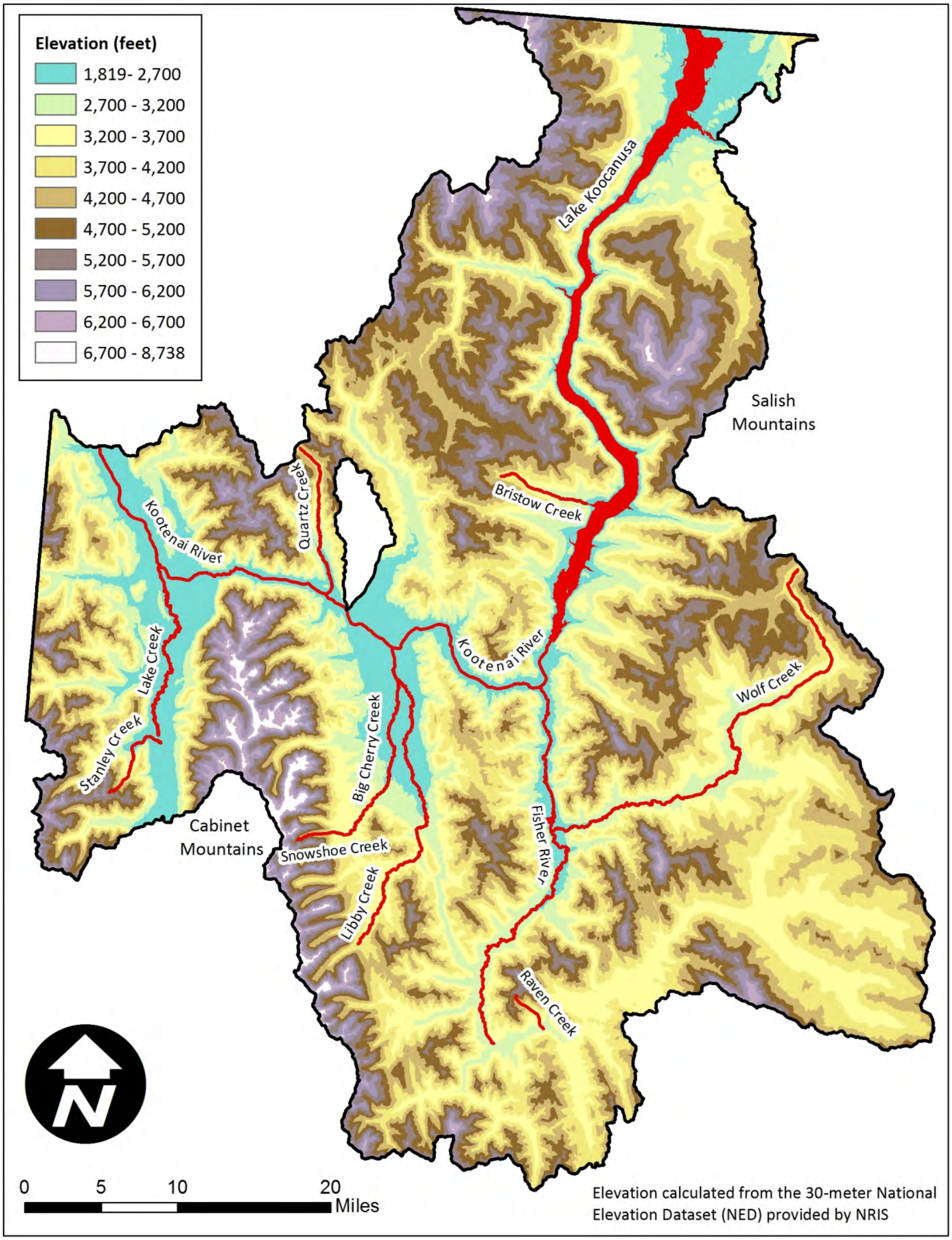


Figure A-2. Elevation of the Kootenai-Fisher Project Area

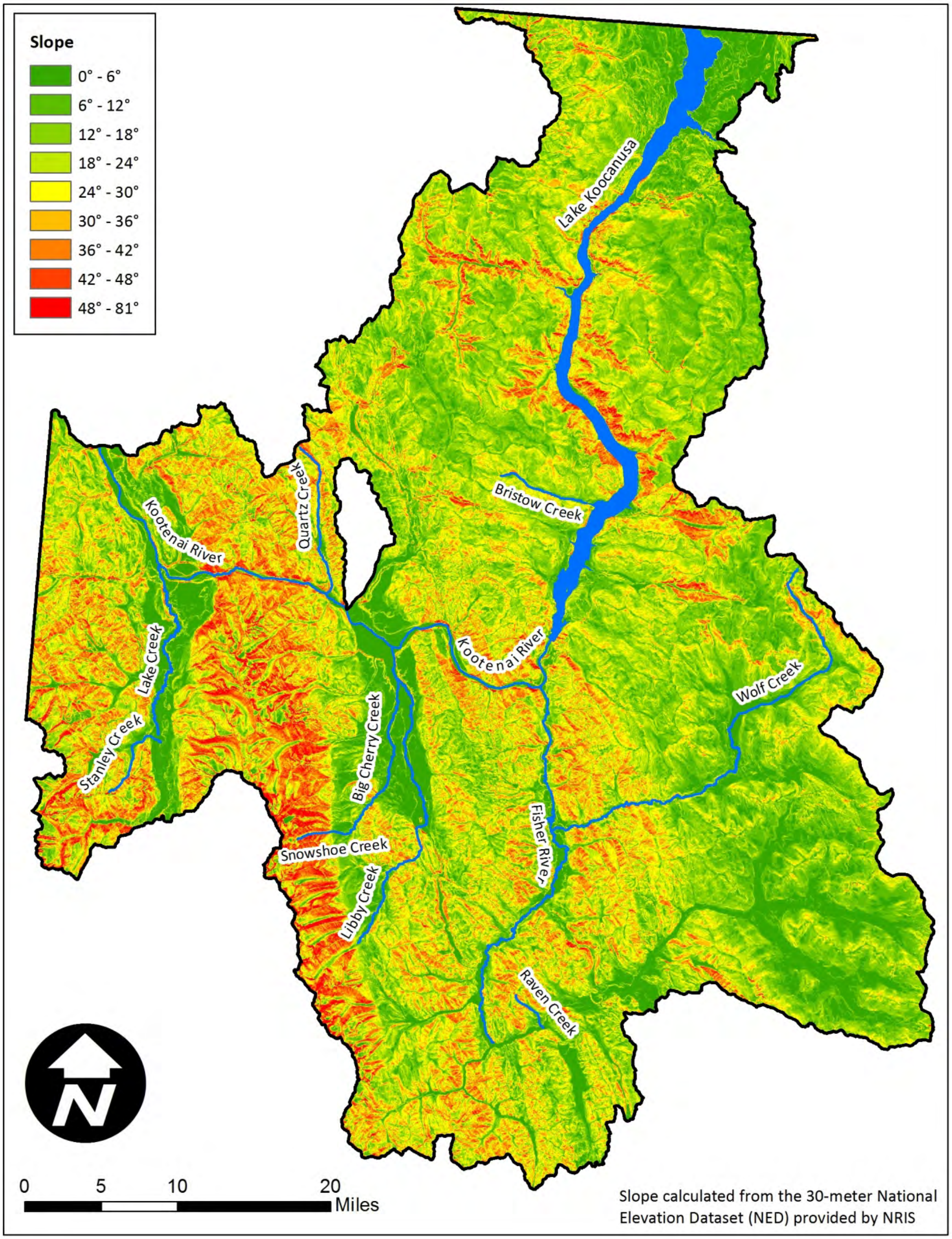


Figure A-3. Topography of the Kootenai-Fisher Project Area

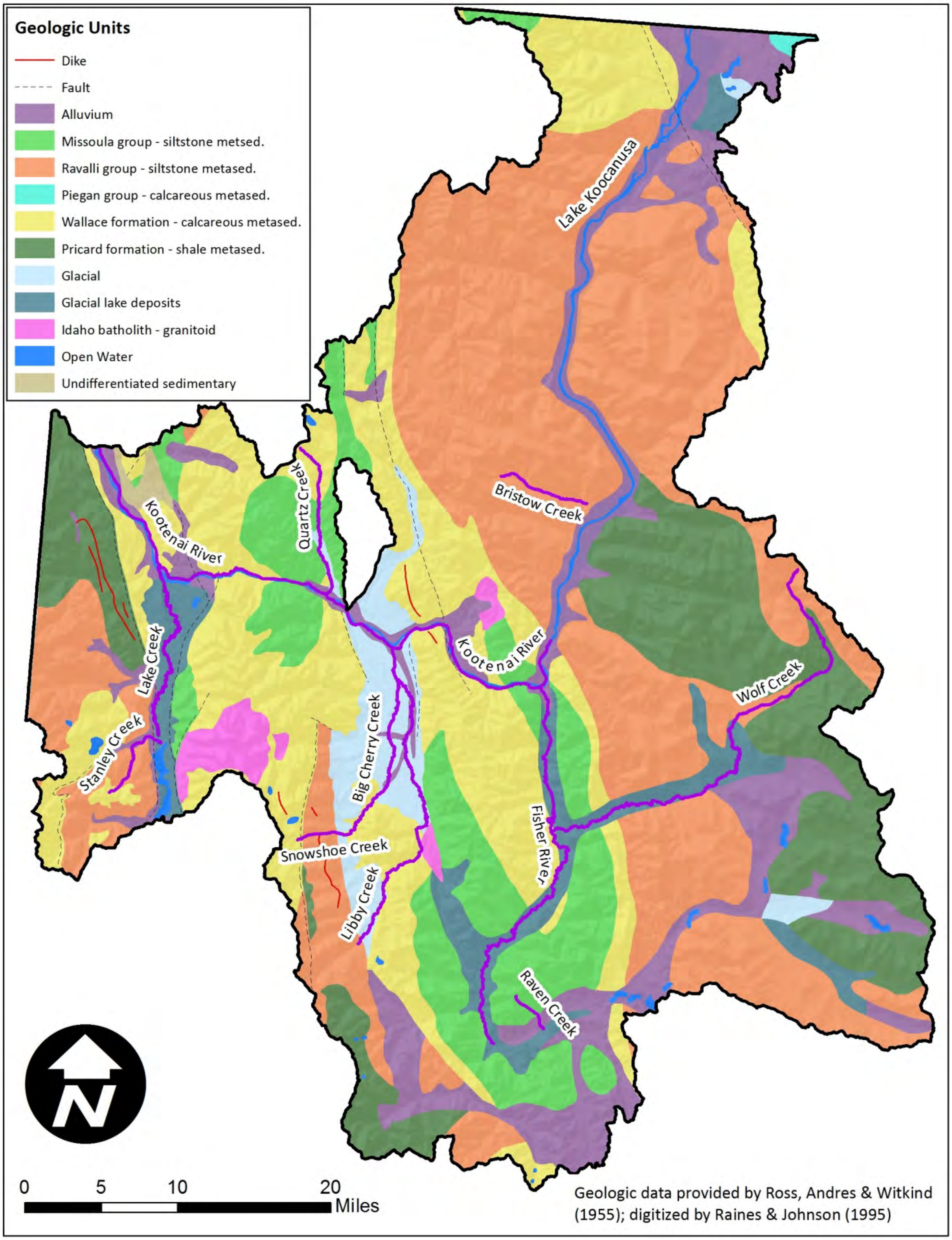


Figure A-4. Geologic units of the Kootenai-Fisher Project Area

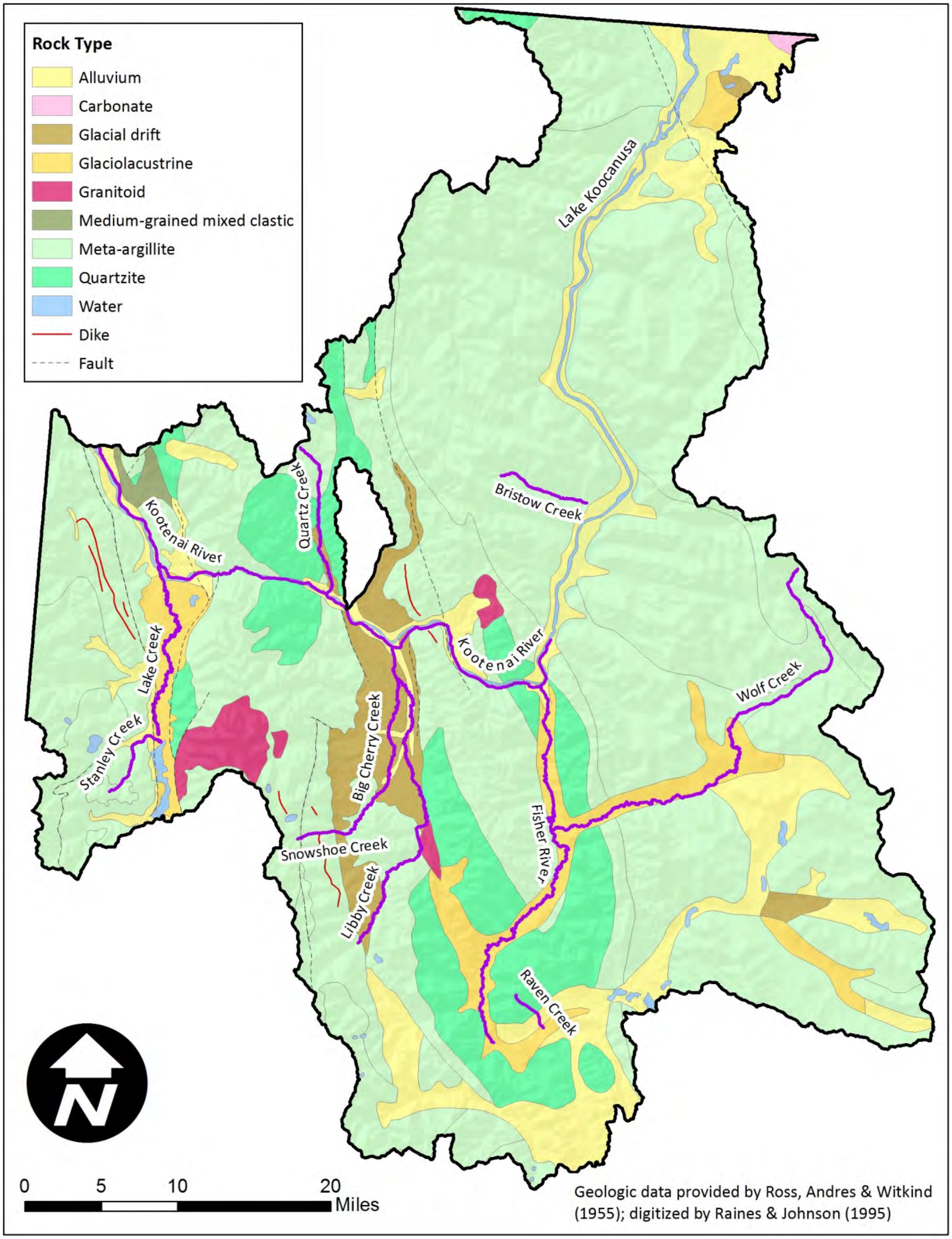


Figure A-5. Geologic rock types of the Kootenai-Fisher Project Area

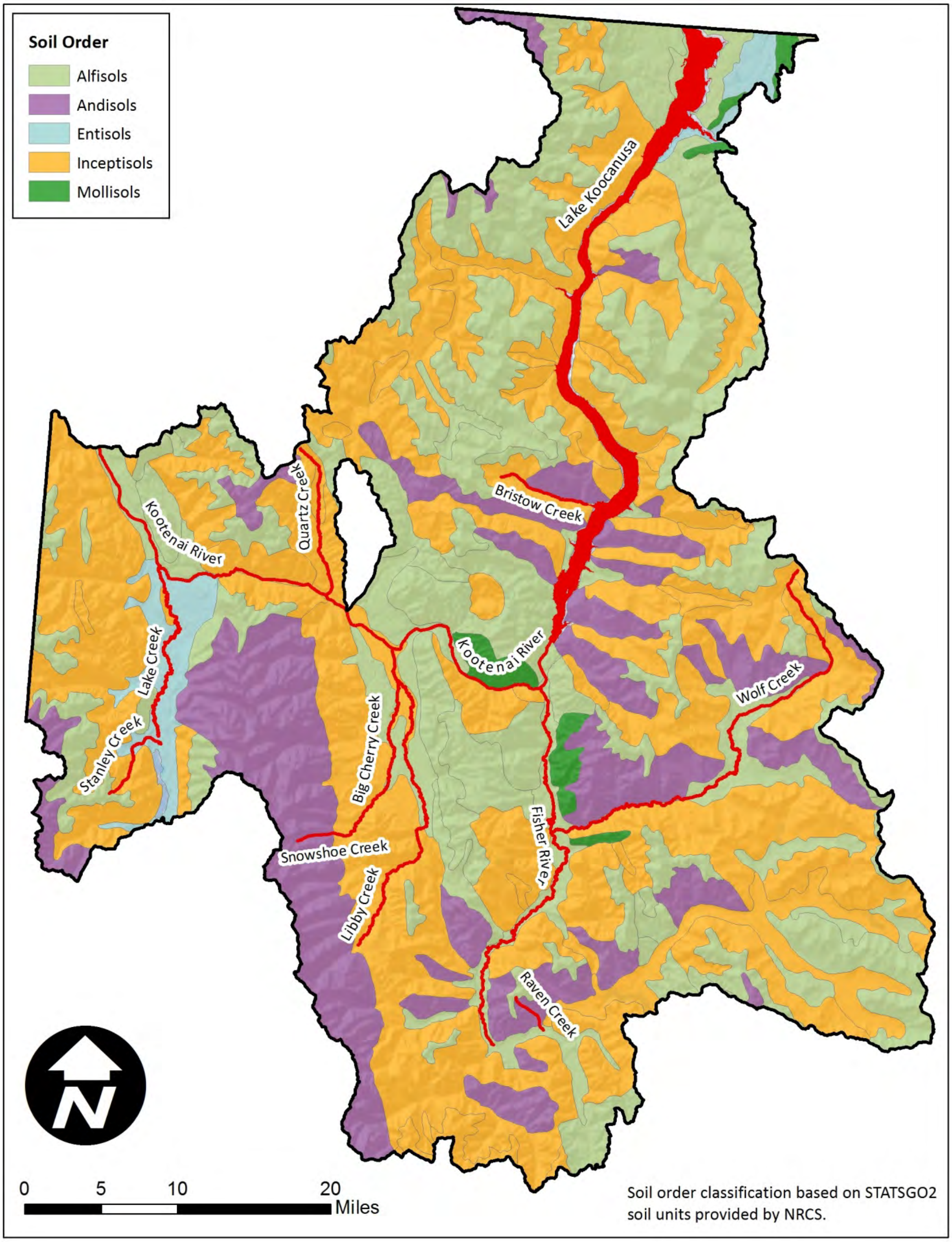


Figure A-6. Soil orders of the Kootenai-Fisher Project Area

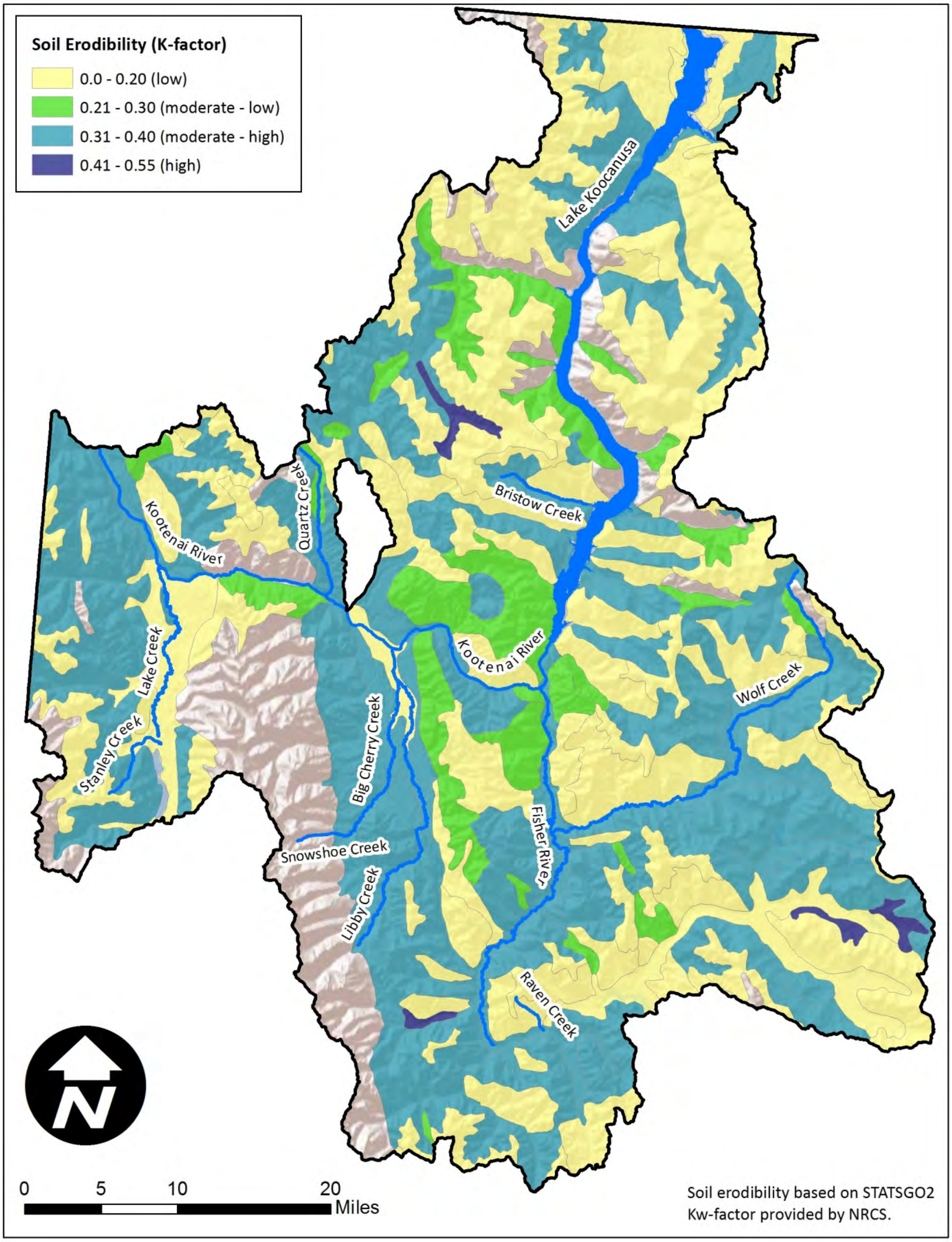


Figure A-7. Soil erodibility values of the Kootenai-Fisher Project Area

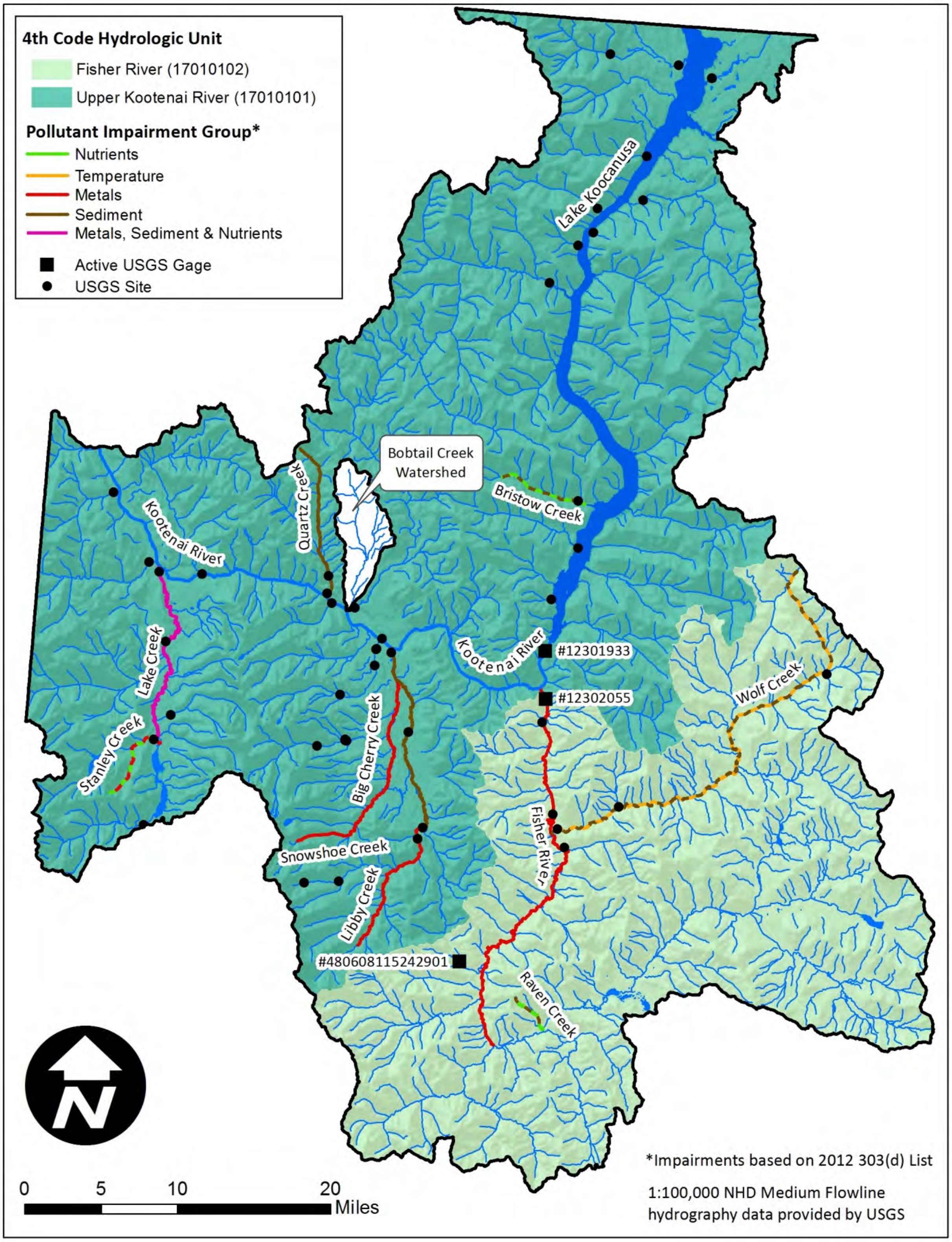


Figure A-8. Surface water hydrography of the Kootenai-Fisher Project Area

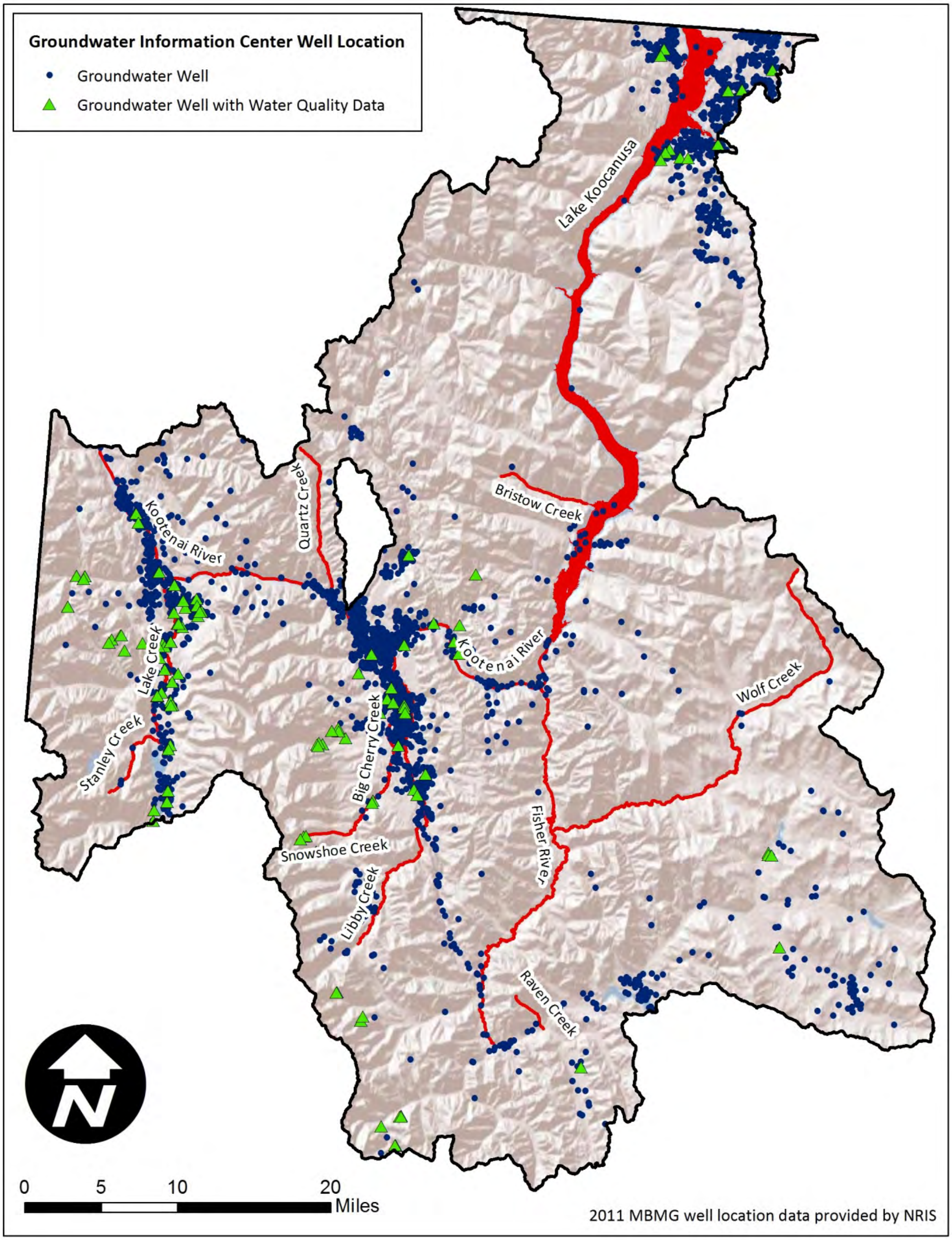
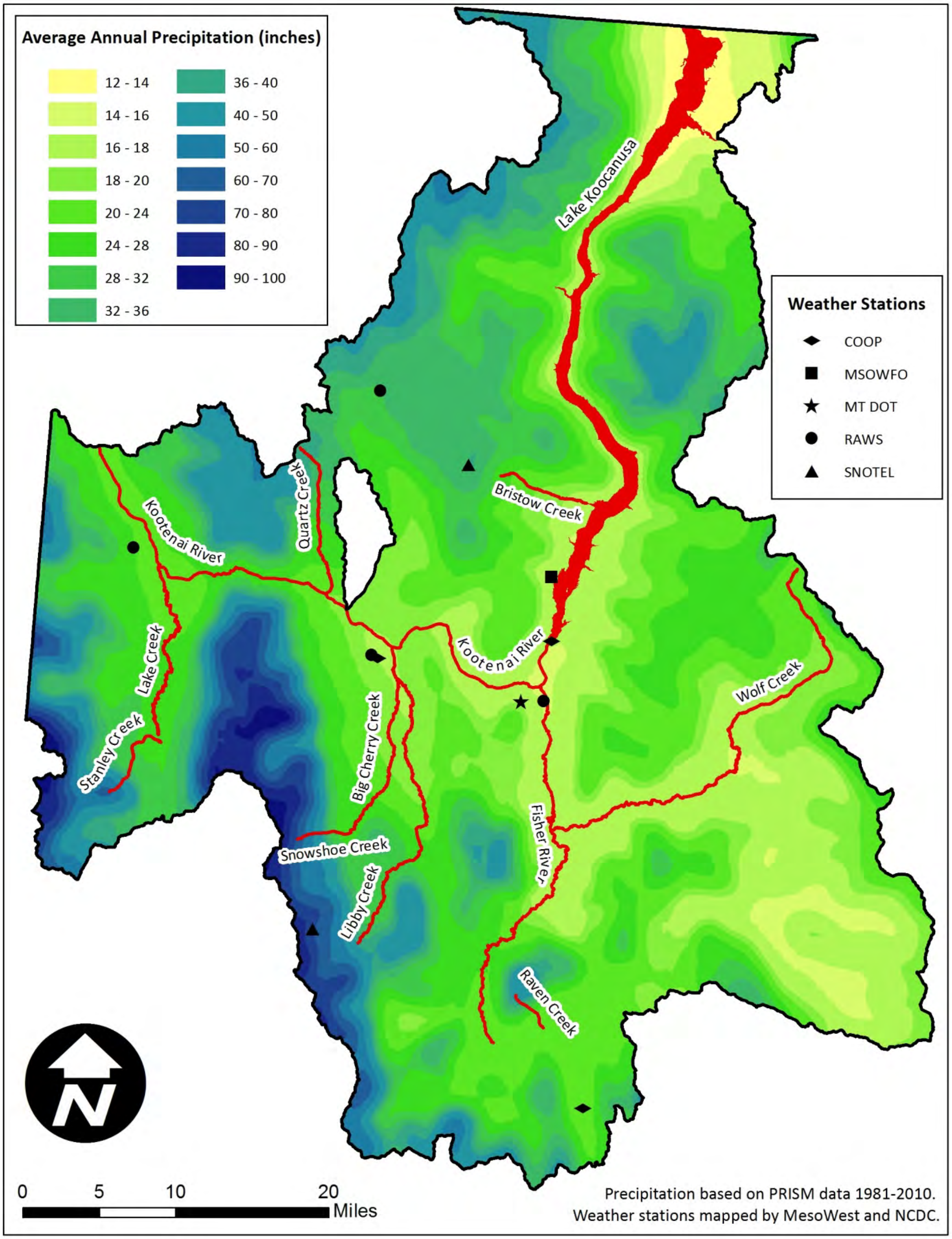


Figure A-9. Groundwater wells in the Kootenai-Fisher Project Area



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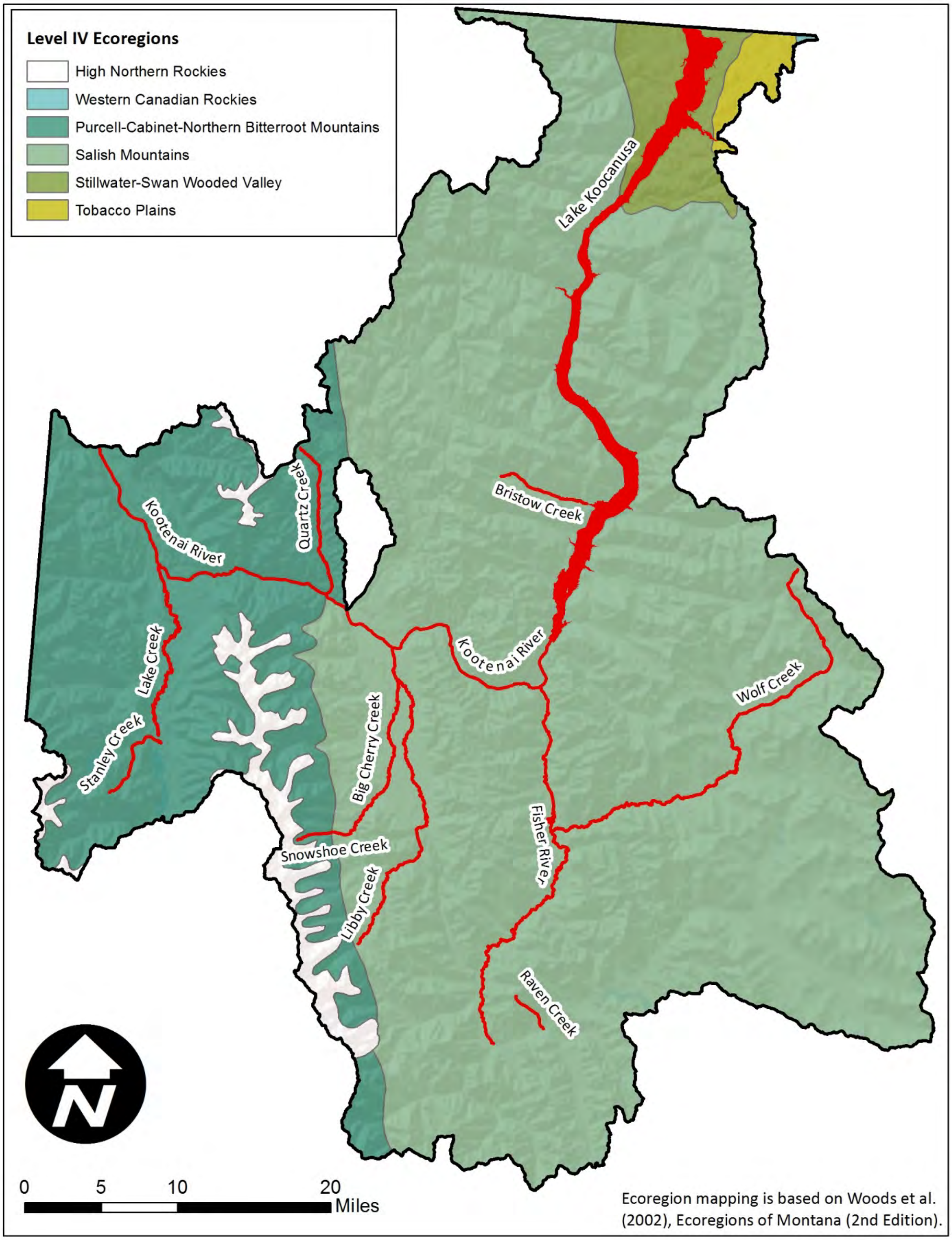

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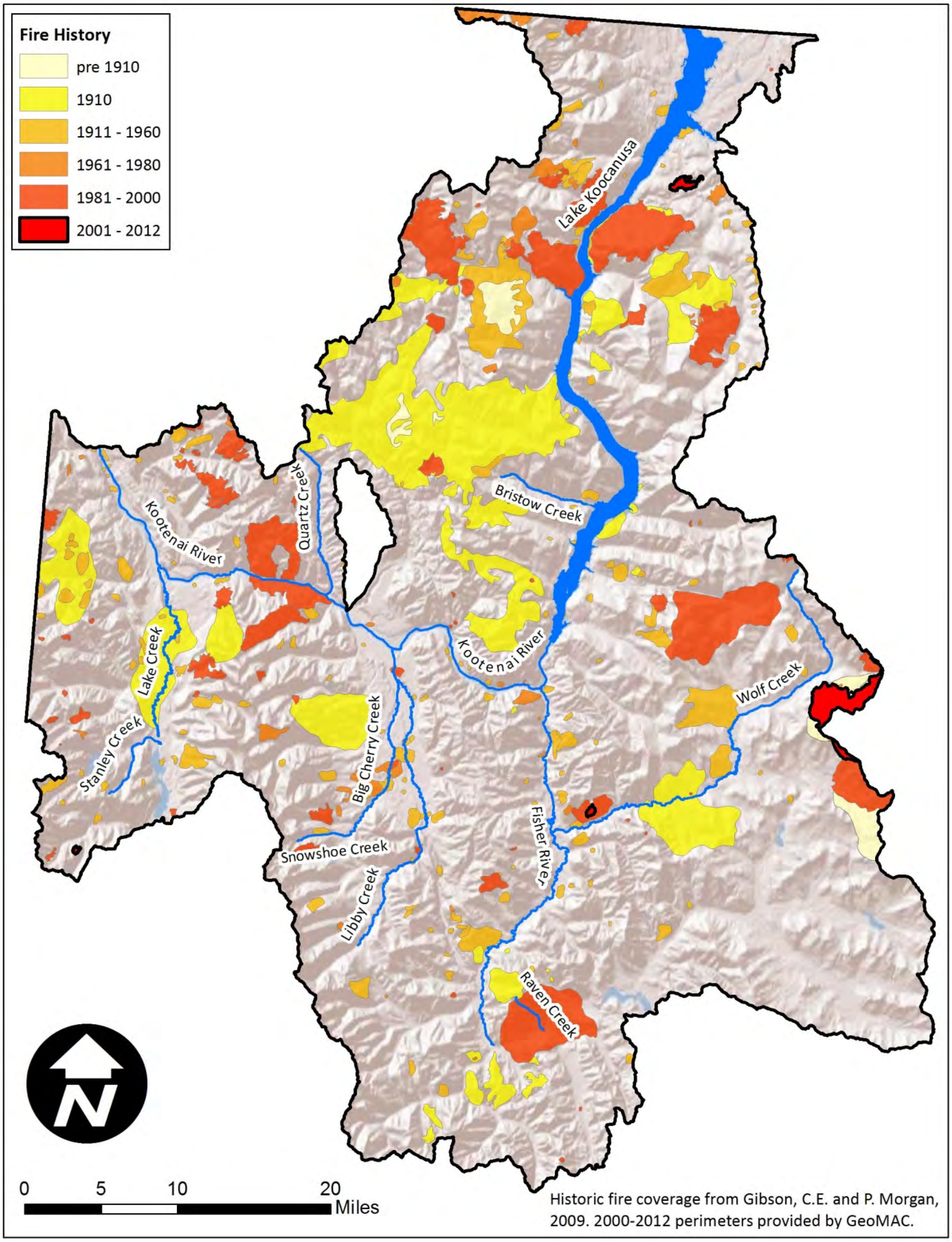

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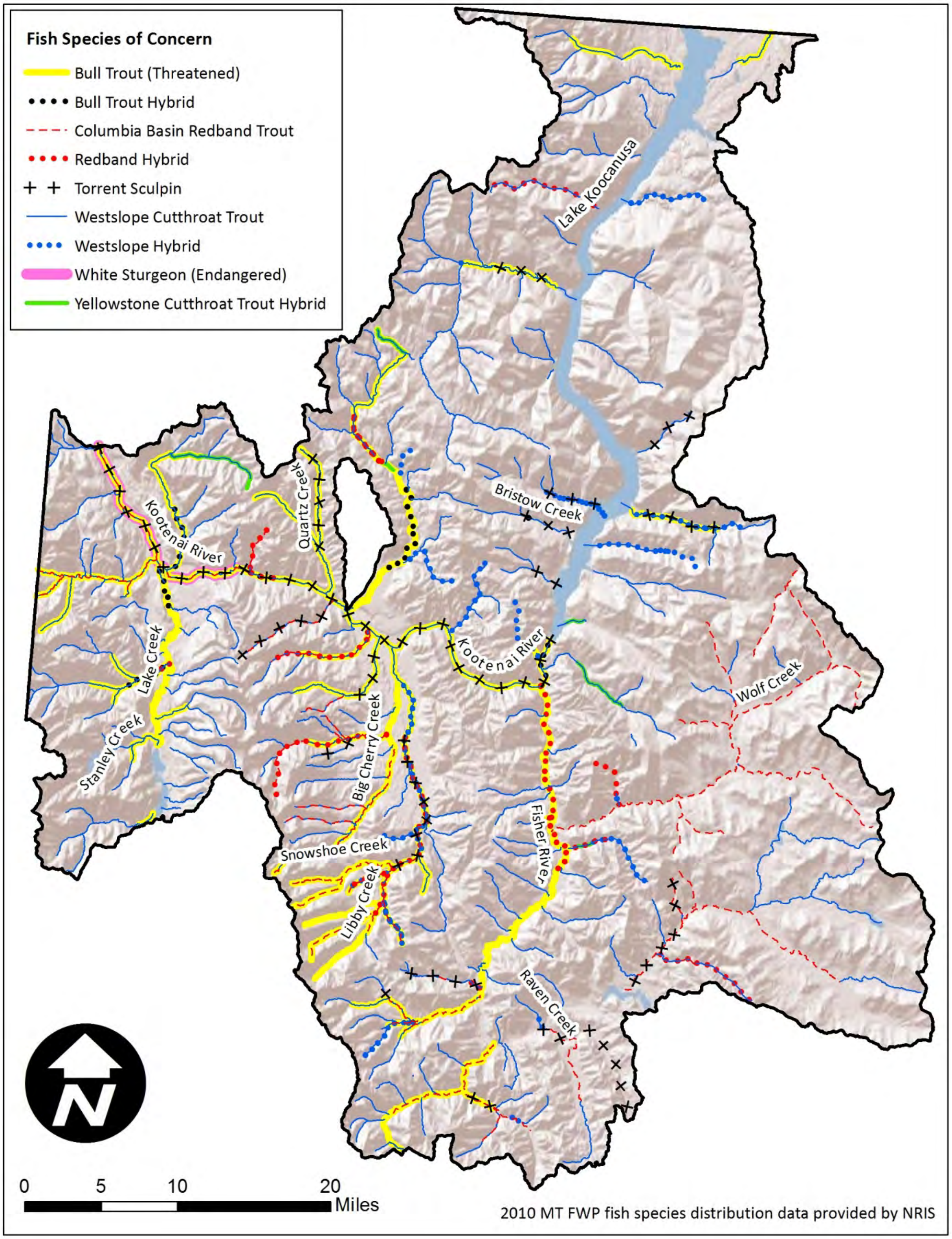

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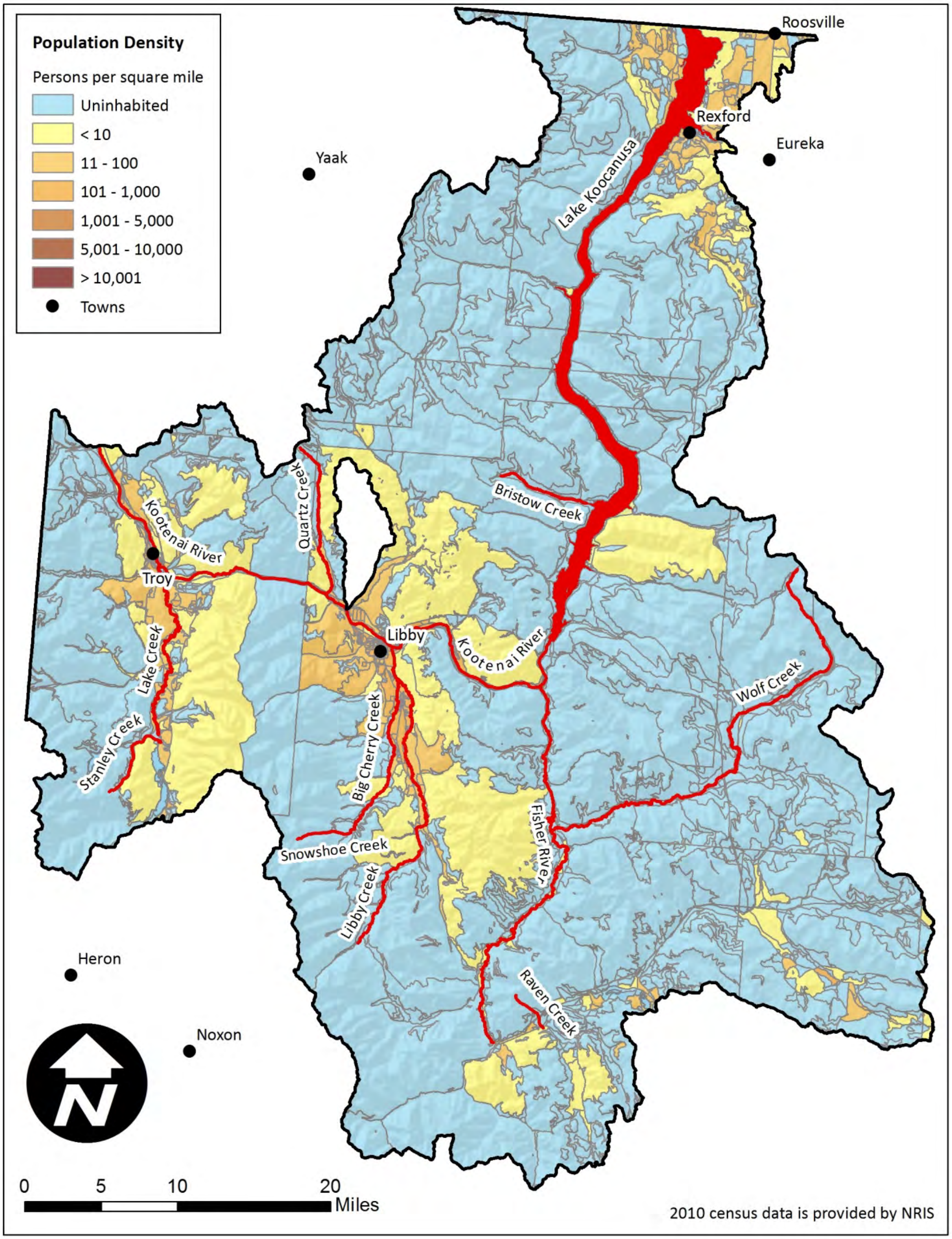

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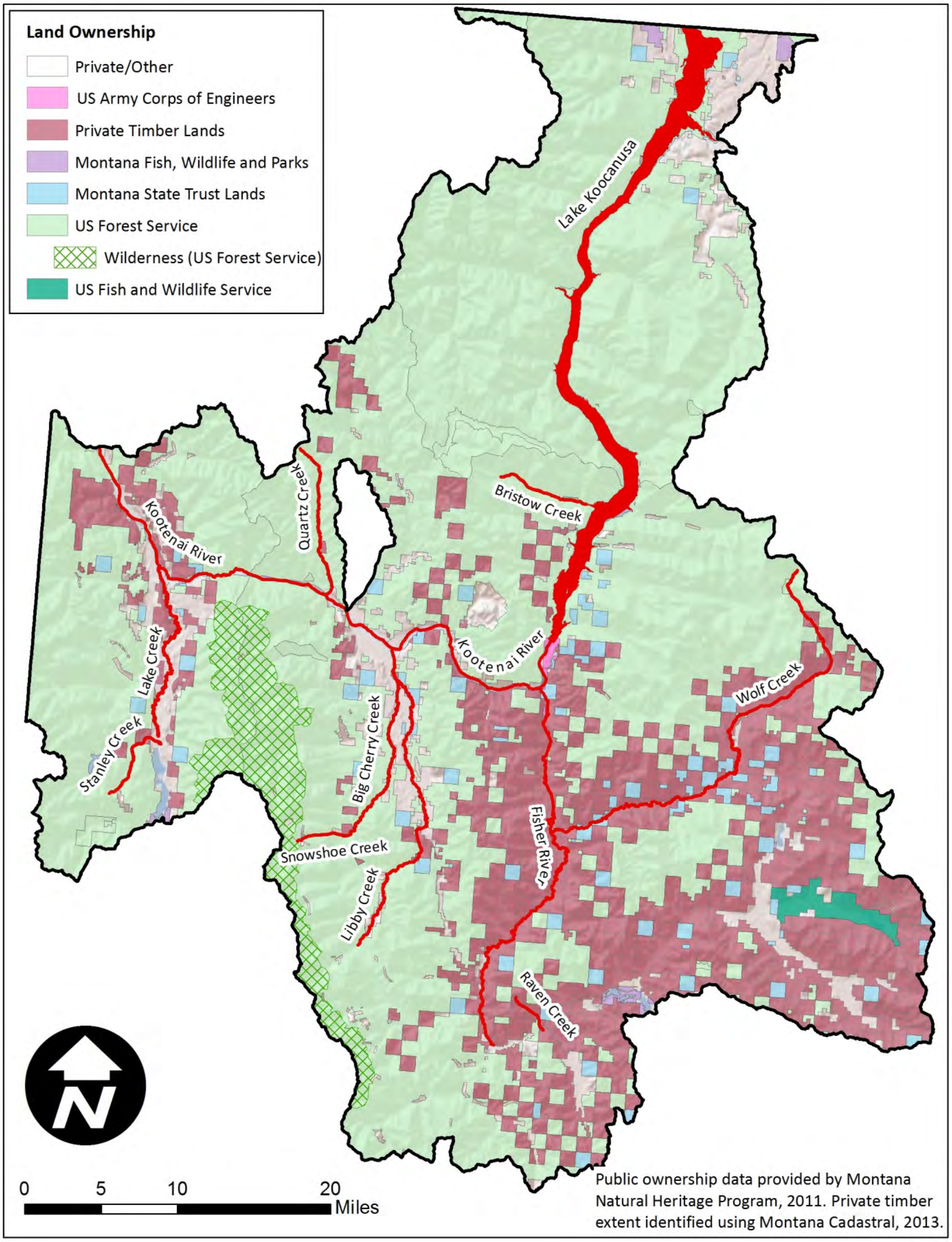
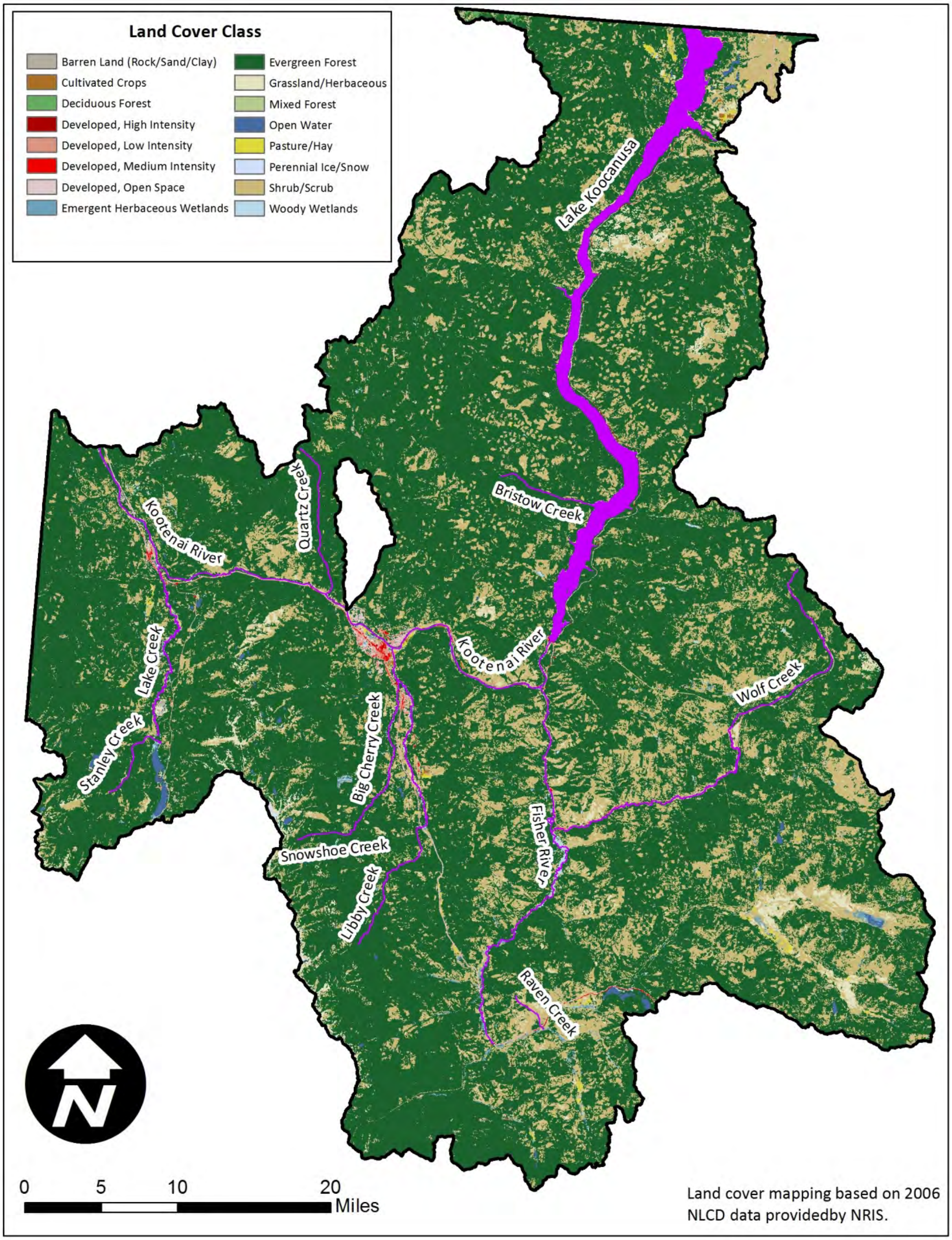


Figure A-15. Land ownership of the Kootenai-Fisher Project Area



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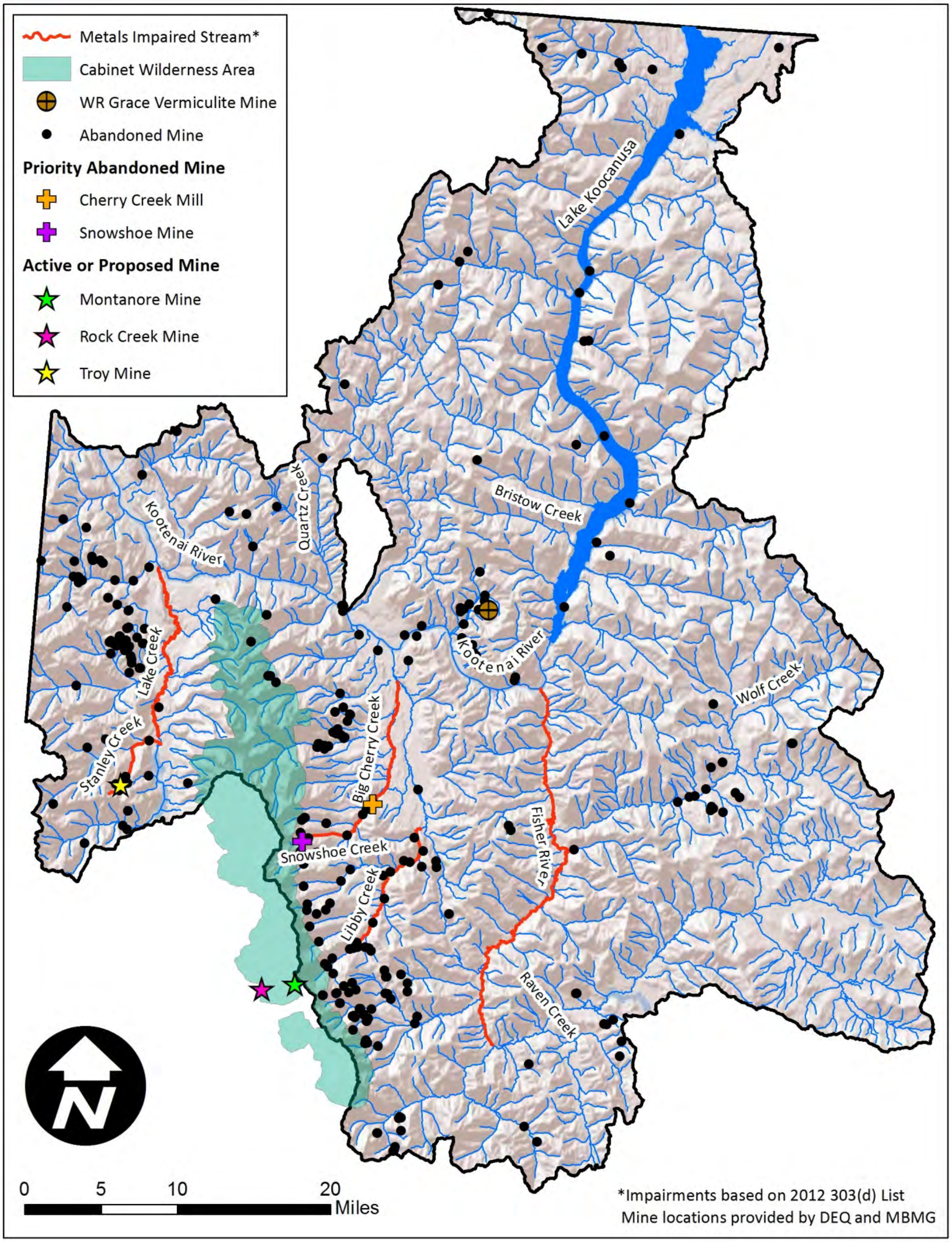

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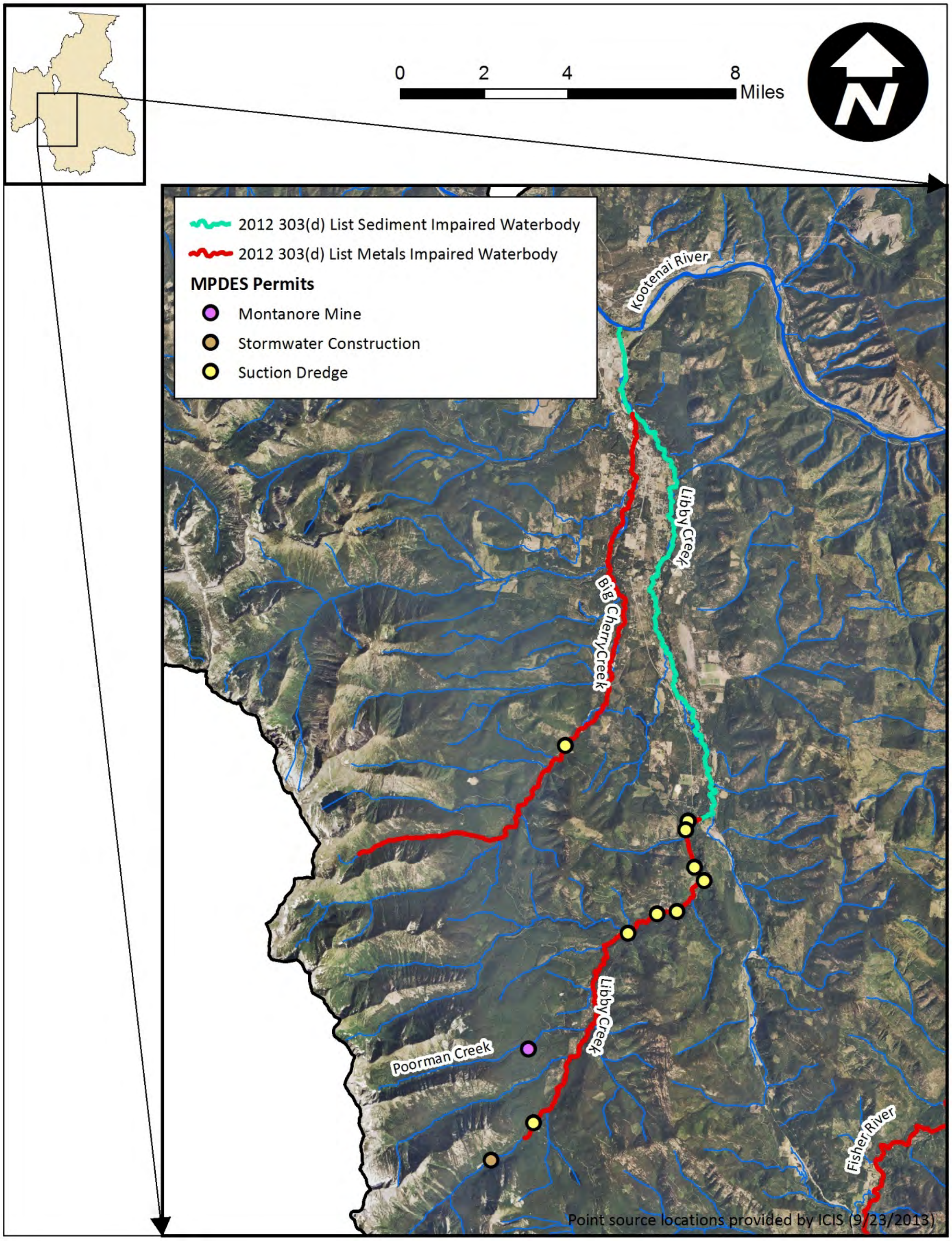

Figure A-18. Permitted point sources discharging to TMDL streams

APPENDIX B - 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.

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ACRONYMS

Acronym	Definition
ARM	Administrative Rules of Montana
BER	Board of Environmental Review (Montana)
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
EPA	Environmental Protection Agency (U.S.)
HHC	Human Health Criteria
MCA	Montana Code Annotated
MCL	Maximum Contaminant Level
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
WQA	Water Quality Act
WQS	Water Quality Standards

B1.0 TMDL DEVELOPMENT REQUIREMENTS

Section 303(d) of the federal Clean Water Act (CWA) and the Montana Water Quality Act (WQA) (Section 75-5-703) requires development of TMDLs for impaired waterbodies that do not meet Montana WQS. Although waterbodies can become impaired from pollution (e.g. low flow alterations and habitat degradation) and pollutants (e.g. nutrients, sediment, metals, pathogens, and temperature), the CWA and Montana state law (75-5-703) require TMDL development only for impaired waters with pollutant causes. Section 303(d) also requires states to submit a list of impaired waterbodies to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, EPA and DEQ referred to this list simply as the 303(d) list.

Since 2004, EPA has requested that states combine the 303(d) list with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) list also includes identification of the probable cause(s) of the water quality impairment (e.g. pollutants such as metals, nutrients, sediment, pathogens or temperature), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). 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 impairment status determination methodology is identified in DEQ's Water Quality Assessment Process and Methods found in Attachment 1 of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, 2012b).

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)). 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(d) of the CWA require states to develop all necessary TMDLs for impaired or threatened waterbodies. None of the waterbodies being addressed within the scope of this document are listed as threatened.

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 (violated). TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). 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. **Section 4.0** of the main document provides a description of the components of a TMDL.

To satisfy the federal CWA and Montana state law, TMDLs are developed for each waterbody-pollutant combination identified on Montana's 303(d) list of impaired or threatened waters, and are often presented within the context of a water quality restoration or protection plan. 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.

B2.0 Applicable Water Quality Standards

WQS 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 water quality standards are met. Water quality standards form the basis for the targets described in **Sections 5.0**, **6.0**, **7.0** and **8.0**. Pollutants addressed in this framework water quality improvement plan include sediment, nutrients, temperature, and metals. This section provides a summary of the applicable water quality standards for these pollutants.

B2.1 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 WQA directs the Board of Environmental Review (BER) (i.e., the state) 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 (ARM 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

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. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. 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 must 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 B2-1**. In 2003, Montana added four classes: D, E, F, and G. These classes include ephemeral streams (E-1 and E-2), ditches (D-1 and D-2), seasonal or semi-permanent lakes and ponds (E-3, E-4, E-5) and waters with low or sporadic flow (F-1). All waterbodies within the Kootenai-Fisher Project Area are classified as B-1 (see **Section 3.1** and **Table 3-1** in the main document for individual stream classifications).

Table B2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1:	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:	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:	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:	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:	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:	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:	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.
I:	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.
D-1:	Waters classified D-1 are to be maintained suitable for agricultural purposes and secondary contact recreation.
D-2:	Waters classified D-2 are to be maintained suitable for agricultural purposes and secondary contact recreation. Because of conditions resulting from low flow regulations, maintenance of the ditch, or geomorphologic and riparian habitat conditions, quality is marginally suitable for aquatic life.
E-1:	Waters classified E-1 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife.
E-2:	Waters classified E-2 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife. Because of habitat, low flow, hydro-geomorphic, and other physical conditions, waters are marginally suitable for aquatic life.
E-3:	Waters classified E-3 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife.
E-4:	Waters classified E-4 are to be maintained suitable for aquatic life, agricultural purposes, secondary contact recreation, and wildlife.

Table B2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
E-5:	Waters classified E-5 are to be maintained suitable for agricultural purposes, secondary contact recreation, saline-tolerant aquatic life, and wildlife.
F-1:	Waters classified F-1 are to be maintained suitable for secondary contact recreation, wildlife, and aquatic life, not including fish.
G-1:	Waters classified G-1 are to be maintained suitable for watering wildlife and livestock; aquatic life, not including fish; secondary contact recreation; marginally suitable for irrigation after treatment or with mitigation measures.

B2.2 Standards

In addition to the use classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric Standards

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular DEQ-7 (Montana Department of Environmental Quality, 2012a). 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.

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 DEQ. 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 that the waterbody.

Narrative Standards

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 Kootenai-Fisher Project Area TMDLs are summarized below. In addition to the standards below, the beneficial-use support standard for B-1 streams, as defined above, can apply to other conditions, often linked to pollution, limiting aquatic life. These other conditions can include effects from dewatering/flow alterations and effects from habitat modifications.

B2.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table B2-2**. 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 B2-2**).

Table B2-2. Applicable Rules for Sediment Related Pollutants

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.

Table B2-2. Applicable Rules for Sediment Related Pollutants

Rule(s)	Standard or Definition
	"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.

B2.2.2 Nutrient Standards

The narrative standards applicable to nutrients in Montana are contained in the General Prohibitions of the surface water quality standards (ARM 17.30.637 et. Seq.,). The prohibition against the creation of "*conditions which produce undesirable aquatic life*" is generally the most relevant to nutrients. Undesirable aquatic life includes bacteria, fungi, and algae. Montana has recently developed draft nutrient criteria for nitrate+nitrite nitrogen (NO_2+NO_3), total nitrogen (TN), total phosphorus (TP), and chlorophyll-*a* based on the Level III ecoregion in which a stream is located (Suplee and Watson 2013). For the Northern Rockies Level III Ecoregion, draft water quality criteria for TN and TP are presented in **Table B2-3**. These criteria are growing season, or summer, values applied from July 1st through September 30th. Additionally, numeric human health standards exist for nitrogen (**Table B2-4**), but the narrative standard is most applicable to nutrients as the concentration in most waterbodies in Montana is well below the human health standard and the nutrients contribute to undesirable aquatic life at much lower concentrations than the human health standard.

Table B2-3. Draft Numeric Nutrient Criteria for the Northern Rockies Ecoregion.

Parameter	Target Value
Total Nitrogen (TN)	≤ 0.275 mg/L
Total Phosphorus (TP)	≤ 0.025 mg/L

Table B2-4. Human Health Standards for Nitrogen for the State of Montana.

Parameter	Human Health Standard (µL)[1]
Nitrate as Nitrogen (NO_3-N)	10,000
Nitrite as Nitrogen (NO_2-N)	1,000
Nitrate plus Nitrite as N	10,000

[1]Maximum Allowable Concentration.

B2.2.3 Metals Standards

Water quality standards that are applicable to metals impairments include both numeric water quality criteria given in DEQ-7 (**Table B2-5**) and general prohibitions (narrative criteria) given in **Table B2-6.** As water quality criteria for many metals is dependent upon water hardness, **Table B2-5** presents acute and chronic metals numeric water quality criteria at water harnesses of 25, 100 and 400 mg/L for metals of concern in the Kootenai-Fisher Project Area. Also presented in **Table B2-5** is the Human Health Criteria (HHC): note that for mercury and arsenic, the HHC is lower than applicable chronic criteria.

For iron, the human health standard (i.e., 300ug/L) is a secondary maximum contaminant level that is based on aesthetic water properties such as taste, odor, and the tendency of these metals to cause staining. Iron is not classified as a toxin or a carcinogen. Therefore, for the purposes of this TMDL document, the secondary MCL guidance values for iron is not applied or considered in the evaluation of water quality data. The chronic aquatic life standard of 1,000 µg/L for iron is used as the metals target for iron.

It should be noted that recent studies have indicated in some streams metals concentrations may vary throughout the day because of diel pH and alkalinity changes. In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

Table B2-5. Metals Numeric Water Quality Criteria for the Kootenai-Fisher Project Area.

Metal of concern	Aquatic life criteria (ug/L) at 25 mg/L hardness		Aquatic life criteria (ug/L) at 100 mg/L hardness		Aquatic life criteria (ug/L) at 400 mg/L hardness		HHS (ug/L)
	Acute	Chronic	Acute	Chronic	Acute	Chronic	
Aluminum, dissolved	750	87	750	87	750	87	---
Antimony, TR	---	---	---	---	---	---	5.6
Arsenic, TR	340	150	340	150	340	150	10
Cadmium, TR	0.52	0.1	2.1	0.27	8.7	0.76	5
Copper, TR	3.79	2.85	14	9.33	51.7	30.5	1,300
Cyanide, Total	22	5.2	22	5.2	22	5.2	140
Iron, TR	---	1,000	---	1,000	---	1,000	300*
Lead, TR	13.98	0.545	81.6	3.18	476.8	18.58	15
Mercury, Total	1.7	0.91	1.7	0.91	1.7	0.91	0.05
Zinc, TR	37	37	119.8	119.8	387.8	387.8	2,000

*HHC for iron is a secondary maximum contaminant level based on aesthetic properties
TR = total recoverable

In addition to numeric criteria given in **Table B2-5**, narrative criteria also provides protection of beneficial uses. Toxic levels of metals in stream sediment are prohibited via ARM 17.30.637(1)(d). Metals concentrations in stream sediment are addressed via the suite of narrative criteria presented in **Table B2-6**. The relevant narrative criteria do not allow for 'concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.' This is 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 B2-6**). Evaluation of numeric and narrative criteria for specific metals impairments by stream segment is given in **Section 7.4.3**.

Table B2-6. Applicable Rules for Metals Concentrations in Sediment

Rule(s)	Criteria
17.30.623 (1) 17.30.624 (1)	Waters classified B-1 (B-2) 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.
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).
17.30.623 (2)(f) 17.30.624 (2)(f)	(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 injurious to public health, recreation,
17.30.623 (2)(h) 17.30.624 (2)(h)	(h) Concentrations of carcinogenic, bioconcentrating, toxic, radioactive, nutrient, or harmful parameters may not exceed the applicable standards set forth in department Circular DEQ-7.
17.30.637	General Prohibitions

Table B2-6. Applicable Rules for Metals Concentrations in Sediment

Rule(s)	Criteria
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.

B2.2.3.1 pH Standards

Waterbodies impaired by metals are also sometimes impaired by pH as a result of acid mine drainage. For human health, changes in pH are addressed by the general narrative criteria in ARM 17.30.601 et seq. and ARM 17.30.1001 et seq. For aquatic life, which can be sensitive to small pH changes, criteria are specified for each waterbody use classification. For B-1 waters, ARM 17.30.623(2)(c) states “Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.”

B2.2.4 Temperature Standards

Montana’s temperature standards were originally developed to address situations associated with point source discharges, making them somewhat awkward to apply when dealing with primarily nonpoint source issues. In practical terms, the temperature standards address a maximum allowable increase above “naturally occurring” temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana’s temperature standards address the maximum allowable decrease or rate at which cooling temperature changes (below naturally occurring) can occur to avoid fish and aquatic life temperature shock.

For waters classified as B-1; from Rule 17.30.622(e) and 17.30.623(e):
A 1° F maximum increase above naturally occurring water temperature is allowed within the range 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per-hour maximum decrease below naturally occurring water temperature is above 55° F. A 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

B3.0 Reference Conditions

B3.1 Reference Conditions as Defined in DEQ’s Standard Operating Procedure for Water Quality Assessment (2006)

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 waterbodies greatest potential for water quality given historic land use activities.

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.

Also, Montana WQS do not contain specific provisions addressing nutrients (nitrogen and phosphorous), or detrimental modifications of habitat or flow. However, these factors are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference conditions approach is used to determine if beneficial uses are supported when nutrients, flow, or habitat modifications are present.

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 pre-settlement 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 reference data are available and uses the secondary approach to estimate reference condition when there is no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

B3.2 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 B3-1 is an example boxplot type 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.

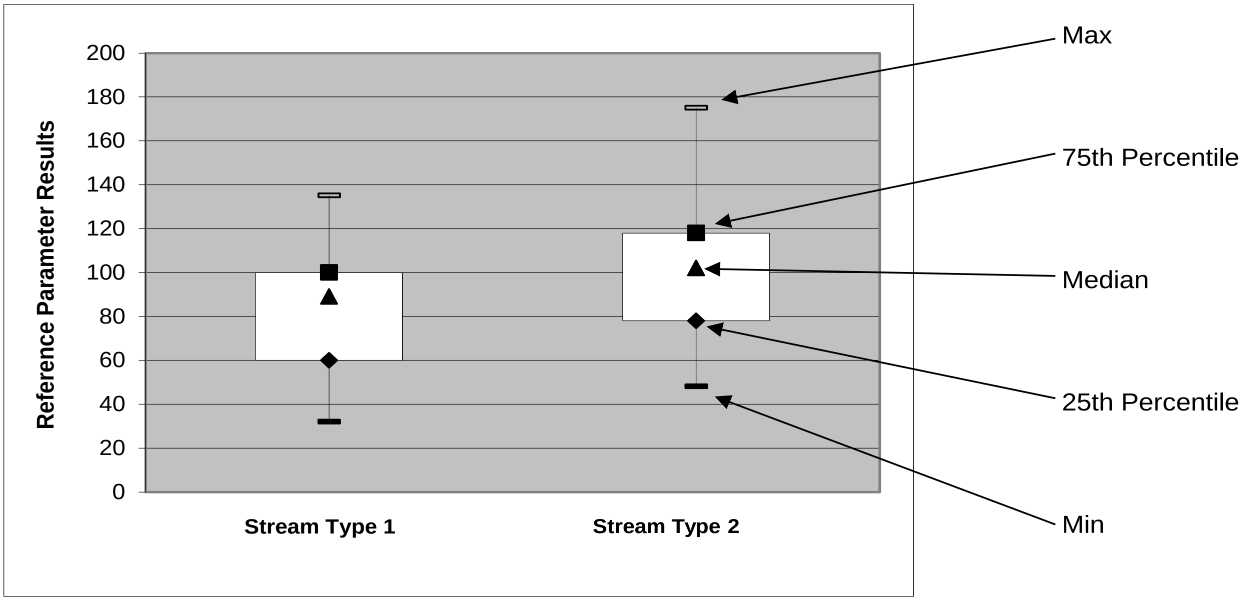

Figure B3-1. Boxplot Example for Reference Data.

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% 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% 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 B2-2**. 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 25^{th} or 75^{th} percentiles as potential target values, but you would use the 25^{th} and 75^{th} 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% to 75% of the results from the whole data distribution represent questionable water quality. **Figure B3-2** is an example statistical distribution of an entire dataset where lower values represent better water quality (and reference data are limited). In **Figure B3-2**, the median and 25^{th} percentiles of all data represent potential target values versus the median and 75^{th} percentiles discussed above for regional reference distribution. Whether you use the median, the 25^{th} 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 also 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 may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

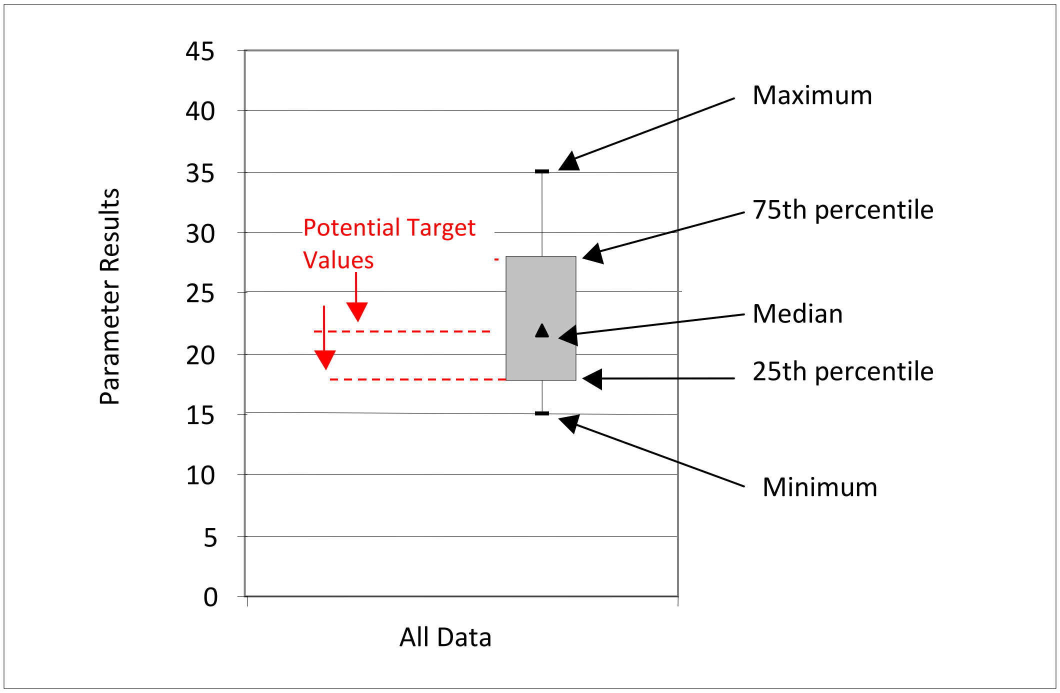

Figure B3-2. Boxplot example for the use of all data to set targets.

B4.0 References

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APPENDIX C – UPLAND EROSION SEDIMENT ASSESSMENT

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ACRONYM LIST

Acronym	Definition
BMP	Best Management Practices
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality (Montana)
GIS	Geographic Information System
LS	Length and Slope Factors
NAIP	National Agricultural Imagery Program
NCSL	Non-Cumulative Slope Length
NLCD	National Land Cover Dataset
NRCS	Natural Resources Conservation Service
RUSLE	Revised Universal Soil Loss Equation
SCAS	Spatial Climate Analysis Service
SDR	Sediment Delivery Ratio
SMZ	Streamside Management Zone
SRE	Sediment Reduction Efficiency
SSURGO	Soil Survey Geographic database
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation

C1.0 INTRODUCTION

An assessment of the sediment loading from hillslope erosion within the Kootenai-Fisher Total Maximum Daily Load (TMDL) Project Area (Project Area) was performed to facilitate the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. Upland sediment loading from hillslope erosion was modeled using a Universal Soil Loss Equation (USLE) based model, which was combined with a sediment delivery ratio (SDR) and riparian health assessment to predict the amount of sediment delivered to streams in the Kootenai-Fisher Project Area. The USLE based model was implemented as a watershed-scale, raster-based, GIS model using ArcGIS software.

C1.1 SEDIMENT IMPAIRMENTS

The Kootenai-Fisher Project Area encompasses an area of approximately 2,511 square miles in Lincoln and Flathead counties in northwestern Montana. The Kootenai-Fisher Project Area includes both the Kootenai TMDL Planning Area (TPA) (1,667 square miles) and the Fisher TPA (844 square miles). The Kootenai TPA encompasses the majority of the Upper Kootenai River HUC8 (17010104), while the Fisher TPA aligns with the Fisher River HUC8 (17010101). Within the Kootenai-Fisher Project Area, there are six waterbody segments listed on the 2012 303(d) List for sediment-related impairments (**Table C1-1**). Bristow Creek, Libby Creek, Lake Creek and Quartz Creek are listed as impaired due to sediment in the Kootenai TPA, while Wolf Creek and Raven Creek are listed as impaired due to sediment in the Fisher TPA.

Table C1-1. Waterbody Segments Addressed during the USLE Assessment

TPA	Segment ID	Waterbody Description
Fisher	MT76C001_020	WOLF CREEK, headwaters to mouth (Fisher River)
Fisher	MT76C001_030	RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)
Kootenai	MT76D002_110	BRISTOW CREEK, the headwaters to mouth at Lake Koocanusa
Kootenai	MT76D002_062	LIBBY CREEK, from the highway 2 bridge to mouth (Kootenai River)
Kootenai	MT76D002_070	LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)
Kootenai	MT76D002_090	QUARTZ CREEK, headwaters to confluence with the Kootenai River

C2.0 METHODS

Upland sediment loading from hillslope erosion was modeled using a Universal Soil Loss Equation (USLE) based model, which was combined with a sediment delivery ratio (SDR) and riparian health assessment to predict the amount of sediment delivered to streams in the Kootenai-Fisher Project Area. USLE is a soil erosion prediction tool that was originally developed for cropland and rangeland and was later modified for application to forested environments (Croke and Nethery, 2006). USLE has been widely used for sediment TMDL development and is a component of numerous more advanced models that are also used for TMDL development (e.g., SWMM, SWAT, GWLF, BASINS, AGNPS). This empirical model was selected for this source assessment because it is well suited for large watersheds since it incorporates local climate and landscape data, but is not overly data-intensive. For this project, the most simplistic uncalibrated version of the USLE model was selected because it meets the needs of the TMDL source assessment and provides the appropriate level of detail for the project. Methods used in this assessment are described in *Quality Assurance Project Plan: Assessment of Upland Sediment Sources for TMDL Development (Task Order 18: Task 2c) (U.S. Environmental Protection Agency and Montana Department of Environmental Quality, 2011)* and summarized in the following sections.

C2.1 Subwatershed Delineation

Prior to USLE model development, subwatersheds were delineated in which the Kootenai-Fisher Project Area upland sediment assessment would be conducted. Subwatersheds were delineated on the basis of the United States Geological Survey (USGS) 6th Hydrologic Unit Code (HUC12) layer and modified where necessary to delineate the subwatersheds of interest (**Table C2-1** and **Figure C2-1**). Delineated subwatersheds include the Upper Lake Creek HUC12, which was split into areas draining upstream (above) and downstream (below) the Bull Lake outlet, along with the Raven Creek subwatershed, which was delineated using watershed delineation tools in ArcGIS and a 30-meter DEM. The Raven Creek watershed is identified with a subwatershed ID of 'sub6code' in **Table C2-1** and **Figure C2-1** since it is located within the Pleasant Valley Fisher River-Loon Lake HUC12. While a portion of the sediment derived from the Upper Lake Creek watershed is likely retained in Bull Lake, no adjustment was made to sediment loading estimates since this assessment is focused on identifying areas where human sources of sediment loading can be reduced.

Table C2-1. Subwatersheds in the Kootenai-Fisher Project Area

HUC10 Name	HUC12 Name	Subwatershed ID
Bristow Creek-Rainy Creek	Bristow Creek	Bristow Creek
Flower Creek-Quartz Creek	Quartz Creek	Quartz Creek
Lake Creek	Keeler Creek	Keeler Creek
	Lower Lake Creek	Lower Lake Creek
	Ross Creek	Ross Creek
	Stanley Creek	Stanley Creek
	Upper Lake Creek	Upper Lake Creek_above Bull Lake
		Upper Lake Creek_below Bull Lake
Libby Creek	Big Cherry Creek	Big Cherry Creek
	Granite Creek	Granite Creek
	Lower Libby Creek	Lower Libby Creek
	Swamp Creek-Cowell Creek	Swamp Creek-Cowell Creek
	Upper Libby Creek	Upper Libby Creek
Wolf Creek	Dry Fork Creek	Dry Fork Creek
	Little Wolf Creek	Little Wolf Creek
	Lower Wolf Creek	Lower Wolf Creek
	Middle Wolf Creek	Middle Wolf Creek
	Upper Wolf Creek	Upper Wolf Creek
	Weigel Creek	Weigel Creek
Pleasant Valley Fisher River	Pleasant Valley Fisher River-Loon Lake	Raven Creek_sub6code

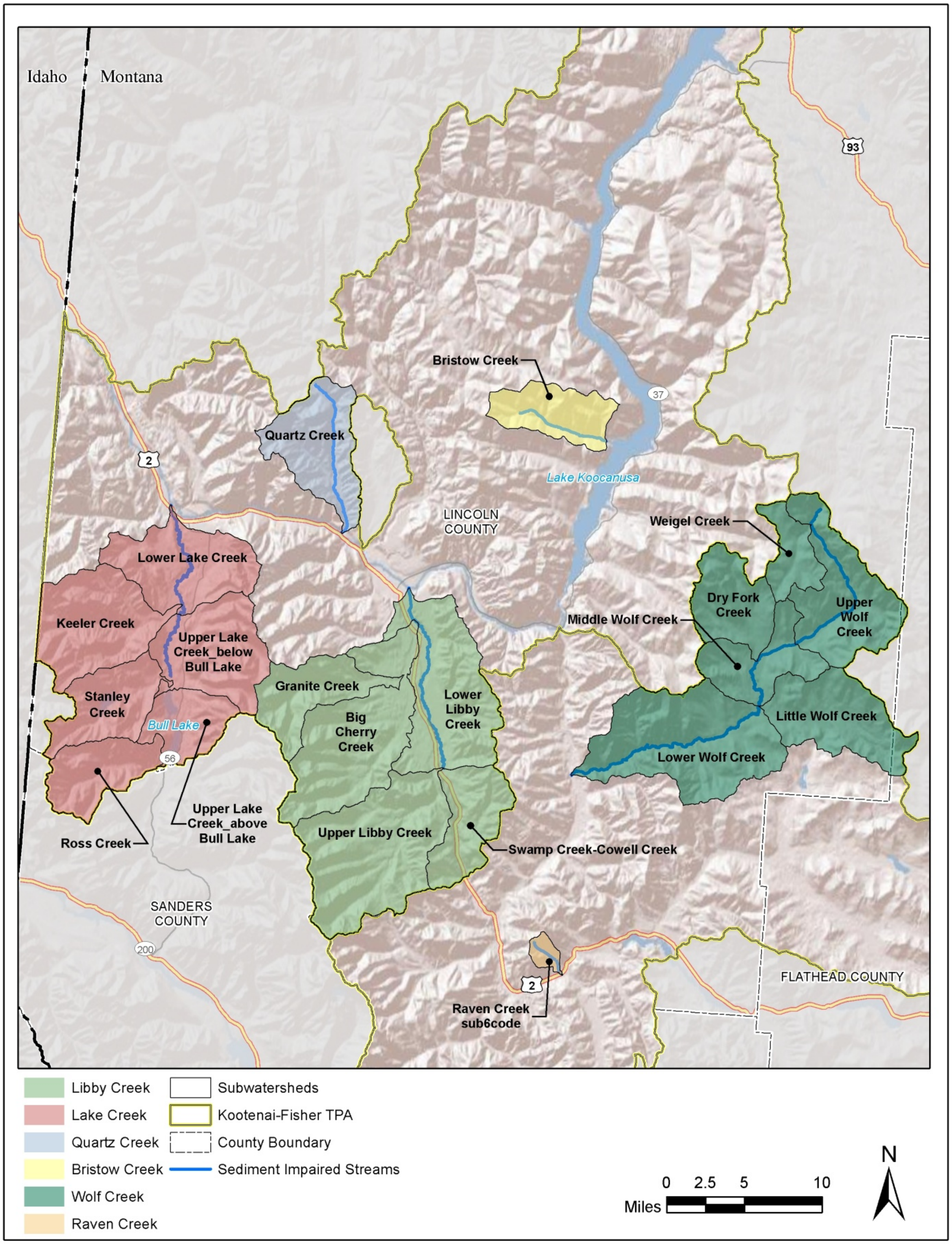

Figure C2-1. Subwatersheds in the Kootenai-Fisher Project Area

C2.2 ULSE MODEL INPUT PARAMETERS

The USLE model requires five landscape factors that are combined to predict upland soil loss, including a rainfall factor (R), soil erodibility factor (K), length and slope factors (LS), cropping factor (C), and 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):

$$A = RK(LS)CP \text{ (in tons per acre per year)}$$

For this assessment, the USLE based model was parameterized using a number of published data sources, including information from: (1) U.S. Geological Survey (USGS), (2) Spatial Climate Analysis Service (SCAS), and (3) Natural Resource Conservation Service (NRCS). Additionally, local information regarding specific land cover was acquired from the U.S. Forest Service (USFS) and the NRCS. Specific GIS data layers used in the modeling effort are presented in the following sections.

C2.2.1 R-Factor

The **R-factor** characterizes the effect of raindrop impact and runoff rates associated with a rainstorm, which is reported in 100s of ft-tons rainfall/ac-yr. The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service of Oregon State University at a 4 km grid cell resolution based on Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation data. The R-factor is determined using the kinetic energy of a rainfall event and the maximum 30-minute rainfall intensity for an area. For the purposes of this analysis, the SCAS R-factor grid was projected to Montana State Plane Coordinates and interpolated to a 10m grid cell (**Figure C2-2**).

C2.2.2 K-Factor

The **K-factor** is a soil erodibility factor that quantifies the susceptibility of soil to erosion. It is a measure of the average soil loss from a particular soil in continuous fallow derived from experimental data (tons soil/100 ft tons rainfall). Polygon data of K-factor values in the Kootenai-Fisher Project Area was obtained from the NRCS General Soil Map (STATSGO) database and the NRCS Soil Survey Geographic (SSURGO) database. While the SSURGO database is more detailed and more current than the STATSGO database, the SSURGO database for the Kootenai-Fisher Project Area did not contain the required K-factor values for Quartz Creek, Bristow Creek, Raven Creek, or Wolf Creek. When the SSURGO database lacked K-factor values, the K-factor was derived from the STATSGO database in which the USLE K-factor is a standard component. Soils polygon data was summarized and interpolated to a 10m grid cell (**Figure C2-2**).

C2.2.3 LS-Factor

The **LS-factor** is a function of the slope and flow length of the eroding slope or cell (units are dimensionless). The LS-factor was derived from 10m USGS digital elevation model (DEM) grid data and interpolated to a 10m grid cell. For the purpose of computing the LS-factor, slope is defined as the average land surface gradient per cell, while the flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. The equation used for calculating the slope length and slope factor is given in the Revised Universal Soil Loss Equation (RUSLE), which provides improved slope length and steepness analysis applicable to mountainous terrain, as published in United States Department of Agriculture (USDA) handbook #703 (Renard et al., 1997). According to McCuen (1998), flow lengths are seldom greater than 400 feet or less than 20 feet.

L, the slope length factor in the RUSLE equation, serves to reference the erosion estimate for a horizontally projected slope length to the experimentally measured erosion for a 72.6 foot (22.1 meters) plot.

$L = (\lambda/72.6)^m$

where:

λ = the horizontal projection of slope length

72.6 = the RUSLE unit plot length in feet

m = the variable slope length component, related to the ratio (β) of rill erosion (caused by flow) to interrill erosion (caused by raindrop impact) defined in the following equation: $= \beta/(1 + \beta)$

And $\beta = (\sin \Theta/0.0896) / [3.0(\sin \Theta)^{0.8} + 0.56]$

Soil loss increases more rapidly with slope steepness than it does with slope length. This is quantified by S, the slope steepness factor of the RUSLE.

$S = 10.8 \sin \theta + 0.03$ for $\theta < 9\%$

$= 16.8 \sin \theta - 0.50$ for $\theta \geq 9\%$

where:

θ = the slope angle

Combined, these factors can be written:

$$LS = S_i (\lambda_i^{m+1} - \lambda_{i-1}^{m+1}) / (\lambda_I - \lambda_{i-1}) (72.6)^m$$

where:

λ_i = length in feet from top of slope to lower end of the ith segment. This value was determined by applying GIS based surface analysis procedures to the each DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters.

S_i = slope steepness factor for the segment

$= 10.8 \sin \theta + 0.03$ for $\theta < 9\%$

$= 16.8 \sin \theta - 0.50$ for $\theta \geq 9\%$

The LS-Factor examines the topography of the area, identifying areas of steepness, flow paths, flow lengths, areas of deposition, and ultimately the concentrated sediment yield. The LS-Factor was calculated using a C++ program which automatically processes the DEM input (Van Remortel et al., 2004). The program evaluates each individual grid cell based on the LS factors mentioned above. The C++ program begins with a fill function of any depressions or sinks found on the DEM input. The highest elevation points on the DEM are then identified by the program and the flow direction is determined. In situations of converging flow, the flow direction of steepest decent takes precedence. The distance between the centers of one grid cell to the next grid cell is then calculated by the C++ program as the non-cumulative slope length (NCSL). A cumulative slope length is then computed by summing the NCSL from each grid cell, beginning at a high point and moving down along the direction of steepest descent.

The calculated slope angle of each cell is first examined by the C++ program, and a sub-routine calls for a table lookup function. The range in which the slope angle falls within the table is indentified and a corresponding slope length exponent (m) is assigned. The program has a function called the cutoff slope angle and is defined as the ratio of change in slope angle from one grid cell to the next along the flow direction. When the slope angle decreases sufficiently, the cumulative slope length calculation stops and then resumes when the land surface extends further downhill in order to recognize areas of deposition versus erosion. The final grid produced combines the effect of these topographic factors into the LS-factor given in the formula above (**Figure C2-2**).

C2.2.3.1 Digital Elevation Model

The digital elevation model (DEM) is the base layer used for developing the LS-factor for the USLE analysis. The USGS 10m (1/3 Arc-second) DEM was used for this analysis. The 10m DEM was projected into Montana State Plan Coordinates and interpolated to a 10m grid cell to render the delineated stream network more representative of the actual size of Kootenai-Fisher Project Area streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m DEM was subjected to standard hydrologic preprocessing, including filling of sinks to create a positive drainage condition for all areas of the watershed (**Figure C2-2**).

C2.2.3.2 Stream Network Delineation

The stream network for each subwatershed in the Kootenai-Fisher Project Area was derived from the 10m DEM using TauDEM (**T**errain **A**nalysis **U**sing **D**igital **E**levation **M**odels) software developed by the Utah State University Hydrology Research Group (http://hydrology.usu.edu/taudem/taudem5.0/index.html). The stream network was generated using TauDEM with the threshold adjusted to most closely mirror the 1:24,000 National Hydrography Dataset (NHD) stream layer.

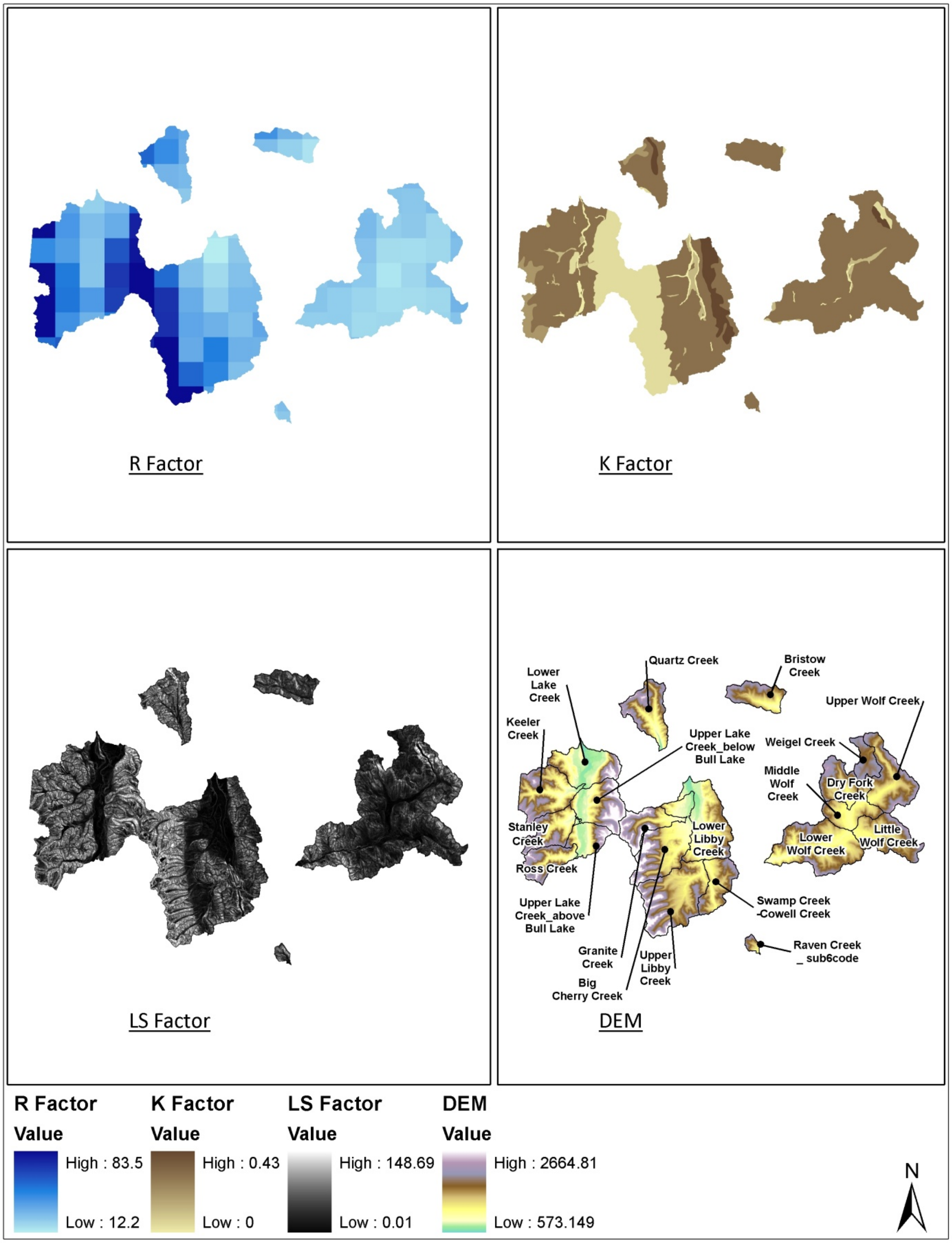

Figure C2-2. R-Factor, K-Factor, LS-Factor, and DEM for the Kootenai-Fisher Project Area

C2.2.4 C-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. The C-factor integrates a number of variables that influence erosion including vegetative cover, plant litter, soil surface, and land management. Original ULSE C-factors were experimentally determined for agricultural crops and have since been modified to include rangeland and forested land cover types. For this assessment, the C-factor was estimated for various land cover types using the National Land Cover Database and C-factor interpretations applied during previous USLE modeling projects conducted for sediment TMDL development. C-factors are intended to be conservatively representative of conditions within the Kootenai-Fisher Project Area.

C2.2.4.1 National Land Cover Database

The 2006 National Land Cover Database (NLCD) was obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium and used for establishing USLE C-factors in the Kootenai-Fisher Project Area. The 2006 NLCD is a categorized 30 meter Landsat Thematic Mapper image shot in 2006. The NLCD image was projected to Montana State Plane Coordinates and interpolated to a 10m grid cell (**Figure C2-3**). For this analysis, areas described as 'cultivated crops' in the NLCD database were redefined as 'hay/pasture' to better represent agricultural practices in the Kootenai-Fisher Project Area based on input from the local Natural Resources Conservation Service representative (Fiest, Don, personal communication). NLCD land cover types for the Kootenai-Fisher Project Area are described in **Attachment CA**.

C2.2.4.2 C-Factor Derivation

USLE C-factors for existing conditions were assigned to the NLCD land cover types in the Kootenai-Fisher Project Area based on ground cover percentages in *Table 10 – Factor C for permanent pasture, range, and idle land* as presented in Predicting Rainfall Erosion Losses: A Guide to Conservation Planning (Wischmeier and Smith, 1978) and summarized in **Table C2-2** and **Attachment CB**. In order to estimate the potential sediment reduction that might be achieved under a Best Management Practices (BMP) scenario, the USLE-based model was also run using C-factors representing desired conditions. Land cover types identified as 'grasslands/ herbaceous' and 'hay/pasture' were conservatively adjusted to reflect a 10% improvement in ground cover over existing conditions based on input from the local Natural Resources Conservation Service representative as depicted in **Table C2-3** (Fiest, Don, personal communication).

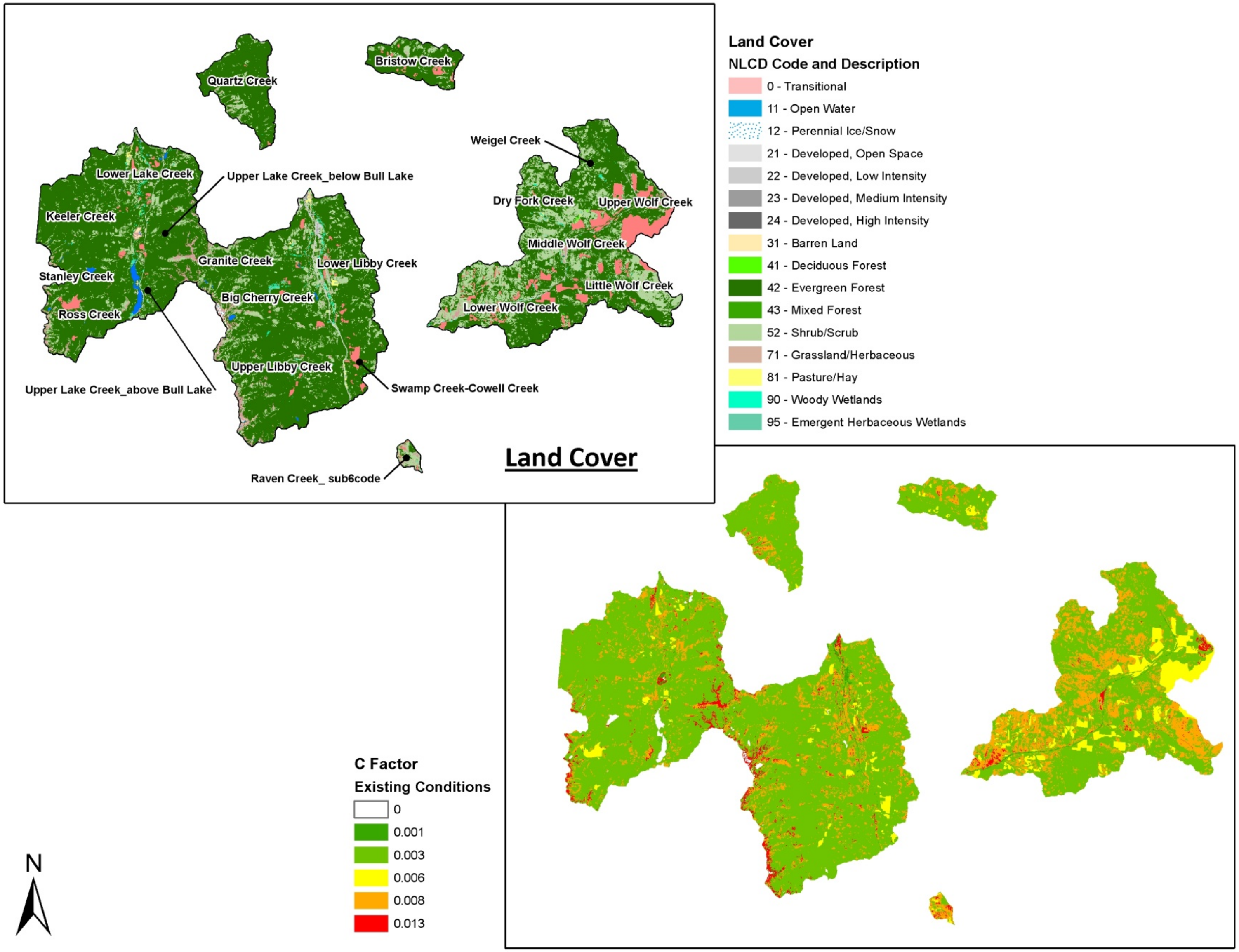

Figure C2-3. Land Cover and C-Factors for the Kootenai-Fisher Project Area

Table C2-2. C-factors for Existing and Desired Conditions

NLCD Code	Description	C-Factor Existing Conditions	C-Factor Desired Conditions
0*	Transitional*	0.006	0.006
11	Open Water*	-	-
12	Perennial Ice/Snow*	-	-
21	Developed, Open Space	0.003	0.003
22	Developed, Low Intensity	0.001	0.001
23	Developed, Medium Intensity	0.001	0.001
24	Developed, High Intensity	0.001	0.001
31	Barren Land	0.001	0.001
41	Deciduous Forest	0.003	0.003
42	Evergreen Forest	0.003	0.003
43	Mixed Forest	0.003	0.003
52	Shrub/Scrub	0.008	0.008
71	Grassland/Herbaceous	0.013	0.008
81	Hay/Pasture	0.013	0.008
90	Woody Wetlands	0.003	0.003
95	Emergent Herbaceous Wetlands	0.003	0.003

* A code of "0" and a description of "Transitional" was developed to describe areas of Fire or Timber Harvest
**Water and ice/snow classes will not be counted as surfaces contributing erosion

Table C2-3. Percent Ground Cover for Existing and Desired Land Cover Types

Land Cover	Existing % ground cover	Desired % ground cover
Grassland/Herbaceous	80	90
Hay/Pasture	80	90

It is acknowledged that land cover is variable within and across watersheds and changes seasonally. The C-factors used for the USLE-based model are intended to represent typical annual conditions at a coarse scale and the percent of improvement achievable via the implementation of BMPs.

C2.2.4.3 Fire and Timber Harvest Adjustments

The 2006 NLCD layer was adjusted to quantify the amount of fire and timber harvest that have occurred since 2006 and also to identify previously disturbed areas that have become reforested over that same period. Adjustments on U.S. Forest Service lands were performed based on fire and timber harvest polygons provided by the U.S. Forest Service. Areas with fire or timber harvest within the past five years (2006-2011) we coded as ‘transitional’, while areas older than five years (pre-2006) were coded based on the NLCD cover type (**Figure C2-4**). On non-USFS property, a polygon layer of fire and timber harvest was digitized in GIS by comparing the 2006 NLCD layer with the 2011 National Agricultural Imagery Program (NAIP) aerial imagery. As with National Forest lands, areas with fire or timber harvest identified within the past five years (2006-2011) were coded as ‘transitional’ (**Figure C2-4**). Adjustments for reforestation were also examined by comparing the 2006 NLCD layer with the 2011 NAIP aerial imagery, though no areas of reforestation were observed.

Areas identified as ‘transitional’ due to recent fire or timber harvest were assigned a C-factor of 0.006 (**Table C2-2** and **Figure C2-3**). This C-factor is slightly higher than a ‘deciduous/evergreen forest’ and was used for logged areas (i.e. ‘transitional’) because logging intensity within the watershed is generally low and because practices, such as riparian clearcutting, that tend to produce high sediment yields have not been used since at least 1991, when the Montana Streamside Management Zone (SMZ) law was enacted. However, since timber harvest has the potential to double the background erosion rate from an undisturbed forest (Elliot, 2007), a conservative C-factor was applied. Additionally, the USLE model is intended to reflect long-term average sediment yield, and while a sediment pulse typically occurs in the first year after logging, sediment production after the first year rapidly declines (Elliot and Robichaud, 2001; Elliot, 2006; Rice et al., 1972). Thus, the 'transitional' value was applied to areas of timber harvest under the assumption that a portion of a given watershed is always being harvested while other areas are recovering. The same C-factor was applied for both the existing conditions and BMP scenarios to indicate that logging will continue sporadically on public and private land within the watershed and will produce sediment at a rate slightly higher than an undisturbed forest. This is not intended to imply that additional best management practices beyond those in the SMZ law should not be used for logging activities.

While upland erosion following fire tends to be greater than erosion following timber harvest (Elliot and Robichaud, 2001), the same C-factor was applied to both disturbance types because of the unpredictable nature of wildfire and the difficulty of estimating the long term average sediment inputs from it. As with timber harvest, the C-factor for fire is the same for both management scenarios since disturbance is expected from periodic forest fires.

C2.2.5 P-Factor

The **P-factor,** or conservation practice factor, is a function of the interaction of the supporting land management practice and slope. It incorporates the use of erosion control practices such as strip-cropping, terracing and contouring, and is applicable only to agricultural lands. Values of the P-factor compare straight-row farming practices with that of certain agriculturally based conservation practices. The P-factor was set to one for this analysis based on existing practices within the Kootenai-Fisher Project Area.

C2.3 Distance and Riparian Health Assessment based Sediment Delivery Ratio

The USLE assessment estimates the amount of sediment generated from the landscape, but the distance that sediment must travel to the stream channel, as well as the sediment removal capacity (i.e., the health) of the riparian vegetation, are important factors for estimating the sediment load that actually enters the stream network. Therefore, results from the USLE hillslope erosion assessment were combined with a sediment delivery ratio (SDR) and riparian health assessment to predict the amount of sediment delivered to streams in the Kootenai-Fisher Project Area. Soil lost from one area on a hillslope due to erosive processes is typically re-deposited a short distance downslope and therefore not all of the sediment produced from a hillslope erosion event is delivered to a stream channel. In the Kootenai-Fisher Project Area, sediment re-deposition is accounted for through the application of a sediment delivery ratio (SDR) which estimates the percentage of hillslope sediment produced that is ultimately delivered to the stream. This distance based sediment delivery ratio reflects the relationship between downslope travel distance and ultimate sediment delivery. In addition to sediment re-deposition during hillslope transport processes, riparian zones also reduce sediment inputs to stream channels. The width and quality of the riparian vegetation buffer zone determines its effectiveness as a sediment filter. Thus, a riparian health-based loading reduction was performed along with the distance based sediment delivery analysis.

C2.3.1 Riparian Health Assessment

A riparian health assessment was conducted during the aerial assessment reach stratification process in which reaches were delineated based on a combination of physical attributes (ecoregion, valley slope, valley confinement, and stream order) and the presence and degree of adjacent human activity. For each reach, a riparian health assessment was performed using aerial photos, field notes, and best professional judgment. Riparian health for each reach was designated as 'poor', 'poor/fair', 'fair', 'fair/good', or 'good' based on adjacent land use practices, streamside vegetation, and the presence or absence of human activities (**Figure C2-5**). The health classifications were then ground-truthed and modified based on field observations during July 2011. The cumulative length of the reaches within each riparian health category was tallied for each stream segment and the percent of stream length in each riparian health category was calculated. This information was then used to refine estimates of sediment delivery to streams from upland sources by incorporating the results of the riparian health assessment into the distance based sediment delivery ratio calculation.

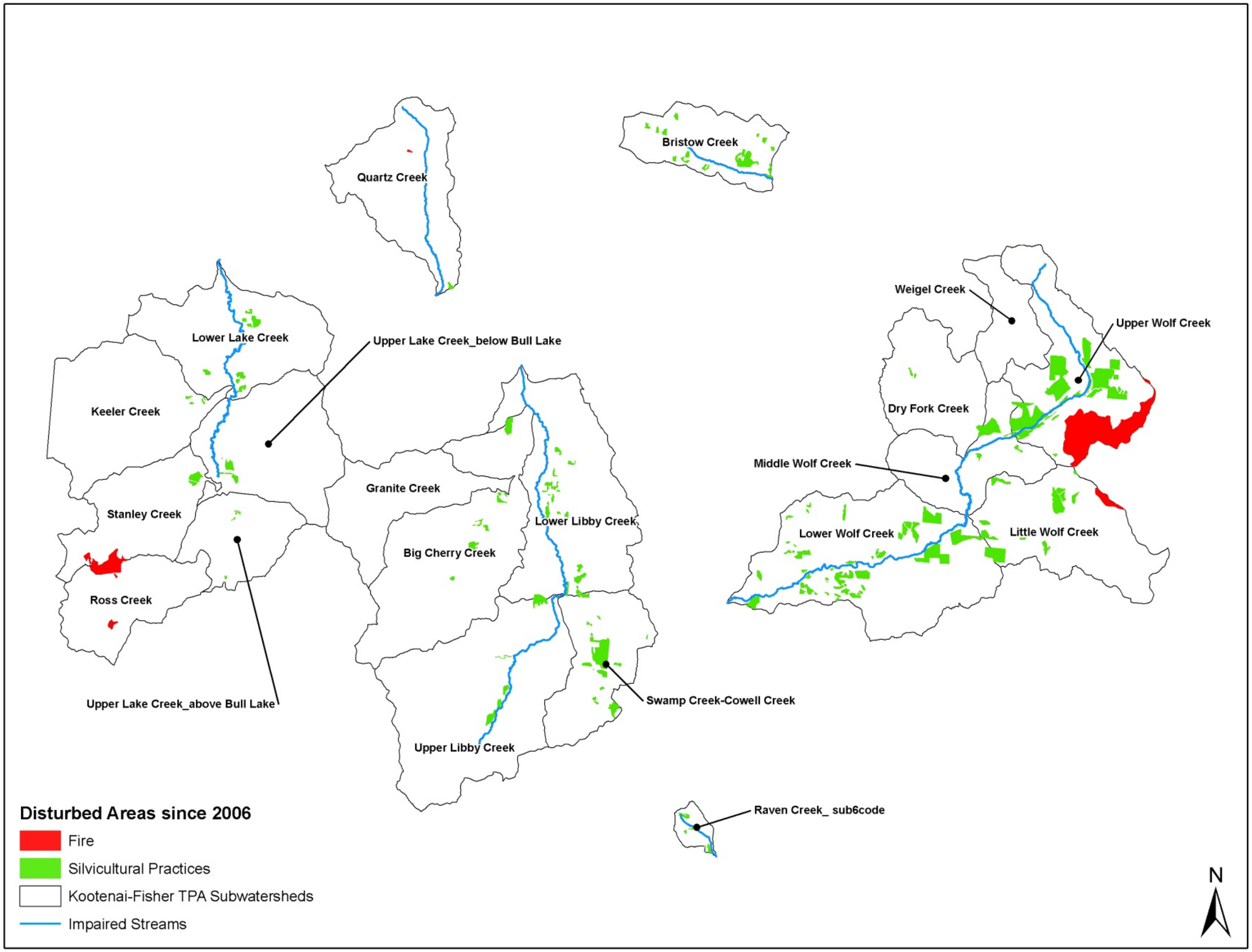

Figure C2-4. Fire and Timber Harvest Areas in the Kootenai-Fisher Project Area since 2006

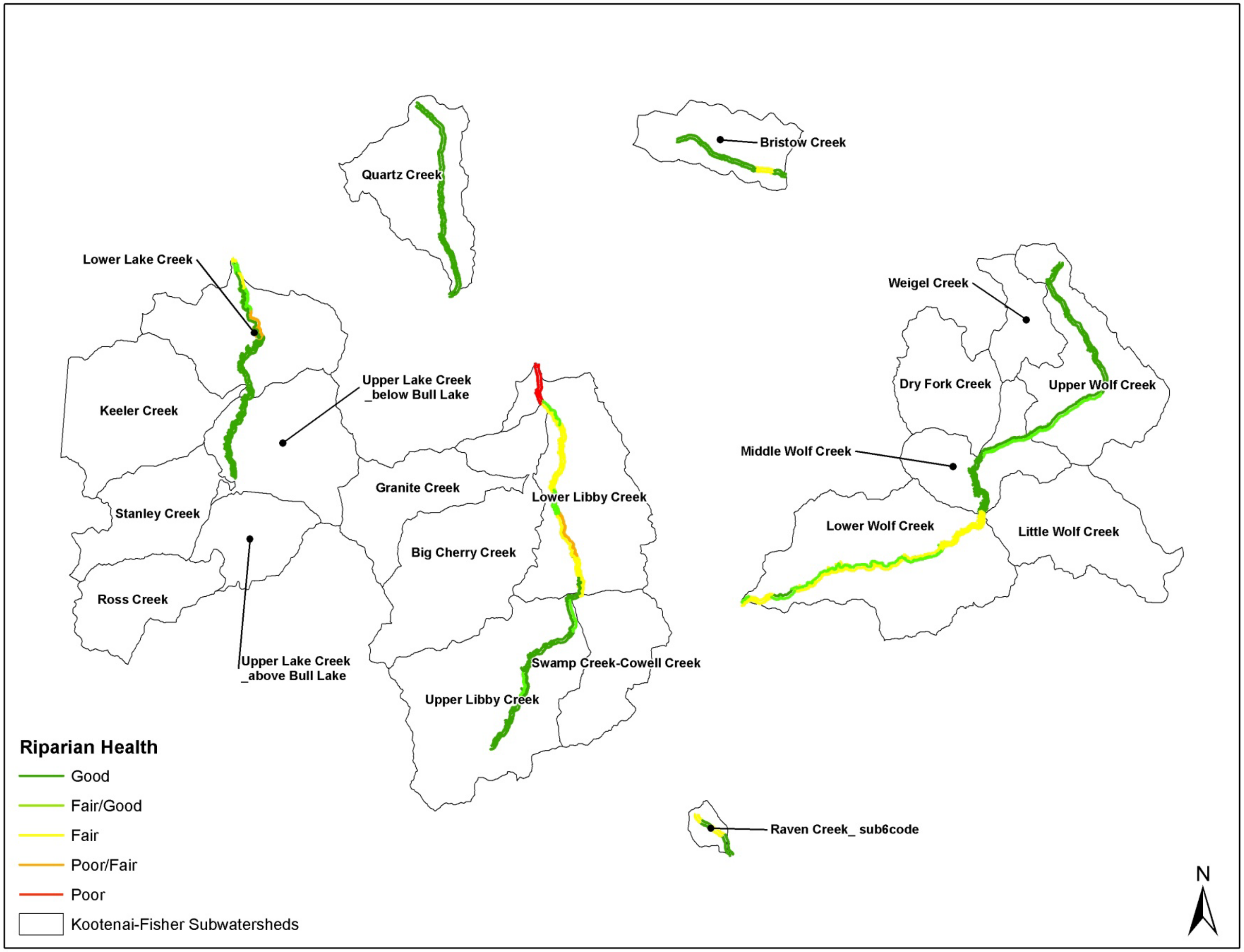

Figure C2-5. Aerial Assessment Reach Stratification Riparian Health Assessment

C2.3.2 Distance based Sediment Delivery Ratio

The distance based sediment delivery ratio was calculated in the model for each grid cell based on the observed relationship between the distance from the delivery point to the stream and the percent of eroded sediment delivered to the stream using an equation developed by Megahan and Ketcheson (1996). Megahan and Ketcheson (1996) found that the relationship between the percentage (by volume) of sediment that travels a given percentage of the maximum distance is as shown in **Figure C2-6**. Megahan and Ketcheson's logarithmic regression of the data permits this relationship to be expressed by the equation presented in **Figure C2-6**, which may be restated as a function of three variables:

Volume % = or 103.62*EXP(-((D/Dtotal)*100)/32.88))-5.55

where:

Volume% = the percentage of sediment mobilized from a source that travels at least distance D from that source

D = distance from the sediment source, and

Dtotal = the maximum distance that sediment travels from the source.

As the Megahan and Ketcheson equation is dimensionless, to serve as an SDR it was scaled to the field conditions of the Kootenai-Fisher TPA by evaluating the equation with site-specific values for D and Volume% at a single point and then solving for Dtotal. Having established a site-specific Dtotal, the Megahan and Ketcheson equation reduces to the two variables that define a distance based SDR: distance and percent sediment delivered beyond that distance. This SDR was then used to estimate sediment delivery at all points on the sediment delivery path extending from the streambank to a distance Dtotal. A sediment delivery ratio example calculation is provided in **Attachment CC**.

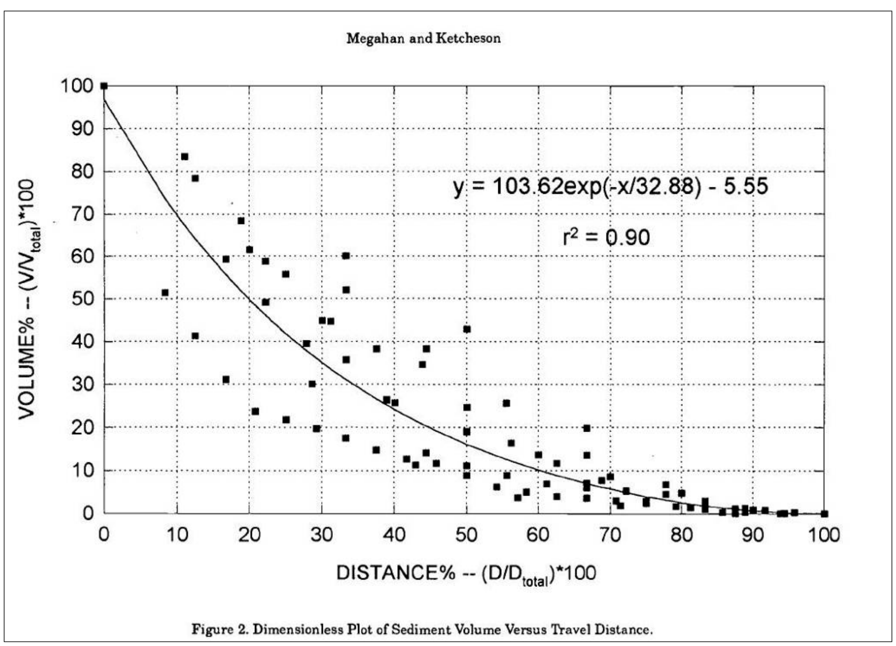

Figure C2-6. Sediment Volume vs. Travel Distance (Megahan and Ketcheson, 1996)

C2.3.3 Subwatershed Specific Sediment Delivery Ratio Scale Factors

Riparian zone sediment filtering capacity is typically expressed as a given percent reduction in delivery of sediment entering a riparian zone of a given buffer width. This rating of a known percent delivery (Volume%) from a known distance from the stream (D) permits scaling of the Megahan and Ketcheson's dimensionless equation (**Section C2.3.2**) for use in predicting percent delivery from other distances. Thirty five feet is the minimum buffer width recommended by NRCS (Natural Resource Conservation Service, 2011b; 2011a) and 50 feet is the minimum width of the streamside management zone in Montana (Montana Department of Natural Resources and Conservation, 2006). Although buffer widths of 30 to 50 feet help reduce upland sediment loading to surface waters, the ability of riparian buffers to effectively filter sediment increases with increasing buffer width. For instance, a 100 foot wide, well-vegetated riparian buffer is a common recommended buffer width (Cappiella et al., 2006; Mayer et al., 2005) and has been found to filter 75-90% of incoming sediment from reaching the stream channel (Wegner, 1999; Knutson and Naef, 1997) .

Although sediment removal efficiency is affected by factors such as ground slope, buffer health, and buffer composition, the literature values for a 100 foot buffer were used as the basis for applying a 75% sediment reduction efficiency (SRE) to buffers classified as 'good' and then scaling down the SRE based on the health classification (i.e., the SRE declines as buffer health/width declines) (**Figure C2-7**). The actual sediment removal efficiency is likely greater than shown in **Figure C2-7**, but conservative values from the literature were used as part of an implicit margin of safety. Note: Even though the health classifications assigned to streams in the Kootenai-Fisher Project Area roughly correspond to different widths, and vegetative condition, density, and potential were considered during field verification of the classifications, the loading reductions based on riparian health are predominantly intended to highlight the importance of maintaining healthy riparian zones in reducing loading from upland sediment erosion. The values were not calibrated and do not necessarily reflect actual loading reductions associated with the riparian zone.

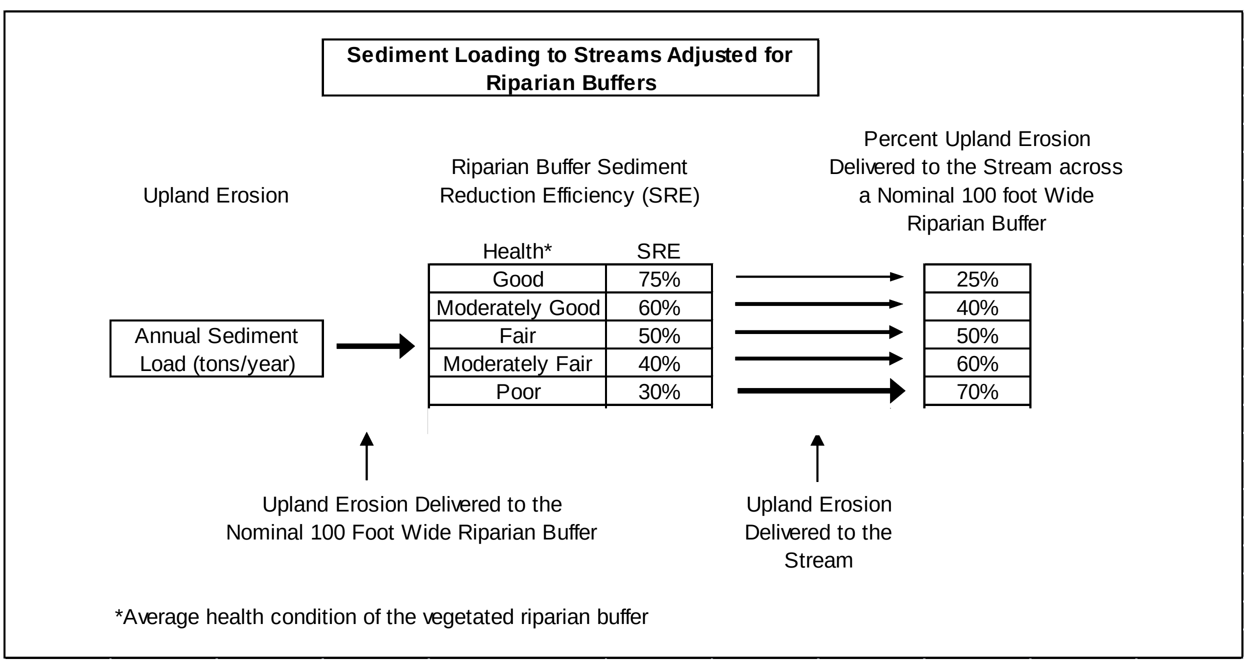

Figure C2-7. USLE Upland Sediment Load Delivery Adjusted for Riparian Buffer Capacity

The Kootenai-Fisher Project Area riparian health assessment was used to develop a riparian health score based on the sediment reduction percentage for each individual stream segment subwatershed. This value represents the percent reduction in sediment delivery under existing conditions. For the BMP scenario, it was assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer will increase riparian health. The potential to improve riparian health was evaluated for each reach based on best professional judgment through a review of color aerial imagery from 2009 and on-the-ground verification during July 2011.

C2.4 Model Scenarios

Management scenarios include: (1) an existing conditions scenario that considers the current land cover, management practices, and riparian health in the watershed; (2) an upland BMP conditions scenario that reflects improved grazing and cover management; and (3) a riparian health BMP and upland BMP conditions scenario that considers improved riparian buffer zones and grazing and cover management. For each scenario, erosion was differentiated into two source categories: (1) natural erosion that occurs on the time scale of geologic processes and (2) anthropogenic erosion that is accelerated by human-caused activity. For scenarios 2 and 3, land cover types identified as 'grasslands/ herbaceous' and 'hay/pasture' were conservatively adjusted to reflect a 10% improvement in ground cover over existing conditions as discussed in **Section C2.2.4.2** and depicted in **Table C2-3**. For scenario 3, the riparian health score was adjusted to reflect improvements in riparian health as discussed in **Section C2.3.3**.

C3.0 Results

The results of this assessment are summarized by subwatershed in **Table C3-1**, with the complete modeling results presented by land cover category for each subwatershed in **Table C3-2**.

Table C3-1. Summary of Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Subwatershed	**Area (Acres)**	**Scenario 1** Upland Erosion Sediment Load for **Existing Conditions** and **Existing Riparian** Health		**Scenario 2 (BMP 1)** Upland Erosion Sediment Load for **BMP Conditions** and **Existing Riparian** Health		**Scenario 2 (BMP 1)** **Percent Reduction**	**Scenario 3 (BMP 2)** Upland Erosion Sediment Load for **BMP Conditions** and **BMP Riparian** Health		**Scenario 3 (BMP 2)** **Percent Reduction**
		(Tons/Year)	(Tons/Acre/Year)	(Tons/Year)	(Tons/Acre/Year)		(Tons/Year)	(Tons/Acre/Year)	
Ross Creek	16,111	327.1	0.020	322.1	0.020	2%	292.0	0.018	11%
Upper Lake - Above Bull Lake	12,925	96.4	0.007	96.3	0.007	<1%	87.5	0.007	9%
Upper Lake - Below Bull Lake	25,177	36.4	0.001	36.4	0.001	<1%	32.6	0.001	11%
Stanley Creek	17,869	310.4	0.017	307.2	0.017	1%	278.8	0.016	10%
Keeler Creek	28,571	352.0	0.012	351.0	0.012	<1%	317.0	0.011	10%
Lower Lake Creek	25,608	87.2	0.003	86.9	0.003	<1%	77.4	0.003	11%
Lake Creek Total	**126,262**	**1,209**	**0.010**	**1,200**	**0.010**	**1%**	**1,085**	**0.009**	**10%**
Upper Libby Creek	42,877	303.9	0.007	303.2	0.007	<1%	245.7	0.006	19%
Swamp Creek-Cowell Creek	17,217	173.5	0.010	172.4	0.010	1%	140.3	0.008	19%
Big Cherry Creek	37,491	128.3	0.003	126.6	0.003	1%	103.3	0.003	19%
Granite Creek	17,327	18.4	0.001	18.4	0.001	0%	14.5	0.001	21%
Lower Libby Creek	34,734	251.5	0.007	250.4	0.007	<1%	205.1	0.006	18%
Libby Creek Total	**149,646**	**876**	**0.006**	**871**	**0.006**	**1%**	**709**	**0.005**	**19%**
Upper Wolf Creek	28,166	192.6	0.007	186.6	0.007	3%	165.7	0.006	14%
Weigel Creek	9,368	29.8	0.003	29.7	0.003	<1%	25.8	0.003	13%
Dry Fork Creek	16,803	98.3	0.006	98.1	0.006	<1%	86.8	0.005	12%
Middle Wolf Creek	16,511	61.1	0.004	60.9	0.004	<1%	54.1	0.003	12%
Little Wolf Creek	24,239	134.0	0.006	133.6	0.006	<1%	118.1	0.005	12%
Lower Wolf Creek	42,748	291.2	0.007	290.0	0.007	0%	254.1	0.006	13%
Wolf Creek Total	**137,836**	**807**	**0.006**	**799**	**0.006**	**1%**	**705**	**0.005**	**13%**
Bristow Creek	**14,849**	**82**	**0.005**	**82**	**0.005**	**<1%**	**74**	**0.005**	**10%**
Raven Creek	**2,202**	**31.1**	**0.014**	**30.5**	**0.014**	**2%**	**25.6**	**0.012**	**18%**
Quartz Creek	**22,855**	**271**	**0.012**	**271**	**0.012**	**<1%**	**271**	**0.012**	**<1%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Ross Creek	Transitional	648	22.134	22.134	0%	19.994	10%
	Open Water	5	0.000	0.000	0%	0.000	0%
	Perennial Snow	1	0.000	0.000	0%	0.000	0%
	Developed, Low Intensity	3	0.119	0.119	0%	0.111	7%
	Barren Land	3	0.000	0.000	0%	0.000	0%
	Evergreen Forest	13,036	232.265	232.265	0%	211.345	9%
	Shrub/Scrub	1,693	59.497	59.497	0%	53.569	10%
	Grassland/Herbaceous	676	12.193	7.504	38%	6.423	47%
	Pasture/Hay	7	0.855	0.526	38%	0.491	43%
	Woody Wetlands	14	0.006	0.006	0%	0.006	10%
	Emergent Herbaceous Wetlands	24	0.013	0.013	0%	0.012	7%
	Total	**16,111**	**327.1**	**322.1**	**2%**	**292.0**	**11%**
Upper Lake Creek - Above Bull Lake	Transitional	44	0.489	0.489	0%	0.431	12%
	Open Water	1,126	0.000	0.000	0%	0.000	0%
	Developed, Open Space	165	0.120	0.120	0%	0.105	12%
	Developed, Low Intensity	76	0.022	0.022	0%	0.020	10%
	Deciduous Forest	4	0.000	0.000	0%	0.000	0%
	Evergreen Forest	10,316	83.282	83.282	0%	75.830	9%
	Shrub/Scrub	839	11.930	11.930	0%	10.694	10%
	Grassland/Herbaceous	192	0.234	0.144	38%	0.131	44%
	Woody Wetlands	76	0.041	0.041	0%	0.037	9%
	Emergent Herbaceous Wetlands	86	0.249	0.249	0%	0.221	11%
	Total	**12,925**	**96.4**	**96.3**	**<1%**	**87.5**	**9%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Upper Lake Creek - Below Bull Lake	Transitional	209	0.547	0.547	0%	0.474	13%
	Open Water	28	0.000	0.000	0%	0.000	0%
	Developed, Open Space	62	0.033	0.033	0%	0.030	11%
	Developed, Low Intensity	75	0.012	0.012	0%	0.011	9%
	Developed, Medium Intensity	4	0.000	0.000	0%	0.000	0%
	Barren Land	168	0.006	0.006	0%	0.006	8%
	Deciduous Forest	23	0.017	0.017	0%	0.014	18%
	Evergreen Forest	19,895	30.395	30.395	0%	27.241	10%
	Mixed Forest	16	0.001	0.001	0%	0.001	26%
	Shrub/Scrub	3,035	5.198	5.198	0%	4.627	11%
	Grassland/Herbaceous	1,468	0.081	0.050	38%	0.045	44%
	Pasture/Hay	14	0.007	0.005	38%	0.004	45%
	Woody Wetlands	129	0.111	0.111	0%	0.099	11%
	Emergent Herbaceous Wetlands	50	0.008	0.008	0%	0.007	9%
	Total	**25,177**	**36.4**	**36.4**	**<1%**	**32.6**	**11%**
Stanley Creek	Transitional	487	5.507	5.507	0%	4.727	14%
	Open Water	336	0.000	0.000	0%	0.000	0%
	Barren Land	10	0.000	0.000	0%	0.000	14%
	Deciduous Forest	25	0.003	0.003	0%	0.003	20%
	Evergreen Forest	15,449	237.229	237.229	0%	215.273	9%
	Shrub/Scrub	1,300	59.345	59.345	0%	54.341	8%
	Grassland/Herbaceous	232	8.277	5.094	38%	4.433	46%
	Woody Wetlands	15	0.003	0.003	0%	0.002	38%
	Emergent Herbaceous Wetlands	16	0.012	0.012	0%	0.011	8%
	Total	**17,869**	**310.4**	**307.2**	**1%**	**278.8**	**10%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Keeler Creek	Transitional	61	0.044	0.044	0%	0.041	6%
	Open Water	38	0.000	0.000	0%	0.000	0%
	Developed, Open Space	3	0.000	0.000	0%	0.000	0%
	Developed, Low Intensity	9	0.004	0.004	0%	0.004	8%
	Barren Land	6	0.000	0.000	0%	0.000	0%
	Deciduous Forest	7	0.063	0.063	0%	0.060	4%
	Evergreen Forest	26,172	301.221	301.221	0%	272.085	10%
	Shrub/Scrub	2,043	47.599	47.599	0%	42.960	10%
	Grassland/Herbaceous	175	2.232	1.374	38%	1.183	47%
	Pasture/Hay	4	0.386	0.237	38%	0.217	44%
	Woody Wetlands	44	0.407	0.407	0%	0.378	7%
	Emergent Herbaceous Wetlands	9	0.083	0.083	0%	0.076	8%
	Total	**28,571**	**352.0**	**351.0**	**<1%**	**317.0**	**10%**
Lower Lake Creek	Transitional	696	0.358	0.358	0%	0.316	12%
	Open Water	138	0.000	0.000	0%	0.000	0%
	Developed, Open Space	145	0.205	0.205	0%	0.183	11%
	Developed, Low Intensity	150	0.022	0.022	0%	0.019	11%
	Developed, Medium Intensity	20	0.003	0.003	0%	0.003	18%
	Barren Land	1	0.000	0.000	0%	0.000	0%
	Deciduous Forest	19	0.000	0.000	0%	0.000	0%
	Evergreen Forest	19,940	73.578	73.578	0%	65.598	11%
	Mixed Forest	2	0.004	0.004	0%	0.004	11%
	Shrub/Scrub	3,612	11.647	11.647	0%	10.270	12%
	Grassland/Herbaceous	244	0.363	0.223	38%	0.208	43%
	Pasture/Hay	175	0.334	0.205	38%	0.190	43%
	Woody Wetlands	313	0.442	0.442	0%	0.402	9%
	Emergent Herbaceous Wetlands	152	0.195	0.195	0%	0.174	11%
	Total	**25,608**	**87.2**	**86.9**	**<1%**	**77.4**	**11%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Lake Creek Total	Transitional	2,145	29.080	29.080	0%	25.983	11%
	Open Water	1,672	0.000	0.000	0%	0.000	0%
	Perennial Snow	1	0.000	0.000	0%	0.000	0%
	Developed, Open Space	375	0.359	0.359	0%	0.318	11%
	Developed, Low Intensity	312	0.179	0.179	0%	0.165	8%
	Developed, Medium Intensity	24	0.003	0.003	0%	0.003	18%
	Barren Land	189	0.006	0.006	0%	0.006	8%
	Deciduous Forest	79	0.084	0.084	0%	0.077	8%
	Evergreen Forest	104,809	957.970	957.970	0%	867.372	9%
	Mixed Forest	18	0.005	0.005	0%	0.004	13%
	Shrub/Scrub	12,522	195.217	195.217	0%	176.461	10%
	Grassland/Herbaceous	2,988	23.381	14.388	38%	12.423	47%
	Pasture/Hay	200	1.582	0.973	38%	0.902	43%
	Woody Wetlands	591	1.009	1.009	0%	0.924	8%
	Emergent Herbaceous Wetlands	336	0.559	0.559	0%	0.502	10%
	Total	**126,262**	**1209.4**	**1199.8**	**1%**	**1,085.1**	**10%**
Upper Libby Creek	Transitional	375	1.862	1.862	0%	1.316	29%
	Open Water	63	0.000	0.000	0%	0.000	0%
	Perennial Snow	49	0.000	0.000	0%	0.000	0%
	Developed, Open Space	20	0.139	0.139	0%	0.114	18%
	Developed, Low Intensity	15	0.010	0.010	0%	0.008	20%
	Developed, Medium Intensity	4	0.004	0.004	0%	0.003	17%
	Barren Land	106	0.000	0.000	0%	0.000	0%
	Evergreen Forest	36,685	247.913	247.913	0%	202.544	18%
	Shrub/Scrub	3,893	51.669	51.669	0%	40.434	22%
	Grassland/Herbaceous	1,514	1.638	1.008	38%	0.759	54%
	Pasture/Hay	21	0.000	0.000	0%	0.000	0%

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
	Woody Wetlands	49	0.099	0.099	0%	0.079	21%
	Emergent Herbaceous Wetlands	83	0.526	0.526	0%	0.434	17%
	Total	**42,877**	**303.9**	**303.2**	**<1%**	**245.7**	**19%**
Swamp Creek-Cowell Creek	Transitional	1,114	4.210	4.210	0%	3.300	22%
	Developed, Open Space	277	3.243	3.243	0%	2.515	22%
	Developed, Low Intensity	63	0.111	0.111	0%	0.085	23%
	Developed, Medium Intensity	0.34	0.000	0.000	0%	0.000	100%
	Evergreen Forest	14,075	138.042	138.042	0%	112.952	18%
	Shrub/Scrub	1,509	24.700	24.700	0%	19.702	20%
	Grassland/Herbaceous	52	2.483	1.528	38%	1.296	48%
	Pasture/Hay	64	0.597	0.368	38%	0.303	49%
	Woody Wetlands	20	0.048	0.048	0%	0.043	11%
	Emergent Herbaceous Wetlands	44	0.109	0.109	0%	0.094	14%
	Total	**17,217**	**173.5**	**172.4**	**1%**	**140.3**	**19%**
Big Cherry Creek	Transitional	446	1.151	1.151	0%	0.878	24%
	Open Water	146	0.000	0.000	0%	0.000	0%
	Perennial Snow	76	0.000	0.000	0%	0.000	0%
	Developed, Open Space	57	0.036	0.036	0%	0.029	19%
	Developed, Low Intensity	111	0.004	0.004	0%	0.003	16%
	Developed, Medium Intensity	28	0.002	0.002	0%	0.002	9%
	Developed, High Intensity	3	0.000	0.000	0%	0.000	13%
	Barren Land	48	0.000	0.000	0%	0.000	0%
	Deciduous Forest	13	0.044	0.044	0%	0.038	15%
	Evergreen Forest	28,802	103.526	103.526	0%	84.531	18%
	Shrub/Scrub	5,867	17.751	17.751	0%	14.347	19%
	Grassland/Herbaceous	1,343	4.008	2.466	38%	2.033	49%
	Pasture/Hay	57	0.253	0.155	38%	0.138	45%
	Woody Wetlands	264	0.774	0.774	0%	0.650	16%
	Emergent Herbaceous Wetlands	229	0.733	0.733	0%	0.627	14%

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
	Total	**37,491**	**128.3**	**126.6**	**1%**	**103.3**	**19%**
Granite Creek	Transitional	0.13	0.000	0.000	0%	0.000	0%
	Open Water	109	0.000	0.000	0%	0.000	0%
	Perennial Snow	159	0.000	0.000	0%	0.000	0%
	Barren Land	20	0.000	0.000	0%	0.000	0%
	Deciduous Forest	9	0.014	0.014	0%	0.007	54%
	Evergreen Forest	13,897	15.512	15.512	0%	12.412	20%
	Shrub/Scrub	2,281	2.813	2.813	0%	2.046	27%
	Grassland/Herbaceous	791	0.000	0.000	0%	0.000	0%
	Woody Wetlands	52	0.028	0.028	0%	0.025	11%
	Emergent Herbaceous Wetlands	8	0.005	0.005	0%	0.005	7%
	Total	**17,327**	**18.4**	**18.4**	**0%**	**14.5**	**21%**
Lower Libby Creek	Transitional	692	1.554	1.554	0%	1.217	22%
	Open Water	71	0.000	0.000	0%	0.000	0%
	Developed, Open Space	475	0.230	0.230	0%	0.189	18%
	Developed, Low Intensity	726	0.081	0.081	0%	0.068	16%
	Developed, Medium Intensity	179	0.048	0.048	0%	0.041	15%
	Barren Land	2	0.002	0.002	0%	0.002	23%
	Deciduous Forest	13	0.000	0.000	0%	0.000	59%
	Evergreen Forest	25,228	206.078	206.078	0%	169.596	18%
	Shrub/Scrub	6,140	40.428	40.428	0%	32.231	20%
	Grassland/Herbaceous	360	2.396	1.474	38%	1.264	47%
	Pasture/Hay	317	0.264	0.162	38%	0.136	48%
	Woody Wetlands	462	0.233	0.233	0%	0.200	14%
	Emergent Herbaceous Wetlands	69	0.139	0.139	0%	0.120	13%
	Total	**34,734**	**251.5**	**250.4**	**<1%**	**205.1**	**18%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Libby Creek Total	Transitional	2,628	8.777	8.777	0%	6.710	24%
	Open Water	389	0.000	0.000	0%	0.000	0%
	Perennial Snow	283	0.000	0.000	0%	0.000	0%
	Developed, Open Space	829	3.649	3.649	0%	2.848	22%
	Developed, Low Intensity	914	0.205	0.205	0%	0.164	20%
	Developed, Medium Intensity	212	0.054	0.054	0%	0.046	15%
	Developed, High Intensity	3	0.000	0.000	0%	0.000	13%
	Barren Land	177	0.002	0.002	0%	0.002	23%
	Deciduous Forest	35	0.059	0.059	0%	0.044	24%
	Evergreen Forest	118,687	711.071	711.071	0%	582.034	18%
	Shrub/Scrub	19,690	137.361	137.361	0%	108.760	21%
	Grassland/Herbaceous	4,060	10.525	6.477	38%	5.352	49%
	Pasture/Hay	459	1.114	0.685	38%	0.578	48%
	Woody Wetlands	847	1.182	1.182	0%	0.997	16%
	Emergent Herbaceous Wetlands	433	1.512	1.512	0%	1.281	15%
	Total	**149,646**	**875.5**	**871.0**	**1%**	**708.8**	**19%**
Upper Wolf Creek	Transitional	8,152	66.137	66.137	0%	58.924	11%
	Developed, Open Space	119	0.284	0.284	0%	0.253	11%
	Developed, Low Intensity	115	0.071	0.071	0%	0.063	12%
	Developed, Medium Intensity	5	0.003	0.003	0%	0.002	22%
	Barren Land	1	0.000	0.000	0%	0.000	0%
	Deciduous Forest	5	0.033	0.033	0%	0.024	26%
	Evergreen Forest	15,347	73.192	73.192	0%	64.958	11%
	Shrub/Scrub	3,895	37.229	37.229	0%	32.929	12%
	Grassland/Herbaceous	463	15.571	9.582	38%	8.450	46%
	Woody Wetlands	35	0.064	0.064	0%	0.058	10%
	Emergent Herbaceous Wetlands	29	0.053	0.053	0%	0.048	11%

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
	Total	**28,166**	**192.6**	**186.6**	**3%**	**165.7**	**14%**
Weigel Creek	Evergreen Forest	6,932	20.280	20.280	0%	17.693	13%
	Shrub/Scrub	2,357	8.948	8.948	0%	7.676	14%
	Grassland/Herbaceous	11	0.122	0.075	38%	0.068	44%
	Pasture/Hay	3	0.047	0.029	38%	0.024	49%
	Woody Wetlands	57	0.295	0.295	0%	0.266	10%
	Emergent Herbaceous Wetlands	8	0.097	0.097	0%	0.086	11%
	Total	**9,368**	**29.8**	**29.7**	**<1%**	**25.8**	**13%**
Dry Fork Creek	Transitional	101	0.152	0.152	0%	0.122	19%
	Barren Land	2	0.000	0.000	0%	0.000	64%
	Deciduous Forest	23	0.035	0.035	0%	0.033	6%
	Evergreen Forest	10,825	48.029	48.029	0%	42.421	12%
	Shrub/Scrub	5,527	47.946	47.946	0%	42.470	11%
	Grassland/Herbaceous	36	0.071	0.044	38%	0.039	44%
	Pasture/Hay	40	0.312	0.192	38%	0.173	45%
	Woody Wetlands	79	0.599	0.599	0%	0.542	10%
	Emergent Herbaceous Wetlands	171	1.152	1.152	0%	1.034	10%
	Total	**16,803**	**98.3**	**98.1**	**<1%**	**86.8**	**12%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Middle Wolf Creek	Transitional	594	1.921	1.921	0%	1.717	11%
	Open Water	5	0.000	0.000	0%	0.000	0%
	Developed, Open Space	73	0.047	0.047	0%	0.039	16%
	Developed, Low Intensity	97	0.027	0.027	0%	0.023	16%
	Developed, Medium Intensity	8	0.000	0.000	0%	0.000	73%
	Barren Land	4	0.003	0.003	0%	0.002	30%
	Deciduous Forest	68	0.001	0.001	0%	0.000	59%
	Evergreen Forest	9,467	20.504	20.504	0%	18.190	11%
	Shrub/Scrub	5,794	37.712	37.712	0%	33.469	11%
	Grassland/Herbaceous	236	0.423	0.260	38%	0.232	45%
	Pasture/Hay	10	0.095	0.058	38%	0.051	46%
	Woody Wetlands	64	0.230	0.230	0%	0.202	12%
	Emergent Herbaceous Wetlands	93	0.155	0.155	0%	0.136	12%
	Total	**16,511**	**61.1**	**60.9**	**<1%**	**54.1**	**12%**
Little Wolf Creek	Transitional	1,988	5.889	5.889	0%	5.143	13%
	Deciduous Forest	10	0.039	0.039	0%	0.032	17%
	Evergreen Forest	13,190	52.503	52.503	0%	46.366	12%
	Shrub/Scrub	8,643	73.654	73.654	0%	65.217	11%
	Grassland/Herbaceous	218	1.254	0.772	38%	0.672	46%
	Pasture/Hay	4	0.022	0.013	38%	0.012	46%
	Woody Wetlands	46	0.301	0.301	0%	0.271	10%
	Emergent Herbaceous Wetlands	139	0.387	0.387	0%	0.349	10%
	Total	**24,239**	**134.0**	**133.6**	**<1%**	**118.1**	**12%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Lower Wolf Creek	Transitional	4,050	19.272	19.272	0%	16.659	14%
	Developed, Open Space	203	0.630	0.630	0%	0.533	15%
	Developed, Low Intensity	347	0.305	0.305	0%	0.259	15%
	Developed, Medium Intensity	59	0.027	0.027	0%	0.022	18%
	Barren Land	3	0.027	0.027	0%	0.024	12%
	Deciduous Forest	26	0.129	0.129	0%	0.117	9%
	Evergreen Forest	24,972	126.870	126.870	0%	112.209	12%
	Shrub/Scrub	12,267	140.158	140.158	0%	122.087	13%
	Grassland/Herbaceous	658	3.150	1.939	38%	1.582	50%
	Pasture/Hay	8	0.000	0.000	0%	0.000	0%
	Woody Wetlands	116	0.493	0.493	0%	0.439	11%
	Emergent Herbaceous Wetlands	40	0.174	0.174	0%	0.158	9%
	Total	**42,748**	**291.2**	**290.0**	**0%**	**254.1**	**13%**
Wolf Creek Total	Transitional	14,885	93.370	93.370	0%	82.564	12%
	Open Water	5	0.000	0.000	0%	0.000	0%
	Developed, Open Space	394	0.961	0.961	0%	0.826	14%
	Developed, Low Intensity	558	0.404	0.404	0%	0.344	15%
	Developed, Medium Intensity	72	0.030	0.030	0%	0.024	19%
	Barren Land	10	0.030	0.030	0%	0.026	14%
	Deciduous Forest	133	0.237	0.237	0%	0.207	13%
	Evergreen Forest	80,734	341.377	341.377	0%	301.838	12%
	Shrub/Scrub	38,483	345.647	345.647	0%	303.848	12%
	Grassland/Herbaceous	1,621	20.592	12.672	38%	11.043	46%
	Pasture/Hay	65	0.476	0.293	38%	0.260	45%
	Woody Wetlands	396	1.983	1.983	0%	1.778	10%
	Emergent Herbaceous Wetlands	480	2.018	2.018	0%	1.810	10%
	Total	**137,836**	**807.1**	**799.0**	**1%**	**704.6**	**13%**

Table C3-2. Delivered Sediment Load by Land Cover Type in the Kootenai-Fisher Project Area

Sub-watershed	Land Cover Classification	Area (Acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (Tons/Year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (Tons/Year)	Percent Reduction	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (Tons/Year)	Percent Reduction
Bristow Creek	Transitional	773	5.186	5.186	0%	4.696	9%
	Deciduous Forest	2	0.000	0.000	0%	0.000	0%
	Evergreen Forest	11,927	70.634	70.634	0%	63.748	10%
	Shrub/Scrub	2,072	5.681	5.681	0%	5.110	10%
	Grassland/Herbaceous	70	0.001	0.000	38%	0.000	77%
	Woody Wetlands	1	0.003	0.003	0%	0.003	7%
	Emergent Herbaceous Wetlands	4	0.016	0.016	0%	0.015	7%
	Total	**14,849**	**81.5**	**81.5**	**<1%**	**73.6**	**10%**
Raven Creek	Transitional	220	1.315	1.315	0%	1.022	22%
	Developed, Open Space	1	0.004	0.004	0%	0.003	8%
	Developed, Low Intensity	1	0.000	0.000	0%	0.000	17%
	Developed, Medium Intensity	0.26	0.001	0.001	0%	0.001	3%
	Barren Land	2	0.000	0.000	0%	0.000	65%
	Evergreen Forest	499	6.129	6.129	0%	5.305	13%
	Shrub/Scrub	1,211	21.812	21.812	0%	18.315	16%
	Grassland/Herbaceous	242	1.672	1.029	38%	0.785	53%
	Emergent Herbaceous Wetlands	28	0.210	0.210	0%	0.190	9%
	Total	**2,202**	**31.1**	**30.5**	**2%**	**25.6**	**18%**
Quartz Creek	Transitional	48	0.000	0.000	0%	0.000	0%
	Developed, Open Space	0.31	0.000	0.000	0%	0.000	0%
	Deciduous Forest	2	0.000	0.000	0%	0.000	0%
	Evergreen Forest	20,707	227.096	227.096	0%	227.096	0%
	Shrub/Scrub	1,943	42.789	42.789	0%	42.789	0%
	Grassland/Herbaceous	146	1.125	0.692	38%	0.692	38%
	Woody Wetlands	3	0.019	0.019	0%	0.019	0%
	Emergent Herbaceous Wetlands	4	0.018	0.018	0%	0.018	0%
	Total	**22,855**	**271.0**	**270.6**	**<1%**	**270.6**	**<1%**

C4.0 Assumptions and Uncertainty

USLE models have been widely used for TMDL development and it is assumed that it adequately estimates sediment from upland sources in the Kootenai Fisher project area. As stated in **Section C2.0**, the USLE model was selected for this source assessment because it is well suited for large watersheds since it incorporates local climate and landscape data, but is not overly data-intensive. It is assumed that the climate and landscape data sources used to build the model were appropriate. The C-factor is the input with the most uncertainty because it was the variable specified by the modeler and changed between the existing condition and BMP scenario. Efforts were made to minimize uncertainty by using a USDA research-based table (**Attachment CB**) and consulting with Montana NRCS personnel, project stakeholders, and Department of Environmental Quality (DEQ) modeling staff to select reasonable C-factors for each land cover type. Input parameters such as existing vegetative cover and the potential for vegetative cover improvement via BMP implementation for a particular land use are applied at the project area scale on an annual basis and are intended to reflect the long-term average condition. Therefore, there is no differentiation by season or ownership.

The upland erosion model integrates sediment delivery based on riparian health; riparian health evaluations linked to the stream stratification work are discussed in **Attachment CA**. The riparian health classifications were performed using aerial imagery and a coarse classification system (i.e., poor, poor/fair, fair, fair/good, and good). There is uncertainty associated with classifying riparian health into such broad categories because vegetation type and health can vary greatly over small distances. Additionally, wetland vegetation, which has a high sediment removal capacity, can be difficult to distinguish from other grasses and is likely to be given a lower health rating than woody shrubs or trees. However, field verification of the original classifications as well as the potential improvement was conducted to help reduce the uncertainty. The riparian health classification is intended to be a general indicator of riparian condition within each watershed but is not detailed enough to identify where additional BMPs are necessary.

Each riparian health class was assigned a sediment reduction efficiency value based on literature values. There is high uncertainty that the reduction efficiencies applied are the actual reduction efficiencies because no field data were collected and they were based on ranges provided in literature. This uncertainty is acceptable for this project. The riparian health analysis was not performed with the expectation that it would identify specific locations for implementation of additional BMPs. Instead it was performed to simulate the buffering capacity of riparian vegetation and emphasize the importance of a healthy riparian buffer. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, and the estimated reductions are consistent with literature values for riparian buffers.

The riparian health classification was also used to scale the maximum travel distance for sediment within each watershed (i.e., beyond that distance, eroding sediment will not reach the channel). Watershed-specific scaling of the sediment delivery ratio is assumed to help reduce the uncertainty associated with a set maximum delivery distance. Nonetheless, values were intentionally chosen to be conservative (and potentially err on high side, allowing more sediment to be delivered) as part of the implicit margin of safety.

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ATTACHMENT CA - NATIONAL LAND COVER DATABASE LAND COVER TYPE DESCRIPTIONS

11. Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.

12. Perennial Ice/Snow - All areas characterized by a perennial cover of ice and/or snow, generally greater than 25 percent of total cover.

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 to 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.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

ATTACHMENT CB - ASSIGNMENT OF USLE C-FACTORS TO NLCD LAND COVER TYPES

TABLE 10.—*Factor C for permanent pasture, range, and idle land*[1]

Vegetative canopy: Type and height[2]	Vegetative canopy: Percent cover[3]	Type[4]	Percent ground cover: 0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.091	.043	.011
Tall weeds or short brush with average drop fall height of 20 in	25	G	.36	.17	.09	.038	.013	.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, with average drop fall height of 6½ ft	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush. Average drop fall height of 13 ft	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

[1] The listed **C** values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in deep.

W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

C-Factors for land cover types in the Kootenai-Fisher TPA for Existing Conditions						
NLCD Code	**Description**	**Type and Height of Raised Canopy**	**Percent Canopy Cover**	**Type**	**Percent Ground Cover**	**C-Factor**
0*	Transitional*	no appreciable canopy	-	-		0.006
11	Open Water**			-		-
12	Perennial Ice/Snow**					-
21	Developed, Open Space	no appreciable canopy	-	G	95-100	0.003
22	Developed, Low Intensity	-	-	-	-	0.001
23	Developed, Medium Intensity	-	-	-	-	0.001
24	Developed, High Intensity	-	-	-	-	0.001
31	Barren Land	-	-	-	-	0.001
41	Deciduous Forest	trees	75	G	95-100	0.003
42	Evergreen Forest	trees	75	G	95-100	0.003
43	Mixed Forest	trees	75	G	95-100	0.003
52	Shrub/Scrub	appreciable brush	25	G	85	0.008
71	Grassland/Herbaceous	no appreciable canopy	-	G	80	0.013
81	Hay/Pasture	no appreciable canopy	-	G	80	0.013
90	Woody Wetlands	trees	25	G	95-100	0.003
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003

* A code of "0" and a description of "Transitional" was developed to describe areas of Fire or Timber Harvest

**Water and ice/snow classes will not be counted as surfaces contributing erosion

C-Factors for land cover types in the Kootenai-Fisher TPA for Desired Conditions						
NLCD Code	**Description**	**Type and Height of Raised Canopy**	**Percent Canopy Cover**	**Type**	**Percent Ground Cover**	**C-Factor**
0*	Transitional*	no appreciable canopy	-	-		0.006
11	Open Water**			-		-
12	Perennial Ice/Snow**					-
21	Developed, Open Space	no appreciable canopy	-	G	95-100	0.003
22	Developed, Low Intensity	-	-	-	-	0.001
23	Developed, Medium Intensity	-	-	-	-	0.001
24	Developed, High Intensity	-	-	-	-	0.001
31	Barren Land	-	-	-	-	0.001
41	Deciduous Forest	trees	75	G	95-100	0.003
42	Evergreen Forest	trees	75	G	95-100	0.003
43	Mixed Forest	trees	75	G	95-100	0.003
52	Shrub/Scrub	appreciable brush	25	G	85	0.008
71	Grassland/Herbaceous	no appreciable canopy	-	G	90	0.008
81	Hay/Pasture	no appreciable canopy	-	G	90	0.008
90	Woody Wetlands	trees	25	G	95-100	0.003
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003

* A code of "0" and a description of "Transitional" was developed to describe areas of Fire or Timber Harvest

**Water and ice/snow classes will not be counted as surfaces contributing erosion

ATTACHMENT CC - SEDIMENT DELIVERY RATIO EXAMPLE CALCULATION

SEDIMENT DELIVERY RATIO EXAMPLE CALCULATION – RAVEN CREEK

Existing Conditions

To create a final, subwatershed specific SDR, Megahan and Ketcheson's (1996) dimensionless equation relating percent sediment volume to percent travel distance was scaled to each subwatershed by using its riparian health assessment based 100-Foot Sediment Reduction Efficiency Percentage to derive a site-specific maximum sediment travel distance. For each subwatershed, the following method was applied as described below using Raven Creek as an example.

From the subwatershed's Riparian Health Assessment, determine the expected % sediment delivery across a nominal 100 foot wide riparian zone. The riparian health assessment based Sediment Reduction Efficiency Percentage (SRE) computed for the Raven Creek subwatershed is presented in **Table CC-1**.

Table CC-1. Raven Creek Sediment Reduction Efficiency Percentage for Existing Conditions.

Riparian Health	Stream Length (Feet)	Percent of Total	Riparian Buffer Sediment Reduction Efficiency Percentage	Weighted Sediment Reduction Efficiency Percentage (Existing Conditions)
Good	11,688	43	75	32
Fair/Good	0	0	60	0
Fair	15,450	57	50	28
Poor/Fair	0	0	40	0
Poor	0	0	30	0
No data	0	0	10	0
Total	27,138	100		**61**

Example:
Per **Table CC-1**, the Raven Creek subwatershed's expected sediment delivery across a **100**-foot wide riparian zone is (100%-61% reduction) = **39%** delivered.

Substitute the expected % sediment delivery across a **100**-foot wide riparian zone into Megahan and Ketcheson's dimensionless sediment volume vs travel distance equation.

Example:
Volume% = 103.62exp(-((D/Dtotal)*100)/32.88) -5.55 =

39% = 103.62exp(-((**100**/Dtotal)*100)/32.88) -5.55

Solve the equation for **Dtotal** to arrive at a representative maximum sediment travel distance for that subwatershed.

Example:
39% = 103.62exp(-((**100**/Dtotal)*100)/32.88) -5.55

Dtotal = **100**/(-0.3288*ln((**39**+5.55)/103.62))

Dtotal = **360** feet

Restate the equation using the subwatershed's calculated maximum sediment travel distance (Dtotal) to arrive at an integrated Distance and Riparian Health based Sediment Deliver Ratio (SDR) for that subwatershed.

Example:
Within the Raven Creek subwatershed, the SDR for an analytical pixel with a drainage path to the nearest stream of length **D** would be given by:

Volume% = 103.62exp(-((D/**360**)*100)/32.88) -5.55

So if the downslope distance (D) were 200 feet in this subwatershed, then

Volume % = 103.62exp(-((200/**360**)*100)/32.88) -5.55

Volume % = 13.5

By this method, the Sediment Delivery Ratio (SDR) for each analytical pixel in a Raven Creek subwatershed is obtained by evaluating this equation:

*SDR = (103.62*EXP(-((D/Dtotal)*100)/32.88)-5.55)/100*

Where:

SDR = the ratio of sediment generated from the pixel that is delivered to a stream,
D = the downslope distance from the pixel to the nearest stream channel, and
Dtotal = the subwatershed specific Riparian Health derived maximum sediment travel distance.

Therefore in the example above, that specific pixel would have an SDR value of 0.135 that will then be multiplied against the existing USLE soil loss to produce the final reduced soil loss rate for that cell.

Best Management Practices (BMP) Conditions

Table CC-2. Raven Creek Sediment Reduction Efficiency Percentage for BMP Conditions.

BMP Riparian Health	Stream Length (Feet)	Percent of Total	Riparian Buffer Sediment Reduction Efficiency Percentage	Weighted Sediment Reduction Efficiency Percentage (BMP Conditions)
Good	11,688	43	75	32
Fair/Good	15,450	57	60	34
Fair	0	0	50	0
Poor/Fair	0	0	40	0
Poor	0	0	30	0
No data	0	0	10	0
Total	27,138	100		**66**

Example:
Per **Table CC-2**, the Raven Creek subwatershed's expected sediment delivery across a **100**-foot wide riparian zone is (100%-66% reduction) = **34%** delivered.

Substitute the expected % sediment delivery across a **100**-foot wide riparian zone into Megahan and Ketcheson's dimensionless sediment volume vs travel distance equation.

Example:
Volume% = 103.62exp(-((D/Dtotal)*100)/32.88) -5.55 =

34% = 103.62exp(-((**100**/Dtotal)*100)/32.88) -5.55

Solve the equation for **Dtotal** to arrive at a representative maximum sediment travel distance for that subwatershed.

Example:
34% = 103.62exp(-((**100**/Dtotal)*100)/32.88) -5.55

Dtotal = **100**/(-0.3288*ln((**34**+5.55)/103.62))

Dtotal = **316** feet

Restate the equation using the subwatershed's calculated maximum sediment travel distance (Dtotal) to arrive at an integrated Distance and Riparian Health based Sediment Deliver Ratio (SDR) for that subwatershed.

Example:
Within the Raven Creek subwatershed, the SDR for an analytical pixel with a drainage path to the nearest stream of length **D** would be given by:

Volume% = 103.62exp(-((D/**316**)*100)/32.88) -5.55

So if the downslope distance (D) were 200 feet in this subwatershed, then

Volume % = 103.62exp(-((200/**316**)*100)/32.88) -5.55

Volume % = 9.6

By this method, the Sediment Delivery Ratio (SDR) for each analytical pixel in a Raven Creek subwatershed is obtained by evaluating this equation:

*SDR = (103.62*EXP(-((D/Dtotal)*100)/32.88)-5.55)/100*

Where:

SDR = the ratio of sediment generated from the pixel that is delivered to a stream,
D = the downslope distance from the pixel to the nearest stream channel, and
Dtotal = the subwatershed specific Riparian Health derived maximum sediment travel distance.

Therefore in the example above, that specific pixel would have an SDR value of 0.096 that will then be multiplied against the existing USLE soil loss to produce the final reduced soil loss rate for that cell.

APPENDIX D - ROAD SEDIMENT ASSESSMENT

List of Tables

List of Figures

Attachments

Acronym	Definition
BMP	Best Management Practices
CMP	Corrugated Metal Pipe
CY	Cubic Yard
EPA	Environmental Protection Agency (U.S.)
GIS	Geographic Information System
NHD	National Hydrography Dataset
QAPP	Quality Assurance Project Plan
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
USFS	United States Forest Service
USGS	United States Geological Survey
WEPP	Water Erosion Prediction Project

D1.0 INTRODUCTION

An assessment of the road network within the Kootenai-Fisher Total Maximum Daily Load (TMDL) Project Area (Project Area) was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. This assessment employed Geographic Information System (GIS), field data collection, and sediment modeling to assess sediment inputs from the unpaved road network. In addition, because undersized and improperly installed and maintained culverts can be a substantial source of sediment to streams and a barrier to fish and other aquatic organisms, potential loading from undersized culverts was also evaluated, along with an evaluation of fish passage at assessed crossings.

D1.1 SEDIMENT IMPAIRMENTS

The Kootenai-Fisher Project Area encompasses an area of approximately 2,511 square miles in Lincoln and Flathead counties in northwestern Montana. The Kootenai-Fisher Project Area includes both the Kootenai TMDL Planning Area (TPA) (1,667 square miles) and the Fisher TPA (844 square miles). The Kootenai TPA encompasses the majority of the Upper Kootenai River HUC8 (17010104), while the Fisher TPA aligns with the Fisher River HUC8 (17010101). Within the Kootenai-Fisher Project Area, there are six water body segments listed on the 2012 303(d) List for sediment-related impairments (**Table D1-1**). Bristow Creek, Libby Creek, Lake Creek and Quartz Creek are listed as impaired due to sediment in the Kootenai TPA, while Wolf Creek and Raven Creek are listed as impaired due to sediment in the Fisher TPA.

Table D1-1. Waterbody Segments Addressed during the Road Assessment

TPA	Segment ID	Waterbody Description
Fisher	MT76C001_020	WOLF CREEK, headwaters to mouth (Fisher River)
Fisher	MT76C001_030	RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)
Kootenai	MT76D002_110	BRISTOW CREEK, the headwaters to mouth at Lake Koocanusa
Kootenai	MT76D002_062	LIBBY CREEK, from the highway 2 bridge to mouth (Kootenai River)
Kootenai	MT76D002_070	LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)
Kootenai	MT76D002_090	QUARTZ CREEK, headwaters to confluence with the Kootenai River

D2.0 METHODS

Methods employed in this assessment are outlined in *Quality Assurance Project Plan and Sampling and Analysis Plan: Assessment of Unpaved Roads for TMDL Development (Task Order 18: Task 2b)* (U.S. Environmental Protection Agency, 2011) and *Road Sediment Assessment and Modeling: Kootenai-Fisher TMDL Planning Area Road GIS Layers and Summary Statistics* (Atkins Water Resources Group, 2011) and summarized below.

D2.1 SEDIMENT INPUTS FROM UNPAVED ROADS

Sediment inputs from unpaved roads were evaluated through a combination of GIS analysis, field data collection and computer modeling.

D2.1.1 GIS Analysis

Prior to field data collection, GIS data layers representing land ownership, road attributes, stream network, watersheds, and ecoregions were used to summarize the road network in the Kootenai-Fisher Project Area (Atkins Water Resources Group, 2011). Because unpaved road crossings and near-stream parallel segments are the most likely sources of sediment loading to streams from the road network, the GIS analysis focused on these areas. Land ownership was divided into five categories based on the Montana Public Lands layer: U.S. Forest Service (USFS), Montana State Trust Lands, Montana Fish, Wildlife and Parks, Private, and Unknown. The roads layer was primarily derived from the Travel Routes for Region 1 geodatabase developed by the USFS and available from the Northern Region Geospatial Library (http://www.fs.fed.us/r1/gis/), supplemented with the State of Montana Base Map Service Center Transportation Framework Theme data. Following the initial GIS analysis, Jurisdiction was assigned to each unpaved road crossing based on information in the USFS Travel Routes for Region 1 layer and the Montana Public Lands layer. Stream layers were developed using the National Hydrography Dataset (NHD) 1:24,000 high-resolution flowline layer. The high-resolution NHD layer was used because it is the most conservative (i.e., inclusive) stream network layer. Flowlines were limited to streams/rivers and artificial paths; ditches and pipelines were not included. Watersheds were delineated on the basis of the United States Geological Survey (USGS) 6^{th} Hydrologic Unit Code (HUC12) layer and modified where necessary to delineate the subwatersheds of interest (**Figure D2-1**). Landscapes were delineated according to the Environmental Protection Agency (EPA) 2002 level IV ecoregions (Woods et al., 2002) (**Figure D2-2**). These GIS layers were utilized to develop a database of stream crossings and parallel road segments that includes land ownership, road surface type, subwatershed, and ecoregion attributes in one attribute table.

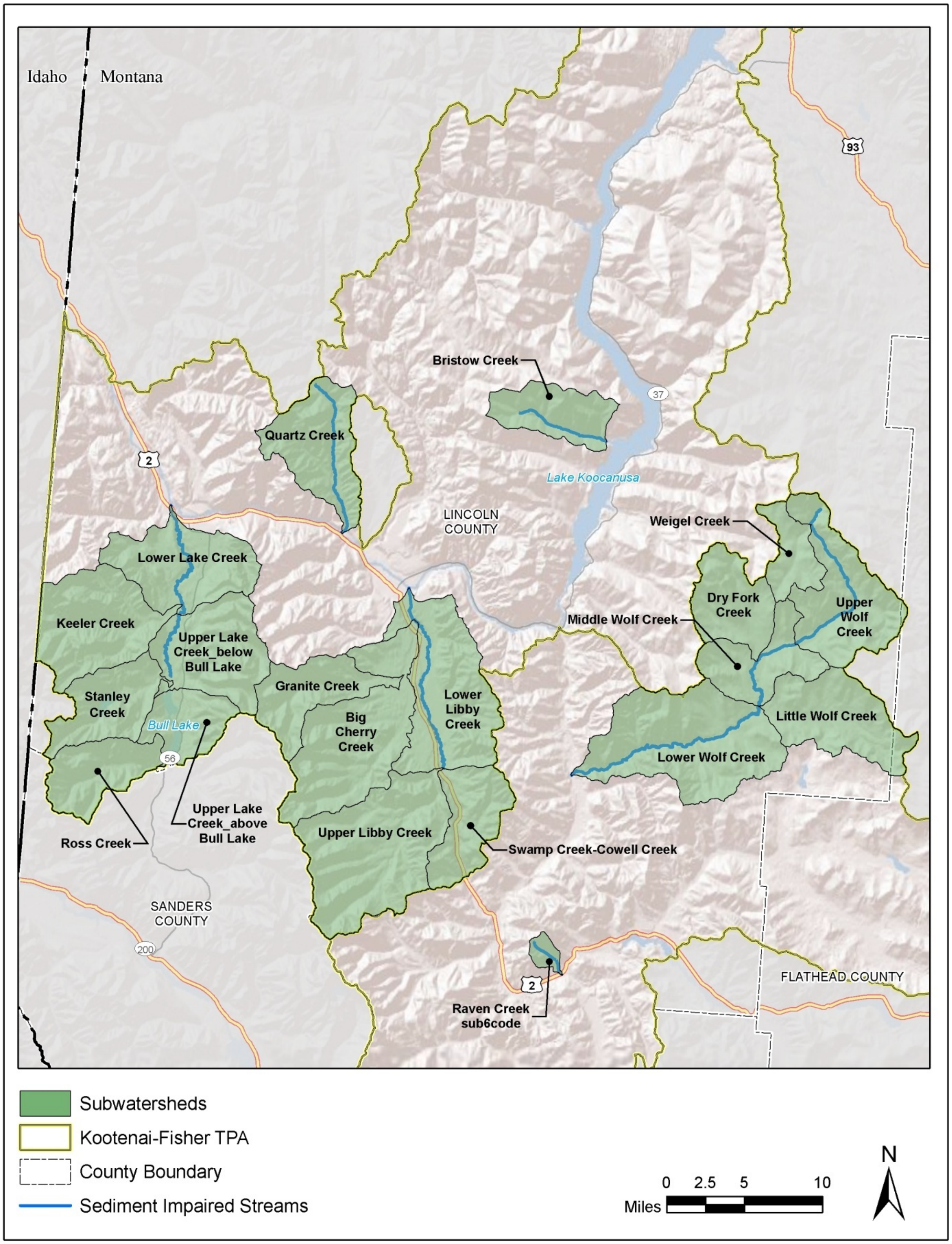

Figure D2-1. HUC12 Subwatersheds in the Kootenai-Fisher Project Area

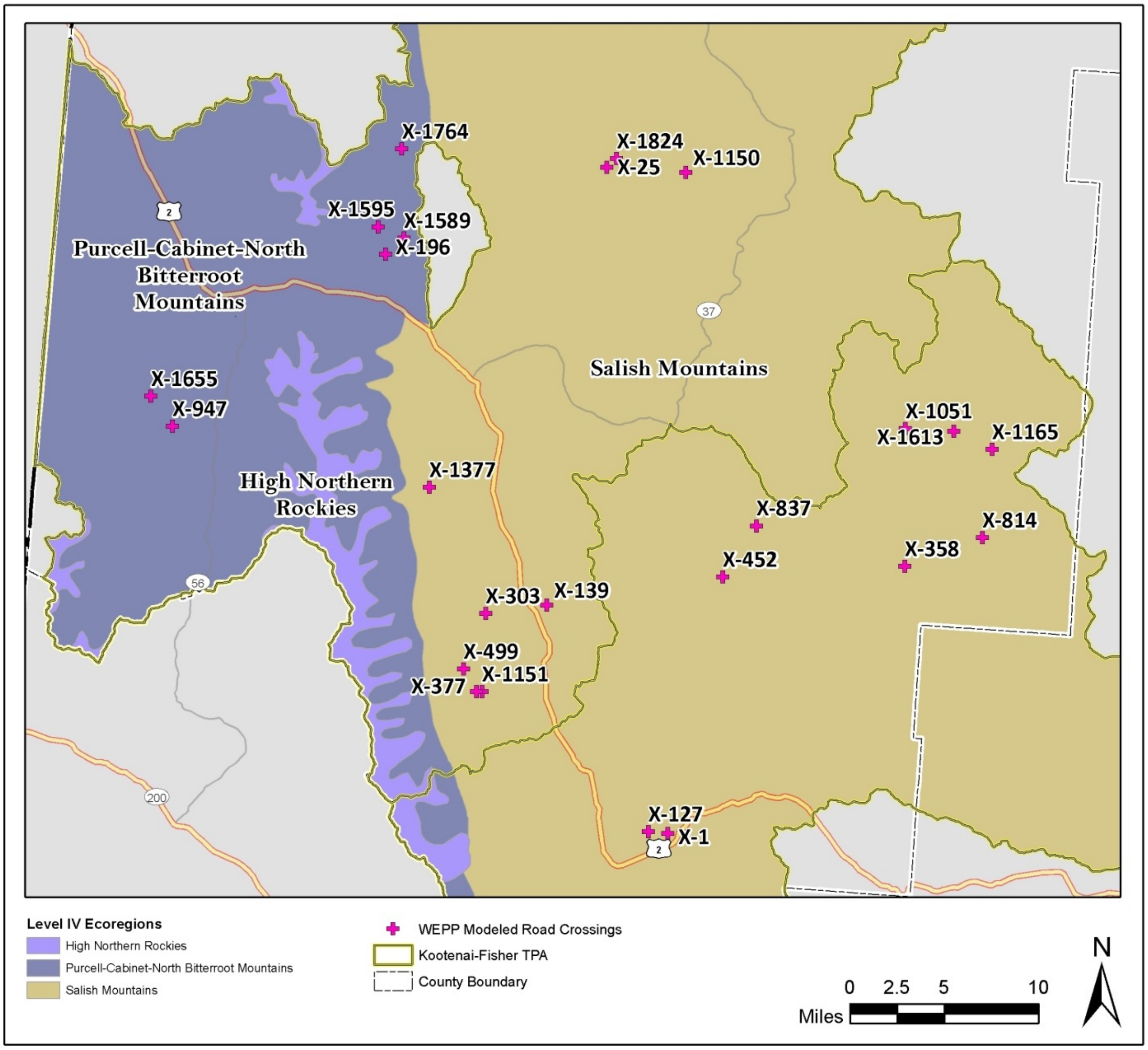

Figure D2-2. Level IV Ecoregions in the Kootenai-Fisher Project Area

Overall, GIS analysis identified 2,235 miles of road within the Kootenai-Fisher Project Area, with all but 195 miles (8.7%) being unpaved. Of the 1,989 road crossings identified within the Kootenai-Fisher Project Area, 1,703 were unpaved (gravel or native material) based on attribute information contained in the GIS roads database (**Figure D2-3**). An additional 102 crossings were identified with an 'unknown' surface type, but based on attributes of proximal road segments they are also likely to be unpaved. Therefore, there are an estimated total of 1,805 unpaved road crossings in the Kootenai-Fisher Project Area (**Table D2-1**). Over half of the crossings are on roads administered by the USFS, with the remainder being a mix of private, state, and county (**Table D2-2**).

Based on the analysis of near-stream parallel road segments, 77 miles (3.4%) are within 150 feet of a stream channel, and 55 of those miles are unpaved road segments. An additional 7.8 miles were classified as 'unknown' based on attribute information in the roads database, the majority of which are likely unpaved.

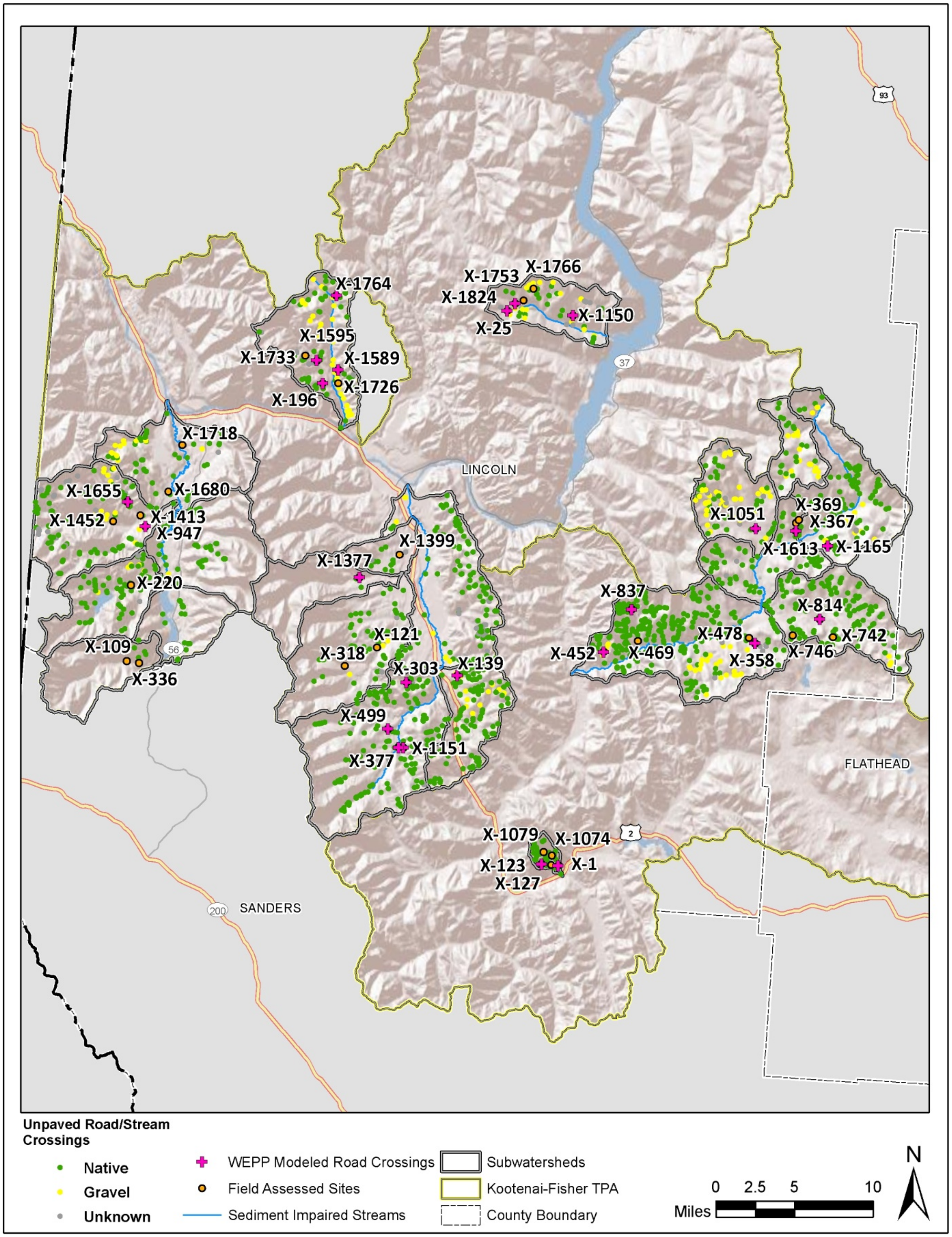

Figure D2-3. Unpaved Road Crossings and Road Surface Type in the Kootenai-Fisher Project Area

Table D2-1. Road Surface Types in the Kootenai-Fisher Project Area

Road Surface Type	Number of Crossings based on GIS Attribute Information	Number of Crossings Re-classified based on Attributes of Proximal Road Segments	Total Number of Crossings
Paved	184		184
Gravel	213	4	217
Native	1,490	98	1,588
Unknown	102		
Total Crossings	**1,989**	**102**	**1,989**
Total Unpaved Crossings	**1,703**	**102**	**1,805**

Table D2-2. Jurisdiction for Unpaved Road Crossings

Jurisdiction	Number of Crossings
County	25
Federal	1,083
Private	657
State	40
Total	**1,805**

D2.1.2 Field Data Collection

A field assessment of unpaved roads was conducted by performing an inspection of road crossings and parallel road segments throughout the Kootenai-Fisher Project Area in July 2011. For each unpaved crossing, a series of measurements were performed to characterize road design, maintenance level, condition, culvert size, and sediment loading potential. Measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any Best Management Practices (BMPs).

D2.1.2.1 Crossing Assessment Sites

Forty sites were randomly selected for field data collection, with a goal of obtaining measurements from at least 24 sites. Field measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any BMPs, while notes were made regarding road condition at all sites visited. Since the high-resolution NHD layer used to identify road crossings includes crossings over intermittent and ephemeral channels that may not be conduits for road-related sediment, many of the randomly selected sites lacked an actual crossing when visited in the field. As outlined in the project Quality Assurance Project Plan (QAPP) (U.S. Environmental Protection Agency, 2011), crossings randomly chosen for field assessment that did not have a defined channel (and were unlikely to be pathways for road-related sediment) were excluded from field measurements, and the percentage of randomly selected field sites that had an undefined channel relative to the total number of randomly selected field sites were factored into the extrapolation process. For each site that was excluded from field assessment because of not having a defined channel, an alternate site was chosen in the field by driving to a nearby crossing. Alternate sites were also chosen if a road was inaccessible due to a gate, the road was paved, or the crossing approach was paved.

Out of the 40 pre-selected sites, 35 were visited in the field in July 2011 and field forms were completed at 15 sites where unpaved road crossings of streams were observed. Of the 35 sites visited, 20 lacked defined stream crossings, had become re-vegetated due to road closures, or were inaccessible due to road closures; no measurements were taken at these sites, but notes were made regarding road condition. Measurements were taken and field forms completed at nine alternate sites. Three additional alternate sites were visited and no data were collected because they lacked defined channels or occurred on roads that were closed, re-vegetated or had a paved approach. Therefore, out of the 47 field assessed sites (i.e., 35 + 12 alternates), field forms were completed at a total of 24 unpaved road crossing sites, and those data were used in the Water Erosion Prediction Project (WEPP) soil erosion model (**Figures D2-2** and **D2-3**). Of the remaining 23 sites, 10 had no defined stream channel and the other 13 were either inaccessible due to closure or on paved roads or paved approaches (**Attachment A**).

D2.1.2.2 Parallel Road Segment Assessment Sites

While driving to the road crossing assessment sites, the field crew visually assessed the potential for sediment loading from parallel road segments identified during the GIS analysis. No evidence of sediment loading from these segments was observed, and based on the condition and composition of the vegetative buffer throughout the Project Area, unpaved parallel road segments were determined to be an insignificant sediment source (**Figure D2-4**). Thus, no field data was collected along parallel road segments in the Kootenai-Fisher Project Area.

Figure D2-4. Vegetative Buffer along Parallel Road Segment, Kootenai-Fisher Project Area

D2.1.3 WEPP Modeling

Sediment loading from unpaved road crossings was estimated using the WEPP: Road soil erosion model version 2011.12.20 (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP: Road is an interface to the Water Erosion Prediction Project (WEPP) model developed by the USFS and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The WEPP: Road model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Field data collected from each field assessed site provided the following input data necessary to run the WEPP: Road model:

- Road design: insloped, bare ditch; insloped, vegetated or rocked ditch; outsloped, rutted; outsloped unrutted

- Road surface: native, graveled, paved
- Traffic level: high, low, none
- Soil texture: clay loam, silt loam, sandy loam, loam
- Rock content
- Gradient, length and width of the road, fill and buffer
- Climate data
- Years to simulate

The WEPP: Road model was used to evaluate existing conditions at each road crossing based on the field collected data. The WEPP: Road model was also used to estimate the potential to reduce sediment loads through the application of BMPs. During field data collection, the location of potential BMPs, such as water bars and rolling dips, were identified and the distance to the stream crossing was measured. During the BMP modeling scenario, the contributing road length was reduced from the existing length to the potential BMP length based on the field measured values.

D2.1.3.1 Model Input Parameters

Road condition data collected throughout the Kootenai-Fisher Project Area in July 2011 was input directly into the WEPP: Road model following guidance outlined in *WEPP Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery Technical Documentation*, which is available on the Internet at http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html (**Attachment B**). In addition to field collected data, the WEPP: Road model requires the selection of a climate station to provide an estimate of mean annual precipitation. The WEPP: Road model contains 55 custom climate stations for Montana. Out of these 55 custom climate stations, two were selected in northwest Montana to represent the range of precipitation conditions at field assessed sites in the Kootenai-Fisher Project Area: LIBBY 1 NE RS MT and TROUT CREEK RS MT. Precipitation in the Kootenai-Fisher Project Area ranges from 16” to 100” annually based on data collected from 1971 to 2000 and compiled by the PRISM Group at Oregon State University (http://nris.mt.gov/nsdi/nris/precip71_00.html) (**Figure D2-5**). Road crossing assessments were conducted at field sites located in precipitation zones ranging from 18” to 42”, which covers over 80% of the unpaved road crossings identified in GIS. Because precipitation is a significant factor in erosion, modeled loads for stream crossings were grouped into three precipitation zones for the purposes of sediment load modeling and extrapolation in WEPP: Road: <20”, 20-26”, and >26”. To help increase the sample size for each zone, the load for each assessed crossing was modeled for each precipitation zone in WEPP: Road. The mean precipitation value of 17.18” at the LIBBY NE RS MT climate station was utilized for the <20” precipitation zone, while the mean precipitation value of 28.58” at the TROUT CREEK RS MT climate station was utilized for the >26” precipitation zone (**Table 2-3** and **Figure D2-5**). For the 20-26” precipitation zone, the mean precipitation value of 28.58” at the TROUT CREEK RS MT climate station was reduced by 20% to a value of 22.87”.

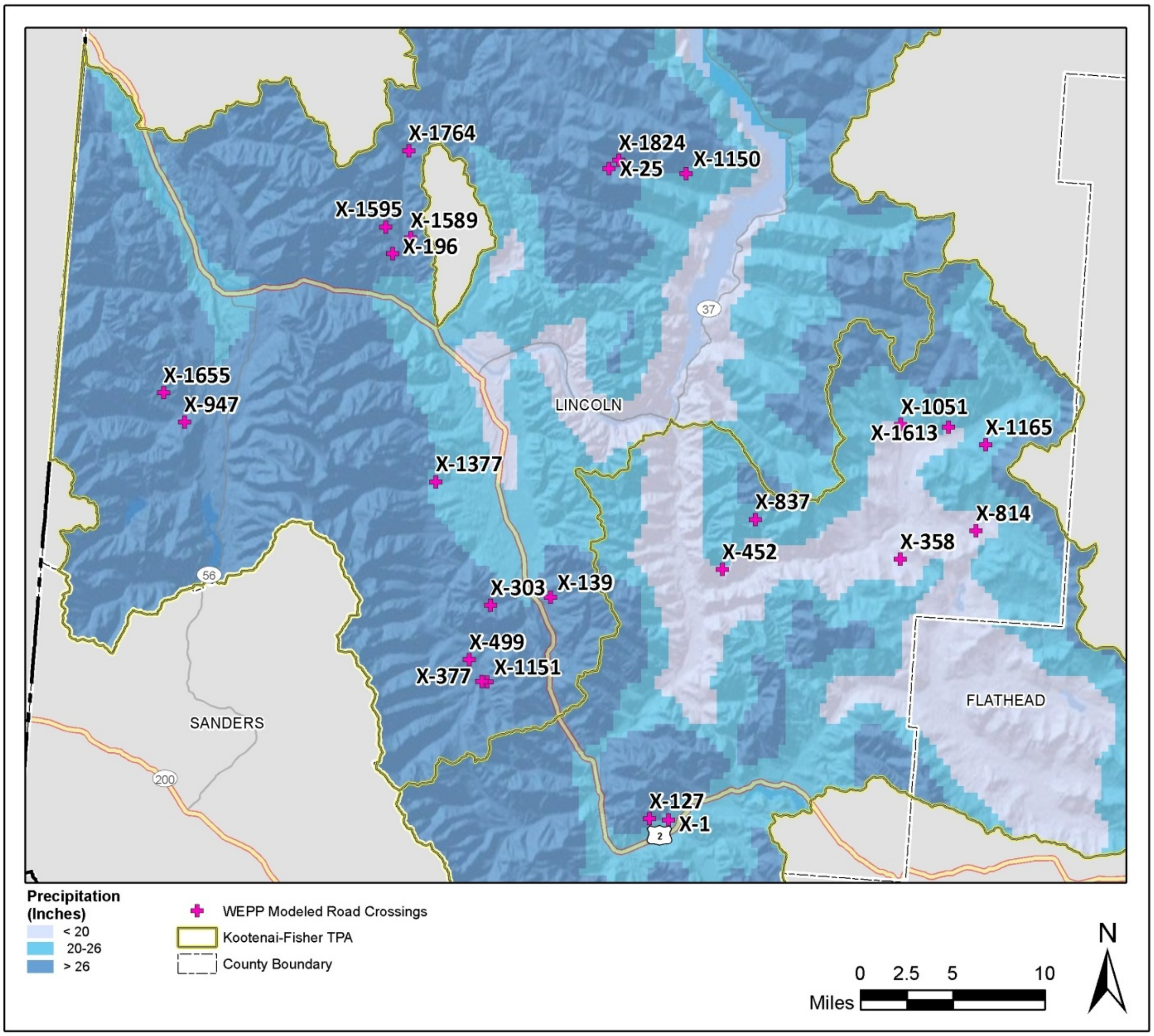

Figure D2-5. Precipitation Patterns in the Kootenai-Fisher Project Area

Table D2-3. Precipitation Data Applied in the WEPP: Road Model

Climate Station	Mean Precipitation (Inches)	Percent Adjustment	Adjusted Mean Precipitation (Inches)	PRISM Precipitation Zone (Inches)
LIBBY 1 NE RS MT	17.18	0	No adjustment	<20
TROUT CREEK RS MT	28.58	-20	22.87	20-26
TROUT CREEK RS MT	28.58	0	No adjustment	>26

D2.1.4 Potential Culvert Failures

A coarse assessment for each culvert was preformed on-site to calculate its conveyance capacity and the amount of sediment at-risk for eroding into the stream channel during culvert failure. The assessment included measurements of structure type, structure diameter, and structure gradient, bankfull width upstream of the culvert, fill height, fill length, fill width, outlet invert, and the presence of streambed materials in the culvert. At each culvert assessed in the field, flood frequencies for the 2, 5, 10, 25, 50, and 100-year events were determined based on the bankfull width upstream of the culvert using U.S.

Geological Survey Montana Region regression equations (Parrett and Johnson, 2004). The Urban Drainage and Flood Control District Sewer and Culvert Hydraulics Version 2.0 (http://www.udfcd.org/) spreadsheet model was then utilized to establish the flow capacity of each field assessed culvert. The amount of sediment contributed during a culvert failure was calculated conservatively, assuming that culvert failure would erode sediment to a width equal to the bankfull width of the stream channel upstream of the culvert. For this analysis, an estimated soil weight of 1.66 tons/yard^3 was utilized based on the maximum unit weight for dry well-graded subangular sand presented in Table 1:4 of *Introductory Soil Mechanics and Foundations: Geotechnical Engineering Forth Edition (Sowers, 1979)*.

D2.2 Fish Passage Analysis

Measurements were collected at each of the field assessed road crossing sites, and these values were used to determine if culverts represented potential fish passage barriers at various flow conditions. The fish passage evaluation was completed using the criteria listed in Table 1 of the document *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska* (U.S. Department of Agriculture, Forest Service, Alaska Region, 2002). The analysis uses site-specific information to classify culverts as green (passing all lifestages of salmonids), red (partial or total barrier to salmonids), or grey (needs additional analysis). Indicators used in the classification are the ratio of the culvert width to bankfull width (constriction ratio), culvert slope, and outlet drop, with large diameter (>48 in) and small (<48 in) culvert groups evaluated differently. Failure of any one of the three indicators results in a red classification.

D3.0 Results

D3.1 Sediment Inputs from Unpaved Roads

The results of the field and WEPP modeling assessment examining sediment loading from roads to streams within the Kootenai-Fisher Project Area are presented in the following sections.

D3.1.1 Summary of BMPs and Contributing Length

Because allocations for sediment TMDLs are based on improving management practices, identifying the current practices and areas where improvements are needed is a significant component of the unpaved roads assessment. During the field assessment, sufficient BMPs were observed at 14 crossings (**Attachment B**). The most common BMPs observed were rolling dips and water bars. Both of these BMPs interrupt the flow of water, reducing the amount of road surface that water can erode as it moves towards the stream channel (i.e., the contributing length). The contributing length was evaluated separately for each side of a crossing and the average contributing length at sites where all reasonable BMPs have been implemented was 51 feet. In general, private/county roads had a higher proportion of crossings with adequate BMPs than federal roads (i.e., 5/7 vs. 4/17, respectively). This trend is also apparent in the contributing lengths when broken down by jurisdiction: the average contributing length at all private/county crossings was 60 feet and the average contributing length at all federal crossings was 167 feet.

During the field assessment, 15 crossings had insufficient BMPs. Note: the total number of crossings with sufficient and insufficient BMPs (i.e., 29 crossings) is greater than the 24 assessed crossings because both sides of each crossing were evaluated separately and some crossings receive sediment from both sides. At each of the 15 crossings with insufficient BMPs, the optimal location (i.e., distance from the stream) of BMP placement to reduce contributing length was identified. This technique incorporated conditions specific to this project area and allowed for loads at each site to be modeled under a BMP scenario to determine achievable reductions in sediment loading from unpaved roads. The average contributing length at the sites needing additional BMPs was 227 feet (**Table 3-1**), and based on field measurements, BMPs could reduce the average contributing length to 91 feet. Although a reduction in contributing length was used for the BMP scenario for the model, other BMPs for unpaved roads include design and siting considerations of topography, soils, and stream crossings; routine maintenance; seasonal usage modification; and filter strips. Additionally, the location of additional BMPs noted in the field was based on best professional judgment and are intended to be installed in the best practicable location, which may not coincide with the distances identified in **Table 3-1**. Just as additional BMPs used are up to the landowner, the placement of additional BMPs is also up to the landowner.

Table D3-1. Contributing Road Lengths at Sites with the Potential for Additional BMPs

GIS Site ID	Segment of Road Contributing Sediment (Facing Downstream)	Existing Contributing Length (Feet)	BMP Contributing Length (Feet)	Percent Reduction in Contributing Length
X-947 (F)	Left	142	75	47%
X-1589 (F)	Left	417	127	70%
X-1589 (F)	Right	285	194	32%
X-1764 (F)	Left	210	75	64%
X-1151 (F)	Left	158	92	42%
X-1151 (F)	Right	271	135	50%
X-499 (F)	Left	409	155	62%
X-837 (P)	Left	180	72	60%
X-358 (F)	Left	296	93	69%
X-1655 (F)	Right	254	56	78%
X-1595 (F)	Right	94	28	70%
X-196 (F)	Right	294	101	66%
X-303 (F)	Right	272	128	53%
X-1824 (F)	Right	149	67	55%
X-25 (F)	Right	275	80	71%
X-452 (F)	Right	70	38	46%
X-127 (P)	Right	80	28	65%
Average		**227**	**91**	**60%**

F = Federal, P = Private

D3.1.2 WEPP Modeled Sediment Loads at Unpaved Road Crossings

The average load per crossing was used during the extrapolation process to estimate loading associated with road crossings at a watershed scale. Loads were initially grouped by precipitation zone for modeling, but then the output was evaluated to determine the most appropriate approach for extrapolation. Considerations included ecoregion, fewer precipitation zones, the same number of precipitation zones, and jurisdiction. The approach selected was to use the three precipitation zones but to group the crossings into two categories based on jurisdiction: Unpaved road crossings with federal jurisdiction were grouped into one category and those with private, county, or state jurisdiction were grouped into a second category. WEPP: Road model results for these two categories are presented by precipitation zone in **Attachment C** and summarized in **Table D3-2** and **Figure D3-1**. As expected, loads for both jurisdictional categories increase with precipitation zone.

Table D3-2. Unpaved Road Crossing Mean Annual Sediment Loads

Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Sites Assessed	Mean Annual Load (Tons)	Standard Error (Tons)	Minimum (Tons)	Maximum (Tons)	Mean Annual Load with BMP's (Tons)	Standard Error (Tons)	Minimum (Tons)	Maximum (Tons)
Federal	<20	17	0.0118	0.0026	0.0005	0.0410	0.0054	0.0011	0.0004	0.0141
Federal	20-26	17	0.0156	0.0033	0.0011	0.0491	0.0073	0.0014	0.0007	0.0186
Federal	>26	17	0.0234	0.0049	0.0009	0.0740	0.0112	0.0024	0.0009	0.0321
Private	<20	7	0.0037	0.0017	0.0002	0.0121	0.0025	0.0011	0.0002	0.0077
Private	20-26	7	0.0039	0.0015	0.0002	0.0113	0.0028	0.0010	0.0002	0.0074
Private	>26	7	0.0054	0.0022	0.0007	0.0162	0.0039	0.0015	0.0007	0.0109
Entire Dataset	<20	24	0.0094	0.0020	0.0002	0.0410	0.0046	0.0009	0.0002	0.0141
Entire Dataset	20-26	24	0.0122	0.0026	0.0002	0.0491	0.0060	0.0011	0.0002	0.0186
Entire Dataset	>26	24	0.0182	0.0039	0.0007	0.0740	0.0090	0.0018	0.0007	0.0321

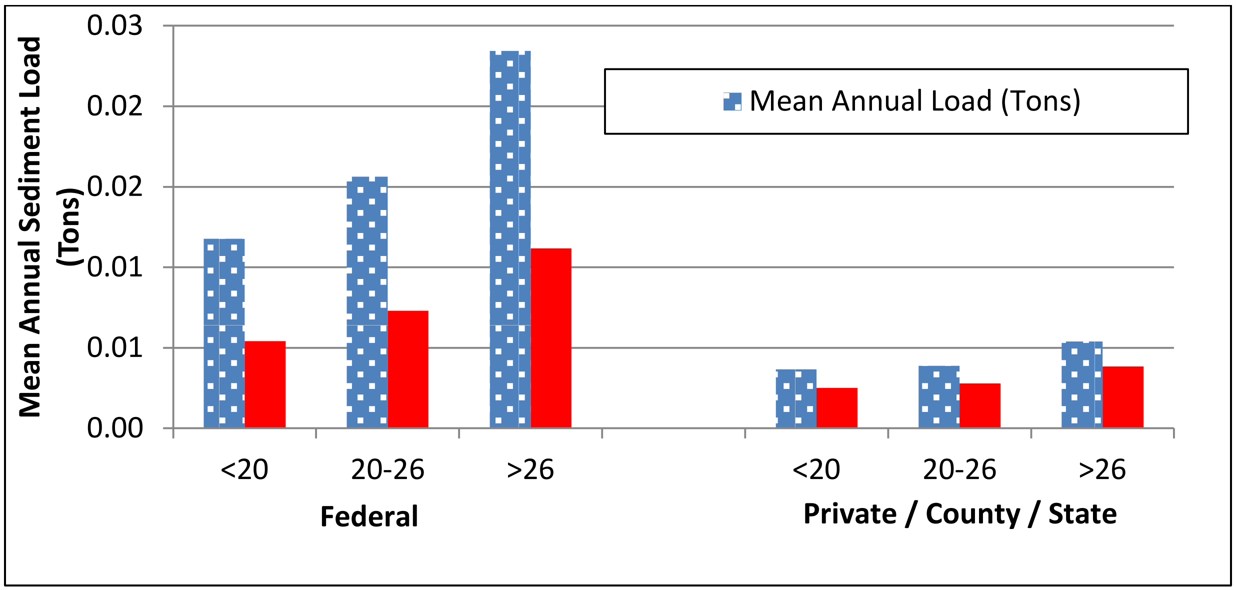

Figure D3-1. Unpaved Road Crossing Mean Annual Sediment Loads

D3.1.3 Unpaved Road Crossing Sediment Load Extrapolation

The 24 unpaved road crossings modeled in WEPP: Road were grouped based on jurisdiction and precipitation zone as presented in **Table D3-3** for extrapolation to the subwatershed scale and the total number of crossings was adjusted to account for crossings over undefined channels (**Attachment D**). A total of 1,805 unpaved road crossings were identified in the GIS analysis, while 10 out of 47 (21%) of all the visited sites were at undefined channels. Thus, the number of unpaved road crossings identified in the GIS analysis was adjusted downward during the extrapolation process to account for crossings over undefined channels that are not contributing road-related sediment to streams. Since 21% of the crossings were excluded for this reason, the total number on unpaved road crossings identified in GIS in each subwatershed was reduced by 21%, for an estimate of 1,426 unpaved road crossings.

Although some additional crossings were not assessed because the approach was paved or the crossing was inaccessible, those exclusions were not factored in because the reduction for undefined channels was performed as a result of the level of detail of the hydrology layer used to identify crossings in GIS, and the source assessment process aims to err on the conservative side as a part of the implicit margin of safety. However, it is noted that the Kootenai National Forest has been paving approaches in recent years as a BMP, particularly in watersheds inhabited by sensitive species, such as bull trout, westslope cutthroat trout, and redband rainbow trout (**Figure D3-2**). Based on data provided by the USFS (Hooper, P., personal communication 1/2/2013), approximately 19 approaches have been paved in the Kootenai Ranger District, with eight of those occurring on sediment listed streams in the project area (i.e., Libby and Wolf).

Figure D3-2. Paved Approach on Road Crossing of Leigh Creek, Tributary to Libby Creek, Kootenai National Forest

D3.1.4 Unpaved Road Sediment Loads by Subwatershed

Both the GIS identified number of unpaved road crossings and the corrected number of unpaved road crossings are presented in **Table D3-3** by jurisdiction for each subwatershed, along with the mean annual sediment load for existing conditions and the mean annual sediment load achievable through the application of BMPs. For unpaved road crossings within the Kootenai-Fisher Project Area, the estimated mean annual sediment load ranges from 0.17 tons in the Raven Creek watershed to 6.86 tons in the Libby Creek watershed. Reductions are slightly greater for federally administered roads than private/county/state roads, but because of the greater average load per crossing at federal crossings, reductions at the subwatershed scale were similar. Sediment loading from unpaved roads could be reduced between 32% and 51% with additional BMPs, which averages to a 50% reduction across the project area. Although the field assessment is a limited sampling of all road crossings, based on observations while completing the field work, the sampled population of road crossings is representative of conditions throughout the project area. Overall, conditions for unpaved roads within the project area are good. Most loading is coming from a limited number of crossings with inadequate or improperly maintained BMPs. A complete evaluation of sediment loads at the HUC12 subwatershed scale by precipitation zone and ownership is presented in **Attachment D**.

Table D3-3. Unpaved Road Crossing Mean Annual Sediment Loads by Subwatershed

Subwatershed	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
Libby Creek Federal	380	300	6.44	3.06	53%
Libby Creek Private/County/State	107	85	0.42	0.30	29%
Libby Creek Total	**487**	**385**	**6.86**	**3.36**	**51%**
Lake Creek Federal	237	187	4.37	2.08	52%
Lake Creek Private/County/State	103	81	0.44	0.31	29%
Lake Creek Total	**340**	**269**	**4.81**	**2.40**	**50%**
Wolf Creek Federal	317	250	4.20	1.97	53%
Wolf Creek Private/County/State	474	374	1.46	1.03	29%
Wolf Creek Total	**791**	**625**	**5.67**	**3.01**	**47%**
Bristow Creek Federal	58	46	0.98	0.46	53%
Bristow Creek Total	**58**	**46**	**0.98**	**0.46**	**53%**
Quartz Creek Federal	89	70	1.62	0.77	52%
Quartz Creek Private/County/State	3	2	0.01	0.01	29%
Quartz Creek Total	**92**	**73**	**1.63**	**0.78**	**52%**
Raven Creek Federal	2	2	0.02	0.01	53%
Raven Creek Private/County/State	35	28	0.15	0.10	29%
Raven Creek Total	**37**	**29**	**0.17**	**0.12**	**32%**
Kootenai-Fisher Project Area Total	**1,805**	**1,426**	**20.11**	**10.12**	**50%**

D3.1.5 Potential Culvert Failures

Out of the 24 field assessed crossings in the Kootenai-Fisher Project Area, 22 crossings had culverts, while two were comprised of log crib structures overarching a natural streambed and no assessment was performed on the culvert at crossing X-947 since it was on a very small headwater channel located under extensive rock fill. While 18 of the culverts had flowing water at the time that field data was collected, all 21 culverts assessed in the field were evaluated for culvert failure to provide a conservative estimate of sediment loading. Of the 21 culverts assessed in the field, 100% are capable of passing the two-year flood event, while 15 of these culverts (71%) pass a 100-year flood event (**Tables D3-4** and **D3-5**, **Attachment E**). Once a culvert's carrying capacity is exceeded, the potential for culvert failure increases, though the point at which a given culvert will fail remains uncertain. Hydraulic analysis of a culvert is extremely complex and potential sediment loads from the eroding fill as presented in **Table D3-5** are estimates assuming the entire height and length of road fill are eroded to a width equal to the bankfull width of the stream.

Table D3-4. Culvert Failure and Potential Sediment Load Evaluation

Location ID	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Culvert Capacity (cfs)	Potential Sediment Load if Culvert Fails (Tons)
X-1655	13	25	35	50	63	76	56	72
X-1589	10	19	27	38	48	59	126	138
X-1764	39	69	92	126	156	185	171	332
X-1595	4	9	13	19	24	30	81	55
X-196	4	9	13	19	24	30	67	172
X-1377	7	14	19	28	36	43	119	28
X-303	1	2	4	6	8	9	30	20
X-1151	2	5	8	12	15	19	100	65
X-499	1	2	4	6	8	9	14	20
X-377	60	104	138	184	227	268	1038	365
X-139	7	14	19	28	36	43	62	46
X-1B	60	104	138	184	227	268	61	162
X-1150	10	19	27	38	48	59	71	66
X-25	10	19	27	38	48	59	164	90
X-837	4	9	13	19	24	30	26	30
X-358	7	14	19	28	36	43	87	93
X-814	32	59	79	108	135	160	426	201
X-1051	86	147	191	252	309	363	351	305
X-1089	13	25	35	50	63	76	132	105
X-127	1	2	4	6	8	9	20	24
X-1	4	9	13	19	24	30	11	18

grey cells indicate culvert fails to pass a given discharge

Table D3-5. Culvert Failure Summary

Flood Frequency	Number of Culverts Passing	Number of Culverts Failing	Percent Passing	Percent Failing
Q2	21	0	100%	0%
Q5	20	1	95%	5%
Q10	19	2	90%	10%
Q25	19	2	90%	10%
Q50	18	3	86%	14%
Q100	15	6	71%	29%

If a culvert fails for a given event, the replacement culvert should address several issues. First, culverts typically cause changes in the upstream elevation and the new culvert should mitigate these effects to ensure that culvert placement does not negatively affect the surrounding habitat. Next, environmental considerations such as fish passage need to be accurately predicted. New three-sided culverts, where the bottom of the culvert is typically the natural channel bottom, allow better holding habitat and maintain a continuous stream channel bottom. The hydrology of the area should also be determined and directly related to the culvert design size for the given watershed. Following these principals will help improve the stream system, increase fish habitat, and reduce potential sediment loads from failed culverts.

D3.2 Fish Passage Analysis

In the Kootenai-Fisher Project Area, none of the 18 culverts assessed at crossings with flowing water had a high probability of allowing fish passage (**Table D3-6**), while 17 culverts (96%) were classified as fish passage barriers (**Attachment F**). The majority of these culverts were located on streams containing fish as evaluated by Montana Fish, Wildlife and Parks, though this was not considered when evaluating a culvert's ability to pass fish (**Figure D3-3**). In general, too steep of slope led to most of these culverts being classified as fish passage barriers. Recent research suggests fish can pass steeper culverts than indicated by the Alaska criteria (Burford et al., 2009; Peterson et al., 2013), particularly if there is no outlet drop (Peterson et al., 2013). When gradients up to 8% are considered at culverts with no outlet perch, five additional culverts may pass some fish. This analysis was conducted to sample a representative subset of the population, and indicates fish passage may be a problem throughout the project area. However, this is a very coarse assessment with a high level of uncertainty, and additional evaluations should be conducted in consultation with a fish biologist at any culvert that may be replaced to facilitate fish passage. Under some circumstances, such as when a genetically pure native population is isolated from non-native species, it is desirable to maintain a fish passage barrier.

Table D3-6. Fish Passage Evaluation

Fish Passage Evaluation Categories	Fish Passage Evaluation Criteria	Number of Culverts	Percentage of Total Culverts Assessed
Green[1]	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows	0	0%
Red[2]	conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows	17	94%
Grey[3]	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability	1	6%

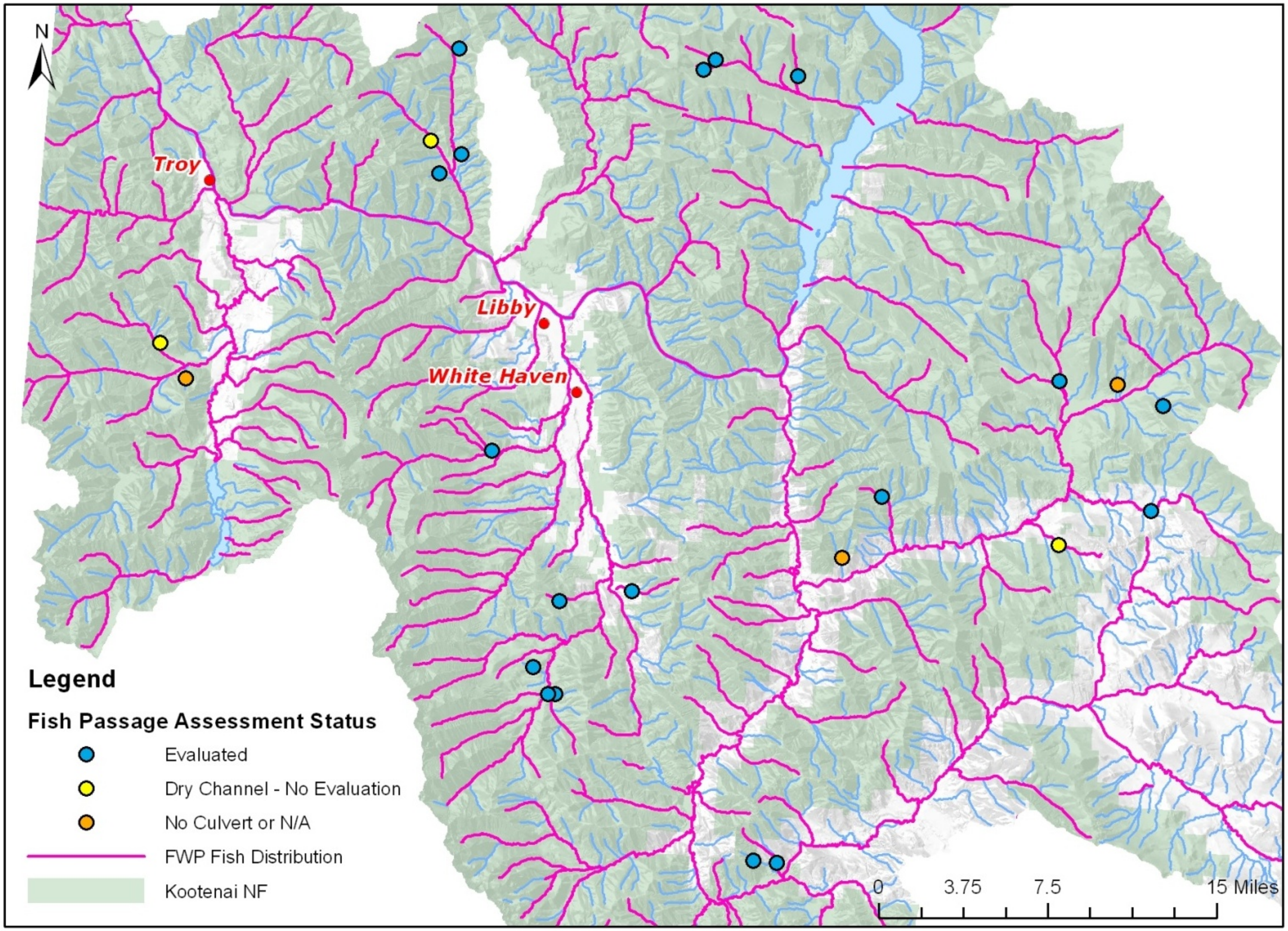

Figure D3-3. Montana Fish, Wildlife and Parks Fish Distribution in the Kootenai-Fisher Project Area

D4.0 Assumptions and Uncertainty

The 47 crossings that were assessed in the field represents approximately 3.3% of all crossings (based on crossings identified using GIS). Ideally, 5% of the roads would have been sampled, which is still a small portion of the unpaved crossings, but the sample size was limited by project resources. However, sites were randomly selected and extras were added in the field when necessary with the goal of selecting representative sites. It is assumed that the crossings assessed in the field are representative of crossings throughout the project area.

However, a degree of uncertainty is unavoidable when extrapolating data from assessed sites to un-assessed sites. The largest potential sources of inaccuracy within the project are the small sample size, which was selected based on available resources, and potential errors in the GIS data layers. These are minimized by performing a random selection of representative monitoring sites and by adjusting the results of the GIS data analysis to account for sites where no active stream crossing was observed during field data collection. Since sediment source modeling may under-estimate or over-estimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each sub-watershed. Instead, the unpaved road assessment model results should be considered an instrument for estimating existing sediment loads and making general comparisons of road sediment loads under different management scenarios.

The fish passage and culvert failure assessments are coarse evaluations with a high level of uncertainty; they were primarily performed to highlight the importance of considering aquatic life passage for prioritizing culvert replacement or when installing new culverts, as well as proper culvert design, installation, and maintenance to minimize the risk of substantial loading to streams from partial to complete culvert failure. Although sediment loading estimates from partial culvert failure are not being incorporated into the estimate of road-related sediment loading for the project area because of the uncertainty of the timing and magnitude of culvert failure in any given year, there is also uncertainty associated with predicting the capacity of each culvert. Peak flows that pass through each assessed culvert were generated using the USGS regression equations, which are subject to large standard errors that may substantially over or underestimate peak discharge. Uncertainty is also associated with the culvert slope values for both the culvert failure and fish passage assessment. Culvert slope was estimated using a handheld inclinometer. Different slope estimates may lead to variations in peak flow calculations and can alter the outcome of the fish passage analysis, which is sensitive to slope. Also, the culvert assessment was conducted on the same crossings that were assessed for road sediment loading, which is a small subset of all culverts in the project area. It is assumed that the culverts evaluated in the field are representative of culverts throughout the Kootenai-Fisher project area. Lastly, no formal evaluation was conducted to determine if streams where culverts were assessed are fish-bearing. Montana Fish, Wildlife and Parks distribution data in GIS was checked after field work was completed (**Figure D3-3**) and indicates that most assessed culverts are on fish bearing streams, but a fish biologist should be consulted before a culvert is installed or replaced. In some instances, it is desirable to maintain fish passage barriers to preserve vulnerable populations.

D5.0 DISCUSSION

Within the Kootenai-Fisher Project Area, there are six water body segments listed on the 2012 303(d) List for sediment-related impairments, including Lake Creek, Libby Creek, Wolf Creek, Bristow Creek, Quartz Creek, and Raven Creek. Mean annual sediment contributions from unpaved roads average 20.11 tons per year (**Table D4-1**). Through the application of BMPs, it is estimated that this sediment load can be reduced to 10.12 tons per year, which is a 50% reduction in sediment loads. This reduction is achieved by reducing contributing road lengths at unpaved road crossings through the application of BMPs.

Table D4-1. Potential Reduction in Sediment Loads from Unpaved Roads through Application of BMPs

Subwatershed	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
Libby Creek	6.86	3.36	51%
Lake Creek	4.81	2.40	50%
Wolf Creek	5.67	3.01	47%
Bristow Creek	0.98	0.46	53%
Quartz Creek	1.63	0.78	52%
Raven Creek	0.17	0.12	32%
Kootenai-Fisher Project Area	**20.11**	**10.12**	**50%**

D6.0 REFERENCES

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ATTACHMENT DA - FIELD ASSESSED SITES

#	Field Site ID	GIS Site ID	Stream Segment Subwatershed	Pre-selected / Alternate	Field Form Completed	Road Closed / Re-vegetated / Obliterated	No Defined Channel	Comment
1	X-1718	X-1718	Lake Creek	pre-selected	no			paved
2	X-1680	X-1680	Lake Creek	pre-selected	no			paved
3	X-1655	X-1655	Lake Creek	pre-selected	yes			
4	X-1413	X-1413	Lake Creek	alternate	no			paved approach at Keeler Rattle 473 crossing of National Forest Keeler Creek
5	X-1452	X-1452	Lake Creek	pre-selected	no	Road Closed - Administrative Use By Permit		
6	X-1A	X-947	Lake Creek	alternate	yes			
7	X-220	X-220	Lake Creek	pre-selected	no	Road Closed - Re-vegetated	X	no channel at GIS identified crossing, but stream audible from site
8	X-336	X-336	Lake Creek	alternate	no	Road Closed - Administrative Use By Permit	X	no channel
9	X-109	X-109	Lake Creek	pre-selected	no			paved, only site noted as AS-ASPHALT out of 40 pre-selected sites
10	X-1736	X-1726	Quartz Creek	pre-selected	no		X	no channel, recorded in the field as X-1736, but at site X-1726
11	X-1589	X-1589	Quartz Creek	pre-selected	yes			
12	X-1764	X-1764	Quartz Creek	pre-selected	yes			
13	X-1595	X-1595	Quartz Creek	pre-selected	yes			
14	X-1733	X-1733	Quartz Creek	pre-selected	no	Road Closed - Re-vegetated		Forest Road 4691 closed
15	X-196	X-196	Quartz Creek	alternate	yes			
16	X-1377	X-1377	Libby Creek	pre-selected	yes			
17	X-1399	X-1399	Libby Creek	pre-selected	no			paved, Bituminous Surface Treatment in GIS database
18	X-121	X-121	Libby Creek	pre-selected	no			paved approach
19	X-318	X-318	Libby Creek	pre-selected	no			paved approach
20	X-303	X-303	Libby Creek	pre-selected	yes			
21	X-1151	X-1151	Libby Creek	pre-selected	yes			
22	X-499	X-499	Libby Creek	pre-selected	yes			
23	X-377	X-377	Libby Creek	alternate	yes			
24	X-139	X-139	Libby Creek	pre-selected	yes			
25	X-1B	X-1824	Bristow Creek	pre-selected	yes			Forest Road 6245 crossing on National Forest Bristow Creek assessed during recon
26	X-1150	X-1150	Bristow Creek	pre-selected	yes			
27	X-1753	X-1753	Bristow Creek	pre-selected	no		X	no channel, recorded as "ditch relief" on field checklist
28	X-1766	X-1766	Bristow Creek	pre-selected	no	Road Closed - Administrative Use By Permit		
29	X-25	X-25	Bristow Creek	alternate	yes			
30	X-452	X-452	Wolf Creek	alternate	yes			
31	X-469	X-469	Wolf Creek	pre-selected	no		X	no channel, recorded as "ditch relief" on field checklist
32	X-837	X-837	Wolf Creek	pre-selected	yes			
33	X-478	X-478	Wolf Creek	pre-selected	no		X	no channel, ponded water
34	X-358	X-358	Wolf Creek	alternate	yes			
35	X-746	X-746	Wolf Creek	pre-selected	no	Road Closed - Re-vegetated	X	no channel, Plum Creek managed road
36	X-742	X-742	Wolf Creek	pre-selected	no	Road Closed - Re-vegetated		
37	X-814	X-814	Wolf Creek	alternate	yes			
38	X-1051	X-1051	Wolf Creek	pre-selected	yes			
39	X-1089	X-1165	Wolf Creek	pre-selected	yes	Road Closed - Re-vegetated		
40	X-369	X-369	Wolf Creek	pre-selected	no	Road Closed - Re-vegetated	X	no channel, dry swale
41	X-367	X-367	Wolf Creek	alternate	no	Road Closed - Re-vegetated		
42	X-1613	X-1613	Wolf Creek	alternate	yes			
43	X-123	X-123	Raven Creek	pre-selected	no		X	no channel
44	X-127	X-127	Raven Creek	pre-selected	yes			
45	X-1074	X-1074	Raven Creek	pre-selected	no		X	no channel, road covered in knapweed
46	X-1	X-1	Raven Creek	alternate	yes			
47	X-1079	X-1079	Raven Creek	pre-selected	no	Road Closed - Re-vegetated		examined during recon

ATTACHMENT DB - UNPAVED ROAD CROSSING FIELD DATA

Waterbody	Stream Segment	Location ID	GIS ID	Date	Latitude	Longitude	Jurisdiction / Ownership	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	WEPP LOAD (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
															L	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R		
unknown	Lake Creek	X-1655	X-1655	07/26/11	48.35566	-115.92236	Federal	>26	Sand L	20	Insloped Veg/rock ditch	Part. Grav.	Low	30	-	-	-	-	-	-	-	0.00	3	254	22	119	5	0.3	1	52.75	52.75	12.81
unknown	Lake Creek	X-1A	X-947	07/26/11	48.33426	-115.89508	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	8	142	12	101	30	0.3	1	56.80	-	-	-	-	-	-	-	0.00	56.80	30.00
unnamed	Quartz Creek	X-1589	X-1589	07/26/11	48.49219	-115.64647	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	3	417	11	84	18	0.3	1	71.73	3	285	11	84	18	0.3	1	49.03	120.76	55.15
Hennessy Creek	Quartz Creek	X-1764	X-1764	07/26/11	48.56023	-115.65687	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	7	210	10	119	26	0.3	1	64.76	3	54	10	119	26	0.3	1	15.24	80.00	38.37
West Fork Quartz Trib	Quartz Creek	X-1595	X-1595	07/26/11	48.49929	-115.67690	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	3	94	11	100	12	0.3	1	13.49	13.49	4.02
unnamed	Quartz Creek	X-196	X-196	07/26/11	48.47878	-115.66622	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	5	294	14	100	35	0.3	1	148.09	148.09	50.87
Shawnesy Creek	Libby Creek	X-1377	X-1377	07/27/11	48.30317	-115.59466	County	20-26	Sand L	30	Outsloped Unrutted	Part. Grav.	Low	30	1	6	16	58	8	0.3	1	0.40	1	6	16	58	8	0.3	1	0.40	0.80	0.80
unnamed	Libby Creek	X-303	X-303	07/27/11	48.21003	-115.51891	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	3	272	11	70	7	0.3	1	21.35	21.35	10.04
unnamed	Libby Creek	X-1151	X-1151	07/27/11	48.15004	-115.51627	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	2	158	10	47	15	0.3	1	11.78	3	271	10	47	15	0.3	1	21.56	33.34	17.60
unnamed	Libby Creek	X-499	X-499	07/27/11	48.16629	-115.53921	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	4	409	13	58	6	0.3	1	38.87	-	-	-	-	-	-	-	0.00	38.87	14.73
Midas Creek	Libby Creek	X-377	X-377	07/27/11	48.14984	-115.52254	Federal	>26	Sand L	20	Outsloped Unrutted	Gravel	High	30	2	97	18	47	22	0.3	1	31.72	1	100	18	47	22	0.3	1	32.40	64.12	64.12
unnamed	Libby Creek	X-139	X-139	07/27/11	48.21997	-115.44976	Private	>26	Loa m	5	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	5	69	15	100	12	0.3	1	21.75	21.75	21.75
North Fork Bristow Creek	Bristow Creek	X-1B	X-1824	07/12/11	48.56548	-115.40845	Federal	>26	Clay L	20	Outsloped Unrutted	Native	Low	30	7	48	14	58	19	0.3	1	12.56	5	149	14	84	15	0.3	1	38.09	50.65	29.69
unnamed	Bristow Creek	X-1150	X-1150	07/27/11	48.55885	-115.32752	Federal	20-26	Sand L	20	Outsloped Unrutted	Gravel	Low	30	3	79	16	58	10	0.3	1	6.80	-	-	-	-	-	-	-	0.00	6.80	6.80
unnamed	Bristow Creek	X-25	X-25	07/27/11	48.55840	-115.41904	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	7	275	15	70	10	0.3	1	53.63	53.63	15.60
Ariana	Wolf Creek	X-452	X-452	07/28/11	48.25176	-115.25048	Federal	<20	Silt L	10	Outsloped Unrutted	Native	Low	50	1	20	7	58	8	0.3	1	0.18	1	70	7	100	8	0.3	1	1.19	1.37	0.82
unnamed	Wolf Creek	X-837	X-837	07/28/11	48.29262	-115.21642	Private	20-26	Silt L	20	Outsloped Unrutted	Native	Low	30	6	180	7	70	7	0.3	1	5.57	-	-	-	-	-	-	-	0.00	5.57	2.23
Kavala	Wolf Creek	X-358	X-358	07/28/11	48.26981	-115.04304	Federal	<20	Silt L	10	Outsloped Unrutted	Native	Low	50	4	296	14	58	17	0.3	1	22.22	2	60	14	58	17	0.3	1	3.50	25.72	10.48
Sinclair	Wolf Creek	X-814	X-814	07/28/11	48.29605	-114.95640	Private	<20	Sand L	30	Outsloped Unrutted	Native	Low	50	1	15	12	84	14	0.3	1	0.81	1	35	12	84	14	0.3	1	1.89	2.70	2.70
Dry Creek	Wolf Creek	X-1051	X-1051	07/28/11	48.37520	-115.05347	Federal	<20	Silt L	40	Outsloped Unrutted	Gravel	Low	50	1	20	20	47	18	0.3	1	0.57	1	16	20	36	18	0.3	1	0.33	0.90	0.90

Waterbody	Stream Segment	Location ID	GIS ID	Date	Latitude	Longitude	Jurisdiction / Ownership	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	WEPP LOAD (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
															L	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R		
unnamed	Wolf Creek	X-1089	X-1165	07/28/11	48.36396	-114.95220	Private	20-26	Silt L	5	Outsloped Unrutted	Native	Low	30	4	78	2	47	17	0.3	1	0.15	3	125	2	47	17	0.3	1	0.27	0.42	0.42
unnamed	Wolf Creek	X-1613	X-1613	07/28/11	48.37565	-114.99744	Private	20-26	Silt L	5	Outsloped Unrutted	Native	Low	30	1	10	10	47	10	0.3	1	0.29	5	60	10	47	10	0.3	1	3.35	3.64	3.64
Raven trib	Raven Creek	X-127	X-127	07/28/11	48.05256	-115.31427	Private	>26	Silt L	10	Outsloped Unrutted	Native	Low	30	2	50	15	84	8	0.3	1	5.95	11	80	15	84	8	0.3	1	26.52	32.47	15.23
Raven Creek	Raven Creek	X-1	X-1	07/28/11	48.05253	-115.29184	Federal	20-26	Sand L	40	Outsloped Unrutted	Native	Low	30	3	80	4	47	6	9	6	3.12	-	-	-	-	-	-	-	0.00	3.12	3.12

Waterbody	Location ID	GIS ID	Segment 1 Potential BMPs		Road Crossing and BMP Notes/Comments
			L	R	
unknown	X-1655	X-1655	n/a	water bar at 56', ditch relief culvert	reduce River Right contributing length to 56', road sloped to the left
unknown	X-1A	X-947	water bar @ 75'	n/a	142' up River Left to pipe, reduce to 75' from River Left, water partly flows past crossing to flat area
unnamed	X-1589	X-1589	water bar/dip @127'	water bar/drain dip @ 194'	reduce River Right to 127', started at culvert from River Left, reduce River Right to 194'
Hennessy Creek	X-1764	X-1764	water bar @ 75'	none	drain dip at top of River Left, add rubber water bar to make length 75'
West Fork Quartz Trib	X-1595	X-1595	-	water bar @ 28'	short length could be slightly reduced from River Right to 28'
unnamed	X-196	X-196	-	upgrade water bar @ 101'	101 at failed water bar on River Right, slopes past River Left
Shawnesy Creek	X-1377	X-1377	none	none	-
unnamed	X-303	X-303	-	water bar/rolling dip @ 128'	-
unnamed	X-1151	X-1151	water bar @ 92'	water bar @ 135'	reduce River Right to 135' feet, reduce River Left to 92' with water bar
unnamed	X-499	X-499	water bar at 155'	-	only from River Left, reduce River Left to 155'
Midas Creek	X-377	X-377	fix water bar	none	-
unnamed	X-139	X-139	-	no more needed	only from River Right, no BMP length reduction
North Fork Bristow Creek	X-1B	X-1824	none	water bar at 67'	grass buffer, rolling dip at ~150' on River Right, culvert drain on ditch on River Right
unnamed	X-1150	X-1150	none required	-	newly bladed
unnamed	X-25	X-25	-	water bar @ 80'	-
Ariana	X-452	X-452	-	water bar/dip @ 38'	reduce River Right to 38' with water bar; 3' vegetated tread reduce width to 7'
unnamed	X-837	X-837	water bar at 72'	-	-
Kavala	X-358	X-358	water bar @ 93'	none	-
Sinclair	X-814	X-814	slash filter	slash filter	-
Dry Creek	X-1051	X-1051	slash filter	slash filter	-
unnamed	X-1089	X-1165	-	-	vegetated road modeled for two 1-foot wide wheel tracks
unnamed	X-1613	X-1613	-	-	lightly used road w/knapweed in centerline
Raven trib	X-127	X-127	none	water bar at 28'	-
Raven Creek	X-1	X-1	none	-	slightly rutted w/veg in center and rocky, buffer then fill

Attachment DC - Unpaved Road Crossing WEPP Modeled Sediment Loads by Precipitation Zone

Waterbody	Stream Segment	Location ID	GIS ID	Jurisdiction / Ownership	<20		20-26		>26	
					MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
unknown	Lake Creek	X-1655	X-1655	Federal	25.56	6.61	31.05	7.04	52.75	12.81
unknown	Lake Creek	X-1A	X-947	Federal	35.25	18.62	39.00	20.60	56.80	30.00
unnamed	Quartz Creek	X-1589	X-1589	Federal	52.07	23.81	81.51	37.28	120.76	55.15
Hennessy Creek	Quartz Creek	X-1764	X-1764	Federal	41.05	19.51	54.29	25.98	80.00	38.37
West Fork Quartz Trib	Quartz Creek	X-1595	X-1595	Federal	6.47	1.93	9.04	2.69	13.49	4.02
unnamed	Quartz Creek	X-196	X-196	Federal	81.94	28.15	98.11	33.70	148.09	50.87
Shawnesy Creek	Libby Creek	X-1377	X-1377	County	0.50	0.50	0.80	0.80	1.34	1.34
unnamed	Libby Creek	X-303	X-303	Federal	8.63	4.06	13.45	6.33	21.35	10.04
unnamed	Libby Creek	X-1151	X-1151	Federal	12.76	6.74	19.19	10.07	33.34	17.60
unnamed	Libby Creek	X-499	X-499	Federal	17.49	6.63	23.32	8.84	38.87	14.73
Midas Creek	Libby Creek	X-377	X-377	Federal	20.10	20.10	30.16	30.16	64.12	64.12
unnamed	Libby Creek	X-139	X-139	Private	15.35	15.35	14.77	14.77	21.75	21.75
North Fork Bristow Creek	Bristow Creek	X-1B	X-1824	Federal	36.24	21.33	36.10	21.26	50.65	29.69
unnamed	Bristow Creek	X-1150	X-1150	Federal	4.80	4.80	6.80	6.80	11.47	11.47
unnamed	Bristow Creek	X-25	X-25	Federal	28.33	8.24	32.82	9.55	53.63	15.60
Ariana	Wolf Creek	X-452	X-452	Federal	1.37	0.82	2.27	1.37	3.48	2.10
unnamed	Wolf Creek	X-837	X-837	Private	5.57	2.23	5.57	2.23	7.51	3.01
Kavala	Wolf Creek	X-358	X-358	Federal	25.72	10.48	47.57	19.89	42.85	17.87
Sinclair	Wolf Creek	X-814	X-814	Private	2.70	2.70	6.74	6.74	6.29	6.29
Dry Creek	Wolf Creek	X-1051	X-1051	Federal	0.90	0.90	3.84	3.84	3.64	3.64
unnamed	Wolf Creek	X-1089	X-1165	Private	0.35	0.35	0.42	0.42	2.57	2.57
unnamed	Wolf Creek	X-1613	X-1613	Private	2.66	2.66	3.64	3.64	3.70	3.70
Raven trib	Raven Creek	X-127	X-127	Private	24.16	11.32	22.53	10.54	32.47	15.23
Raven Creek	Raven Creek	X-1	X-1	Federal	1.62	1.62	3.12	3.12	1.89	1.89

ATTACHMENT DD - UNPAVED ROAD CROSSING SUBWATERSHED SEDIMENT LOADS

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Big Cherry Creek	Federal	20-26	15	12	0.0156	0.0073	0.1853	0.0866	53%
Big Cherry Creek	Federal	>26	38	30	0.0234	0.0112	0.7038	0.3355	52%
			53	42			0.8891	0.4221	53%
Big Cherry Creek	Private	20-26	8	6	0.0039	0.0028	0.0246	0.0177	28%
Big Cherry Creek	Private	>26	5	4	0.0054	0.0039	0.0213	0.0152	29%
			13	10			0.0459	0.0329	28%
Big Cherry Creek	County	<20	1	1	0.0037	0.0025	0.0029	0.0020	32%
Big Cherry Creek	County	20-26	4	3	0.0039	0.0028	0.0123	0.0088	28%
Big Cherry Creek	County	>26	2	2	0.0054	0.0039	0.0085	0.0061	29%
			7	6			0.0237	0.0169	29%
Big Cherry Creek	State	>26	1	1	0.0054	0.0039	0.0043	0.0030	29%
			1	1			0.0043	0.0030	29%
Big Cherry Creek Total			**74**	**58**			**0.9630**	**0.4749**	**51%**
Granite Creek	Federal	20-26	1	1	0.0156	0.0073	0.0124	0.0058	53%
			1	1			0.0124	0.0058	53%
Granite Creek	County	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
			2	2			0.0061	0.0044	28%
Granite Creek Total			**3**	**2**			**0.0185**	**0.0102**	**45%**
Swamp Creek-Cowell Creek	Federal	>26	81	64	0.0234	0.0112	1.5002	0.7151	52%
			81	64			1.5002	0.7151	52%
Swamp Creek-Cowell Creek	Private	>26	44	35	0.0054	0.0039	0.1877	0.1338	29%
			44	35			0.1877	0.1338	29%
Swamp Creek-Crowell Creek Total			**125**	**99**			**1.6879**	**0.8489**	**50%**
Lower Libby Creek	Federal	<20	1	1	0.0118	0.0054	0.0093	0.0043	54%
Lower Libby Creek	Federal	20-26	80	63	0.0156	0.0073	0.9881	0.4620	53%
Lower Libby Creek	Federal	>26	23	18	0.0234	0.0112	0.4260	0.2030	52%
			104	82			1.4234	0.6693	53%
Lower Libby Creek	Private	<20	3	2	0.0037	0.0025	0.0087	0.0059	32%
Lower Libby Creek	Private	20-26	9	7	0.0039	0.0028	0.0277	0.0199	28%
Lower Libby Creek	Private	>26	7	6	0.0054	0.0039	0.0299	0.0213	29%
			19	15			0.0662	0.0471	29%
Lower Libby Creek	County	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
			2	2			0.0061	0.0044	28%
Lower Libby Creek	State	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
			2	2			0.0061	0.0044	28%
Lower Libby Creek Total			**127**	**100**			**1.5019**	**0.7253**	**52%**
Upper Libby Creek	Federal	>26	141	111	0.0234	0.0112	2.6115	1.2448	52%
			141	111			2.6115	1.2448	52%
Upper Libby Creek	Private	>26	12	9	0.0054	0.0039	0.0512	0.0365	29%
			12	9			0.0512	0.0365	29%
Upper Libby Creek	County	>26	5	4	0.0054	0.0039	0.0213	0.0152	29%
			5	4			0.0213	0.0152	29%
Upper Libby Creek Total			**158**	**125**			**2.6841**	**1.2965**	**52%**
Libby Creek Total			**487**	**385**			**6.8554**	**3.3558**	**51%**
Keeler Creek	Federal	>26	126	100	0.0234	0.0112	2.3337	1.1124	52%
			126	100			2.3337	1.1124	52%
Keeler Creek	Private	>26	12	9	0.0054	0.0039	0.0512	0.0365	29%
			12	9			0.0512	0.0365	29%
Keeler Creek	State	>26	1	1	0.0054	0.0039	0.0043	0.0030	29%
			1	1			0.0043	0.0030	29%
Keeler Creek Total			**139**	**110**			**2.3892**	**1.1519**	**52%**
Ross Creek	Federal	>26	4	3	0.0234	0.0112	0.0741	0.0353	52%
			4	3			0.0741	0.0353	52%
Ross Creek	Private	>26	1	1	0.0054	0.0039	0.0043	0.0030	29%
			1	1			0.0043	0.0030	29%
Ross Creek Total			**5**	**4**			**0.0784**	**0.0384**	**51%**
Stanley Creek	Federal	>26	51	40	0.0234	0.0112	0.9446	0.4502	52%
			51	40			0.9446	0.4502	52%
Stanley Creek	Private	>26	18	14	0.0054	0.0039	0.0768	0.0547	29%
			18	14			0.0768	0.0547	29%
Stanley Creek Total			**69**	**55**			**1.0214**	**0.5050**	**51%**
Lower Lake Creek	Federal	20-26	3	2	0.0156	0.0073	0.0371	0.0173	53%
Lower Lake Creek	Federal	>26	24	19	0.0234	0.0112	0.4445	0.2119	52%
			27	21			0.4816	0.2292	52%
Lower Lake Creek	Private	>26	33	26	0.0054	0.0039	0.1408	0.1004	29%
			33	26			0.1408	0.1004	29%
Lower Lake Creek	State	>26	2	2	0.0054	0.0039	0.0085	0.0061	29%
			2	2			0.0085	0.0061	29%
Lower Lake Creek Total			**62**	**49**			**0.6309**	**0.3357**	**47%**
Upper Lake Creek - above Bull Lake	Federal	>26	3	2	0.0234	0.0112	0.0556	0.0265	52%

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
			3	2			0.0556	0.0265	52%
Upper Lake Creek - above Bull Lake	Private	>26	17	13	0.0054	0.0039	0.0725	0.0517	29%
			17	13			0.0725	0.0517	29%
Upper Lake Creek - above Bull Lake Total			**20**	**16**			**0.1281**	**0.0782**	**39%**
Upper Lake Creek - below Bull Lake	Federal	>26	26	21	0.0234	0.0112	0.4816	0.2295	52%
			26	21			0.4816	0.2295	52%
Upper Lake Creek - below Bull Lake	Private	>26	19	15	0.0054	0.0039	0.0811	0.0578	29%
			19	15			0.0811	0.0578	29%
Upper Lake Creek - below Bull Lake Total			**45**	**36**			**0.5626**	**0.2873**	**49%**
Lake Creek Total			**340**	**269**			**4.8105**	**2.3964**	**50%**
Lower Wolf Creek	Federal	<20	40	32	0.0118	0.0054	0.3721	0.1713	54%
Lower Wolf Creek	Federal	20-26	44	35	0.0156	0.0073	0.5435	0.2541	53%
			84	66			0.9156	0.4254	54%
Lower Wolf Creek	Private	<20	109	86	0.0037	0.0025	0.3156	0.2161	32%
Lower Wolf Creek	Private	20-26	111	88	0.0039	0.0028	0.3411	0.2451	28%
Lower Wolf Creek	Private	>26	4	3	0.0054	0.0039	0.0171	0.0122	29%
			224	177			0.6738	0.4734	30%
Lower Wolf Creek	County	<20	5	4	0.0037	0.0025	0.0145	0.0099	32%
			5	4			0.0145	0.0099	32%
Lower Wolf Creek	State	<20	17	13	0.0037	0.0025	0.0492	0.0337	32%
Lower Wolf Creek	State	20-26	11	9	0.0039	0.0028	0.0338	0.0243	28%
			28	22			0.0830	0.0580	30%
Lower Wolf Creek Total			**341**	**269**			**1.6868**	**0.9667**	**43%**
Middle Wolf Creek	Federal	<20	12	9	0.0118	0.0054	0.1116	0.0514	54%
Middle Wolf Creek	Federal	20-26	28	22	0.0156	0.0073	0.3458	0.1617	53%
			40	32			0.4575	0.2131	53%
Middle Wolf Creek	Private	<20	7	6	0.0037	0.0025	0.0203	0.0139	32%
Middle Wolf Creek	Private	20-26	18	14	0.0039	0.0028	0.0553	0.0397	28%
			25	20			0.0756	0.0536	29%
Middle Wolf Creek	State	<20	2	2	0.0037	0.0025	0.0058	0.0040	32%
			2	2			0.0058	0.0040	32%
Middle Wolf Creek Total			**67**	**53**			**0.5388**	**0.2707**	**50%**
Little Wolf Creek	Federal	20-26	18	14	0.0156	0.0073	0.2223	0.1039	53%
Little Wolf Creek	Federal	>26	10	8	0.0234	0.0112	0.1852	0.0883	52%
			28	22			0.4075	0.1922	53%
Little Wolf Creek	Private	<20	31	24	0.0037	0.0025	0.0898	0.0615	32%
Little Wolf Creek	Private	20-26	64	51	0.0039	0.0028	0.1967	0.1413	28%
Little Wolf Creek	Private	>26	7	6	0.0054	0.0039	0.0299	0.0213	29%
			102	81			0.3163	0.2241	29%
Little Wolf Creek	County	>26	4	3	0.0054	0.0039	0.0171	0.0122	29%
			4	3			0.0171	0.0122	29%
Little Wolf Creek	State	>26	3	2	0.0054	0.0039	0.0128	0.0091	29%
			3	2			0.0128	0.0091	29%
Little Wolf Creek Total			**137**	**108**			**0.7537**	**0.4376**	**42%**
Dry Fork Creek	Federal	<20	3	2	0.0118	0.0054	0.0279	0.0128	54%
Dry Fork Creek	Federal	20-26	31	24	0.0156	0.0073	0.3829	0.1790	53%
Dry Fork Creek	Federal	>26	32	25	0.0234	0.0112	0.5927	0.2825	52%
			66	52			1.0035	0.4744	53%
Dry Fork Creek	Private	<20	4	3	0.0037	0.0025	0.0116	0.0079	32%
Dry Fork Creek	Private	20-26	18	14	0.0039	0.0028	0.0553	0.0397	28%
			22	17			0.0669	0.0477	29%
Dry Fork Creek Total			**88**	**70**			**1.0704**	**0.5220**	**51%**
Upper Wolf Creek	Federal	20-26	58	46	0.0156	0.0073	0.7164	0.3349	53%
Upper Wolf Creek	Federal	>26	5	4	0.0234	0.0112	0.0926	0.0441	52%
			63	50			0.8090	0.3791	53%
Upper Wolf Creek	Private	<20	2	2	0.0037	0.0025	0.0058	0.0040	32%
Upper Wolf Creek	Private	20-26	44	35	0.0039	0.0028	0.1352	0.0972	28%
Upper Wolf Creek	Private	>26	13	10	0.0054	0.0039	0.0555	0.0395	29%
			59	47			0.1965	0.1407	28%
Upper Wolf Creek Total			**122**	**96**			**1.0055**	**0.5197**	**48%**
Weigel Creek	Federal	20-26	9	7	0.0156	0.0073	0.1112	0.0520	53%
Weigel Creek	Federal	>26	27	21	0.0234	0.0112	0.5001	0.2384	52%
			36	28			0.6112	0.2903	53%
Weigel Creek Total			**36**	**28**			**0.6112**	**0.2903**	**53%**
Wolf Creek Total			**791**	**625**			**5.6665**	**3.0071**	**47%**
Bristow Creek	Federal	<20	1	1	0.0118	0.0054	0.0093	0.0043	54%
Bristow Creek	Federal	20-26	14	11	0.0156	0.0073	0.1729	0.0808	53%
Bristow Creek	Federal	>26	43	34	0.0234	0.0112	0.7964	0.3796	52%
			58	46			0.9787	0.4647	53%

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Bristow Creek Total			**58**	**46**			**0.9787**	**0.4647**	**53%**
Quartz Creek	Federal	20-26	5	4	0.0156	0.0073	0.0618	0.0289	53%
Quartz Creek	Federal	>26	84	66	0.0234	0.0112	1.5558	0.7416	52%
			89	70			1.6176	0.7704	52%
Quartz Creek	Private	>26	2	2	0.0054	0.0039	0.0085	0.0061	29%
			2	2			0.0085	0.0061	29%
Quartz Creek	State	20-26	1	1	0.0039	0.0028	0.0031	0.0022	28%
			1	1			0.0031	0.0022	28%
Quartz Creek Total			**92**	**73**			**1.6292**	**0.7787**	**52%**
Raven Creek	Federal	20-26	2	2	0.0156	0.0073	0.0247	0.0115	53%
			2	2			0.0247	0.0115	53%
Raven Creek	Private	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
Raven Creek	Private	>26	33	26	0.0054	0.0039	0.1408	0.1004	29%
			35	28			0.1469	0.1048	29%
Raven Creek Total			**37**	**29**			**0.1716**	**0.1163**	**32%**
Kootenai-Fisher Project Area Total			**1,805**	**1,426**			**20.11**	**10.12**	**50%**

ATTACHMENT DE - CULVERT FAILURE ANALYSIS

Location ID	Structure Type	Culvert Dimensions	Culvert Slope	Bankfull Width	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Capacity at Cross Section	Headwater Hieght (Fill Hieght)	Field Measured Fill Width	Modeled Fill Width*	Fill Length	Fill Volume*	Fill Volume*	Potential Sediment Load if Culvert Fails*
		(ft)	(%)	(ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft³)	(CY)	(tons)
X-1655	CMP	2	5	7	13	25	35	50	63	76	56	4.5	15	7	37	1166	43	72
X-1589	CMP	3	8	6	10	19	27	38	48	59	126	15	45	6	25	2250	83	138
X-1764	CMP	4	8	12	39	69	92	126	156	185	171	10	50	12	45	5400	200	332
X-1595	CMP	2	12	4	4	9	13	19	24	30	81	8	23	4	28	896	33	55
X-196	CMP	2	16	4	4	9	13	19	24	30	67	20	25	4	35	2800	104	172
X-1377	Squash CMP	5 span 3.5 rise	3	5	7	14	19	28	36	43	119	4.5	24	5	20	450	17	28
X-303	CMP	2	7	2	1	2	4	6	8	9	30	5	60	2	32	320	12	20
X-1151	CMP	3	8	3	2	5	8	12	15	19	100	10	48	3	35	1050	39	65
X-499	CMP	1.5	3	2	1	2	4	6	8	9	14	4	60	2	40	320	12	20
X-377	Squash CMP	12.5 span 7 rise	3.5	15	60	104	138	184	227	268	1038	11	90	15	36	5940	220	365
X-139	CMP	3	5	5	7	14	19	28	36	43	62	5	35	5	30	750	28	46
X-1B	Squash CMP	3.6 span 2.25 rise	1.5	15	60	104	138	184	227	268	61	4	NA	15	44	2640	98	162
X-1150	CMP	3	5	6	10	19	27	38	48	59	71	6	4	6	30	1080	40	66
X-25	Squash CMP	4.5 span 3.5 rise	5	6	10	19	27	38	48	59	164	7	15	6	35	1470	54	90
X-837	CMP	2	8	4	4	9	13	19	24	30	26	4	20	4	30	480	18	30
X-358	CMP	3	9	5	7	14	19	28	36	43	87	8	40	5	38	1520	56	93
X-814	Squash CMP	7.5 span 5.5 rise	1.5	11	32	59	79	108	135	160	426	9	60	11	33	3267	121	201
X-1051	Squash CMP	9 span 8 rise	3	18	86	147	191	252	309	363	351	6	38	18	46	4968	184	305
X-1089	CMP	4	5	7	13	25	35	50	63	76	132	7	30	7	35	1715	64	105
X-127	CMP	1.5	10	2	1	2	4	6	8	9	20	6	30	2	33	396	15	24
X-1	CMP	1.5	3	4	4	9	13	19	24	30	11	2.5	12	4	30	300	11	18

*assuming a fill width equal to the bankfull width

culvert fails to pass a given discharge

CMP = Corrugated Metal Pipe, CY=cubic yard

ATTACHMENT DF - FISH PASSAGE ASSESSMENT

Location ID	Structure Type	Evaluation Method	Culvert Dimensions (ft)	Width (ft)	Culvert Slope (%)	Bankfull Width (ft)	Culvert/ Bankfull Ratio	Outlet Perch (inches)	Final Classification (# of failures)
X-1655	Corrugated metal pipe	3	2	2	5[2]	7	0.29[1]	9[2]	2[2]
X-1589	Corrugated metal pipe	3	3	3	8[2]	6	0.50[3]	26[2]	2[2]
X-1764	Corrugated metal pipe	3	4	4	8[2]	12	0.33[1]	24[2]	2[2]
X-1595	Corrugated metal pipe	3	2	2	12[2]	4	0.50[3]	24[2]	2[2]
X-196	Corrugated metal pipe	3	2	2	16[2]	4	0.50[3]	60[2]	2[2]
X-1377	Squash Corrugated metal pipe	3	3.5	5	3[2]	5	1.00[3]	18[2]	2[2]
X-303	Corrugated metal pipe	3	2	2	7[2]	2	1.00[3]	0[1]	1[2]
X-1151	Corrugated metal pipe	3	3	3	8[2]	3	1.00[3]	36[2]	2[2]
X-499	Corrugated metal pipe	3	1.5	1.5	3[2]	2	0.75[3]	0[1]	1[2]
X-377	Squash Corrugated metal pipe	4	7	12.5	3.5[2]	15	0.83[3]	0[1]	1[2]
X-139	Corrugated metal pipe	3	3	3	5[2]	5	0.60[3]	8[2]	2[2]
X-1B	Squash Corrugated metal pipe	3	3.6	2.25	1.5[2]	15	0.15[1]	0[1]	1[2]
X-1150	Corrugated metal pipe	3	3	3	5[2]	6	0.50[3]	7[2]	2[2]
X-25	Squash Corrugated metal pipe	3	3.5	4.5	5[2]	6	0.75[3]	9[2]	2[2]
X-837	Corrugated metal pipe	3	2	2	8[2]	4	0.50[3]	24[2]	2[2]
X-358	Corrugated metal pipe	3	3	3	9[2]	5	0.60[3]	12[2]	2[2]
X-814	Squash Corrugated metal pipe	4	5.5	7.5	1.5[3]	11	0.68[3]	0[1]	0[3]
X-1051	Squash Corrugated metal pipe	4	8	9	3[2]	18	0.50[3]	0[1]	1[2]
X-1089	Corrugated metal pipe	3	4	4	5[2]	7	0.57[3]	9[2]	2[2]
X-127	Corrugated metal pipe	3	1.5	1.5	10[2]	2	0.75[3]	24[2]	2[2]
X-1	Corrugated metal pipe	3	1.5	1.5	3[2]	4	0.38[1]	24[2]	2[2]

Note: Evaluation Method based on Table:1 Fish Passage Evaluation Criteria located in *A Summary of Techincal Considerations to Minimize the Blockage of Fish at Culverts on the National Forests of Alaska*

1 (green): conditions that have a high certainty of meeting juvenile fish passage at all desired streamflows

2 (red): conditions that have a high certainty of not providing juvenile fish passage at all desired streamflows

3 (gray): conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability

APPENDIX E - TOTAL MAXIMUM DAILY LOADS (TMDLS)

E.1 SEDIMENT

E.1.1 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 the 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 absolutely conclusive 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.

E.1.2 APPROACH

The preferred approach for calculating daily sediment loads is to use a nearby water quality gage with a long-term dataset for flow and suspended sediment. Because the gage on the Kootenai River is downstream of the Libby Dam and the hydrology of the river is altered by the dam, data from USGS gage on the Fisher River near Libby (#12302055) will be used to calculate daily sediment loads. A sediment rating curve was developed using daily flow and suspended solids load data collected from 1967 through 1976, which is the only period of record with available daily suspended sediment data (**Figure E-1**). Sediment load records during January of 1974 were removed from the rating curve because these values corresponded to an extreme flood event that was not deemed representative of typical conditions in the Kootenai-Fisher project area. The daily mean discharge based on 42 years of record (1968-2010) at the USGS gage was then plugged into the equation for the sediment rating curve to get a daily suspended sediment load. Although the suspended sediment load is only a portion of the total load from the source assessment, it provides an approximation of the relationship between sediment and flow in the Kootenai-Fisher project area. Based on the sum of the calculated daily sediment loads, a daily percentage relative to the annual suspended sediment load was calculated for each day. The daily percentages were then applied to the total average annual loads associated with the TMDL percent reductions from **Section 5.0** to determine the average daily load.

To conserve resources, this appendix contains daily loads for Wolf Creek as an example. As discussed in **Section 5.6.3.4**, the TMDL for Wolf Creek is a 29% reduction in the total average annual sediment load, which is roughly equivalent to 4,575 tons/year. The daily percentages discussed above were then multiplied by the annual load of 4,575 tons to get a daily expression of the Wolf Creek TMDL (**Figure E-2, Table E-1**). For all other waterbodies, daily TMDLs may be derived by using the daily percentages in **Table E-2** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.6.3** and presented in **Table E-2**. 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 5.6.3** to the daily load.

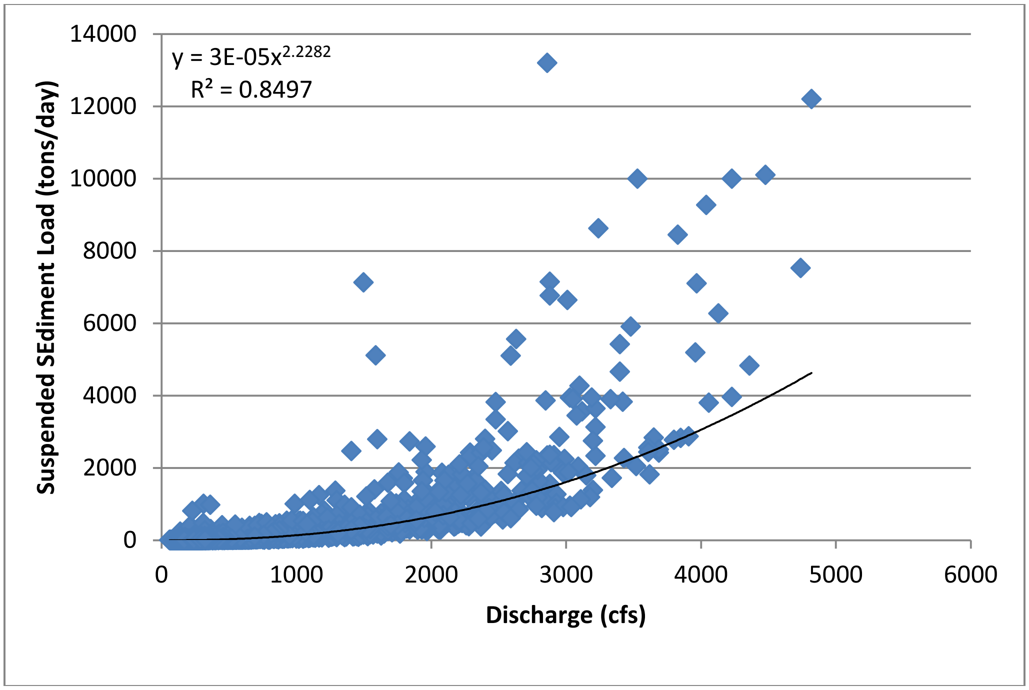

Figure E-1. Sediment Rating Curve for Fisher River based on USGS gage 12302055

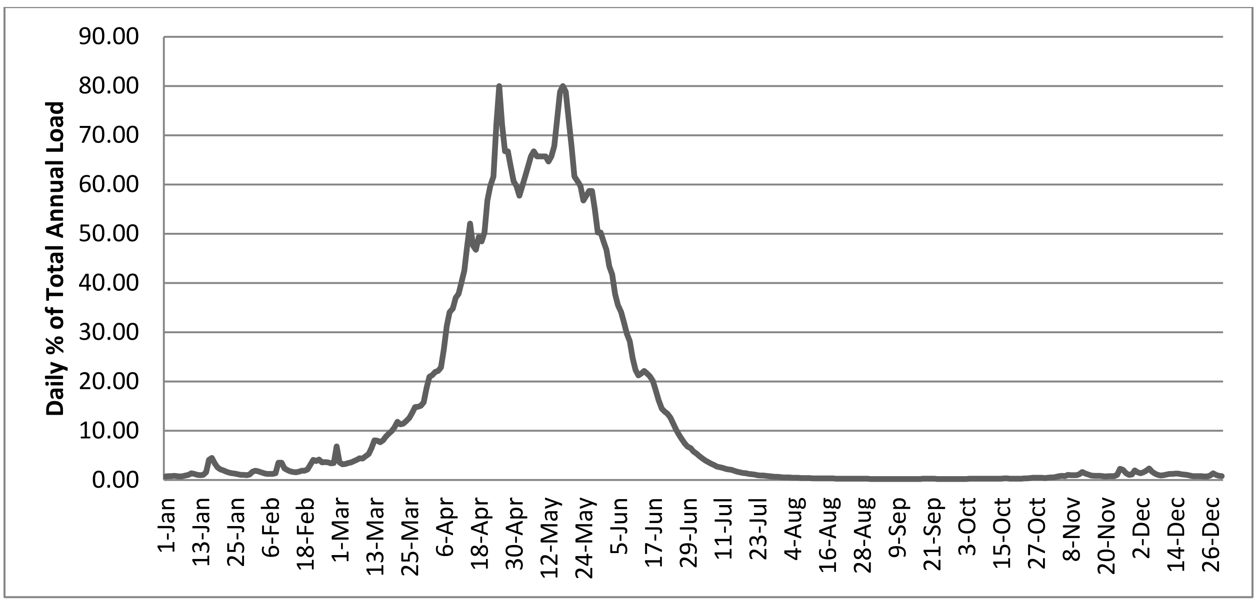

Figure E-2. TMDL for Wolf Creek

Table E-1. Daily Sediment TMDL for Wolf Creek

Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)	Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)
Jan	1	0.02	0.75	Feb	13	0.04	1.79
Jan	2	0.02	0.80	Feb	14	0.04	1.67
Jan	3	0.02	0.81	Feb	15	0.03	1.60
Jan	4	0.02	0.85	Feb	16	0.04	1.72
Jan	5	0.02	0.81	Feb	17	0.04	1.91
Jan	6	0.02	0.76	Feb	18	0.04	1.94

Table E-1. Daily Sediment TMDL for Wolf Creek

Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)	Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)
Jan	7	0.02	0.78	Feb	19	0.05	2.20
Jan	8	0.02	0.95	Feb	20	0.07	3.12
Jan	9	0.02	1.09	Feb	21	0.09	4.15
Jan	10	0.03	1.37	Feb	22	0.08	3.84
Jan	11	0.03	1.28	Feb	23	0.09	4.17
Jan	12	0.02	1.08	Feb	24	0.08	3.58
Jan	13	0.02	1.02	Feb	25	0.08	3.66
Jan	14	0.02	1.08	Feb	26	0.08	3.62
Jan	15	0.04	1.61	Feb	27	0.07	3.37
Jan	16	0.09	4.15	Feb	28	0.08	3.50
Jan	17	0.10	4.49	Mar	1	0.15	6.82
Jan	18	0.07	3.41	Mar	2	0.08	3.58
Jan	19	0.06	2.53	Mar	3	0.07	3.23
Jan	20	0.05	2.18	Mar	4	0.07	3.25
Jan	21	0.04	1.97	Mar	5	0.08	3.50
Jan	22	0.04	1.72	Mar	6	0.08	3.60
Jan	23	0.03	1.53	Mar	7	0.08	3.84
Jan	24	0.03	1.38	Mar	8	0.09	4.10
Jan	25	0.03	1.32	Mar	9	0.10	4.45
Jan	26	0.03	1.18	Mar	10	0.10	4.40
Jan	27	0.02	1.10	Mar	11	0.11	4.81
Jan	28	0.02	1.05	Mar	12	0.12	5.31
Jan	29	0.02	1.03	Mar	13	0.14	6.52
Jan	30	0.02	1.12	Mar	14	0.18	8.06
Jan	31	0.04	1.72	Mar	15	0.18	8.03
Feb	1	0.04	1.94	Mar	16	0.17	7.68
Feb	2	0.04	1.81	Mar	17	0.18	8.06
Feb	3	0.03	1.57	Mar	18	0.19	8.87
Feb	4	0.03	1.40	Mar	19	0.21	9.47
Feb	5	0.03	1.29	Mar	20	0.22	9.97
Feb	6	0.03	1.25	Mar	21	0.23	10.72
Feb	7	0.03	1.25	Mar	22	0.26	11.82
Feb	8	0.03	1.39	Mar	23	0.25	11.34
Feb	9	0.08	3.56	Mar	24	0.25	11.46
Feb	10	0.08	3.56	Mar	25	0.26	11.98
Feb	11	0.05	2.36	Mar	26	0.28	12.64
Feb	12	0.04	2.01	Mar	27	0.30	13.63
Mar	28	0.32	14.8	May	10	1.44	65.7
Mar	29	0.33	14.9	May	11	1.44	65.7
Mar	30	0.33	15.1	May	12	1.44	65.7
Mar	31	0.35	15.8	May	13	1.41	64.7
Apr	1	0.41	18.7	May	14	1.44	65.7
Apr	2	0.46	21.0	May	15	1.48	67.8
Apr	3	0.47	21.3	May	16	1.60	73.2
Apr	4	0.48	21.9	May	17	1.72	78.8
Apr	5	0.48	22.2	May	18	1.75	80.0
Apr	6	0.50	22.9	May	19	1.72	78.8

Table E-1. Daily Sediment TMDL for Wolf Creek

Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)	Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)
Apr	7	0.58	26.6	May	20	1.60	73.2
Apr	8	0.68	31.2	May	21	1.48	67.8
Apr	9	0.74	34.1	May	22	1.35	61.6
Apr	10	0.76	34.8	May	23	1.33	60.6
Apr	11	0.81	37.0	May	24	1.30	59.6
Apr	12	0.83	37.8	May	25	1.24	56.7
Apr	13	0.88	40.1	May	26	1.26	57.7
Apr	14	0.93	42.5	May	27	1.28	58.7
Apr	15	1.04	47.6	May	28	1.28	58.7
Apr	16	1.14	52.0	May	29	1.20	54.8
Apr	17	1.04	47.6	May	30	1.10	50.2
Apr	18	1.02	46.7	May	31	1.10	50.2
Apr	19	1.08	49.3	Jun	1	1.06	48.5
Apr	20	1.06	48.5	Jun	2	1.02	46.7
Apr	21	1.10	50.2	Jun	3	0.95	43.4
Apr	22	1.24	56.7	Jun	4	0.91	41.7
Apr	23	1.30	59.6	Jun	5	0.83	37.8
Apr	24	1.35	61.6	Jun	6	0.78	35.5
Apr	25	1.58	72.1	Jun	7	0.74	34.1
Apr	26	1.75	80.0	Jun	8	0.70	31.9
Apr	27	1.58	72.1	Jun	9	0.65	29.7
Apr	28	1.46	66.7	Jun	10	0.62	28.2
Apr	29	1.46	66.7	Jun	11	0.54	24.8
Apr	30	1.39	63.6	Jun	12	0.49	22.3
May	1	1.33	60.6	Jun	13	0.46	21.3
May	2	1.30	59.6	Jun	14	0.47	21.6
May	3	1.26	57.7	Jun	15	0.48	22.2
May	4	1.30	59.6	Jun	16	0.47	21.6
May	5	1.35	61.6	Jun	17	0.46	21.1
May	6	1.39	63.6	Jun	18	0.44	20.2
May	7	1.44	65.7	Jun	19	0.40	18.3
May	8	1.46	66.7	Jun	20	0.35	16.2
May	9	1.44	65.7	Jun	21	0.32	14.5
Jun	22	0.30	13.9	Aug	4	0.01	0.5
Jun	23	0.29	13.5	Aug	5	0.01	0.5
Jun	24	0.28	12.7	Aug	6	0.01	0.5
Jun	25	0.25	11.5	Aug	7	0.01	0.5
Jun	26	0.22	10.2	Aug	8	0.01	0.5
Jun	27	0.20	9.1	Aug	9	0.01	0.4
Jun	28	0.18	8.3	Aug	10	0.01	0.4
Jun	29	0.16	7.5	Aug	11	0.01	0.4
Jun	30	0.15	6.8	Aug	12	0.01	0.4
Jul	1	0.14	6.5	Aug	13	0.01	0.4
Jul	2	0.13	5.8	Aug	14	0.01	0.4
Jul	3	0.12	5.4	Aug	15	0.01	0.3
Jul	4	0.11	4.9	Aug	16	0.01	0.3
Jul	5	0.10	4.4	Aug	17	0.01	0.3

Table E-1. Daily Sediment TMDL for Wolf Creek

Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)	Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)
Jul	6	0.09	4.0	Aug	18	0.01	0.3
Jul	7	0.08	3.7	Aug	19	0.01	0.3
Jul	8	0.07	3.3	Aug	20	0.01	0.3
Jul	9	0.07	3.1	Aug	21	0.01	0.3
Jul	10	0.06	2.8	Aug	22	0.01	0.3
Jul	11	0.06	2.7	Aug	23	0.01	0.3
Jul	12	0.05	2.5	Aug	24	0.01	0.3
Jul	13	0.05	2.3	Aug	25	0.01	0.3
Jul	14	0.05	2.2	Aug	26	0.01	0.3
Jul	15	0.05	2.1	Aug	27	0.01	0.3
Jul	16	0.04	1.9	Aug	28	0.01	0.3
Jul	17	0.04	1.7	Aug	29	0.01	0.3
Jul	18	0.03	1.6	Aug	30	0.01	0.3
Jul	19	0.03	1.5	Aug	31	0.01	0.3
Jul	20	0.03	1.4	Sep	1	0.01	0.3
Jul	21	0.03	1.3	Sep	2	0.01	0.3
Jul	22	0.03	1.2	Sep	3	0.01	0.3
Jul	23	0.02	1.1	Sep	4	0.01	0.3
Jul	24	0.02	1.0	Sep	5	0.01	0.2
Jul	25	0.02	1.0	Sep	6	0.01	0.2
Jul	26	0.02	0.9	Sep	7	0.01	0.2
Jul	27	0.02	0.9	Sep	8	0.01	0.2
Jul	28	0.02	0.8	Sep	9	0.01	0.2
Jul	29	0.02	0.7	Sep	10	0.01	0.2
Jul	30	0.02	0.7	Sep	11	0.01	0.2
Jul	31	0.01	0.7	Sep	12	0.005	0.2
Aug	1	0.01	0.6	Sep	13	0.005	0.2
Aug	2	0.01	0.6	Sep	14	0.005	0.2
Aug	3	0.01	0.6	Sep	15	0.005	0.2
Sep	16	0.005	0.2	Oct	29	0.01	0.5
Sep	17	0.01	0.2	Oct	30	0.01	0.5
Sep	18	0.01	0.2	Oct	31	0.01	0.4
Sep	19	0.01	0.3	Nov	1	0.01	0.5
Sep	20	0.01	0.3	Nov	2	0.01	0.6
Sep	21	0.01	0.3	Nov	3	0.01	0.6
Sep	22	0.01	0.3	Nov	4	0.01	0.7
Sep	23	0.01	0.3	Nov	5	0.02	0.8
Sep	24	0.01	0.3	Nov	6	0.02	0.9
Sep	25	0.01	0.3	Nov	7	0.02	0.8
Sep	26	0.01	0.3	Nov	8	0.02	1.1
Sep	27	0.01	0.3	Nov	9	0.02	1.0
Sep	28	0.01	0.2	Nov	10	0.02	1.0
Sep	29	0.01	0.2	Nov	11	0.02	1.0
Sep	30	0.01	0.2	Nov	12	0.03	1.2
Oct	1	0.005	0.2	Nov	13	0.04	1.7
Oct	2	0.01	0.2	Nov	14	0.03	1.3
Oct	3	0.01	0.3	Nov	15	0.02	1.1

Table E-1. Daily Sediment TMDL for Wolf Creek

Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)	Month	Day	Daily % of annual load	Wolf Creek TMDL (tons/day)
Oct	4	0.01	0.3	Nov	16	0.02	0.9
Oct	5	0.01	0.3	Nov	17	0.02	0.9
Oct	6	0.01	0.3	Nov	18	0.02	0.9
Oct	7	0.01	0.3	Nov	19	0.02	0.8
Oct	8	0.01	0.3	Nov	20	0.02	0.8
Oct	9	0.01	0.3	Nov	21	0.02	0.7
Oct	10	0.01	0.3	Nov	22	0.02	0.8
Oct	11	0.01	0.3	Nov	23	0.02	0.8
Oct	12	0.01	0.3	Nov	24	0.02	0.8
Oct	13	0.01	0.3	Nov	25	0.02	1.1
Oct	14	0.01	0.3	Nov	26	0.05	2.3
Oct	15	0.01	0.3	Nov	27	0.05	2.1
Oct	16	0.01	0.3	Nov	28	0.03	1.4
Oct	17	0.01	0.3	Nov	29	0.02	1.1
Oct	18	0.01	0.3	Nov	30	0.03	1.2
Oct	19	0.01	0.3	Dec	1	0.04	2.0
Oct	20	0.01	0.3	Dec	2	0.03	1.6
Oct	21	0.01	0.3	Dec	3	0.03	1.4
Oct	22	0.01	0.3	Dec	4	0.03	1.6
Oct	23	0.01	0.3	Dec	5	0.04	1.9
Oct	24	0.01	0.3	Dec	6	0.05	2.4
Oct	25	0.01	0.3	Dec	7	0.04	1.7
Oct	26	0.01	0.4	Dec	8	0.03	1.3
Oct	27	0.01	0.5	Dec	9	0.02	1.1
Oct	28	0.01	0.5	Dec	10	0.02	1.0
Dec	11	0.02	1.0				
Dec	12	0.03	1.1				
Dec	13	0.03	1.2				
Dec	14	0.03	1.2				
Dec	15	0.03	1.3				
Dec	16	0.03	1.3				
Dec	17	0.03	1.2				
Dec	18	0.03	1.1				
Dec	19	0.02	1.1				
Dec	20	0.02	1.0				
Dec	21	0.02	0.8				
Dec	22	0.02	0.8				
Dec	23	0.02	0.8				
Dec	24	0.02	0.8				
Dec	25	0.02	0.8				
Dec	26	0.02	0.8				
Dec	27	0.02	1.0				
Dec	28	0.03	1.4				
Dec	29	0.02	1.1				
Dec	30	0.02	0.9				
Dec	31	0.02	0.8				

Table E-2. Sediment TMDLs expressed as an average annual load (tons/year)

Stream Segment	Waterbody #	TMDL expressed as average annual load (tons/year)
LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)	MT76D002_070	3,818
LIBBY CREEK, from the highway 2 bridge to mouth (Kootenai River)	MT76D002_062	4,234
RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)	MT76C001_030	81
WOLF CREEK, headwaters to mouth (Fisher River)	MT76C001_020	4,575

Appendix F – Nutrient and Metals Water Quality Data for Impaired Streams in the Kootenai-Fisher TMDL Planning Area

This appendix contains water quality data for nutrients and metals in the Kootenai Fisher TMDL Project Area. **Table F-1** contains streamflow, water column nutrient data, and available chlorophyll-*a*/ash free dry mass results for streams of concern in the Kootenai - Fisher TMDL Project Area. **Table F-2** contains surface water flow and water column metals concentration data for stream sampling locations in the Kootenai - Fisher TMDL Project Area. **Table F-3** contains stream channel sediment metals concentration data. **Table F-4** contains background metals water quality data used for load allocations to background sources for streams in the Kootenai - Fisher TMDL Project Area.

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
Troy Mine Data	Lake Creek	LC01	4/15/2003			307			0.06			
Troy Mine Data	Lake Creek	LC01	8/25/2003			70			0.12			
Troy Mine Data	Lake Creek	LC01	4/6/2004			196			0.04			
Troy Mine Data	Lake Creek	LC01	8/30/2004			172			0.03			
Troy Mine Data	Lake Creek	LC01	1/11/2005						0.05			
Troy Mine Data	Lake Creek	LC01	4/4/2005						0.06	0.012		
Troy Mine Data	Lake Creek	LC01	8/19/2005			75			0.059	0.008		
Troy Mine Data	Lake Creek	LC01	10/4/2005			79			0.04	0.011		
Troy Mine Data	Lake Creek	LC01	4/10/2006						0.04	0.012		
Troy Mine Data	Lake Creek	LC01	7/17/2006			132.8			0.05	0.014		
Troy Mine Data	Lake Creek	LC01	10/3/2006						0.06	0.01		
Troy Mine Data	Lake Creek	LC01	5/3/2007						0.04	0.009		
Troy Mine Data	Lake Creek	LC01	8/1/2007			136.6			0.06	0.007		
Troy Mine Data	Lake Creek	LC01	10/2/2007			129			0.06	0.013		
Troy Mine Data	Lake Creek	LC01	3/18/2008						0.07	< 0.005		
Troy Mine Data	Lake Creek	LC01	8/20/2008			139.7						
Troy Mine Data	Lake Creek	LC01	10/10/2008						0.06	0.013		
Troy Mine Data	Lake Creek	LC01	11/4/2008			134.3			0.08	0.009		
Troy Mine Data	Lake Creek	LC01	4/22/2009			130.8			0.06	0.012		
Troy Mine Data	Lake Creek	LC01	7/30/2009			141.3			0.07	0.006		
Troy Mine Data	Lake Creek	LC01	11/4/2009			135.3			0.07	0.01		
Troy Mine Data	Lake Creek	LC01	3/30/2010			138.6			0.08	0.013		
Troy Mine Data	Lake Creek	LC01	8/16/2010			176.5			0.07	< 0.005		
Troy Mine Data	Lake Creek	LC01	10/11/2010			155.6			0.07	0.006		
Troy Mine Data	Lake Creek	LC01	4/20/2011			145.6			0.07	0.01		
Troy Mine Data	Lake Creek	LC01	8/17/2011			147.2			0.04	0.007		
Troy Mine Data	Lake Creek	LC01	10/18/2011			148.2			0.1	0.006		
Troy Mine Data	Lake Creek	LC02	4/15/2003						< 0.05			
Troy Mine Data	Lake Creek	LC02	8/25/2003			84			< 0.1			
Troy Mine Data	Lake Creek	LC02	4/6/2004			170			0.04			
Troy Mine Data	Lake Creek	LC02	8/30/2004			129			0.03			
Troy Mine Data	Lake Creek	LC02	4/4/2005						0.03	0.012		
Troy Mine Data	Lake Creek	LC02	8/19/2005			90.09			0.09	0.008		
Troy Mine Data	Lake Creek	LC02	10/4/2005			76			0.04	0.01		
Troy Mine Data	Lake Creek	LC02	4/10/2006						0.06	0.012		
Troy Mine Data	Lake Creek	LC02	7/17/2006			144.2			0.03	0.015		
Troy Mine Data	Lake Creek	LC02	10/3/2006						0.05	0.009		
Troy Mine Data	Lake Creek	LC02	5/3/2007						0.05	0.012		
Troy Mine Data	Lake Creek	LC02	8/1/2007			149.2			0.06	0.005		
Troy Mine Data	Lake Creek	LC02	10/2/2007			139.8			0.06	0.012		
Troy Mine Data	Lake Creek	LC02	8/20/2008			152.3						
Troy Mine Data	Lake Creek	LC02	10/10/2008						0.06	0.016		
Troy Mine Data	Lake Creek	LC02	11/4/2008			143.8			0.08	0.009		
Troy Mine Data	Lake Creek	LC02	4/22/2009			137.7			0.06	0.019		
Troy Mine Data	Lake Creek	LC02	7/30/2009			154.5			0.06	0.006		
Troy Mine Data	Lake Creek	LC02	11/4/2009			144.4			0.07	0.009		

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
Troy Mine Data	Lake Creek	LC02	3/29/2010			142.4			0.06	0.013		
Troy Mine Data	Lake Creek	LC02	8/16/2010			174.1			0.07	< 0.005		
Troy Mine Data	Lake Creek	LC02	10/11/2010			157.3			0.07	0.007		
Troy Mine Data	Lake Creek	LC02	4/20/2011			161.3			0.06	0.011		
Troy Mine Data	Lake Creek	LC02	8/17/2011						0.05	0.006		
Troy Mine Data	Lake Creek	LC02	10/18/2011			164.3			0.1	< 0.0025		
Troy Mine Data	Lake Creek	LC04	4/15/2003						0.09			
Troy Mine Data	Lake Creek	LC04	5/15/2003						0.09			
Troy Mine Data	Lake Creek	LC04	8/25/2003			94			< 0.1			
Troy Mine Data	Lake Creek	LC04	4/6/2004			410			0.07			
Troy Mine Data	Lake Creek	LC04	8/30/2004			342			0.06			
Troy Mine Data	Lake Creek	LC04	1/11/2005						0.08			
Troy Mine Data	Lake Creek	LC04	4/4/2005						0.06	0.013		
Troy Mine Data	Lake Creek	LC04	8/19/2005			81.4			0.14	0.008		
Troy Mine Data	Lake Creek	LC04	10/4/2005			115			0.09	0.01		
Troy Mine Data	Lake Creek	LC04	4/10/2006						0.06	0.014		
Troy Mine Data	Lake Creek	LC04	7/17/2006			158.7			0.07	0.015		
Troy Mine Data	Lake Creek	LC04	10/3/2006						0.11	0.011		
Troy Mine Data	Lake Creek	LC04	5/3/2007						0.06	0.017		
Troy Mine Data	Lake Creek	LC04	8/1/2007			161.3			0.1	0.006		
Troy Mine Data	Lake Creek	LC04	10/2/2007			149.7			0.12	0.01		
Troy Mine Data	Lake Creek	LC04	3/18/2008						0.13	0.007		
Troy Mine Data	Lake Creek	LC04	8/20/2008			164.6						
Troy Mine Data	Lake Creek	LC04	10/10/2008						0.07	0.014		
Troy Mine Data	Lake Creek	LC04	11/4/2008			154.9			0.14	0.01		
Troy Mine Data	Lake Creek	LC04	4/22/2009			147.4			0.08	0.02		
Troy Mine Data	Lake Creek	LC04	7/30/2009			167.7			0.11	0.006		
Troy Mine Data	Lake Creek	LC04	11/4/2009			155.6			0.17	0.01		
Troy Mine Data	Lake Creek	LC04	3/29/2010			160.3			0.14	0.105		
Troy Mine Data	Lake Creek	LC04	8/16/2010						0.12	0.006		
Troy Mine Data	Lake Creek	LC04	10/11/2010			159.7			0.15	< 0.005		
Troy Mine Data	Lake Creek	LC04	4/20/2011			178.2			0.11	0.009		
Troy Mine Data	Lake Creek	LC04	8/17/2011						0.11	0.008		
Troy Mine Data	Lake Creek	LC04	10/18/2011			163.8			0.23	0.007		
R8MONTWQ	Lake Creek above Falls Creek	LKC-278	8/16/2011 14:30	48.39893	-115.846	285.67						
R8MONTWQ	Lake Creek above Falls Creek	LKC-278	8/16/2011 14:30	48.39893	-115.846			0.1	0.06	< 0.005		
R8MONTWQ	Lake Creek above Falls Creek	LKC-278	8/16/2011 14:30	48.39893	-115.846		21.3 mg/m2				18.5 g/m2	
R8MONTWQ	Lake Creek above Falls Creek	LKC-278	8/16/2011 14:30	48.39893	-115.846		C 21.3 mg/m2					Weighted average of 11 templates.
MDEQ_WQ_WQX	Lake Creek above Hwy 2 crossing	K01LAKEC01	8/7/2012 9:15	48.4485	-115.879	312.56						
MDEQ_WQ_WQX	Lake Creek above Hwy 2 crossing	K01LAKEC01	8/7/2012 9:15	48.4485	-115.879			0.06	0.04	< 0.005		

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
MDEQ_WQ_WQX	Lake Creek above Hwy 2 crossing	K01LAKEC01	8/7/2012 9:15	48.4485	-115.879		7.3 mg/m2				69.5 g/m2	Only Transect F. - 10 template samples composited at lab.
MDEQ_WQ_WQX	Lake Creek above Hwy 2 crossing	K01LAKEC01	9/18/2012 10:00	48.4485	-115.879	160.95						
MDEQ_WQ_WQX	Lake Creek above Hwy 2 crossing	K01LAKEC01	9/18/2012 10:00	48.4485	-115.879			0.12	0.08	< 0.005		
R8MONTWQ	Lake Creek at Chase Cutoff crossing	LKC-279	8/17/2011 8:45	48.38121	-115.859	260.73						
R8MONTWQ	Lake Creek at Chase Cutoff crossing	LKC-279	8/17/2011 8:45	48.38121	-115.859			0.12	0.09	< 0.005		
R8MONTWQ	Lake Creek at Chase Cutoff crossing	LKC-279	8/17/2011 8:45	48.38121	-115.859		38.9 mg/m2				37.3 g/m2	
R8MONTWQ	Lake Creek at Chase Cutoff crossing	LKC-279	8/17/2011 8:45	48.38121	-115.859		C 38.9 mg/m2					Weighted average of 11 templates.
R8MONTWQ	Lake Creek at Cotten residence	LKCA	8/17/2011 11:00	48.33305	-115.859	174.88						
R8MONTWQ	Lake Creek at Cotten residence	LKCA	8/17/2011 11:00	48.33305	-115.859			0.08	0.05	< 0.005		
R8MONTWQ	Lake Creek at Cotten residence	LKCA	8/17/2011 11:00	48.33305	-115.859		5.5 mg/m2				13.5 g/m2	
R8MONTWQ	Lake Creek at Cotten residence	LKCA	8/17/2011 11:00	48.33305	-115.859		C 5.5 mg/m2					Weighted average of 11 templates.
MDEQ_WQ_WQX	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	8/7/2012 12:15	48.40037	-115.845	304.13						
MDEQ_WQ_WQX	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	8/7/2012 12:15	48.40037	-115.845			0.07	0.04	< 0.005		
MDEQ_WQ_WQX	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	9/17/2012 19:00	48.40037	-115.845	167.3						
MDEQ_WQ_WQX	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	9/17/2012 19:00	48.40037	-115.845			0.1	0.06	< 0.005		
MDEQ_WQ_WQX	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	8/7/2012 15:45	48.33307	-115.86	157.74						
MDEQ_WQ_WQX	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	8/7/2012 15:45	48.33307	-115.86			0.1	0.02	< 0.005		
MDEQ_WQ_WQX	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	9/17/2012 16:00	48.33307	-115.86	81.52						
MDEQ_WQ_WQX	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	9/17/2012 16:00	48.33307	-115.86			0.08	0.03	< 0.005		

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
MDEQ_WQ_WQX	Lake Creek at Troy Mine Road crossing	K01LAKEC05	8/7/2012 17:00	48.30422	-115.866	162.93						
MDEQ_WQ_WQX	Lake Creek at Troy Mine Road crossing	K01LAKEC05	8/7/2012 17:00	48.30422	-115.866			< 0.04	0.03	< 0.005		
MDEQ_WQ_WQX	Lake Creek at Troy Mine Road crossing	K01LAKEC05	9/17/2012 15:00	48.30422	-115.866	85.07						
MDEQ_WQ_WQX	Lake Creek at Troy Mine Road crossing	K01LAKEC05	9/17/2012 15:00	48.30422	-115.866			0.11	0.04	< 0.005		
R8MONTWQ	Lake Creek at Troy Mine Road crossing	LKC-280	8/17/2011 14:00	48.3042	-115.866	152.27						
R8MONTWQ	Lake Creek at Troy Mine Road crossing	LKC-280	8/17/2011 14:00	48.3042	-115.866			0.09	0.04	< 0.005		
R8MONTWQ	Lake Creek at Troy Mine Road crossing	LKC-280	8/17/2011 14:00	48.3042	-115.866		14 mg/m2				27.5 g/m2	
R8MONTWQ	Lake Creek at Troy Mine Road crossing	LKC-280	8/17/2011 14:00	48.3042	-115.866		C 14 mg/m2					Weighted average of 11 templates.
MDEQ_WQ_WQX	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	8/9/2007 11:00	48.3811	-115.859			< 0.01	0.091	0.005		
MDEQ_WQ_WQX	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	8/7/2012 13:30	48.3811	-115.859	275.41						
MDEQ_WQ_WQX	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	8/7/2012 13:30	48.3811	-115.859			0.08	0.05	< 0.005		
MDEQ_WQ_WQX	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	8/7/2012 13:30	48.3811	-115.859		11.5 mg/m2				52.4 g/m2	Only Transect F. - 10 template samples composited at lab.
MDEQ_WQ_WQX	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	9/17/2012 17:00	48.3811	-115.859	143.77						
MDEQ_WQ_WQX	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	9/17/2012 17:00	48.3811	-115.859			0.12	0.08	< 0.005		
R8MONTWQ	Lake Creek near mouth (Kootenai River)	LKC-276	8/16/2011 9:30	48.44694	-115.877	287.64						
R8MONTWQ	Lake Creek near mouth (Kootenai River)	LKC-276	8/16/2011 9:30	48.44694	-115.877			0.08	0.06	< 0.005		
R8MONTWQ	Lake Creek near mouth (Kootenai River)	LKC-276	8/16/2011 9:30	48.44694	-115.877		32.4 mg/m2				59.5 g/m2	
R8MONTWQ	Lake Creek near mouth (Kootenai River)	LKC-276	8/16/2011 9:30	48.44694	-115.877		C 32.4 mg/m2					Weighted average of 11 templates.
MDEQ_WQ_WQX	Raven Creek 40 yards d/s of Raven & East Raven Cr confluence	K02RAVNC01	8/3/2004	48.04844	-115.29	E 1						

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
MDEQ_WQ_WQX	Raven Creek 40 yards d/s of Raven & East Raven Cr confluence	K02RAVNC01	8/3/2004 11:00	48.04844	-115.29				0.04	0.055		
MDEQ_WQ_WQX	Raven Creek 40 yards d/s of Raven & East Raven Cr confluence	K02RAVNC01	8/3/2004 11:00	48.04844	-115.29							C0587-CR - 6 rocks - Rainy day.
R8MONTWQ	Raven Creek at power line corridor crossing	RAVN-02	8/18/2011 18:30	48.05217	-115.293	0.73						
R8MONTWQ	Raven Creek at power line corridor crossing	RAVN-02	8/18/2011 18:30	48.05217	-115.293			< 0.05	0.03	0.017		
R8MONTWQ	Raven Creek at power line corridor crossing	RAVN-02	8/18/2011 18:30	48.05217	-115.293		E 20 mg/m2					Visual estimation; photos taken.
MDEQ_WQ_WQX	Raven Creek at upper road crossing	K02RAVNC05	7/10/2012 18:41	48.0603	-115.304	E 0						
R8MONTWQ	Raven Creek at upper road crossing	RAVN-01	8/18/2011 18:00	48.0605	-115.304	E 0						
R8MONTWQ	Raven Creek near mouth (Pleasant Valley Fisher R.)	RAVN-03	8/18/2011 19:30	48.04395	-115.285	0.93						
R8MONTWQ	Raven Creek near mouth (Pleasant Valley Fisher R.)	RAVN-03	8/18/2011 19:30	48.04395	-115.285			< 0.05	0.02	0.018		
R8MONTWQ	Raven Creek near mouth (Pleasant Valley Fisher R.)	RAVN-03	8/18/2011 19:30	48.04395	-115.285		E 20 mg/m2					Visual estimation; photos taken.
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	7/11/2012 10:10	48.0439	-115.287	1.27						
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	7/11/2012 10:10	48.0439	-115.287			0.05	0.06	0.018		
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	7/11/2012 10:10	48.0439	-115.287		7.7 mg/m2				4.27 g/m2	Total Site Length - 150m; Average Wetted Width - 1.5m; Transect Length - 15m. - 3 template samples composited at lab.
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	7/11/2012 10:10	48.0439	-115.287		6.8 mg/m2					Total Site Length - 150m; Average Wetted Width - 1.5m; Transect Length - 15m. - 8 core samples composited at lab.
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	8/9/2012 12:00	48.0439	-115.287	0.75						
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	8/9/2012 12:00	48.0439	-115.287			0.21	0.02	0.015		
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	8/9/2012 12:00	48.0439	-115.287		22.4 mg/m2				6.49 g/m2	Creek is low and clear. Sampled just above county road crossing culverts. - 10 template samples composited at lab.
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	8/9/2012 12:00	48.0439	-115.287		5.7 mg/m2					Creek is low and clear. Sampled just above county road crossing culverts. - 1 core sample collected.

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	9/21/2012 11:30	48.0439	-115.287	0.51						
MDEQ_WQ_WQX	Raven Creek near mouth, downstream Hwy 2 crossing	K02RAVNC03	9/21/2012 11:30	48.0439	-115.287			0.11	0.01	0.019		
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	7/10/2012 17:44	48.05262	-115.293	0.6						
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	7/10/2012 17:44	48.05262	-115.293			0.09	0.07	0.017		
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	8/9/2012 9:00	48.05262	-115.293	0.58						
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	8/9/2012 9:00	48.05262	-115.293			0.11	0.03	0.018		
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	8/9/2012 9:00	48.05262	-115.293		13.5 mg/m2				5.79 g/m2	Creek is low and clear. Sampled upstream of powerline road crossing. - 11 template samples composited at lab.
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	9/21/2012 11:00	48.05262	-115.293	0.3						
MDEQ_WQ_WQX	Raven Creek near power line corridor crossing	K02RAVNC04	9/21/2012 11:00	48.05262	-115.293			0.12	0.02	0.02		
Troy Mine Data	Stanley Creek	SC02	4/15/2003			97			0.091			
Troy Mine Data	Stanley Creek	SC02	8/25/2003			74						
Troy Mine Data	Stanley Creek	SC02	4/5/2004			65.09			0.08			
Troy Mine Data	Stanley Creek	SC02	8/30/2004			80			0.09			
Troy Mine Data	Stanley Creek	SC02	4/4/2005						0.1	0.013		
Troy Mine Data	Stanley Creek	SC02	8/19/2005			51			0.09	0.009		
Troy Mine Data	Stanley Creek	SC02	10/5/2005			35			0.1	0.007		
Troy Mine Data	Stanley Creek	SC02	4/10/2006						0.08	0.008		
Troy Mine Data	Stanley Creek	SC02	7/17/2006			90			0.07	0.014		
Troy Mine Data	Stanley Creek	SC02	10/4/2006						0.09	0.011		
Troy Mine Data	Stanley Creek	SC02	5/4/2007						0.1	0.009		
Troy Mine Data	Stanley Creek	SC02	8/2/2007			105			0.09	0.006		
Troy Mine Data	Stanley Creek	SC02	10/3/2007			89			0.09	0.019		
Troy Mine Data	Stanley Creek	SC02	3/19/2008						0.13	0.009		
Troy Mine Data	Stanley Creek	SC02	8/20/2008			100						
Troy Mine Data	Stanley Creek	SC02	10/9/2008						0.11	0.009		
Troy Mine Data	Stanley Creek	SC02	11/5/2008			92.2			0.12	0.009		
Troy Mine Data	Stanley Creek	SC02	4/23/2009			91.4			0.12	0.008		
Troy Mine Data	Stanley Creek	SC02	7/31/2009			101.1			0.11	0.006		
Troy Mine Data	Stanley Creek	SC02	11/5/2009			94.3			0.12	0.008		
Troy Mine Data	Stanley Creek	SC02	3/31/2010			97.4			0.11	0.008		
Troy Mine Data	Stanley Creek	SC02	8/17/2010			110.3			0.12	< 0.005		
Troy Mine Data	Stanley Creek	SC02	10/13/2010			92.9			0.12	< 0.005		
Troy Mine Data	Stanley Creek	SC02	4/21/2011			102.9			0.1	0.008		
Troy Mine Data	Stanley Creek	SC02	8/18/2011			110.6			0.07	< 0.005		

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
Troy Mine Data	Stanley Creek	SC02	10/19/2011			103.8			0.14	0.005		
Troy Mine Data	Stanley Creek	SC-15	4/15/2003						0.063			
Troy Mine Data	Stanley Creek	SC-15	8/25/2003						0.11			
Troy Mine Data	Stanley Creek	SC-15	8/30/2004						0.079			
Troy Mine Data	Stanley Creek	SC-15	4/4/2005						0.2	0.02		
Troy Mine Data	Stanley Creek	SC-15	8/19/2005						0.06	0.013		
Troy Mine Data	Stanley Creek	SC-15	10/7/2005						0.705	0.04		
Troy Mine Data	Stanley Creek	SC-15B	11/9/2005						0.47 H	H 0.01		
Troy Mine Data	Stanley Creek	SC-15B	8/12/2010			DRY						
Troy Mine Data	Stanley Creek	SC-17A	4/15/2003						0.099			
Troy Mine Data	Stanley Creek	SC-17A	4/4/2005						0.11	0.017		
Troy Mine Data	Stanley Creek	SC-17A	8/22/2005			Dry						
Troy Mine Data	Stanley Creek	SC-17A	5/1/2006						0.09	0.026		
Troy Mine Data	Stanley Creek	SC-17A	8/1/2007						0.08	0.005		
Troy Mine Data	Stanley Creek	SC-17A	6/16/2009						0.13	0.011		
Troy Mine Data	Stanley Creek	SC-17A	9/14/2010			DRY						
MDEQ_WQ_WQX	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	7/11/2012 16:00	48.29017	-115.874			< 0.05	0.06	< 0.003		
MDEQ_WQ_WQX	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	8/6/2012 16:45	48.29017	-115.874	122.06						
MDEQ_WQ_WQX	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	8/6/2012 16:45	48.29017	-115.874			0.09	0.06	< 0.005		
MDEQ_WQ_WQX	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	9/17/2012 13:00	48.29017	-115.874	69.67						
MDEQ_WQ_WQX	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	9/17/2012 13:00	48.29017	-115.874			0.11	0.07	< 0.005		
R8MONTWQ	Stanley Creek below Fairway Creek	SC-02	8/15/2011 16:45	48.28109	-115.893	106.87						
R8MONTWQ	Stanley Creek below Fairway Creek	SC-02	8/15/2011 16:45	48.28109	-115.893			0.1	0.07	< 0.005		
MDEQ_WQ_WQX	Stanley Creek below Troy Mine	K01STNLC02	5/21/2012 11:15	48.25981	-115.896	20.9						
MDEQ_WQ_WQX	Stanley Creek below Troy Mine	K01STNLC02	8/6/2012 9:30	48.25981	-115.896	E 0						
MDEQ_WQ_WQX	Stanley Creek below Troy Mine	K01STNLC05	7/12/2012 9:40	48.26638	-115.893	0.32						
MDEQ_WQ_WQX	Stanley Creek below Troy Mine	K01STNLC05	7/12/2012 9:40	48.26638	-115.893			0.14	0.09	< 0.003		
R8MONTWQ	Stanley Creek below Troy Mine	SC-01	8/15/2011 18:00	48.2578	-115.892	E 0						
MDEQ_WQ_WQX	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	5/21/2012 15:00	48.28117	-115.893	133.66						
MDEQ_WQ_WQX	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	7/11/2012 16:50	48.28117	-115.893			0.08	0.09	< 0.003		

Table F-1. Nutrient Water Quality Data for the Kootenai-Fisher TMDL Project Area

Org ID	Station (Site) Name	Site ID	Activity Date	Latitude	Longitude	Flow (cfs)	Chlor-*a* (corrected) (uncorrected)	Total N per Sulfate Method (mg/L)	$NO_2 + NO_3$ as N (mg/L)	Total P (mg/L)	Ash Free Dry Weight	COMMENTS or UNKNOWN
MDEQ_WQ_WQX	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	8/6/2012 12:00	48.28117	-115.893	110.01						
MDEQ_WQ_WQX	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	8/6/2012 12:00	48.28117	-115.893			0.09	0.06	< 0.005		
MDEQ_WQ_WQX	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	9/17/2012 12:00	48.28117	-115.893	68.55						
MDEQ_WQ_WQX	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	9/17/2012 12:00	48.28117	-115.893			0.12	0.08	< 0.005		
MDEQ_WQ_WQX	Stanley Creek upstream of Fairway Creek at Troy Mine Road	K01STNLC03	5/21/2012 13:30	48.2724	-115.893	24.42						
MDEQ_WQ_WQX	Stanley Creek upstream of Fairway Creek at Troy Mine Road	K01STNLC03	8/6/2012 9:45	48.2724	-115.893	E 0						

Table F-2 Metals Surface Water Quality Data

Data Collection Entity	Site Location & Description	Site ID	Activity Date	Hardness	Flow (cfs)	pH	Al (ug/L)	As (ug/L)	Cd (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Hg (ug/L)	Ag (ug/L)	Zn (ug/L)
DEQ	Big Cherry Creek below Granite Creek	BCC-284	8/20/2011	25	73.93	7.56	< 30	< 3	0.57	< 1	< 30	< .5	–	< 5	30
DEQ	Big Cherry Creek below Smearl Creek	BCC-285	8/20/2011	25	37.79	7.7	< 30	< 3	0.74	< 1	< 30	0.7	–	< 5	50
DEQ	Big Cherry Creek below Snowshoe Creek	BCC-287	8/20/2011	25	36.83	7.73	< 30	< 3	0.78	< 1	< 30	0.8	–	< 5	60
DEQ	Big Cherry Creek at Hwy 2 crossing	BCCA	8/20/2011	25	65.64	7.78	< 30	< 3	0.41	< 1	< 30	< .5	–	< 5	20
DEQ	Big Cherry Creek at Forest Road 867 crossing	K01BCHRC01	9/28/2006	40.3	–	–	< 10	3	1.12	< 1	< 10	0.7	< .05	< 1	61.7
DEQ	Big Cherry Creek at Forest Road 867 crossing	K01BCHRC01	9/19/2012	34	8.57	7.81	< 30	< 3	0.83	< 1	< 30	< .5	–	< .2	50
DEQ	Big Cherry Creek at Forest Road 867 crossing	K01BCHRC01	5/30/2012	25	–	–	< 30	< 3	0.71	< 1	< 30	3.6	–	< 5	60
DEQ	Big Cherry Creek at Hwy 2 crossing just south of Libby	K01BCHRC02	9/28/2006	30.5	–	–	< 10	1	0.36	< 1	10	< .5	< .05	< 1	12.8
DEQ	Big Cherry Creek at Hwy 2 crossing just south of Libby	K01BCHRC02	9/21/2012	28	14.06	7.31	< 30	< 3	0.29	< 1	< 30	< .5	–	< .2	20
DEQ	Big Cherry Creek at Hwy 2 crossing just south of Libby	K01BCHRC02	5/24/2012	25		7.55	< 30	< 3	0.39	1	230	2.3	–	< .5	20
DEQ	Big Cherry Creek downstream from Granite Creek	K01BCHRC03	9/19/2012	26	14.12	7.56	< 30	< 3	0.58	< 1	< 30	< .5	–	< .2	30
DEQ	Big Cherry Creek downstream from Granite Creek	K01BCHRC03	5/30/2012	25		7.7	< 30	< 3	0.42	< 1	< 30	1	–	< 5	30

Table F-2 Metals Surface Water Quality Data

Data Collection Entity	Site Location & Description	Site ID	Activity Date	Hardness	Flow (cfs)	pH	Al (ug/L)	As (ug/L)	Cd (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Hg (ug/L)	Ag (ug/L)	Zn (ug/L)
DEQ	Big Cherry Creek below Snowshoe Creek	K01BCHRC04	9/19/2012	33	8.3*	8.05	< 30	< 3	***0.84***	< 1	< 30	**0.7**	–	< .2	**50**
DEQ	Big Cherry Creek below Snowshoe Creek	K01BCHRC04	5/30/2012	25	E 75*	7.65	< 30	< 3	***0.79***	< 1	< 30	**4.2**	–	< 5	**60**
DEQ	Snowshoe Creek above Big Cherry Creek	K01SNOWC01	5/30/2012	25	E 40*	7.5	< 30	3	***2.93***	1	50	**27.9**	–	< 5	**230**
DEQ	Snowshoe Creek above Big Cherry Creek	K01SNOWC01	9/19/2012	31	0.37	7.79	< 30	**13**	**7.03**	1	< 30	7.6	–	< .2	**480**
DEQ	Snowshoe Creek above Snowshoe Mine	SNSCA	8/19/2011	25	3.27	7.64	< 30	**< 3**	< .08	< 1	< 30	< .5	–	< 5	< 10
DEQ	Snowshoe Creek below Snowshoe Mine	SNSCB	8/19/2011	25	2.65	7.66	< 30	< 3	2.02	< 1	< 30	9.5	–	< 5	130
DEQ	Snowshoe Creek near mouth (Libby Creek)	SNSCC	8/19/2011	25	3.53	7.6	< 30	8	6.58	1	< 30	12.4	–	< 5	410
DEQ	Snowshoe Creek upstream from Snowshoe Mine	BKK134	5/30/2012	25	22.57	7.4	< 30	< 3	1.18	< 1	< 30	2.9	–	< 5	110
DEQ	Snowshoe Creek upstream from Snowshoe Mine	BKK134	9/18/2012	43	0.11*	8	< 30	< 3	< .08	< 1	< 30	1.6	–	< .2	< 10
DEQ	Snowshoe Creek downstream from Snowshoe Mine	BKK135	5/30/2012	25	28.21	7.46	< 30	< 3	2.47	< 1	< 30	21.6	–	< 5	210
DEQ	Snowshoe Creek downstream from Snowshoe Mine	BKK135	9/18/2012	40	0.2	7.68	< 30	6	5.73	1	< 30	**18.3**	–	< .2	400
DEQ	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	5/21/2012	29	133.66*	7.43	< 30	< 3	< .08	< 1	< 30	< .5	–	< .5	< 10
DEQ	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	7/11/2012	32		8.1	< 30	< 3	< .08	< 1	< 50	< .5	–	< .5	< 10
DEQ	Stanley Creek downstream of Fairway Creek at Troy Mine Road	K01STNLC01	9/17/2012	30	68.55	7.94	< 30	< 3	< .08	< 1	< 30	< .5	–	< .2	< 10
DEQ	Stanley Creek below Troy Mine	K01STNLC02	5/21/2012	25	20.9	7.68	< 30	< 3	< .08	8	40	0.7	–	< .5	< 10
DEQ	Stanley Creek upstream of Fairway Creek at Troy Mine Road	K01STNLC03	5/21/2012	25	24.42	7.07	< 30	< 3	< .08	**9**	50	**0.9**	–	< .5	< 10
DEQ	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	7/11/2012	36	–	–	< 30	< 3	< .08	25	< 50	< .5	–	< .5	20
DEQ	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	9/17/2012	31	69.67	8	< 30	< 3	< .08	< 1	< 30	< .5	–	< .2	< 10
DEQ	Stanley Creek below Troy Mine	K01STNLC05	7/12/2012	25	0.32*	7.8	< 30	< 3	< .08	5	< 50	< .5	–	< .5	< 10
DEQ	Stanley Creek below Fairway Creek	SC-02	8/15/2011	33	106.87	7.68	< 30	< 3	< .08	< 1	< 30	< .5	–	< 5	< 10
Troy Mine	Stanley Creek	SC02	4/4/2005	27	–	7.4	–	–	–	<1	10	<3	< 3	<3	–
Troy Mine	Stanley Creek	SC02	8/19/2005	36	51	7.6	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10

Table F-2 Metals Surface Water Quality Data

Data Collection Entity	Site Location & Description	Site ID	Activity Date	Hardness	Flow (cfs)	pH	Al (ug/L)	As (ug/L)	Cd (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Hg (ug/L)	Ag (ug/L)	Zn (ug/L)
Troy Mine	Stanley Creek	SC02	10/5/2005	30	35	7.66	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	4/10/2006	33	–	7.59	–	< 1	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	7/17/2006	35	90	7.4	–	< 3	–	< 1	10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	10/4/2006	33	–	7.5	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	5/4/2007	31	–	6.94	–	< 3	–	< 1	< 10	< 3	–	< 5	< 10
Troy Mine	Stanley Creek	SC02	8/2/2007	29	105	6.97	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	10/3/2007	29	89	7.21	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	3/19/2008	31	–	7.75	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	10/9/2008	38	–	6.59	–	< 3	–	< 1	70	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	11/5/2008	27	92.2	7.3	–	< 3	–	< 1	< 10	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	4/23/2009	27	91.4	7.03	–	< 3	–	< 1	< 10	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	7/31/2009	31	101.1	6.92	–	< 3	–	< 1	< 10	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	11/5/2009	30	94.3	7.43	–	< 3	–	< 1	< 10	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	3/31/2010	28	97.4	7.24	–	< 3	< 0.1	< 1	< 10	<0.5	–	< 3	< 10
Troy Mine	Stanley Creek	SC02	8/17/2010	30	110.3	7.5	–	< 3	< 0.1	< 1	< 10	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	10/13/2010	30	92.9	7.7	–	< 3	< 0.1	< 1	90	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	4/21/2011	31	102.9	7.3	–	< 3	–	< 1	< 50	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	8/18/2011	33	110.6	7.6	–	< 3	–	< 1	< 10	<0.5	–	< 0.5	< 10
Troy Mine	Stanley Creek	SC02	10/19/2011	30	103.8	7.4	–	< 2	–	< 0.5	< 5	< 0.3	–	< 0.3	< 5
Troy Mine	Stanley Creek	SC-15	4/4/2005	12	–	7.3	–	–	–	4	20	<3	< 3	<3	–
Troy Mine	Stanley Creek	SC-15	8/19/2005	24	–	7.14	–	–	–	2	30	<3	< 3	<4	–
Troy Mine	Stanley Creek	SC-15	10/7/2005	–	–	7.3	–	–	0.8	< 3	–	10	–	< 1	**230**
Troy Mine	Stanley Creek	SC-15B	11/9/2005	–	–	–	<	< 1	< 0.1	20	< 5	< 2	–	< 0.5	2
Troy Mine	Stanley Creek	SC-17A	4/4/2005	16	–	7.2	–	–	–	11	10	<3	< 3	<3	–
Troy Mine	Stanley Creek	SC-17A	5/1/2006	11	–	6.98	–	< 3	–	2	20	< 3	–	< 3	< 10
Troy Mine	Stanley Creek	SC-17A	8/1/2007	21	–	6.49	–	< 3	–	4	< 10	< 3	–	< 3	200
Troy Mine	Stanley Creek	SC-17A	6/16/2009	15	–	7.07	–	< 3	–	4	< 10	<0.5	–	< 0.5	< 10
DEQ	Lake Creek near mouth (Kootenai River)	LKC-276	8/16/2011	40	287.64*	7.87	< 30	< 3	< .08	< 1	40	< .5	–	< 5	< 10
DEQ	Lake Creek above Falls Creek	LKC-278	8/16/2011	38	285.67	7.81	< 30	< 3	< .08	< 1	50	< .5	–	< 5	< 10
DEQ	Lake Creek at Chase Cutoff crossing	LKC-279	8/17/2011	37	260.73	7.72	< 30	< 3	< .08	< 1	40	< .5	–	< 5	< 10
DEQ	Lake Creek at Troy Mine Road crossing	LKC-280	8/17/2011	33	152.27	7.79	< 30	< 3	< .08	< 1	30	< .5	–	< 5	< 10
DEQ	Lake Creek at Cotten residence	LKCA	8/17/2011	34	174.88	7.88	< 30	< 3	< .08	< 1	< 30	< .5	–	< 5	< 10
DEQ	Lake Creek above Hwy 2 crossing	K01LAKEC01	5/22/2012	25	–	7.63	< 30	< 3	< .08	3	1610	1.4	–	< .5	< 10
DEQ	Lake Creek above Hwy 2 crossing	K01LAKEC01	9/18/2012	48	160.95	7.97	< 30	< 3	< .08	< 1	< 30	< .5	–	< .2	10
DEQ	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	5/22/2012	25	–	7.61	< 30	< 3	< .08	2	990	0.9	–	< .5	< 10
DEQ	Lake Creek downstream of the Chase Cutoff Road Bridge	K01LAKEC02	9/17/2012	41	143.77	8.58	< 30	< 3	< .08	< 1	< 30	< .5	–	< .2	< 10
DEQ	Lake Creek at Troy Mine Road crossing	K01LAKEC05	5/21/2012	25	–	7.45	< 30	< 3	< .08	< 1	30	< .5	–	< .5	< 10

Table F-2 Metals Surface Water Quality Data

Data Collection Entity	Site Location & Description	Site ID	Activity Date	Hardness	Flow (cfs)	pH	Al (ug/L)	As (ug/L)	Cd (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Hg (ug/L)	Ag (ug/L)	Zn (ug/L)
DEQ	Lake Creek at Troy Mine Road crossing	K01LAKEC05	9/17/2012	32	85.07	8.37	< 30	< 3	< .08	< 1	< 30	< .5	–	< .2	< 10
DEQ	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	5/22/2012	25		7.43	< 30	< 3	< .08	2	420	< .5	–	< .5	< 10
DEQ	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	9/17/2012	33	81.52	8.28	< 30	< 3	< .08	< 1	30	< .5	–	< .2	< 10
DEQ	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	5/22/2012	25	–	7.59	< 30	< 3	< .08	2	1470	1.3	–	< .5	< 10
DEQ	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	9/17/2012	44	167.3	8.38	< 30	< 3	< .08	< 1	50	< .5	–	< .2	< 10
Troy Mine	Lake Creek	LC01	4/4/2005	31	–	7.5	–	–	–	6	40	<3	< 3	<3	–
Troy Mine	Lake Creek	LC01	8/19/2005	40	75*	7.65	–	–	–	<1	39	<3	< 3	<3	–
Troy Mine	Lake Creek	LC01	10/4/2005	36	79	7.65	–	< 3	–	< 1	50	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	4/10/2006	37	–	7.51	–	<1	–	< 1	50	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	7/17/2006	33	132.8	7.52	–	< 3	–	< 1	30	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	10/3/2006	38	–	7.61	–	< 3	–	< 1	20	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	5/3/2007	28	–	7.07	–	< 3	–	< 1	40	< 3	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	8/1/2007	31	136.6	7.43	–	< 3	–	< 1	20	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	10/2/2007	32	129	7.17	–	< 3	–	< 1	30	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	3/18/2008	31	–	6.53	–	< 3	–	< 1	40	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	10/10/2008	30	–	6.85	–	< 3	–	< 1	50	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	11/4/2008	30	134.3	7.07	–	< 3	–	< 1	30	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC01	4/22/2009	29	130.8	7.25	–	< 3	–	1	140	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	7/30/2009	33	141.3	6.88	–	< 3	–	< 1	50	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	11/4/2009	33	135.3	7.38	–	< 3	–	< 1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	3/30/2010	31	138.6	6.75	–	< 3	<0.1	< 1	60	< 0.5	–	< 3	< 10
Troy Mine	Lake Creek	LC01	8/16/2010	31	176.5	7.7	–	< 3	< 0.1	< 1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	10/11/2010	33	155.6	7.8	–	< 3	< 0.1	< 1	30	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	4/20/2011	32	145.6	7.4	–	< 3	–	< 1	<50	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	8/17/2011	32	147.2	7.6	–	< 3	–	< 1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC01	10/18/2011	32	148.2	7.3	–	<2	–	<.5	30	< 0.3	–	< 0.3	< 0.005
Troy Mine	Lake Creek	LC02	4/4/2005	32	–	7.6	–	–	–	<1	60	<3	< 3	<3	–
Troy Mine	Lake Creek	LC02	8/19/2005	53	90.09	7.83	–	–	–	<1	50	<3	< 3	<3	–
Troy Mine	Lake Creek	LC02	10/4/2005	36	76	7.13	–	< 3	–	< 1	50	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	4/10/2006	40	–	7.79	–	< 1	–	< 1	130	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	7/17/2006	36	144.2	6.92	–	< 3	–	1	230	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	10/3/2006	39	–	7.21	–	< 3	–	< 1	30	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	5/3/2007	26	–	7.07	–	< 3	–	< 1	30	< 3	–	< 5	< 10
Troy Mine	Lake Creek	LC02	8/1/2007	33	149.2	7.44	–	< 3	–	< 1	20	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	10/2/2007	34	139.8	7.33	–	< 3	–	< 1	20	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	10/10/2008	30	–	6.43	–	< 3	–	**49**	70	**6**	–	< 3	< 10
Troy Mine	Lake Creek	LC02	11/4/2008	31	143.8	6.84	–	< 3	–	< 1	40	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC02	4/22/2009	27	137.7	7.35	–	< 3	–	1	50	0.7	–	< 0.5	< 10
Troy Mine	Lake Creek	LC02	7/30/2009	35	154.5	7.37	–	< 3	–	< 1	40	< 0.5	–	< 0.5	< 10

Table F-2 Metals Surface Water Quality Data

Data Collection Entity	Site Location & Description	Site ID	Activity Date	Hardness	Flow (cfs)	pH	Al (ug/L)	As (ug/L)	Cd (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Hg (ug/L)	Ag (ug/L)	Zn (ug/L)
Troy Mine	Lake Creek	LC02	11/4/2009	33	144.4	7.4	–	< 3	–	< 1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC02	3/29/2010	33	142.4	7.29	–	< 3	< 0.1	< 1	120	< 0.5	–	< 3	< 10
Troy Mine	Lake Creek	LC02	8/16/2010	32	174.1	7.8	–	< 3	< 0.1	< 1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC02	10/11/2010	34	157.3	7.7	–	< 3	< 0.1	< 1	30	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC02	4/20/2011	34	161.3	7.6	–	< 3	–	1	<50	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC02	8/17/2011	34	–	7.6	–	< 3	–	<1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC02	10/18/2011	34	164.3	7.4	–	<2	–	<0.5	20	< 0.3	–	< 0.3	< 5
Troy Mine	Lake Creek	LC04	4/4/2005	36	–	7.6	–	–	–	<1	90	<3	< 3	<3	–
Troy Mine	Lake Creek	LC04	8/19/2005	49	81.4	7.41	–	–	–	<1	50	<3	< 3	<3	–
Troy Mine	Lake Creek	LC04	10/4/2005	41	115	7.2	–	< 3	–	< 1	70	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	4/10/2006	40	–	7.51	–	< 1	–	< 1	60	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	7/17/2006	38	158.7	7.46	–	< 3	–	< 1	60	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	10/3/2006	46	–	7.34	–	< 3	–	< 1	20	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	5/3/2007	28	–	6.8	–	< 3	–	< 1	240	< 3	–	< 5	< 10
Troy Mine	Lake Creek	LC04	8/1/2007	39	161.3	7.26	–	< 3	–	< 1	30	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	10/2/2007	42	149.7	7.27	–	< 3	–	< 1	50	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	3/18/2008	41	–	7.03	–	< 3	–	< 1	190	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	10/10/2008	36	–	6.28	–	< 3	–	< 1	210	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	11/4/2008	39	154.9	7.05	–	< 3	–	< 1	30	< 3	–	< 3	< 10
Troy Mine	Lake Creek	LC04	4/22/2009	31	147.4	7.29	–	< 3	–	**2**	**730**	**0.9**	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	7/30/2009	39	167.7	6.8	–	< 3	–	3	50	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	11/4/2009	40	155.6	7.81	–	< 3	–	< 1	20	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	3/29/2010	41	160.3	7.35	–	< 3	< 0.1	6	3.6	2.9	–	< 3	10
Troy Mine	Lake Creek	LC04	8/16/2010	39	–	7.7	–	< 3	< 0.1	2	30	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	10/11/2010	41	159.7	7.7	–	< 3	< 0.1	< 1	40	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	4/20/2011	38	178.2	7.5	–	< 3	–	< 1	60	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	8/17/2011	38	–	7.6	–	< 3	–	< 1	30	< 0.5	–	< 0.5	< 10
Troy Mine	Lake Creek	LC04	10/18/2011	42	163.8	7.4	–	<2	–	<0.5	30	< 0.3	–	< 0.3	< 5

Bold = values used in % reduction calculations
* = values used in TMDL calculations
Grey =values used in existing load calculations

Table F-3. Metals Stream Channel Sediment Quality Data for the Kootenai-Fisher TMDL Project Area

Data Collection Entity	Site Location & Description	Site ID	Activity Date	Al (ug/g)	As (ug/g)	Cd (ug/g)	Cu (ug/g)	Fe (ug/g)	Pb (ug/g)	Hg (ug/g)	Zn (ug/g)
DEQ	Big Cherry Creek at Forest Road 867 crossing	K01BCHRC01	9/28/2006	6460	151	17.8	37.5	14200	903		1280
DEQ	Big Cherry Creek at Hwy 2 crossing just south of Libby	K01BCHRC02	9/28/2006	4690	11.6	2.03	11.4	7750	78.9		173
DEQ	Lake Creek at private residence at end of Shining Mountain Trail	K01LAKEC06	9/17/2012	7480	4	< 0.2	20	13700	19	< 0.05	42
DEQ	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	9/17/2012	4550	3	< 0.2	< 20	8800	8	< 0.05	26
DEQ	Lake Creek at Lake Creek Road crossing above Falls Creek	K01LAKEC07	9/17/2012	8980	6	< 0.2	21	17600	17	< 0.05	52
DEQ	Libby Creek below Ramsey Creek	K01LIBYC05	9/18/2012	9020	30	1	21	17100	34	0.068	71
DEQ	Stanley Creek about 1 mile upstream from mouth	K01STNLC04	9/17/2012	7000	4	0.3	215	8940	75	< 0.05	69

Table F-4. Background Metals Water Quality Data for the Kootenai-Fisher TMDL Project Area

Flow Regime	Data Collection Entity	Site Location & Description	Site ID	Activity Date	Flow (cfs)	pH	As (ug/L) TR	Cd (ug/L) TR	Cu (ug/L) TR	Pb (ug/L) TR	Hg (ug/L) T	Zn (ug/L) TR
High Flow	DEQ	Snowshoe Creek upstream from Snowshoe Mine	BKK134	5/30/2012	22.57	7.4	<3	1.18	<1	2.9	-	110
	DEQ	Libby Creek upstream of Howard Creek	K01LIBYC03	5/23/2012	-	6.76	<3	0.08	<1	<0.5	<0.005	<10
	DEQ	Libby Creek below Ramsey Creek	K01LIBYC05	5/23/2012	-	6.95	<3	<0.08	1	<0.5	<0.005	<10
Low Flow	DEQ	Bear Creek about 1.5 miles upstream from mouth	K01BEARC01	9/19/2012	-	-	<3	<0.08	<1	<0.5	<0.005	<10
	DEQ	Bear Creek at trailhead at end of FS Road 4784	K01BEARC02	9/19/2012	-	-	<3	<0.08	<1	<0.5	<0.005	<10
	DEQ	Bear Creek upstream Cable Creek confluence	K01BEARC03	9/19/2012	-	-	<3	<0.08	<1	<0.5	<0.005	<10
	DEQ	Bear Creek downstream Cable Creek at FS Road 278 crossing	K01BEARC04	9/19/2012	-	-	<3	<0.08	<1	<0.5	<0.005	<10
	DEQ	Snowshoe Creek above Snowshoe Mine	SNSCA	8/19/2011	3.27	7.64	<3	<0.08	<1	<0.5	-	<10
	DEQ	Snowshoe Creek upstream from Snowshoe Mine	BKK134	9/18/2012	0.11	8	<3	<0.08	<1	1.6	-	<10
	DEQ	Libby Creek upstream of Howard Creek	K01LIBYC03	9/18/2012	1.49	7.52	<3	<0.08	<1	<0.5	-	<10

APPENDIX G – WOLF CREEK QUAL2K MODEL REPORT

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ACRONYMS AND ABBREVIATIONS

AME	Absolute Mean Error
EPA	Environmental Protection Agency (U.S.)
DEQ	Department of Environmental Quality (Montana)
MRLC	Multi-Resolution Land Characteristics Consortium
NLCD	National Land Cover Dataset
NRCS	Natural Resources Conservation Service (U.S. Department of Agriculture)
QUAL2K	River and Stream Water Quality Model
REL	Relative Error
RM	Rivermile
TMDL	Total Maximum Daily Load
USFS	U.S. Forest Service (U.S. Department of Agriculture)
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WRCC	Western Regional Climate Center

UNITS OF MEASURE

°F	degrees Fahrenheit
cfs	cubic feet per second
MSL	mean sea level
RM	river mile

EXECUTIVE SUMMARY

Wolf Creek is listed on the 2012 303(d) List as impaired because of elevated water temperatures. The cause of the impairment was attributed to channelization and highways, roads, bridges, and infrastructure (new construction). Field studies were carried out in 2012 to support water quality model development for the project. A QUAL2K water quality model was then developed for Wolf Creek to evaluate the impairment status and the effect that human sources have had on stream temperatures. The QUAL2K model was constructed, in part, using field collected data from the summer of 2012. Shadev3.0 models were also developed to assess shade conditions using previously collected field data. The calibrated and validated QUAL2K model met previously designated acceptance criteria. Once developed, various water temperature responses were evaluated for a range of potential watershed management activities. Four scenarios were evaluated:

- **Scenario 1:** Critical existing condition (i.e., the calibrated model with critical weather and low-flow conditions). This served as the baseline scenario from which to compare the other scenarios.
- **Scenario 2:** Critical existing conditions with a 15 percent reduction of water withdrawals. This is to simulate standards attainment regarding water conservation practices.
- **Scenario 3:** Critical existing condition with improved riparian vegetation in a 50-foot buffer. This is to simulate standards attainment regarding soil and land conservation practices.
- **Scenario 4:** An improved flow and shade scenario that combines the potential benefits associated with a 15 percent reduction in water withdrawals with a 50-foot vegetated buffer. This is to simulate full standards attainment via the use of all reasonable land, soil, and water conservation practices.

In comparison to scenario 1, the results ranged from almost no change in water temperatures (scenarios 2) to considerable reductions (scenarios 3 and 4). Scenario 4 resulted in overall reductions along the entire reach which ranged from 0.7° F to 7.8° F. Generally, small changes in shade or inflow had minimal effects on water temperatures while large increases in shade had considerable effects on water temperatures. The scenarios indicate the allowable human caused temperature change is being exceeded and support the impairment listing.

G1.0 INTRODUCTION

This appendix is based on a model report completed by Tetra Tech (2013) for a temperature model (QUAL2K) that was used to support TMDL development for Wolf Creek. Background information is provided in the following section (**Section G.2**). A summary of model set up, calibration, and validation is provided in **Section G.3** and a series of model scenarios and results are presented in **Section G.4**.

G2.0 BACKGROUND

This section presents background information to support QUAL2K model development.

G2.1 Problem Statement

Wolf Creek (MT76C001_020) is located in northwest Montana in the Northern Rockies ecoregion and is located in the Kootenai-Fisher TMDL Project Area. The impaired segment is 39.26 miles long and is a tributary to the Fisher River (**Figure G-1**).

Wolf Creek has a B-1 use class. It is in partial attainment of its aquatic life designated use (Montana Department of Environmental Quality, 2012). The agricultural and primary contact recreation uses are fully supported. Three potential causes of impairment are identified in the assessment record, including water temperature (Montana Department of Environmental Quality, 2012). The potential sources of the water temperature impairment are: channelization and highways, roads, bridges, and infrastructure (new construction).

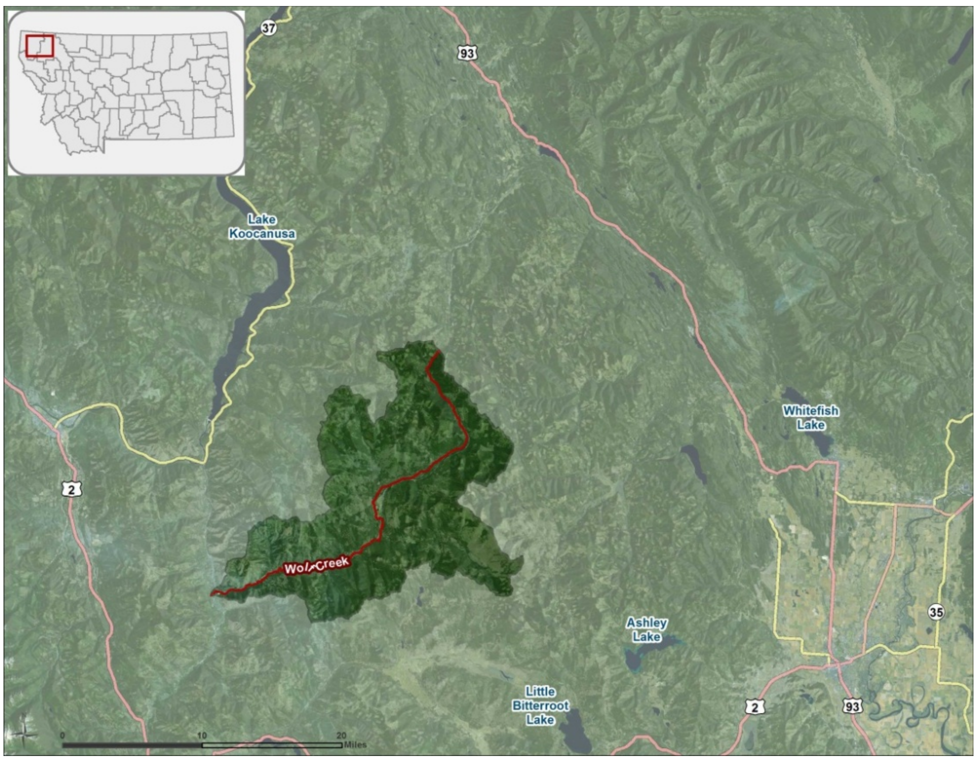


Figure G-1. Wolf Creek watershed

G2.2 Montana Temperature Standard

The model results will be used to verify if Wolf Creek is not meeting the temperature standard. For a waterbody with a use classification of B-1, such as Wolf Creek, the following temperature criteria apply:[1]

> A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring[2] range of 66° F to 66.5° F, no discharge is allowed [that] will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water

[1] Administrative Rules of the state of Montana 17.30.623(e).

[2] Administrative Rules of the state of Montana 17.30.602(17): "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. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural."

temperature is 0.5° F. A 2° F per-hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F. A 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

G2.3 Factors Potentially Influencing Stream Temperature

Stream temperature regimes are influenced by processes that are external to the stream as well as processes that occur within the stream and its associated riparian zone (Poole et al., 2001). Examples of factors external to the stream that can affect instream water temperatures include: topographic shade, land use/land cover (e.g., vegetation and the shading it provides, impervious surfaces), solar angle, meteorological conditions (e.g., precipitation, air temperature, cloud cover, relative humidity), groundwater exchange and temperature, and tributary inflow temperatures and volumes. The shape of the channel can also affect the temperature—wide shallow channels are more easily heated and cooled than deep, narrow channels. The amount of water in the stream is another factor influencing stream temperature regimes. Streams that carry large amounts of water resist heating and cooling, whereas temperature in small streams (or reduced flows) can be changed more easily.

The following factors that may have an influence on stream temperatures in Wolf Creek were evaluated prior to model development and are further discussed in **Attachment G-1**:

- Local/regional climate
- Land ownership
- Land use
- Riparian vegetation
- Shade
- Hydrology
- Point sources

G2.4 Stream Temperature Data

In 2012, EPA collected continuous temperature data at seven locations in Wolf Creek (sites WLFC-T0.1, WLFC-T0.2, WLFC-T1, WLFC-T1.5, WLFC-T2, WLFC-T2.5, and WLFC-T3) and at five tributary locations (BRSHC on Brush Creek, CALXC on Calx Creek, DRFKC on Dry Fork Creek, LWLFC on Little Wolf Creek, and RCHDC on Richard Creek) (**Figure G-2**). Data loggers recorded temperatures every one-half hour for approximately two months between June 26 or July 13, 2012[3] and September 17 or 19, 2012. Instantaneous water temperatures[4] were recorded during logger deployment and retrieval (**Table G-1**). Plum Creek deployed temperature loggers at two locations in Wolf Creek. Both sites were upstream of the confluence with Dry Fork Creek and between EPA monitoring sites WLFC-T1 and WLFC-0.2.

Additionally, a temperature logger was deployed in one location in Little Wolf Creek during the same time period (**Figure G-2**). Plum Creek's loggers were deployed form June 20, 2012 to December 2, 2012. To provide a comparison to the EPA data, only the Plum Creek data collected between June 20 and September 19th are considered herein.

[3] Temperature loggers were deployed on July 13, 2012 at the following sites because in-stream flow was too high to deploy loggers on June 26, 2012: WLFC-T0.1, WLFC-T0.2, WLFC-T1, WLFC-T1.5, WLFC-T2, WLFC-T2.5, and WLFC-T3.

[4] EPA also collected instantaneous water temperatures on August 8, 2010 at WLFC-T1 (62.9°F), WLFC-T2 (66.6° F), and WLFC-T3 (65.8°F).

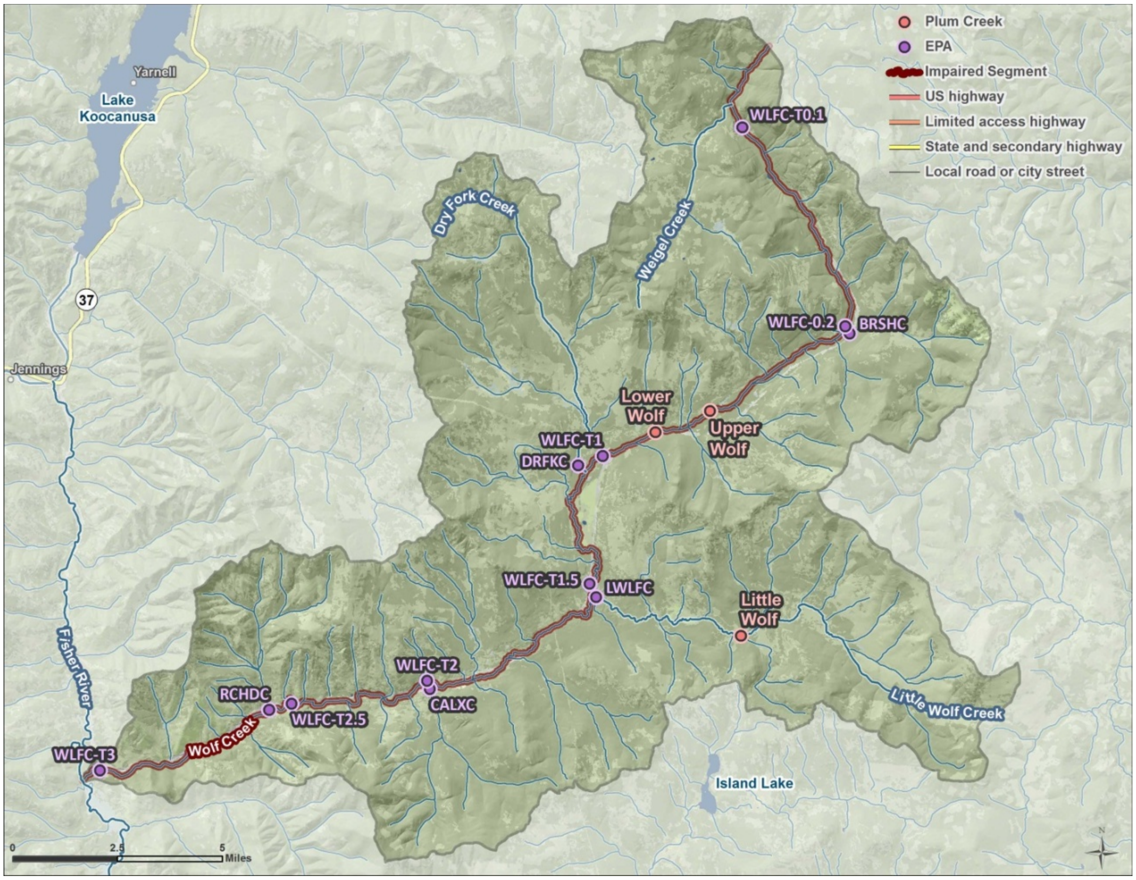


Figure G-2. Temperature loggers in the Wolf Creek watershed.

Table G-1. EPA instantaneous water temperature measurements (°F), summer 2012

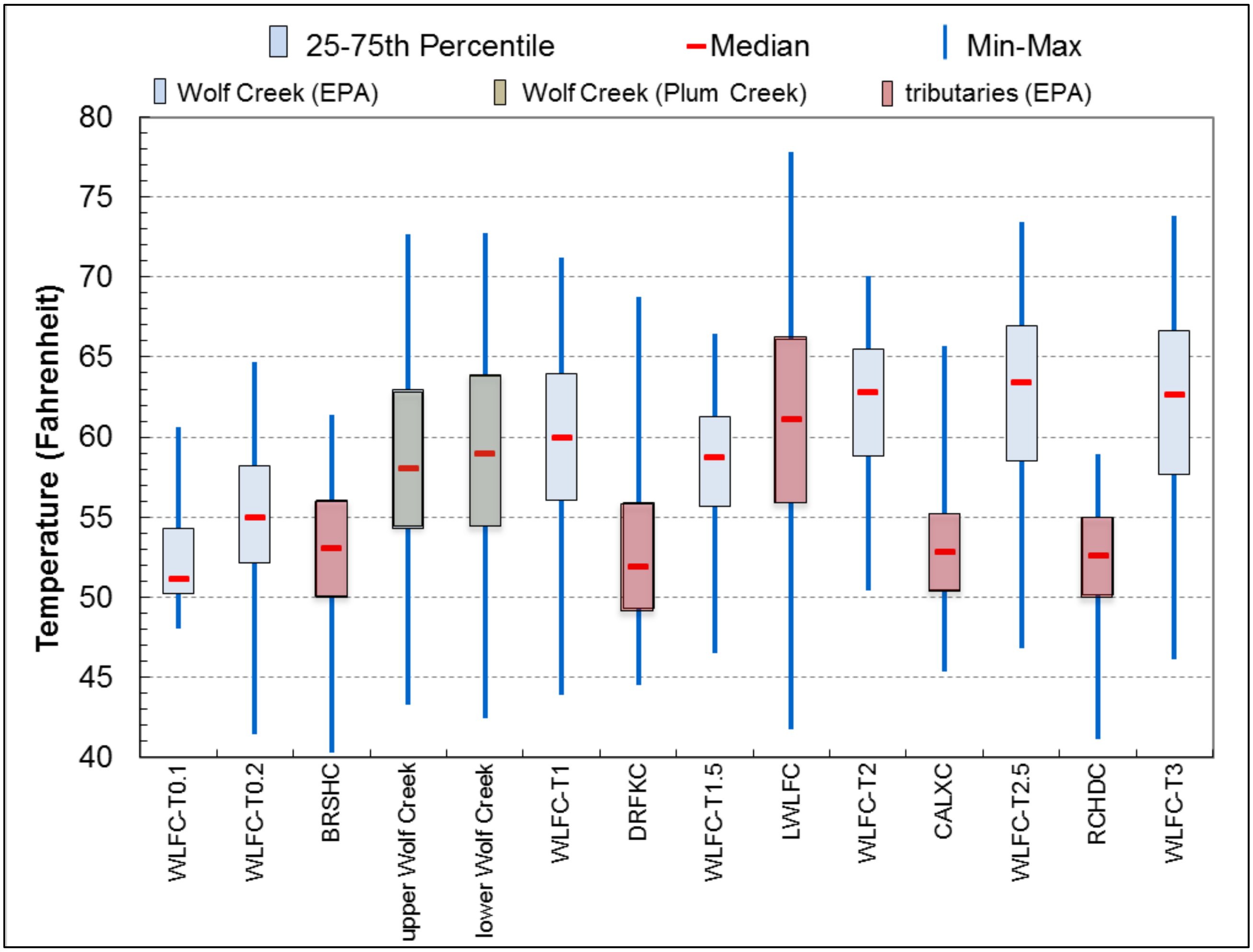
Date	WLFC-T0.1	WLFC-T0.2	BRSHC a	WLFC-T1	DRFKC b	WLFC-T1.5	LWLFC c	WLFC-T2	CALXC d	WLFC-T2.5	RCHDC	WLFC-T3
June 26, 2012	--	--	49.5	--	49.6	--	53.4	--	50.4	--	49.1	--
July 13, 2012	57.0	56.8	--	61.3	--	62.1	--	67.6	--	70.9	--	72.9
August 9-10, 2012	55.4	53.1	53.2	58.5	dry	62.4	66.7	67.3	dry	68.7	56.8	69.6
September 17-19, 2012	dry	52.7	51.1	55.9	dry	54.1	52.2	52.7	dry	52.2	46.0	49.5

G2.5 Temperature Data Analysis

Stream temperatures in Wolf Creek generally increase from its source downstream to its mouth **(Figure G-3)**. Brush (BRSHC) and Richard (RCHDC) creeks, tributaries to Wolf Creek, contributed considerably cooler water while the highest temperatures were observed at the mouth of Little Wolf Creek (LWLFC). Maximum temperatures (**Figure G-4**, **Figure G-5**, and **Figure G-6**) generally follow similar patterns with temperatures steadily increasing downstream of the confluence with Brush Creek with coolest temperatures in the headwaters of Wolf Creek (WLFC-T0.1 and WLFC-T0.2), Brush Creek (BRSHC) and Richard Creek (RCHDC).

Four temperature loggers (WLFC-T0.1, DRFKC, LWLFC, and CALXC) were observed to be either fully exposed to ambient air in dry channels or partially exposed and partially submerged in shallow wet channels on August 9 or 10, 2012 and September 17 or 19, 2012. Therefore, the temperature data from each logger were evaluated and as described below, data from certain time periods were excluded from further analyses.

- **Calx Creek:** Daily maximum temperature increased 13° F between July 6 and 7, 2012. Maximum daily temperatures in the high 70s °F though lower 100s °F persisted until the logger was retrieved on September 17, 2012. During this time period, diurnal variation was considerably larger than the diurnal variation for loggers that remained fully submerged through the summer. Therefore, data collected between July 7 and September 17, 2012 were excluded from further analyses.
- **Dry Fork Creek:** Daily maximum temperatures increased 15° F between July 7 and 8, 2012. Maximum daily temperatures in the high 70s°F though the lower 90s°F were regularly monitored through July and August. Daily maximum temperatures decreased into the 60s°F in September; however, such temperatures were considerably warmer as compared to the loggers that were fully submerged in September. Additionally, from July 8 through September 17, 2012, diurnal variation was considerably larger than the diurnal variation for the loggers that remained fully submerged through the summer. Therefore, data collected between July 8 and September 17, 2012 were excluded from further analyses.
- **Little Wolf Creek:** Daily maximum temperatures began increasing considerably on August 27, 2012 and remained elevated through September 8, 2012. From August 28 through September 8, 2012, daily maximum temperatures were in the 90s° F and were 25° F warmer than any other logger that remained fully submerged throughout the summer. Diurnal variation was consistently in excess of 40° F during this time period. Temperatures rapidly fell on September 8 and 9, 2012 and appeared to remain consistent with submerged loggers until this logger was retrieved on September 17, 2012. Therefore, data collected between August 27 and September 8, 2012 were excluded from further analyses.
- **Wolf Creek (RM 0.1**): The daily variations between daily maximum temperatures from August 18 through September 19, 2012 were inconsistent with such variation for the other loggers on Wolf Creek. From August 18 through August 25, 2012, the variations between one-half hourly measurements were inconsistent with such variations from earlier in the summer and were inconsistent with such variations from other loggers in Wolf Creek. During this time period, temperatures would vary a few tenths of a degree between measurements at other loggers while temperatures at this logger remained constant or nearly constant for many hours at a time. On August 26, 2012, temperatures began to increase and daily maximum temperatures continued to increase and remain elevated (as compared to daily maximums earlier in the summer when this logger was submerged) until retrieval on September 19, 2012. Therefore, data collected between September 1 and 19, 2012 were excluded from further analyses.



Note: Elevated temperature data, that likely represent periods when the loggers were exposed to ambient air, were excluded from this figure.

Figure G-3. Box-and-whisker plots of DEQ temperature data, June 26 or July13 to September 17 or 19, 2012.

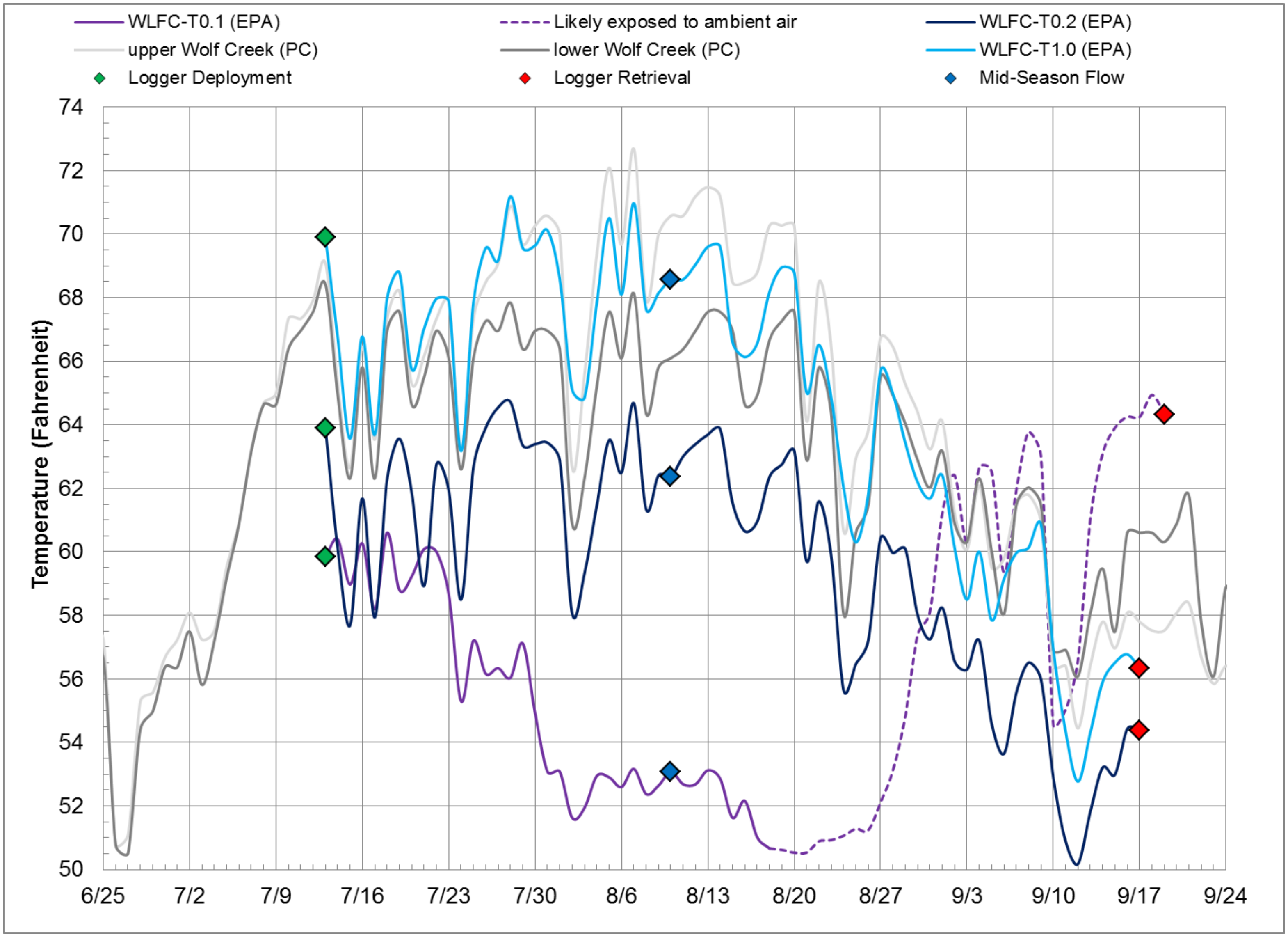


Figure G-4. Daily maximum temperatures along Wolf Creek, upper half of the watershed, June 25, 2012 to September 24, 2012.

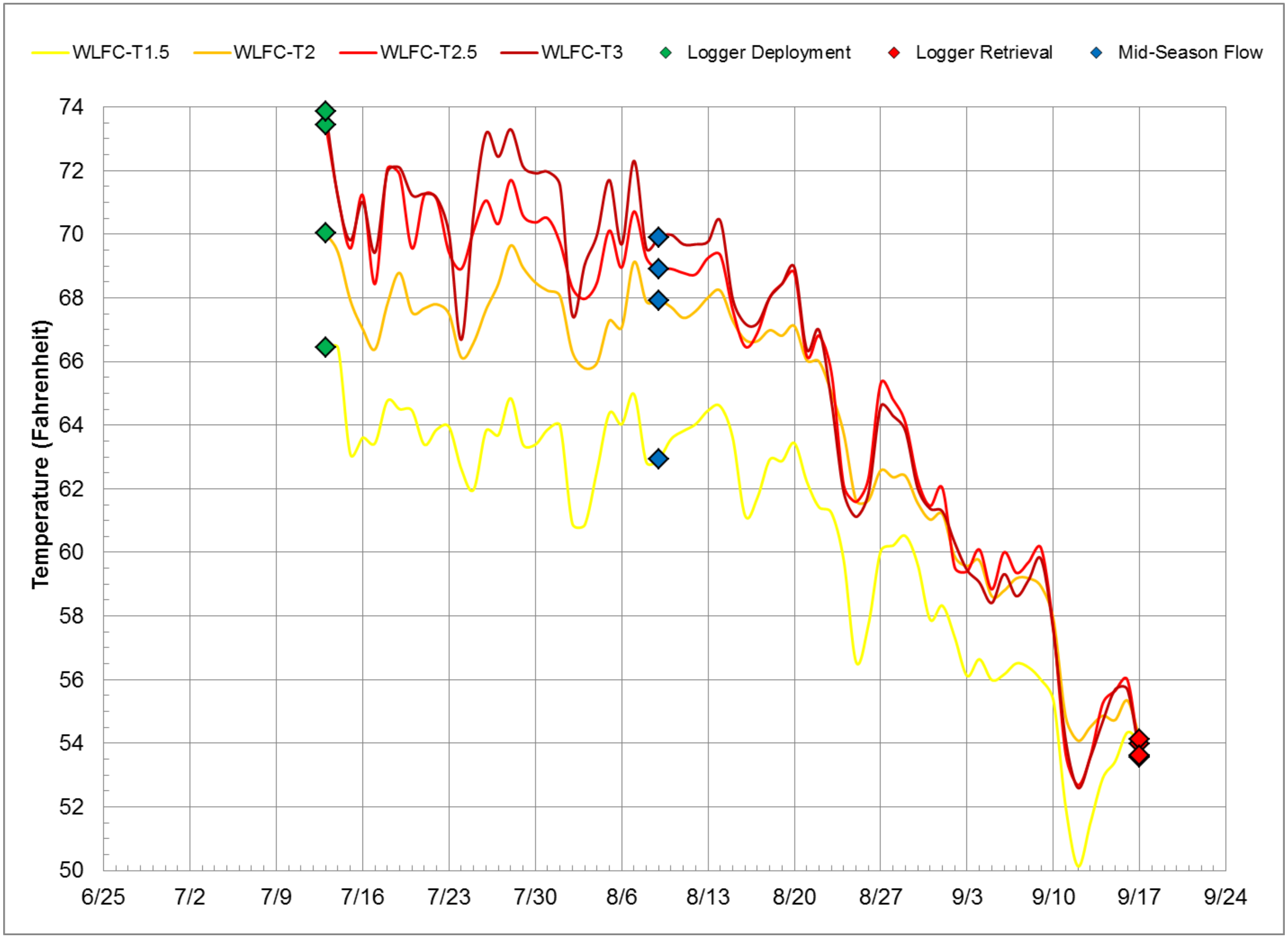


Figure G-5. Daily maximum temperatures along Wolf Creek, lower half of the watershed, June 25, 2012 to September 24, 2012.

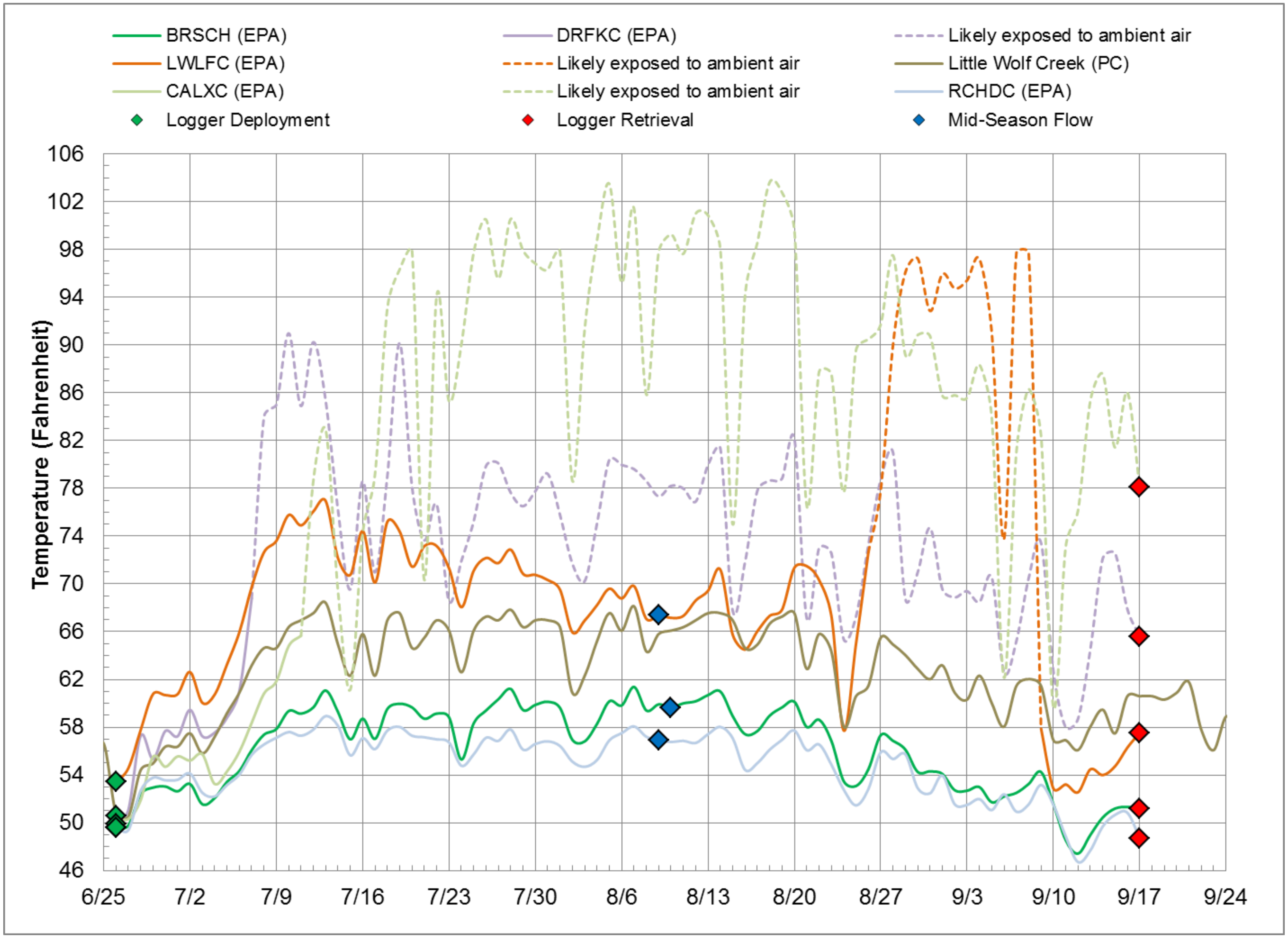


Figure G-6. Daily maximum temperatures on the tributaries to Wolf Creek, June 25, 2012 to September 24, 2012.

G3.0 QUAL2K MODEL DEVELOPMENT

A QUAL2K model was used to simulate temperatures in Wolf Creek. QUAL2K is supported by EPA and has been used extensively for TMDL development and point source permitting across the country. The QUAL2K model is suitable for simulating hydraulics and water quality conditions of small rivers and creeks. It is a one-dimensional uniform flow model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The heat budget and temperature are simulated as a function of meteorology on a daily time scale. Heat and mass inputs through point and nonpoint sources are also simulated. The model allows for multiple waste discharges, water withdrawals, nonpoint source loading, tributary flows, and incremental inflows and outflows. QUAL2K simulates instream temperatures via a heat balance that accounts “for heat transfers from adjacent elements, loads, withdrawals, the atmosphere, and the sediments” (Chapra et al., 2007, p. 19).

The most current release of QUAL2K was used (version 2.11b8, January 2009). The model is publicly available at http://www.epa.gov/athens/wwqtsc/html/QUAL2K.html. Additional information regarding QUAL2K is presented in the *Quality Assurance Project Plan for Montana TMDL Support: Temperature Modeling* (Tetra Tech, Inc., 2012).

The following describes the process that was used to setup, calibrate, and validate the QUAL2K model for Wolf Creek.

G3.1 MODEL FRAMEWORK

The modeling domain included the area just near the confluence with Weigel Creek down to the confluence with the Fisher River (**Figure G-2**). Channel geometry and stream temperature, flow, and shade data were collected in 2012 to support the QUAL2K model for the Wolf Creek. Data are summarized within this appendix; raw data may be obtained by contacting DEQ’s Water Quality Planning Bureau.

G3.2 MODEL CONFIGURATION AND SETUP

Model configuration involved setting up the model computational grid and setting initial conditions, boundary conditions, and hydraulic and light and heat parameters. All inputs were longitudinally referenced, allowing spatial and continuous inputs to apply to certain zones or specific stream segments. This section describes the configuration and key components of the model.

G3.2.1 Modeling Time Period

The calibration period input parameters were based upon August 9, 2012; flow was monitored August 9 or 10, 2012 at all EPA logger sites on Wolf Creek and its major tributaries. Since flow was monitored at more sites on Wolf Creek on August 9, 2012, this date was selected for calibration. Dry channels were observed during August 9, 2012 at the logger sites on Calx Creek and Dry Fork Creek.

The validation period input parameters were based upon September 16, 2012, which is just before the retrieval of all the EPA loggers. EPA loggers were retrieved on September 17 and 19, 2012. The last full day of temperature data for all EPA loggers was September 16, 2012. Plum Creek loggers were deployed until October 2, 2012 and have full temperature records for September 16, 2012. Flow data monitored on September 17, 2012 was assumed to be representative of flow conditions on September 16, 2012.

G3.2.2 Segmentation

Segmentation refers to discretization of a waterbody into smaller computational units (e.g., reaches and elements). Segmentation into reaches allows for representation of stretches of the river that have constant hydraulic characteristics (e.g. slope, bottom width). Each reach is further divided into elements that are the fundamental computational units in QUAL2K. The Wolf Creek mainstem was segmented into reach lengths of 0.93 miles (1.50 kilometers), with an element size of 0.16 mile (0.25 kilometer) within each reach (i.e., six elements per reach). An element size of 0.16 mile was sufficient to incorporate any point inputs to the waterbody (i.e., tributaries). In addition since shading is applied at the reach level this allowed for better representation of the spatial variability observed in the shade model results along Wolf Creek. Five major tributaries were represented through boundary condition designation (see **Section G3.2.4** for a discussion of boundary conditions). **Figure G-7** shows the Wolf Creek mainstem and its tributaries.

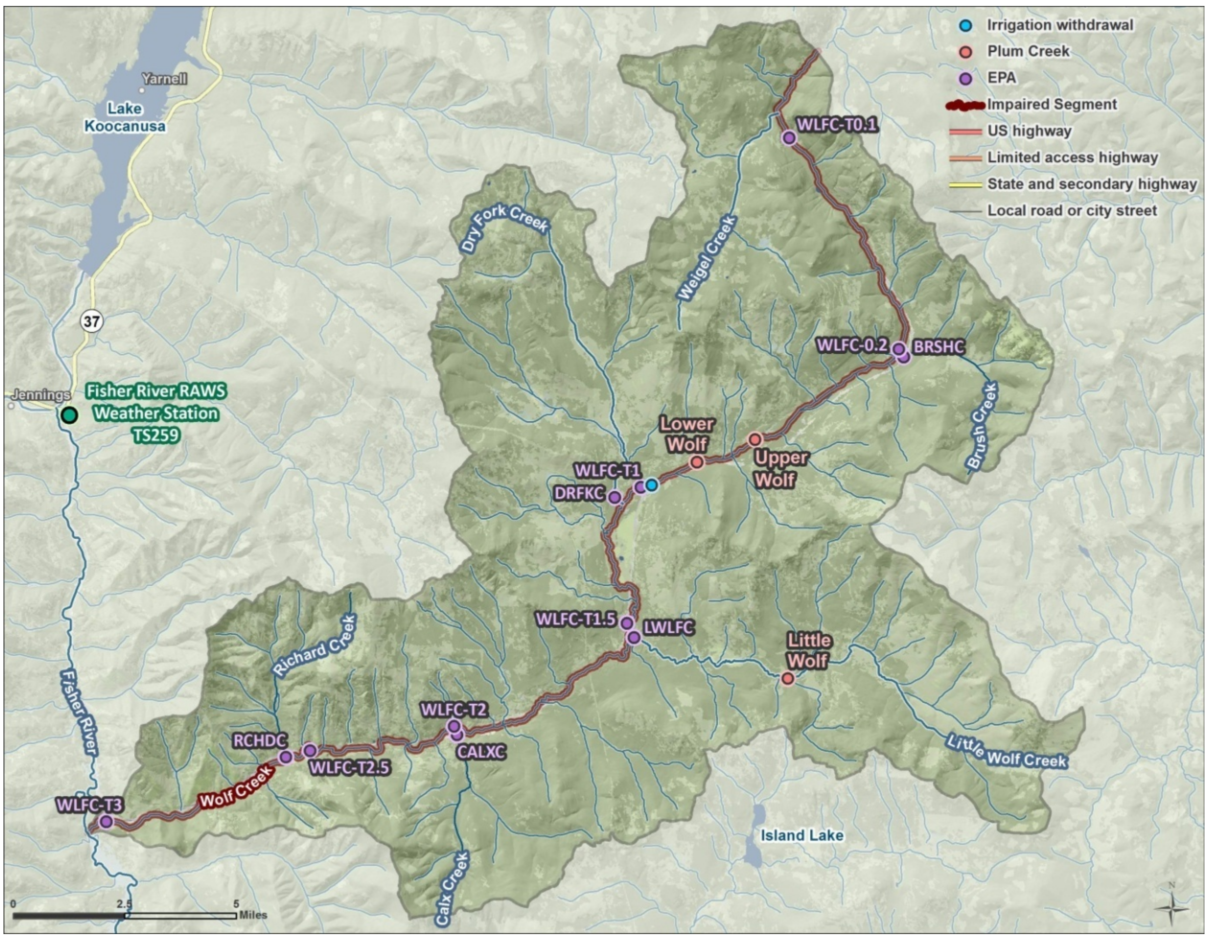


Figure G-7. Wolf Creek modeling domain, logger locations, RAWS, and irrigation withdrawal.

G3.2.2 Hydraulics

System hydraulics were specified using the Manning formula method. This method requires specification of the bottom width, side slope, channel slope and Manning roughness coefficient (i.e., Manning *n* value) for each reach segment. These geometric and physical characteristics of Wolf Creek were estimated based on the cross-section survey conducted during 2012. The bottom width and side slopes were first estimated from the channel cross-section data at each of the seven logger locations.

Intermediate widths and side slopes were defined using linear interpolation based on longitudinal distance travelled between end points, with minor adjustments at certain locations during calibration. Channel slope information was calculated based on the centerline elevations sampled during Shade modeling (calculated every 98 feet [30 meters] along a 33 foot digital elevation model [10 meter DEM] from the National Elevation Dataset). For each QUAL2K reach an elevation was assigned based on the centerline elevations sampled during Shade modeling. The elevation data were then used to calculate the slope between two end points. Channel slopes were typically around 0.5 percent (median) and ranged from 0.06 percent to 2.58 percent. **Figure G-8** shows the channel elevations and slopes assigned in the QUAL2K model.

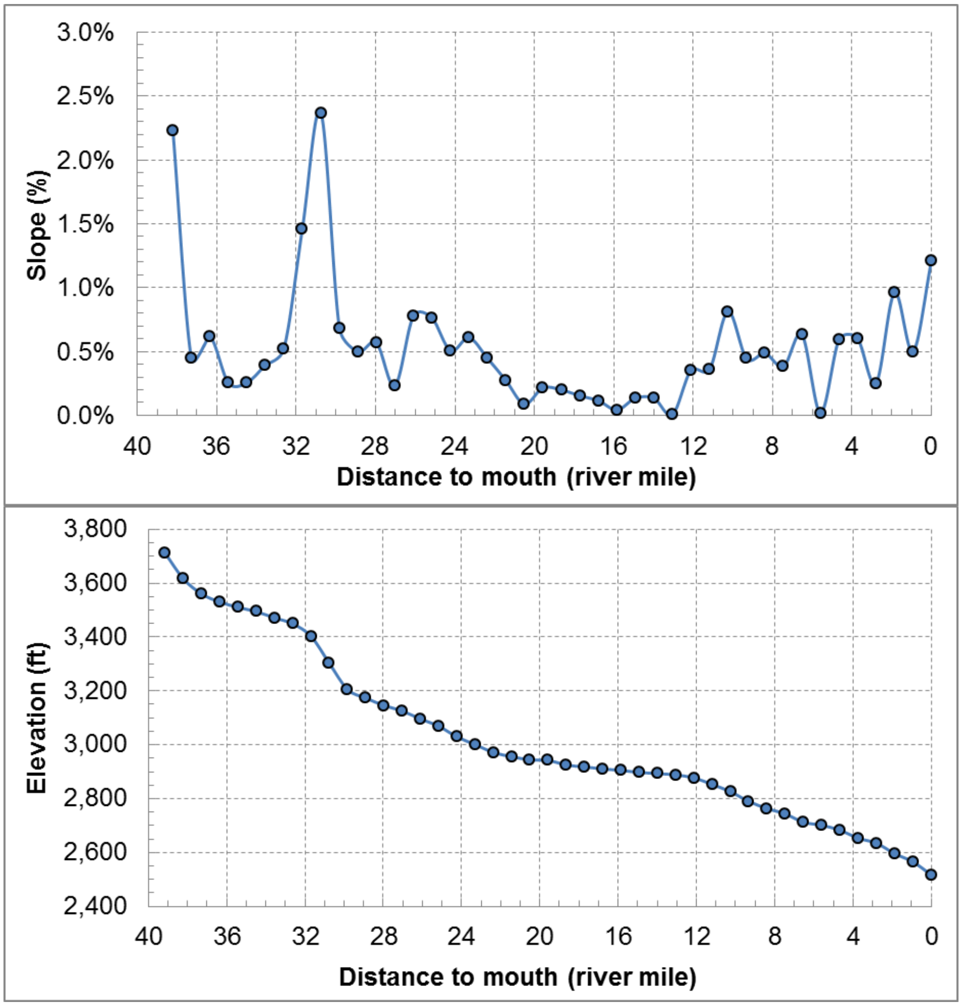


Figure G-8. Wolf Creek channel elevation and slope representations.

G3.2.4 Boundary Conditions

Boundary conditions represent external contributions to the waterbody being modeled. A flow and temperature input file was configured for inputs to Wolf Creek. Boundary conditions were specified at the upstream terminus of Wolf Creek, for each of the five major tributaries' confluences with Wolf Creek, and for diffuse sources along the creek. These are further discussed in the following subsections.

G3.2.4.1 Headwater (Upstream) Boundary

QUAL2K requires specification of the headwater flow and temperature. Headwater flow (August 10, 2012) and diurnal temperature (August 9, 2012) at the upstream boundary were specified using observed data from the instream logger at site WLFC-T0.1 for the calibration period. A flow of 0.57 cubic feet per second (cfs) was specified for the calibration period. Note that flow for August 9, 2012 was not available and observed flow from August 10, 2012 was used. A dry channel was observed on Wolf Creek at WLFC-T0.1 on September 17, 2012. Hence flow and temperature at this location were unusable for the validation period. However, since the model requires specification of a headwater flow a very small flow of 0.0001 cfs was input into the model along with observed diurnal temperature data from WLFC-T0.2 (6.8 miles downstream) collected on September 16, 2012. The model is not sensitive to the temperature at this location due to the very small negligible flow that was specified, so this adjustment has no impact on the model results. **Figure G-9** shows the headwater temperatures specified in the model.

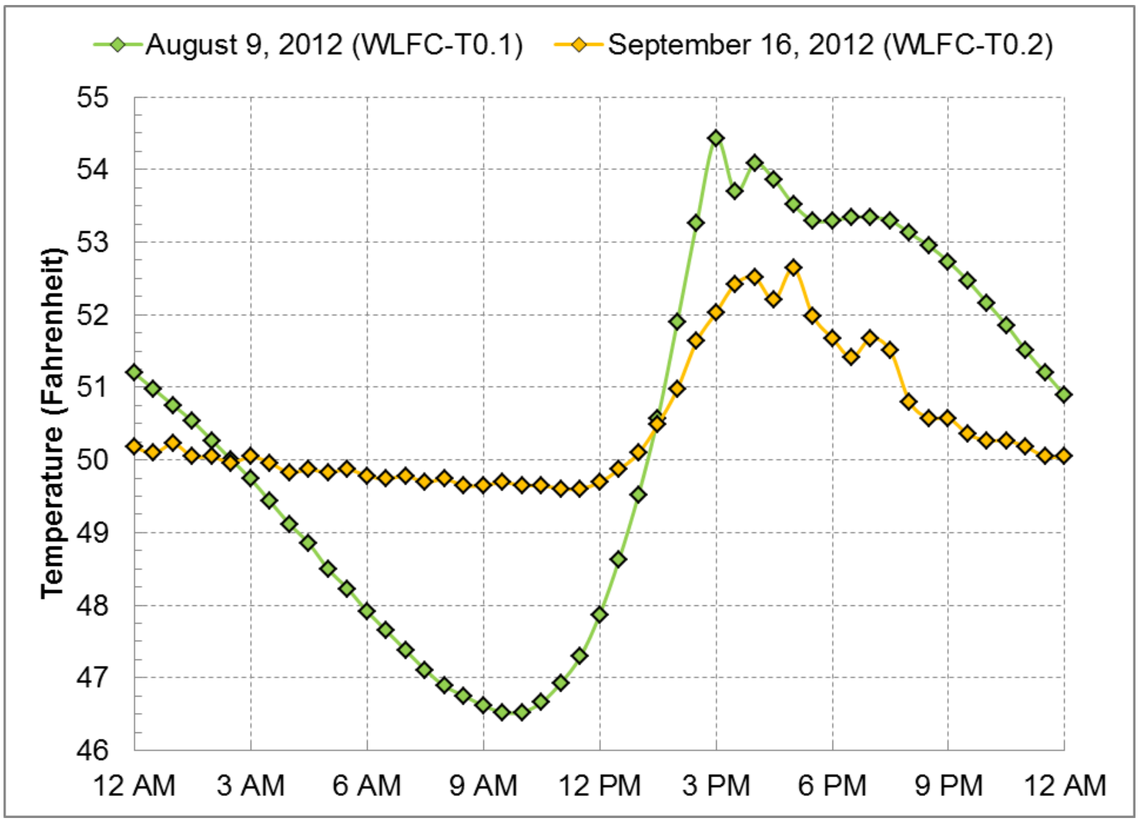


Figure G-9. Diurnal temperature at the headwaters to Wolf Creek.

G3.2.4.2 Tributary Inputs

There are many small tributaries in the watershed; however, monitoring data were available for only five major tributaries feeding into Wolf Creek – Brush Creek, Dry Fork Creek, Little Wolf Creek, Calx Creek, and Richards Creek (**Figure G-7**). **Table G-2** shows the flow and temperature assigned to the tributaries in the model. Both Calx Creek and Dry Fork Creek were dry on August 9, 2012 and September 17, 2012 at the logger sites. It should be noted that for the calibration model the flows for Brush Creek were observed on August 10, 2012 (all other tributaries were monitored on August 9, 2012). Flows during the validation period were observed on September 17, 2012 and were used in conjunction with temperatures observed on August 16, 2012, which was the last day of full temperature data available.

In addition to tributary inputs, an irrigation withdrawal from Wolf Creek was also identified (see **Attachment G-1** for a discussion of this withdrawal) and assigned in the model. Information on withdrawal rates or whether withdrawal is occurring during the calibration and validation dates was not readily available. Net irrigation requirements to irrigate the fields were queried from the Montana Natural Resource Information System for the months of August and September (which were 7.28 cfs and 4.29 cfs respectively). A maximum daily flow rate was estimated using the net irrigation requirements and the maximum area irrigated (151 acres). It was calculated that up to 1.49 cfs and 0.865 cfs may be withdrawn from Wolf Creek on a daily basis during August and September, respectively. These calculated withdrawals were used in the model (rows identified as "Irrigation Withdrawal - 76D 7266 00 in **Table G-2**). More information on the irrigation withdrawal can be found in **Attachment G-1**.

Table G-2. QUAL2K model flow and temperature inputs to Wolf Creek - Tributaries and withdrawal

Description	Location	Point sources a		Temperature b		
		Abstraction	Inflow	Daily mean	½ daily range	Time of maximum
	(RM)	(cfs)	(cfs)	(°F)	(°F)	(hour)
August 9, 2012						
Brush Creek (BRSHC)	30.6	--	0.52	56.3	3.5	5:00 PM
Irrigation Withdrawal - 76D 7266 00	23.8	1.49	--	--	--	--
Dry Fork Creek (DRFKC)	22.9	--	--	--	--	--
Little Wolf Creek (LWLFC)	17.7	--	0.23	63.5	4.4	6:00 PM
Calx Creek (CALXC)	11.0	--	--	--	--	--
Richards Creek (RCHDH)	6.2	--	1.36	54.9	2.5	6:00 PM
September 16, 2012						
Brush Creek (BRSHC)	49.26	--	0.17	48.2	2.9	7:00 PM
Irrigation Withdrawal - 76D 7266 00	38.34	0.87	--	--	--	--
Dry Fork Creek (DRFKC)	36.81	--	--	--	--	--
Little Wolf Creek (LWLFC)	28.41	--	0.01	50.5	5.4	2:00 PM
Calx Creek (CALXC)	17.67	--	--	--	--	--
Richards Creek (RCHDH)	10.02	--	0.80	48.6	2.6	5:00 PM

°F = degrees Fahrenheit; cfs = cubic feet per second; RM = river mile.

[a.] Points sources represent abstractions (i.e., withdrawals) or inflows. Each point source can be an abstraction or an inflow.

[b.] The daily temperature, one-half of the range of temperatures across the model period, and time of the maximum hourly temperature are only applicable to point source inflows.

G3.2.4.3 Diffuse Sources

Groundwater and other sources of water not accounted for in the tributaries can be specified along the length of the waterbody using the Diffuse Sources tab in the QUAL2K model. A flow balance was constructed using the observed flows along Wolf Creek and the observed tributary flows, and the amount of diffuse flow along Wolf Creek was calculated for the days when flow was available on August 10, 2012 and September 17, 2012.

Temperature assignment for the diffuse sources was done using the mean of the average air temperature of the preceding months (May, June, and July), which was 59° F. This value was used as an estimate for water temperature, which was further refined during calibration and validation. The final diffuse source water temperatures were kept the same for the calibration and validation period. The final flow and water temperature assignments are shown **Table G-3**.

Table G-3. QUAL2K model flow and temperature inputs to Wolf Creek - Diffuse sources

Description	Location a		Diffuse	Diffuse Inflow	
	Upstream	Downstream	Abstraction	Inflow	Temp
	(RM)	(RM)	(cfs)	(cfs)	(°F)
August 9, 2012					
From WLFC-0.1 to WLFC-0.2	37.8	30.6	--	3.86	57.2
From WLFC-0.2 to WLFC-T1	30.6	22.9	--	1.95	57.2
From WLFC-T1 to WLFC-T1.5	22.9	17.7	--	9.23	57.2
From WLFC-T1.5 to WLFC-T2	17.7	11.0	--	<0.01	57.2
From WLFC-T2 to WLFC-T2.5	11.0	6.2	--	3.28	57.2
From WLFC-T2.5 to WLFC-T3	6.2	0.0	--	0.67	57.2
September 16, 2012					
From WLFC-0.1 to WLFC-0.2	37.8	30.6	--	2.48	57.2
From WLFC-0.2 to WLFC-T1	30.6	22.9	--	0.34	57.2
From WLFC-T1 to WLFC-T1.5	22.9	17.7	--	5.14	57.2
From WLFC-T1.5 to WLFC-T2	17.7	11.0	--	0.08	57.2
From WLFC-T2 to WLFC-T2.5	11.0	6.2	--	0.55	57.2
From WLFC-T2.5 to WLFC-T3	6.2	0.0	--	1.00	57.2

°F = degrees Fahrenheit; cfs = cubic feet per second; RM = river mile.
a. Upstream and downstream termini of segment

G3.2.5 Meteorological Data

The surface boundary conditions are determined by the meteorological conditions in QUAL2K. The QUAL2K model requires hourly meteorological input for the following parameters: air temperature, dew point temperature, wind speed, and cloud cover. There are two weather stations in the vicinity of the Wolf Creek watershed – Fisher River RAWS (TS259) and Hand Creek Weather Station (USS0014A14S). The Fisher River RAWS (**Figure G-7**) records hourly air temperature, dew point temperature, wind speed and solar radiation, whereas the Hand Creek weather station only records hourly air temperature data. The Fisher River RAWS hourly observed meteorological data were used to develop the QUAL2K model after appropriate unit conversions.

The wind speed measurements at the Fisher River RAWS were measured at 20 feet (6.1 meters) above the ground. QUAL2K requires that the wind speed be at a height of 23 feet (7.0 meters). The wind speed measurements ($U_{w,z}$ in meters/second) taken at a height of 6.1 meters (z_w in meters) were converted to equivalent conditions at a height of z = 7.0 meters (the appropriate height for input to the evaporative heat loss equation), using the exponential wind law equation suggested in the QUAL2K user's manual:

$$U_w = U_{wz}\left(\frac{z}{z_w}\right)^{0.15}$$

G3.2.6 Shade Data

The QUAL2K model allows for spatial and temporal specification of shade, which is the fraction of potential solar radiation that is blocked by topography and vegetation. A shade model was developed and calibrated for the Wolf Creek. The calibrated shade model was first run to simulate hourly shade estimates for August 9, 2012 and September 16, 2012 every 98 feet (i.e., 30 meters, the resolution of the shade model) along Wolf Creek. Reach-averaged integrated hourly effective shade results were then computed at every 0.93 miles (1.5 kilometer) using the macro in the Shade model located under the “Diel Shade QUAL2K” worksheet. The reach-averaged results were then input into each reach within the QUAL2K model. The overall average shade on September 16, 2012 (71.7%) was greater than that predicted on August 9, 2012 (60.7%). A more detailed discussion on the shade modeling can be found under **Attachment G-1**.

G3.3 Model Evaluation Criteria

The goodness of fit for the simulated temperature using the QUAL2K model was summarized using the absolute mean error (AME) and relative error (REL) as a measure of the deviation of model-predicted temperature values (P) from the measured, observed values (O). These model performance measures were calculated as follows:

$$AME = \frac{1}{N}\sum_{n=1}^{n}\left|P_n - O_n\right|$$

$$REL = \frac{\sum_{n=1}^{n}\left|P_n - O_n\right|}{\sum_{n=1}^{n} O_n}$$

These performance measures are detailed in the following section relative to model calibration and validation.

G3.4 Model Calibration and Validation

The time periods selected for calibration and validation were August 9, 2012 and September 16, 2012, respectively. These dates were selected as they had the most comprehensive dataset available for modeling and corresponded to the synoptic study done for Wolf Creek, which included collecting flow, temperature, shade, and channel geometry information.

Flow, depth, velocity and temperature data were available at eight locations along the mainstem of Wolf Creek. **Table G-4** shows the monitoring sites used for calibration and validation. Data from both available sources, EPA and Plum Creek Timber Company, were used.

Table G-4. Temperature calibration and validation locations

Site name	Distance (RM)	Available Data	Source
WLFC-T0.2	30.9	Flow, depth, velocity, and temperature	EPA
Upper Wolf	26.7	Temperature	Plum Creek Timber Company
Lower Wolf	25.0	Temperature	Plum Creek Timber Company
WLFC-T1	23.5	Flow, depth, velocity, and temperature	EPA
WLFC-T1.5	18.0	Flow, depth, velocity, and temperature	EPA
WLFC-T2	11.1	Flow, depth, velocity, and temperature	EPA
WLFC-T2.5	6.9	Flow, depth, velocity, and temperature	EPA
WLFC-T3	0.7	Flow, depth, velocity, and temperature	EPA

The first step for calibration was adjusting the flow balance and calibrating the system hydraulics. A flow balance was first constructed for the calibration and validation dates. This involved accounting for all the flow in the system. Observed flows along Wolf Creek, tributary flows, and withdrawals were used to estimate the amount of diffuse flow along the system

After the mass balance of the flow rates, channel roughness was adjusted to better match simulated velocities and depths to observed conditions. Since streamflow, depth, and geometry measurements were monitored at sites distributed along Wolf Creek, Manning n values were calculated numerically (Chapra, 1997) for each model segment based on the field data The calculated Manning roughness coefficients were further refined during calibration and validation. Final Manning roughness coefficients ranged from 0.024 to 0.414 during calibration for August 9, 2012 and ranged from 0.031 to 0.412 during validation for September 20, 2012. Adjustments to the validation dataset were necessary because flows were lower and vegetation increased from the calibration dataset. These Manning roughness coefficients are higher than coefficients in traditional applications due to low flow conditions in Wolf Creek and the substrate type. Traditional applications with higher, bankfull flow conditions typically range from 0.025 to 0.2 for natural main channels (Chow et al., 1988). The calibrated/validated coefficients were deemed appropriate since they were based upon observed data and yielded reasonable fits of velocity and depth, as shown in **Figure G-10** and **Figure G-11**.

Comparison of the observed and predicted longitudinal changes in flow, depth, and velocity for the calibration and validation period are shown below in **Figure G-10** and **Figure G-11**, respectively. The fit was optimized as much as possible, for depth since depth is likely to have a greater impact on water temperature than velocity. Note that, based on measured flow rates during the validation, there was an apparent *losing* reach for the last few miles (near WLFC-T3); however, during modeling a constant flow rate was assumed. Additionally, Dry Fork Creek, Calx Creek, and the headwater sites went dry and are not depicted in **Figure G-10** or **Figure G-11.**

Once the system hydraulics were established (i.e. adjust the flow balance) and the stream depth and velocity were calibrated, the model was then calibrated for water temperature. Temperature calibration included calibrating the model by adjusting the light and heat parameters with available data. A discussion of the solar radiation model and calibration along with other heat related inputs that were selected is presented below.

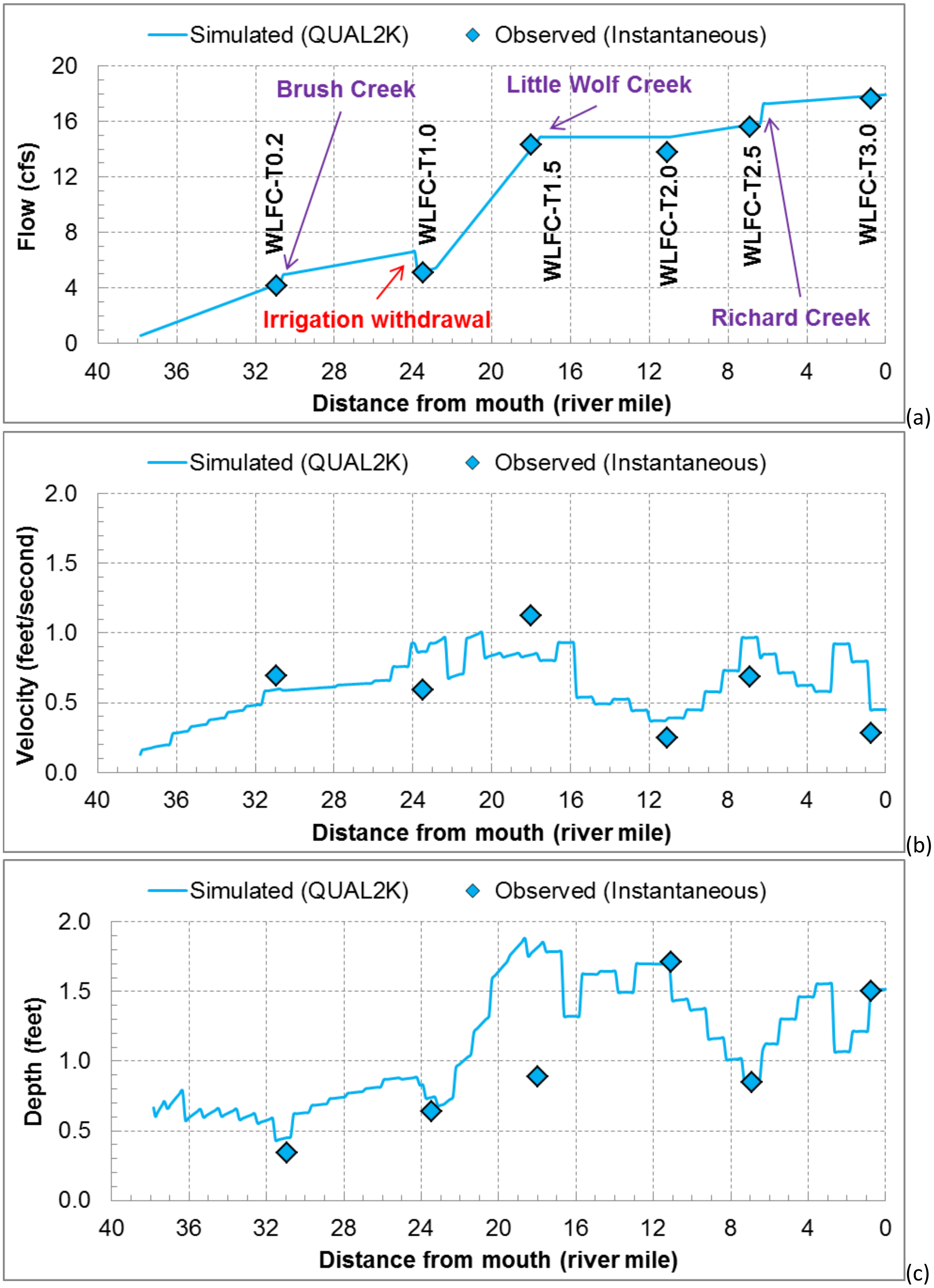


Figure G-10. Observed and predicted flow (Q), velocity (U), and depth (H) on August 9, 2012 (calibration).

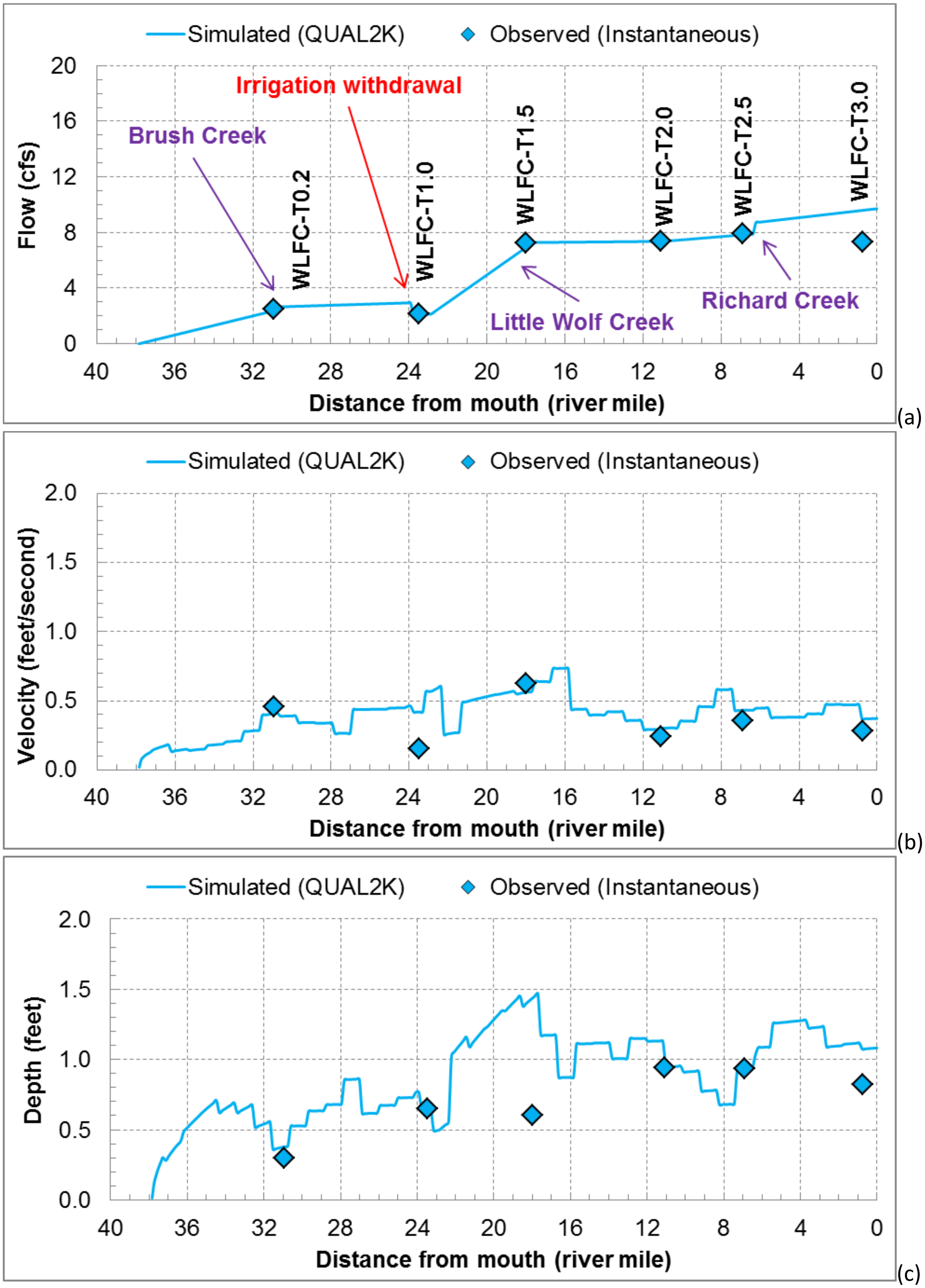
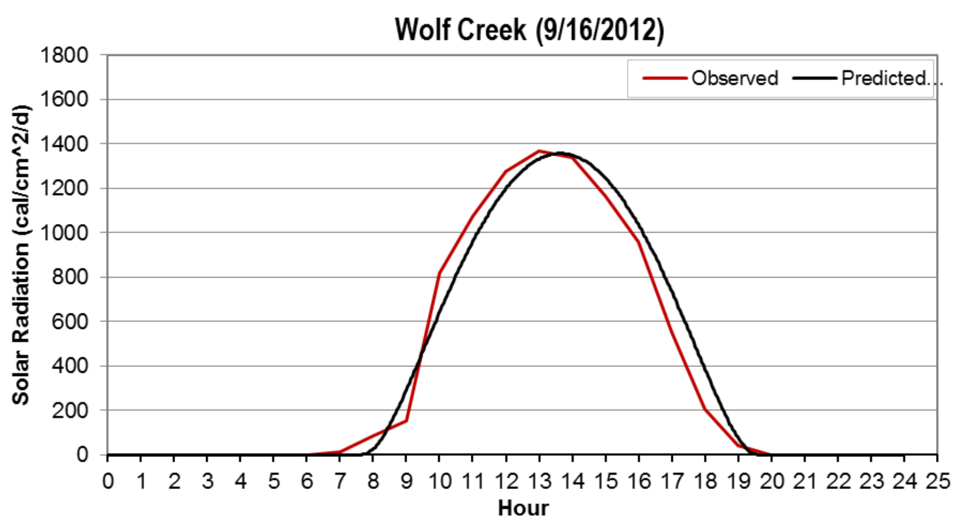
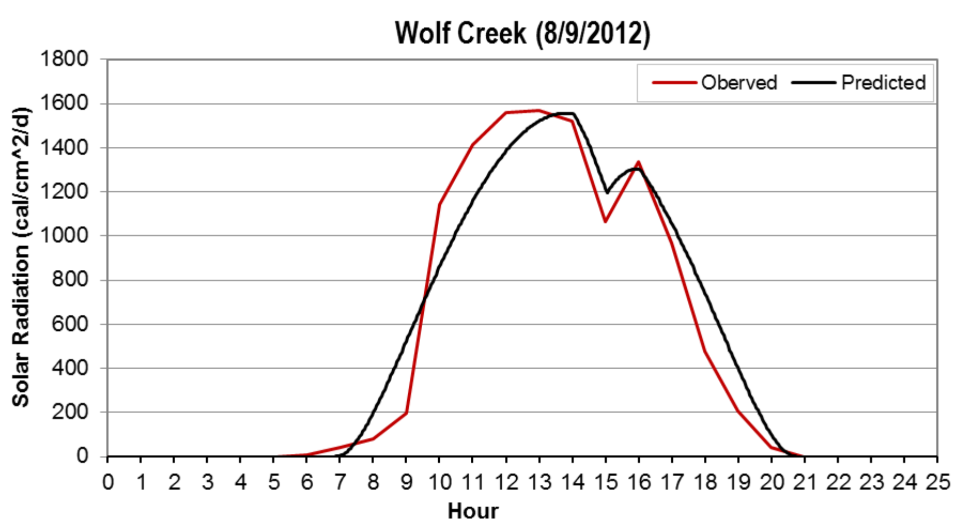


Figure G-11. Observed and predicted flow (Q), velocity (U), and depth (H) on September 16, 2012 (validation).

Hourly solar radiation is an important factor that affects stream temperature. The QUAL2K model does not allow for input of solar radiation measurements. Instead the model calculates short wave solar radiation using an atmospheric attenuation model. For the Wolf Creek QUAL2K model, the Ryan-Stolzenbach model was used to calculate the solar radiation. The calculated solar radiation values (without stream shade) for the calibration and validation date were compared with observed solar radiation measurements at the Fisher Creek RAWS. **Figure G-12** shows the observed and predicted solar radiation for the calibration and validation. No cloud cover data were available and the observed solar radiation during calibration showed some influence due to cloud cover especially during hour 15. The cloud cover was adjusted to more closely mimic observed solar radiation during calibration on August 9, 2012. A cloud cover specification of 75 percent at hour 15 and a 40 percent cloud cover adjustment at all other times during the day was specified to match the observed solar radiation on the calibration day. No adjustment was required to be made to the cloud cover during the validation period on September 16, 2012. The Ryan-Stolzenbach atmospheric transmission coefficient was set at 0.8 for the calibration and validation dates.



(a)



(b)

Figure G-12. Observed and predicted solar radiation on August 9, 2012 and September 16, 2012 (calibration and validation).

The longwave solar radiation model and the evaporation and air conduction/convections models were kept at the default QUAL2K settings. The solar radiation settings are shown in **Table G-5**.

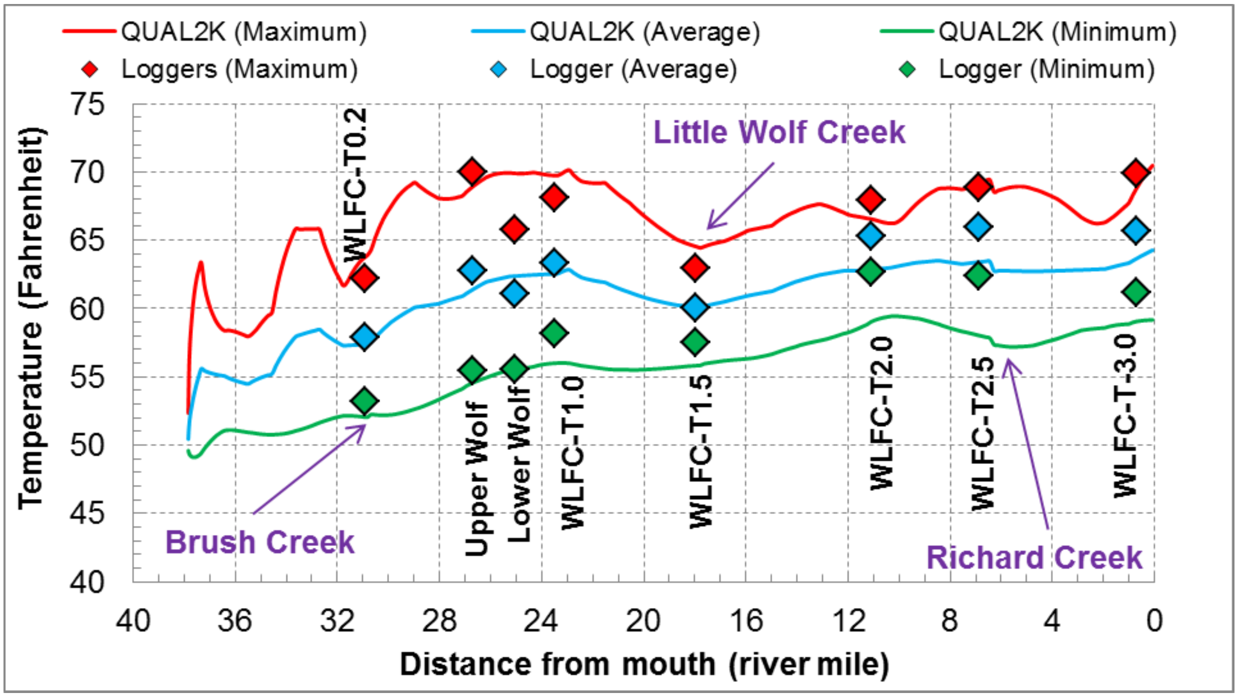
Table G-5. Solar radiation settings

Parameter	Value
Solar shortwave radiation model	
Atmospheric attenuation model for solar	Ryan-Stolzenbach
Ryan-Stolzenbach solar parameter	--
atmospheric transmission coefficient (0.70-0.91, default 0.8)	0.8
Downwelling atmospheric longwave infrared radiation	
Atmospheric longwave emissivity model	Brunt
Evaporation and air convection/conduction	
Wind speed function for evaporation and air convection/conduction	Brady-Graves-Geyer

The sediment heat parameters were also evaluated for calibration. These parameters have an impact especially on the minimum temperatures simulated. In particular the sediment thermal thickness, sediment thermal diffusivity, and sediment heat capacity were adjusted during calibration. The sediment thermal thickness was slightly increased from the default value of 10 cm to 15 cm, and the sediment heat capacity of all component materials of the stream was also increased to 0.55 calories per gram °C from the default value of 0.432 calories per gram °C. The sediment thermal diffusivity was set to a value of 0.0118 square centimeters per second (Chapra et al., 2007). This was consistent with the stream photos that indicated a predominant rocky substrate along the main channel. These adjustments helped in improving the minimum temperatures simulated.

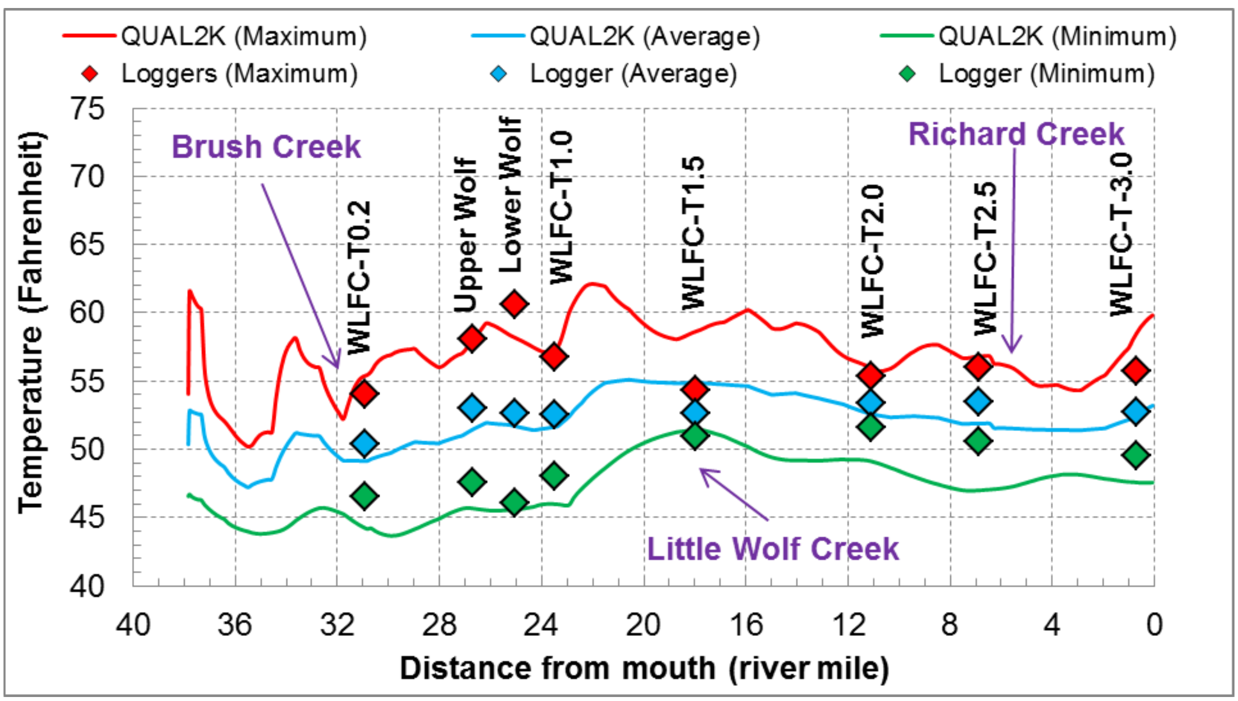
Calibration was followed by validation. The validation provides a test of the calibrated model parameters under a different set of conditions. Only those variables that changed with time were changed during validation to confirm the hydraulic variables. Variables that changed with time included headwater and tributary instream temperatures, air and dew point temperatures, wind speed, cloud cover, solar radiation, and shade. Reach properties such as slope, width, and other associated parameters were unchanged from the calibration. Stream depth and velocities varied greatly during September and the Manning roughness coefficients were varied to reflect these conditions (this is further discussed in **Section G3.2.3**). All other inputs were based on observed data in September 16, 2012. Groundwater temperatures, for which there were no direct observed data, were unchanged since they are not expected to change significantly between August 9 and September 16.

Figure G-13 and **Figure F-14** show the calibration and validation results along Wolf Creek. As can be seen in the figures, the ranges of temperatures during calibration and validation are quite different. In addition, the observed temperatures during the calibration are much warmer than those during the validation and can be as high as 6° C warmer. The temperature calibration and validation statistics of the average, maximum, and minimum temperatures are shown in **Table G-6** and **Table G-7**, respectively.



Note: Dry Fork Creek and Calx Creek ran dry and are not shown in this figure.

Figure G-13. Longitudinal profile of the temperature calibration (August 9, 2012).



Note: Dry Fork Creek, Calx Creek, and the headwaters of Wolf Creek ran dry and are not shown in this figure.

Figure G-14. Longitudinal profile of the temperature validation (September 16, 2012).

Table G-6. Calibration statistics of observed versus predicted water temperatures

Site name	RM	Average daily temperature		Maximum daily temperature		Minimum daily temperature	
		AME (°F)	REL (%)	AME (°F)	REL (%)	AME (°F)	REL (%)
WLFC-0.2	30.9	0.10	0.2%	2.13	3.4%	0.58	1.1%
Upper Wolf	26.7	1.56	2.5%	1.26	1.8%	1.00	1.8%
Lower Wolf	25.0	1.14	1.9%	3.88	5.9%	0.17	0.3%
WLFC-T1	23.5	1.10	1.7%	1.33	1.9%	2.42	4.2%
WLFC-T1.5	18.0	0.93	1.5%	2.52	4.0%	0.85	1.5%
WLFC-T2	11.1	2.16	3.3%	1.01	1.5%	3.30	5.3%
WLFC-T2.5	6.9	2.55	3.9%	0.15	0.2%	4.30	6.9%
WLFC-T3	0.7	2.30	3.5%	1.68	2.4%	2.29	3.7%
Overall Calibration		**1.48**	**2.0%**	**1.74**	**2.6%**	**1.86**	**3.2%**

Note: AME = absolute mean error; REL = relative error; RM = river mile.

Table G-7. Validation statistics of observed versus predicted water temperatures

Site name	km	Average daily temperature		Maximum daily temperature		Minimum daily temperature	
		AME (°F)	REL (%)	AME (°F)	REL (%)	AME (°F)	REL (%)
WLFC-0.2	30.9	49.77	0.67	1.3%	1.88	3.5%	1.79
Upper Wolf	26.7	42.93	1.54	2.9%	0.15	0.3%	1.82
Lower Wolf	25.0	40.29	0.84	1.6%	2.28	3.8%	0.44
WLFC-T1	23.5	37.80	0.90	1.7%	0.63	1.1%	2.08
WLFC-T1.5	18.0	28.95	3.14	6.0%	5.14	9.5%	1.36
WLFC-T2	11.1	17.85	0.51	1.0%	0.89	1.6%	2.24
WLFC-T2.5	6.9	11.10	1.53	2.9%	0.92	1.6%	3.60
WLFC-T3	0.7	1.17	0.40	0.8%	2.30	4.1%	1.99
Overall Validation		**1.19**	**2.3%**	**1.77**	**3.1%**	**1.91**	**3.9%**

Note: AME = absolute mean error; REL = relative error; RM = river mile.

Based on the statistics in **Table G-6** and **Table G-7**, the model is able to simulate the mean and maximum temperatures fairly well but does have some difficulty consistently accurately simulating the minimum temperatures at several locations, especially at the downstream locations. The overall calibration results showed an overall 2.6 percent relative error with an AME of 1.7° F for the maximum temperatures. The overall validation results for the maximum temperatures were similar to the calibration statistics with an overall 3.1 percent relative error and an AME of 1.77° F. The model is not able to simulate the maximum temperatures well at the Lower Wolf (during calibration) and WLFTC-1.5 (during validation). Model results indicate that the impact of the irrigation withdrawal at river mile 23.8 is minimal. However, increased withdrawals could potentially increase the temperatures along the stream, especially in the near vicinity downstream due to the existing low flows.

The observed diurnal temperature pattern between Upper Wolf and WLFC-T1 location (river miles 23 to 26) showed a different diurnal pattern for the calibration and validation. Also, maximum temperatures at the Lower Wolf logger were not captured during the calibration period. During the calibration period observed data indicate cooling along the segment bounded by loggers at Upper Wolf and Lower Wolf, which the model is unable to predict (AME for the maximum temperature at the Lower Wolf was 2.28° F). However, at the same location during validation, the model is able to capture the spatial and temporal variability fairly well. This may indicate a local cooling diffuse source which is not captured by the model within the short distance. No further adjustment was made since the temperatures during validation were reasonable.

During validation the model was unable to simulate the observed temperatures at WLFC-T1.5 (AME = 5.14° F and REL = 9.5 percent); whereas at the same location during the calibration period, the model is able to capture the diurnal range (AME = 2.52° F and REL = 4.0 percent). This location is characterized by relatively flat winding terrain and probably has a localized pool area; the pool area is reflected by the relatively low diurnal range as compared to other locations (5.5° F on August 9, 2012and 3.5° F on September 16, 2012). In both periods, the model does show a decreasing trend around these locations with a lower diurnal range. The model then simulates a gradual increase downstream of this location, although the model is unable to match the observed data during validation. During calibration the model velocity and depth were reviewed, and the depths in the vicinity were adjusted to reflect a deeper pool at this location, which helped in the calibration; however the model could not achieve the observed diurnal range of temperature during validation.

G4.0 Model Scenarios and Results

The Wolf Creek QUAL2K model was used to evaluate instream temperature response associated with multiple scenarios. **Table G-8** summarizes the alterations to input parameters for each model scenario. The following sections present a discussion of the modifications to the QUAL2K models and the results for each scenario.

Table G-8. QUAL2K model scenarios for Wolf Creek

Existing Condition Scenarios			
1	Critical Existing Condition	Existing shade and irrigation practices under critical summer flow and weather conditions.	The baseline model simulation from which to construct the other scenarios and compare the results against.
Water Use Scenario			
2	15 % reduction in withdrawals	Reduce existing withdrawals by 15 percent	Represent application of conservation practices for agricultural and domestic water use.
Shade Scenarios			
3	50-foot buffer	Transform all vegetation communities, with the exception of hydrophytic shrubs, roads, and railroads to **medium density trees** within 50 feet of the streambanks. Existing conditions vegetation to be retained beyond the 50-foot buffer.	Represent application of conservation practices for riparian vegetation.
Water Use and Shade Scenario			
4	Improved Flow and Shade	Existing conditions with critical flow (scenario1), reduced withdrawals (scenario 2), and a 50-foot buffer (scenario 3)	Represent application of conservation practices for water withdrawals and riparian vegetation.

G4.1 Critical Existing Condition Scenario (Baseline)

The critical existing conditions model (Scenario 1) serves as the baseline model simulation from which to construct the other scenarios and compare the results against. The calibrated model was modified to represent critical flow and meteorological conditions. The critical low flow was set at the 25th percentile using the long-term discharge record from USGS gage 12302055 – Fisher River near Libby MT as a surrogate for Wolf Creek. The observed flow for August 9th (the calibration month and day) was extracted from the daily flow time series for each year from 1968 through 2012. The observed flow on August 9, 2012 (i.e. the calibration date) was estimated to be the 77th percentile flow across all the years (at 184 cfs). The 25th percentile flow value for August 9th across the entire flow time-period was estimated to be 102 cfs (45 percent less than the calibration period flow). The flows in Wolf Creek (headwaters, tributaries and diffuse sources) were adjusted by reducing them by 45 percent to achieve the critical 25th percentile flow condition in Wolf Creek.

Meteorological conditions were established by calculating a critical meteorological condition using historical data from the Fisher River RAWS (TS259). These changes included adjusting the air temperature; dew point temperatures, wind speed, and cloud cover to represent critical conditions. The Fisher River RAWS has hourly data available for the period from July 27, 2004 to August 7, 2013. Since the weather data extends only for a period of eight years, a nearby station with long-term meteorological data (Kalispell Glacier Park International Airport [1988-2012]) was queried to confirm if the period from 2004 to 2013 were not anomalously warm or cold years and were similar to the overall historical normal. The monthly median and maximum air temperatures for the period from 2004 to 2012 were estimated to be similar to the overall period from 1988 through 2012, indicating that the period from 2004 through 2012 were not anomalous years (**Figure G-15**).

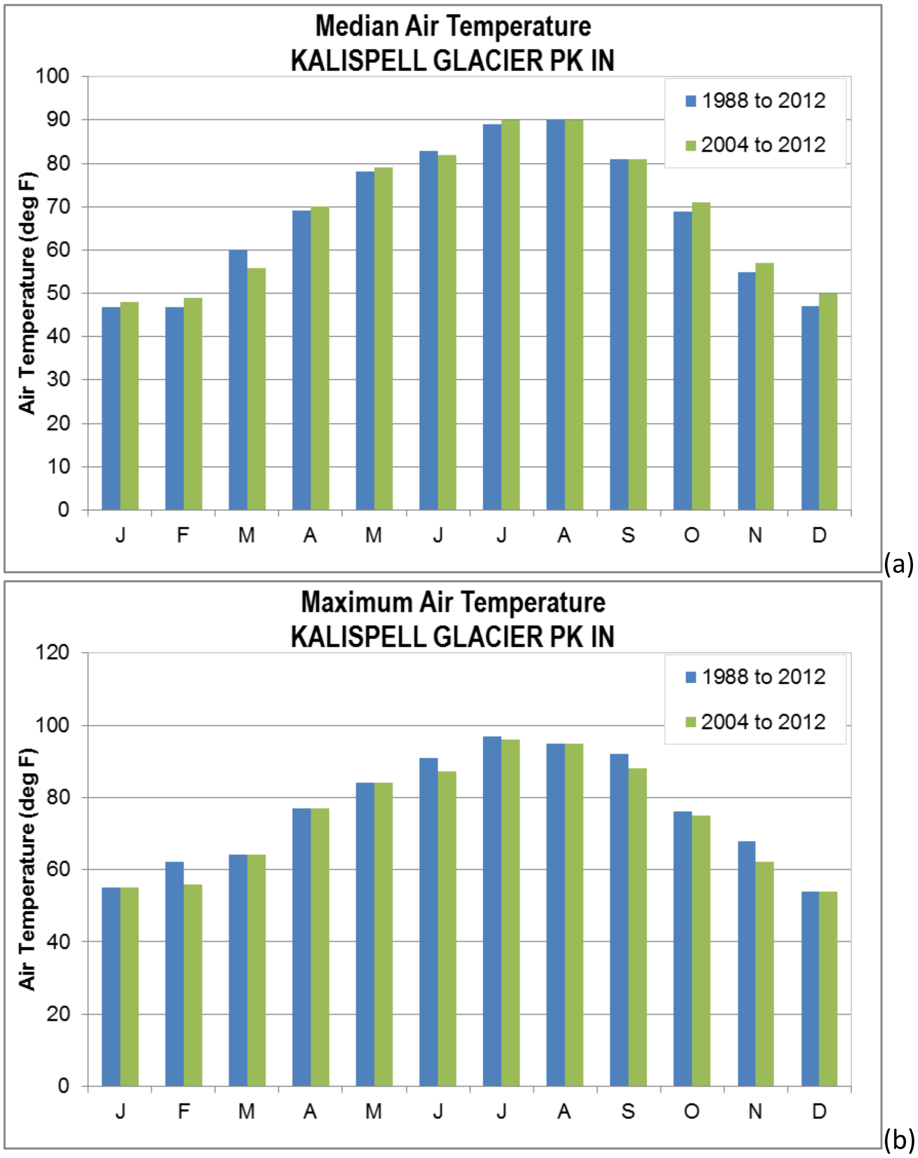


Figure G-15. Monthly air temperature at Kalispell Glacier Park International Airport.

This Fisher River RAWS data were then used to calculate the four day moving average of the daily maximum temperature. The 4-day duration for averaging was selected based on the travel time of the Wolf Creek QUAL2K model. The maximum of the four day maximum air temperature for each year was then calculated for the month of August. Using this dataset the median air temperature was then calculated across the years, which defined the critical temperature period. Once the critical temperature period was identified, the hourly air temperature, dew point temperature and wind data represented by the critical four day period were averaged to create an hourly data set to represent the critical meteorological conditions in the model. The cloud cover in the model was set to zero to represent clear sky conditions. The modeled water temperature using the critical flow and meteorological data is shown below in **Figure G-16**.

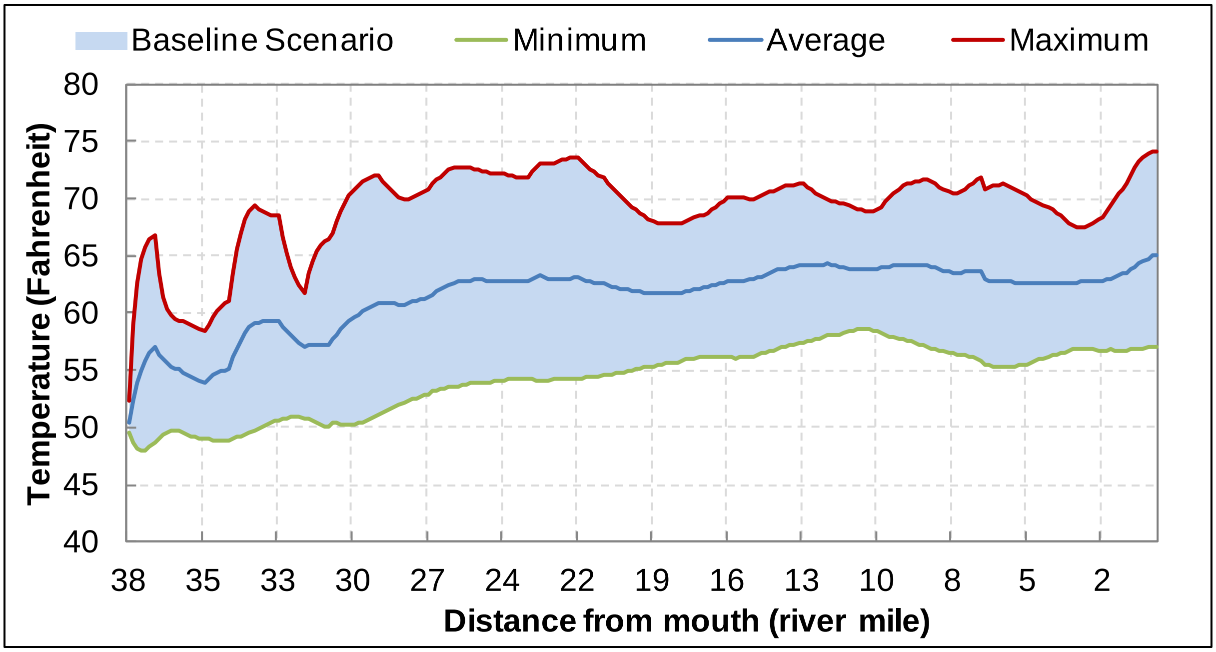


Figure G-16. Simulated water temperature for the existing condition (August 8. 2012).

G4.2 Water Use Scenario

Irrigation (or other water withdrawals) depletes the volume of water in the stream and reduces instream volumetric heat capacity. Theoretically the reduced stream water volume heats up more quickly, and to a higher temperature, given the same amount of thermal input. A single water use scenario was modeled to evaluate the potential benefits associated with application of water use best management practices (scenario 2).

In this scenario, the single irrigation withdrawal (see **Attachment G-1** for information regarding the withdrawal) in the QUAL2K model is reduced by 15 percent. The Natural Resources Conservation Service Irrigation Guide (Natural Resources Conservation Service, 1997) states that improving an existing irrigation system often increases water application efficiency by more than 30 percent and installing a new system typically adds an additional 5 percent to 10 percent savings. These improvements in efficiency could be used to grow different crops, expand production, or withdraw less water from the stream. Since leaving additional water instream could lower the maximum daily temperature, converting efficiency savings to a lower amount of water usage is the focus of this scenario. However, per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-705), so any voluntary water savings and subsequent instream flow augmentation must be done in a way that protects water rights. In the water use scenario, a 15 percent reduction in withdrawal volume was used to simulate the outcome of leaving some of the water saved by implementing improvements to the irrigation network instream. Fifteen percent was chosen to be a reasonable starting point, but as no detailed analysis was conducted of the irrigation network in the Wolf Creek watershed, this scenario is not a formal efficiency improvement goal; it is an example intended to represent application of water conservation practices for water withdrawals.

The water temperatures for Wolf Creek in this scenario exhibited a very small incremental change (**Figure G-17**). The maximum change in the maximum daily water temperature is representative of the worst case conditions. A maximum change in the maximum daily water temperature of 0.21°F from the critical existing condition was observed in the segment from river kilometer 36.6 to 36.4. The difference in water temperature was always less than 0.5° F, signifying minimal sensitivity and conditions that are similar to the critical existing condition.

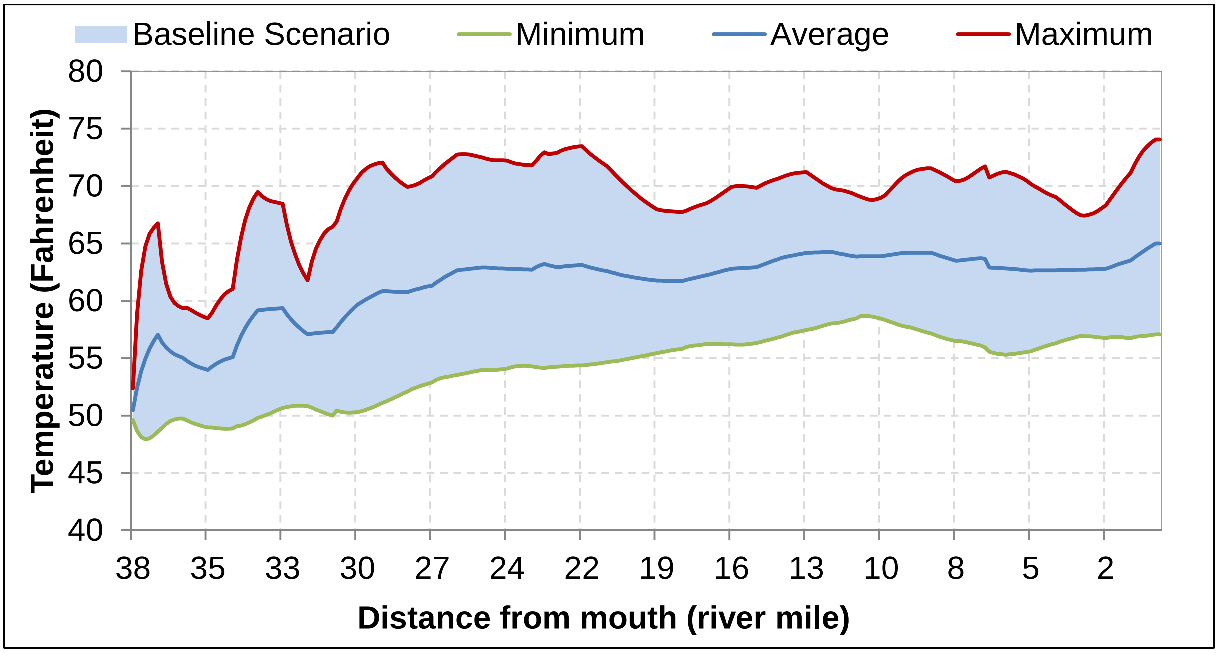


Figure G-17. Simulated water temperatures for the critical existing critical condition (scenario 1) and 15-percent withdrawal reduction (scenario 2).

G4.3 Shade Scenario

The riparian plant community blocks incoming solar radiation, which directly reduces the heat load to the stream. A single shade scenario was modeled to evaluate the potential benefits associated with increased shade within a 50-foot buffer along Wolf Creek.

The 50-foot buffer scenario consists of the critical existing condition scenario with a 50-foot buffer along the stream channel where vegetation is allowed to grow naturally. All vegetation communities (with the exception of areas with hydrophytic shrubs, roads, and railroads) are transformed to medium density trees within 50 feet of the streambanks. Beyond 50 feet, existing condition vegetation remains. The Shade Model was re-run using this vegetation configuration (**Figure G-18**). The 50-foot buffer was selected to be generally consistent with Montana's Streamside Management Zone Law, which limits clearcutting within 50 feet of the ordinary high water mark in order to provide large woody debris, stream shading, water filtering effects, and to protect stream channels and banks. This scenario is intended to represent application of conservation practices relative to shade.

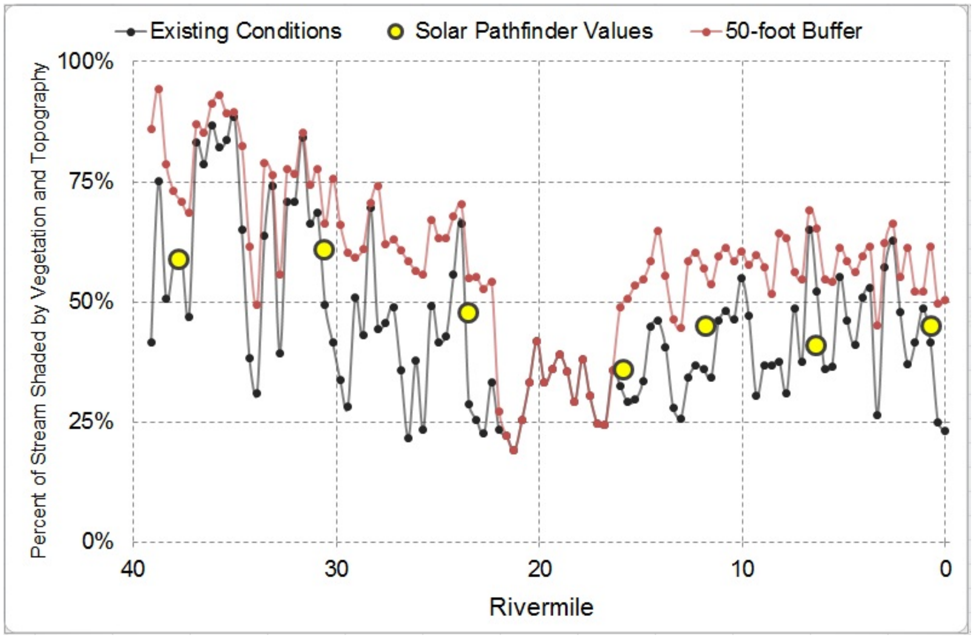


Figure G-18. Effective shading along Wolf Creek for the critical existing condition and 50-foot buffer shade scenario.

The water temperatures for Wolf Creek in this scenario decrease throughout the system (**Figure G-19**). The impact in the middle of the system (i.e., approximately river miles 15.5 to 16.8) showed the least impact due to shade. The change in shade was minimal because this area is dominated by hydrophytic shrubs, which are already considered to be at their maximum site potential and hence were not changed from the existing condition. A maximum change in the maximum daily water temperature of 7.82° F from the critical existing condition was observed at river mile 29.9. The difference in the daily maximum water temperature between the critical existing condition and maximum potential shade scenario was always greater than 0.5° F.

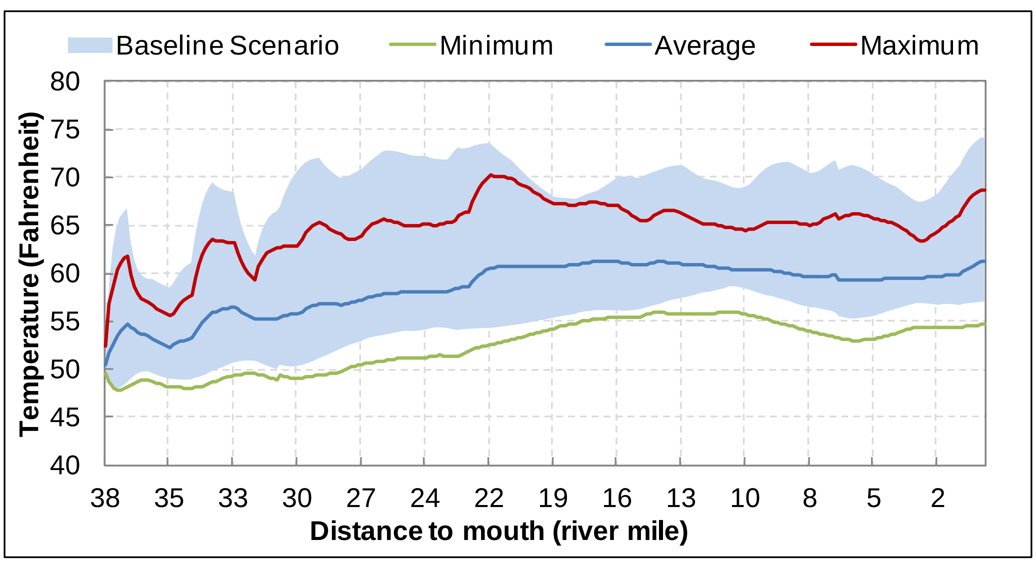


Figure G-19. Simulated water temperatures for the critical existing condition (scenario 1) and shade with 50 feet buffer (scenario 3).

G4.4 Improved Flow and Shade Scenario

The improved flow and shade scenario (scenario 4) combines the potential benefits associated with a 15 percent reduction in water withdrawals (scenario 2) with a 50-foot vegetated buffer (Scenario 3). The water temperatures for Wolf Creek in this scenario decrease throughout the system (**Figure G-20** and **Figure G-21**). A maximum change in the maximum daily water temperature of 7.82° F from the critical existing condition was observed at river mile 29.9.

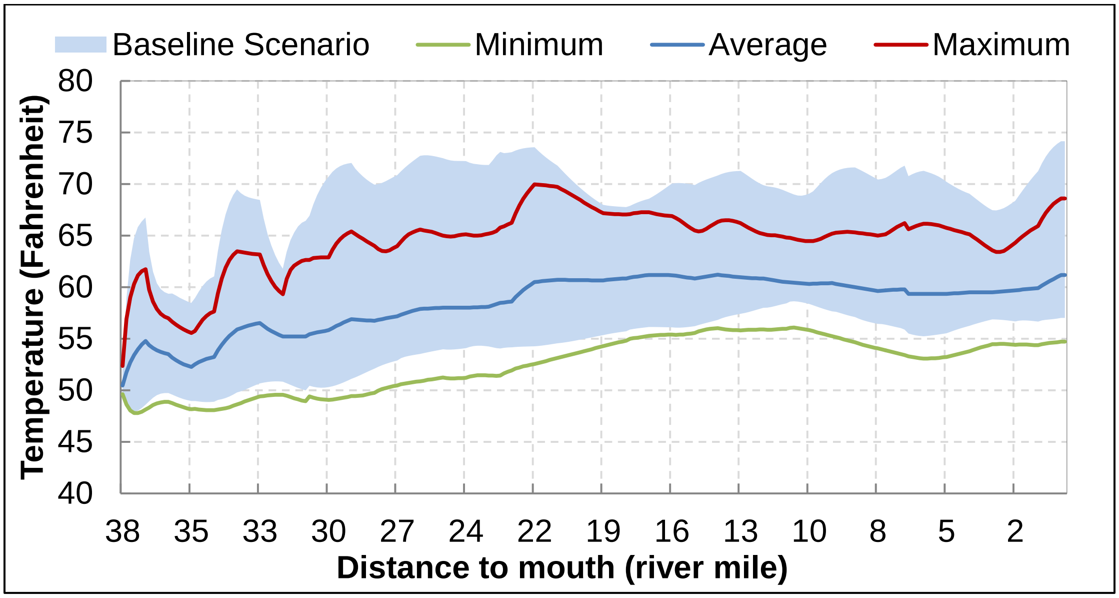


Figure G-20. Simulated water temperature for the critical existing condition (scenario 1) and the improved flow and shade scenario (scenario 4).

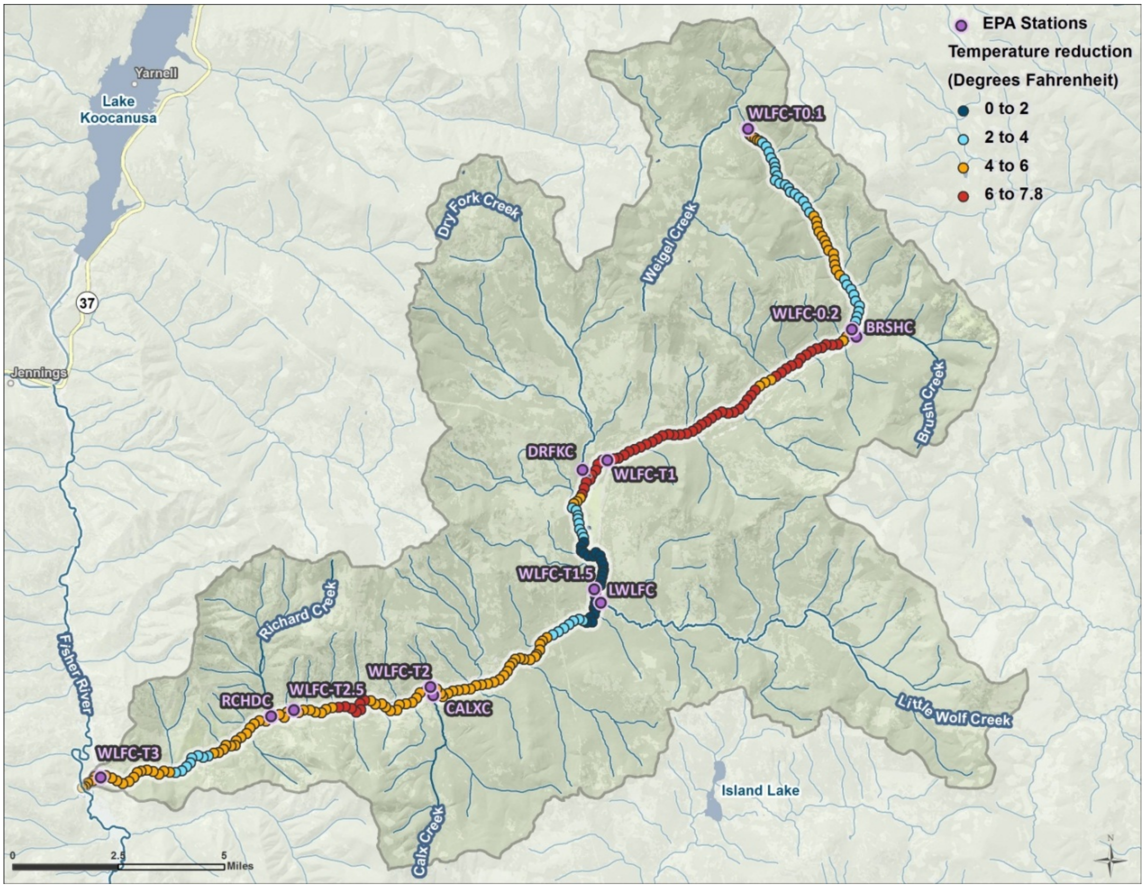


Figure G-21. Instream temperature difference from critical existing condition (scenario 1) to the improved flow and shade scenario (scenario 4).

G5.0 Assumptions and Uncertainty

As with any model, the QUAL2K model is subject to uncertainty. The major sources of model uncertainty include the mathematical formulation, input and boundary conditions data uncertainty, calibration data uncertainty, and parameter specification (Tetra Tech, Inc., 2012). As discussed in the QAPP (Tetra Tech, Inc., 2012), the QUAL2K model code has a long history of testing and application, so outright errors in the coding of the temperature model is unlikely. The Shade Model has also been widely used so a similar sentiment exists. A potentially significant amount of the overall prediction uncertainty is due to uncertainty in the observed data used for model setup, calibration, and validation.

The secondary data used during model setup included instantaneous flow, continuous temperature, channel geometry, hourly weather, and spatial data. Weather and spatial data were obtained from other government agencies, the values seemed reasonable, and the data are therefore assumed to be accurate. Uncertainty was minimized for the use of other secondary data following procedures described in the QAPP (Tetra Tech, Inc., 2012).

In addition to uncertainty associated with secondary datasets, assumptions regarding how the secondary data are used during model development contain uncertainty. The following key assumptions were used during model development:

- Wolf Creek can be divided into distinct segments, each considered homogeneous for shade, flow, and channel geometry characteristics. Monitoring sites at discrete locations were selected to be representative of segments of Wolf Creek.
- Stream meander and hyporheic flow paths (both of which may affect depth-velocity and temperature) are inherently represented during the estimation of various parameters (e.g., stream slope, channel geometry, and Manning's roughness coefficient) for each segment.
- Weather conditions at the Fisher River RAWS, which were elevation-corrected, are representative of local weather conditions along Wolf Creek.
- Shade Model results are representative of riparian shading along segments of Wolf Creek. Shade Model development relied upon the following three estimations of riparian vegetation characteristics:
    - Riparian vegetation communities were identified from visual interpretation of aerial imagery.
    - Tree height and percent overhang were estimated from other similar studies conducted outside of the Wolf Creek watershed.
    - Vegetation density was estimated using the NLCD and best professional judgment.

  Shade Model results were corroborated with field measured Solar Pathfinder™ results and were found to be reasonable. The average absolute mean error is 7 percent. (i.e., the average error from the Shade Model output and Solar Pathfinder™ measurements was 7 percent daily average shade).
- All of the cropland associated with water rights is fully irrigated. No field measurements of irrigation withdrawals or returns were available.
- Simulated diffuse flow rates are representative of groundwater inflow/outflow, irrigation diversion, irrigation return flow, and other sources of inflow and outflow not explicitly modeled. Diffuse flow rates were estimated using flow mass balance equations for each model reach.
- Shallow groundwater temperature is approximately 57.2° F (as the model was calibrated and validated), which were derived, in part, from the average of mean daily air temperatures from the preceding three months (May, June, and July).

Sensitivity analysis is the most widely applied approach for evaluating parameter uncertainty for complex simulation models. Although sensitivity analysis is limited in its ability to evaluate nonlinear interactions among multiple parameters, model sensitivity was evaluated by making changes to shade and water use (i.e., the key thermal mechanisms (Tetra Tech, Inc., 2012)) in separate model runs and evaluating the model response.

> Model Sensitivity to Water Withdrawals and Shade
>
> *Model sensitivity to water withdrawal and shade was further evaluated by varying the amounts of water withdrawn and shade and re-running the model. To assess model sensitivity to water withdrawals, the point source abstractions representing the withdrawals (see* ***Attachment G-1*** *for the withdrawals) were removed and the existing condition model was run to represent the maximum achievable change in water temperatures from changes in water use. To assess model sensitivity to shade, all vegetation was converted to high density trees (with the exception of roads, railroads, and hydrophytic shrubs) to represent the maximum potential shade. While not likely feasible, these conditions were run to assess model sensitivity. The results suggest that the model is not very sensitive to changes in water use but is sensitive to changes in shade.*

The increased shade scenario (scenario 3) assumes that the system potential vegetation for the riparian area within 50 feet of the streambank is medium density trees (i.e., with the exception of areas currently dominated by hydrophytic shrubs or areas such as roads or railroads that no longer have the potential to support vegetation). The increased shade scenario (scenario 3) represents the maximum temperature benefit that could be achieved over a time period long enough to allow vegetation to mature (tens of years). Therefore, temperature improvements in the short term are likely to be less than those identified in the scenario 3 results. Natural events such as flood and fire may also alter the maximum potential for the riparian vegetation or shift the time needed to achieve the maximum potential. This condition may not be achievable for all areas due to the coarse scale used to identify the current and potential shade conditions.

G6.0 Model Use and Limitations

The model is only valid for summertime, low flow conditions and should not be used to evaluate high flow or other conditions. As described above, steps were taken to minimize uncertainty as much as possible. Despite the uncertainty, the model adequately addresses the primary questions:

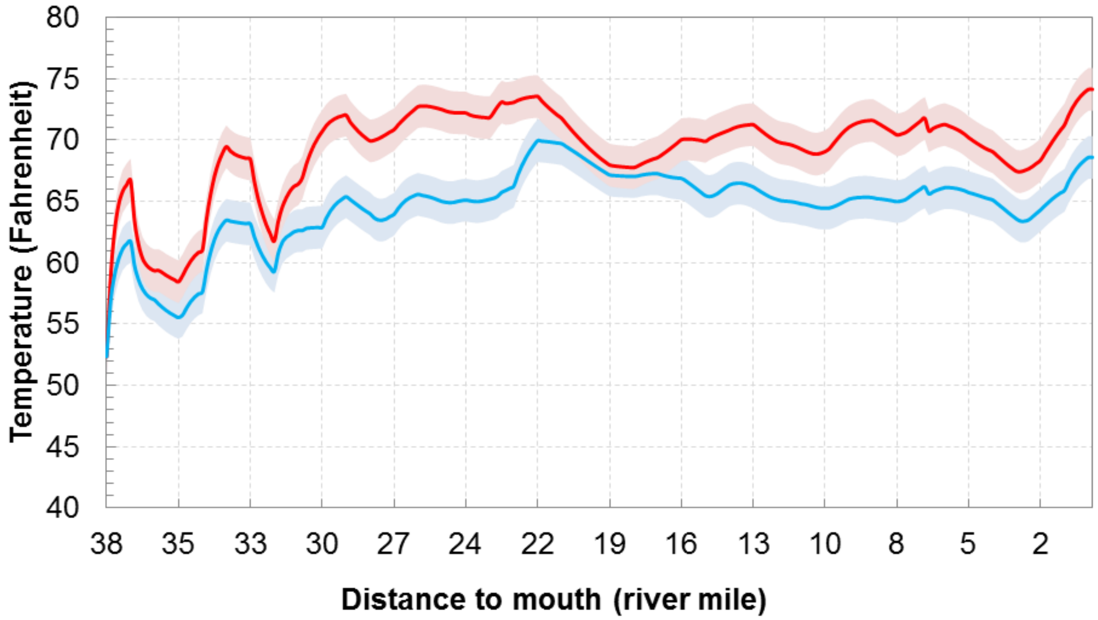
1. What is the sensitivity of instream temperature to the following thermal mechanisms and stressors: shade, irrigation withdrawal and return?
2. What levels of reductions in controllable stressors are needed to achieve temperature standards?

The first principal study question can be answered using the calibrated and validated QUAL2K model for Wolf Creek. As previously discussed, Wolf Creek is sensitive to shade.

The second principal study questions can be answered using the calibrated QUAL2K model and the scenarios developed to assess shade. Increasing riparian shading will decrease instream temperatures; however, there is uncertainty in the magnitude of temperature reduction necessary to achieve the temperature standard caused by uncertainty in the Shade Model results and QUAL2K model results. While a “good” model calibration was achieved, the overall Absolute Mean Error (AME) for the maximum daily temperature was 1.7° F.

Montana’s temperature standard as applied to Wolf Creek is limited to an increase of 1° F. The model results, therefore, should be used with caution relative to the second primary question. However, in spite of the uncertainty, the magnitude of difference between the maximum daily temperatures under scenarios 1 and 4 is greater than the AME for most of the length of Wolf Creek (**Figure G-22**). This suggests that, on average[5], a reduction of 4.6°F (range: 0.7° F to 7.8° F) is necessary to achieve the temperature standard in Wolf Creek.

[5] Spatial average of the QUAL2K output at each element along the entire length of Wolf Creek.



Note: The critical existing condition (scenario 1) is the red line and the improved flow and shade (scenario 4) is the blue line. The shaded areas are plus or minus the average AME (1.7° F).

Figure G-22. Simulated daily maximum water temperatures from the critical existing condition (red; scenario 1) and improved flow and shade scenario (blue; scenario 4).

G7.0 CONCLUSIONS

A difference of more than 0.5°F between existing conditions and the improved flow and shade scenario (scenario 4) was determined to be significant and indicative of impairment using the state temperature standard. The scenarios resulted in a range of almost no change in water temperatures to considerable reductions. Some of the reductions in water temperatures were localized and others affected nearly the entire reach.

Scenarios were constructed to evaluate the reduction of water withdrawals (e.g., through increased irrigation efficiency) and the restoration of riparian vegetation upon instream temperatures. The 15-percent reductions in water use did not result in any appreciable reduction to the temperature with a maximum change of 0.2° F. The 50-foot buffer scenario that represents a more realistic representation of potential shade improvements showed reductions in temperature ranging from 0.6 ° F to 7.8° F.
The improved flow and shade scenario (scenario 4) that combined the potential benefits associated with a 15 percent reduction in water withdrawals (scenario 2) with a 50-foot vegetated buffer (scenario 3) to represent application of conservation practices was also simulated. This scenario resulted in overall reductions along the entire reach which ranged from 0.7 ° F to 7.8 ° F. The scenario shows that significant reductions in water temperatures are achievable throughout the reach (**Figure G-23**). The areas with the greatest changes demonstrate the most sensitive areas. The greatest potential improvement (i.e., reduction) occurs near river miles 23.6 to 29.8 (about an 8° F improvement) with several other areas upstream and downstream along the system also showing sensitivity to shade (**Figure G-24**). The reach between river miles 15.5 and 23.6 shows the least impact due to the presence of hydrophytic shrubs, which are considered to be at their maximum site potential.

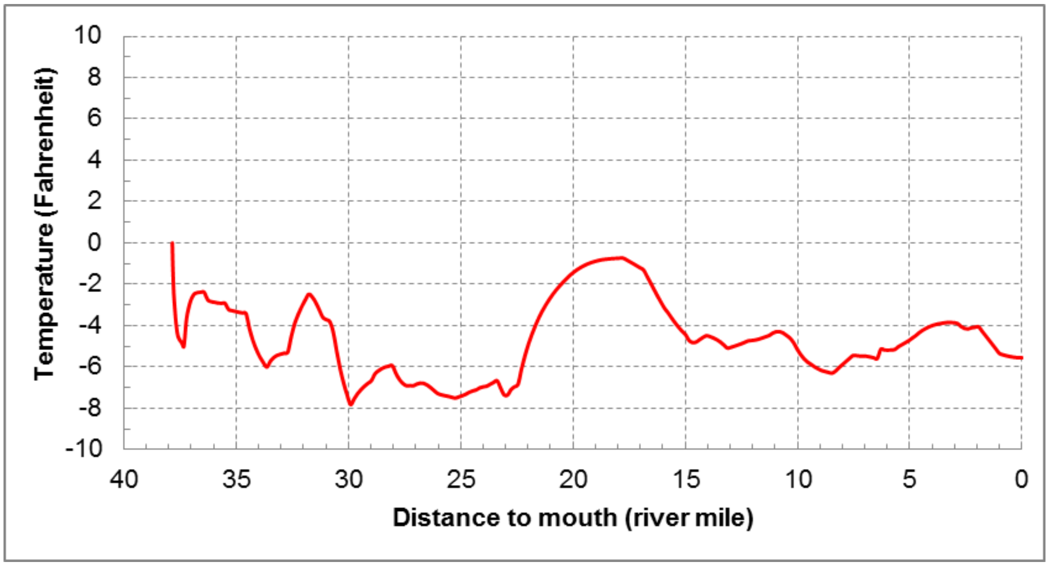


Figure G-23. Simulated water temperature reduction from the critical existing condition (scenario 1) to the improved flow and shade scenario (scenario 4).

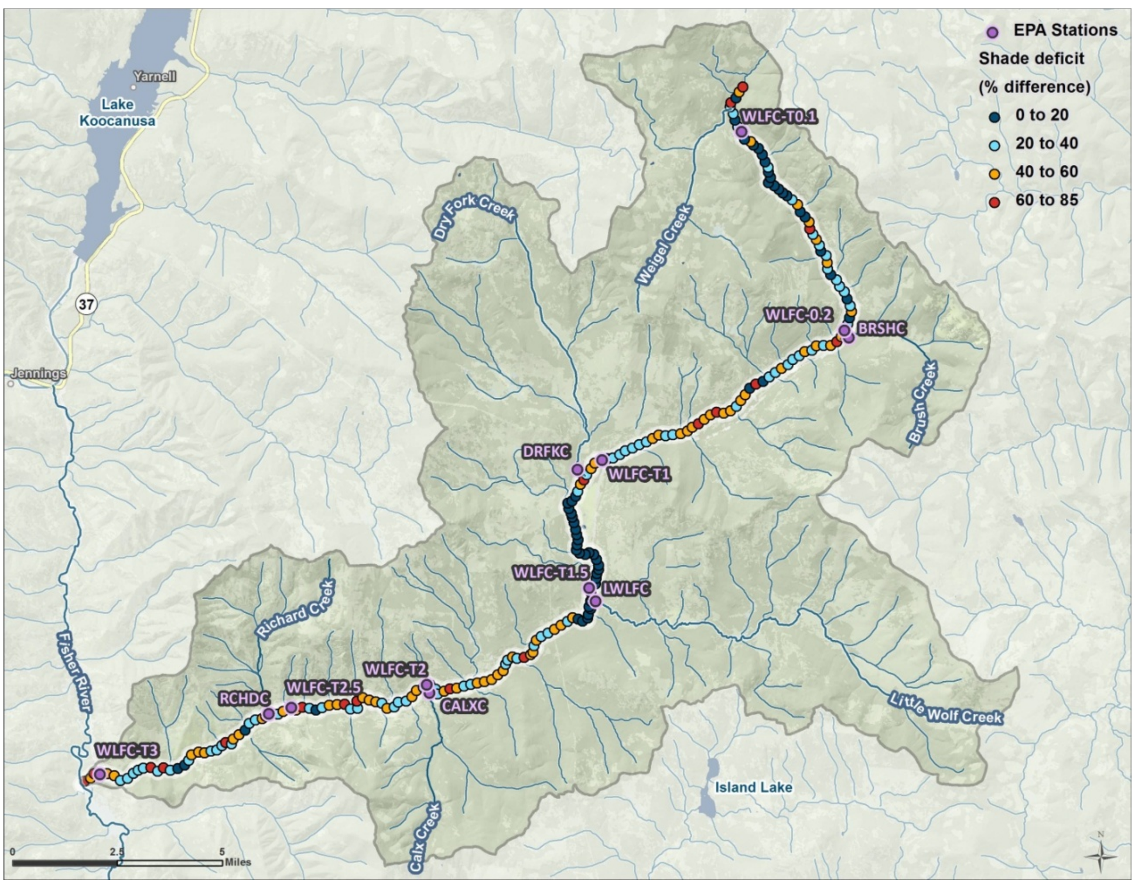


Figure G-24. Shade deficit of the critical existing condition (scenario 1) from the improved flow and shade scenario (scenario 4).

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Attachment G-1 - Factors Potentially Influencing Stream Temperature in Wolf Creek

G1-1.0 Introduction

Stream temperature regimes are influenced by processes that are external to the stream as well as processes that occur within the stream and its associated riparian zone (Poole et al., 2001). Examples of factors external to the stream that can affect instream water temperatures include: topographic shade, land use/land cover (e.g., vegetation and the shading it provides, impervious surfaces), solar angle, meteorological conditions (e.g., precipitation, air temperature, cloud cover, relative humidity), groundwater exchange and temperature, and tributary inflow temperatures and volumes. The shape of the channel can also affect the temperature—wide shallow channels are more easily heated and cooled than deep, narrow channels. The amount of water in the stream is another factor influencing stream temperature regimes. Streams that carry large amounts of water resist heating and cooling, whereas temperature in small streams (or reduced flows) can be changed more easily.
The following factors that may have an influence on stream temperatures in Wolf Creek are discussed below:

- Local/regional climate
- Land ownership
- Land use
- Riparian vegetation
- Shade
- Hydrology
- Point sources

G1-2.0 Climate

The nearest weather station to the Wolf Creek watershed is the Hand Creek SNOpack TELemetry (SNOTEL) station (USS0014A14S, HANM8) (**Figure G1-1**). Average annual precipitation is 30.8 inches with the greatest amounts falling in June and November (**Figure G1-2**). Average maximum temperatures occur in July and August and are 74.8 °F and 74.7°F, respectively. It should be noted that the Hand Creek weather station is located at an elevation of 5,032 feet above mean sea level (MSL), compared to the impaired reach of Wolf Creek that ranges in elevation from approximately 2,500 to 3,740 feet above MSL.

A Remote Automatic Weather Station (RAWS) named Fisher River (National Weather Service station ID 240118, RAWS ID: TS259) at 2,600 feet above MSL is 8 miles north of the mouth of Wolf Creek (**Figure G1-2**). This station records weather data hourly whereas stations US0014A14S record weather data daily. Thus, Fisher River RAWS hourly temperature data will be used to develop the QUAL2K inputs.

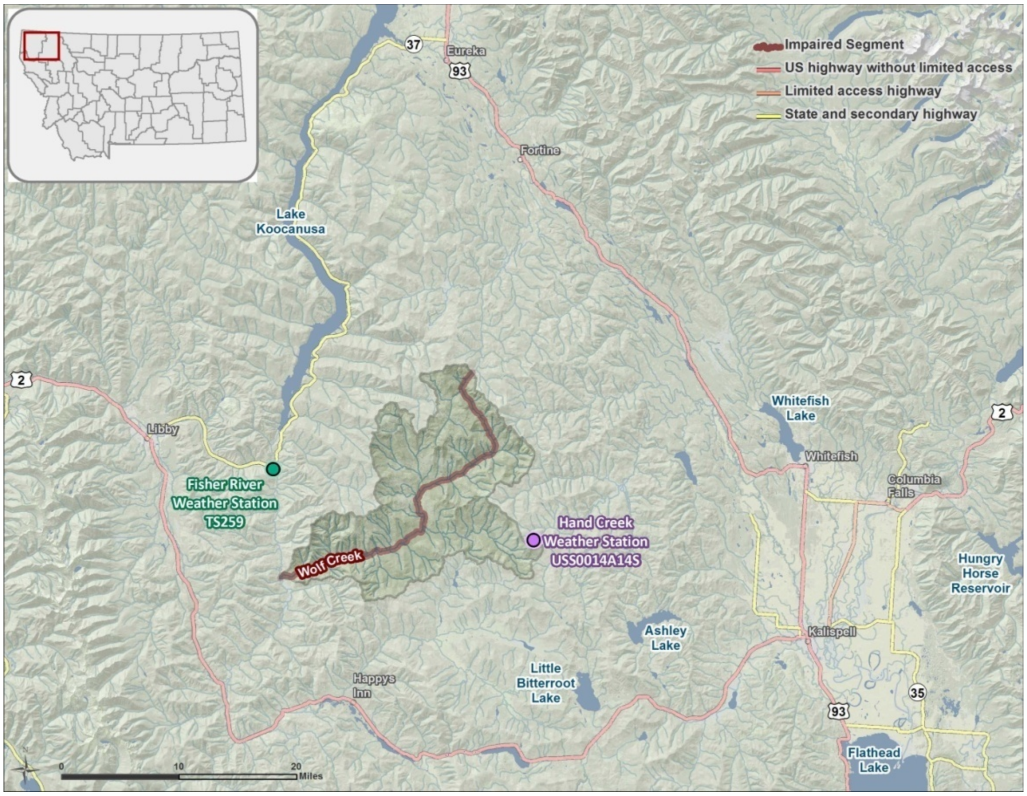
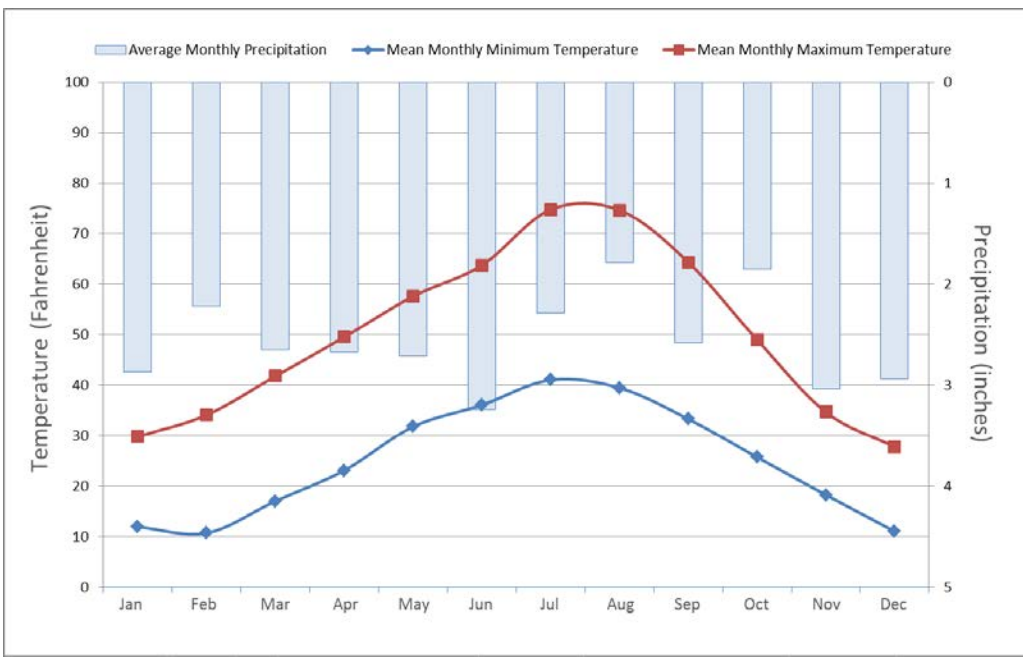


Figure G1-1. Location of Wolf Creek watershed and nearby weather stations.

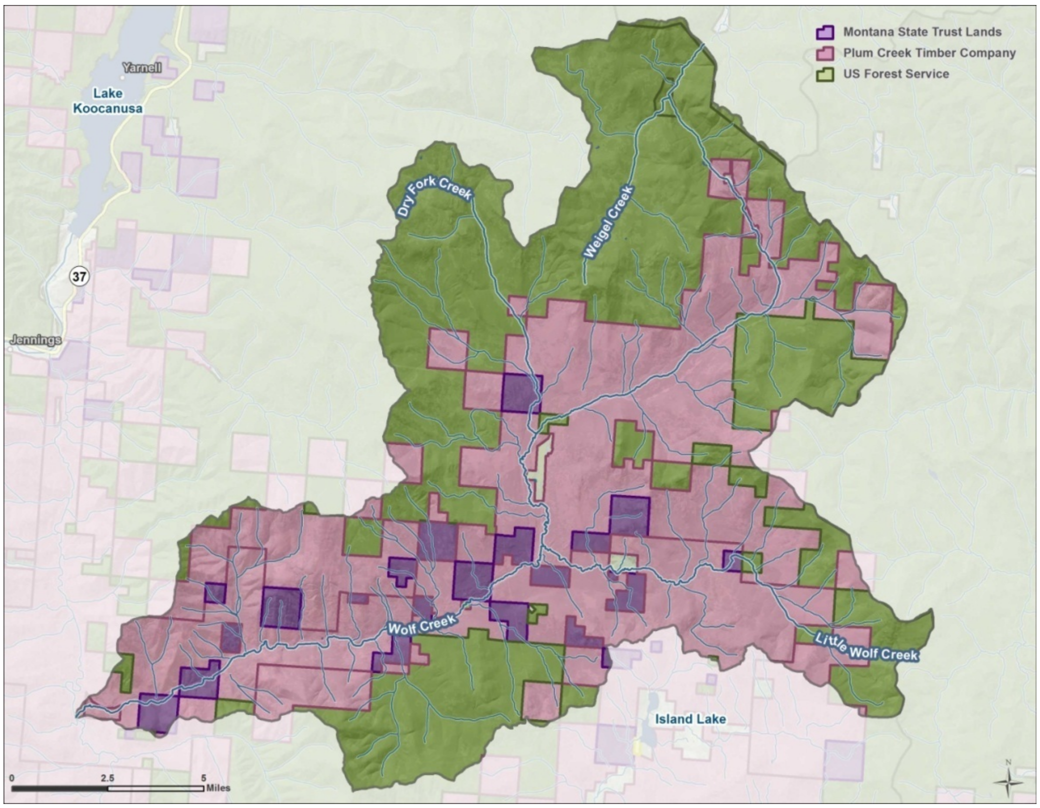


Source: GHCN-D Monthly Summaries from 1979 to 2012 at Station USS0014A14S (NCDC)

Figure G1-2. Monthly average temperatures and precipitation at Hand Creek Weather Station.

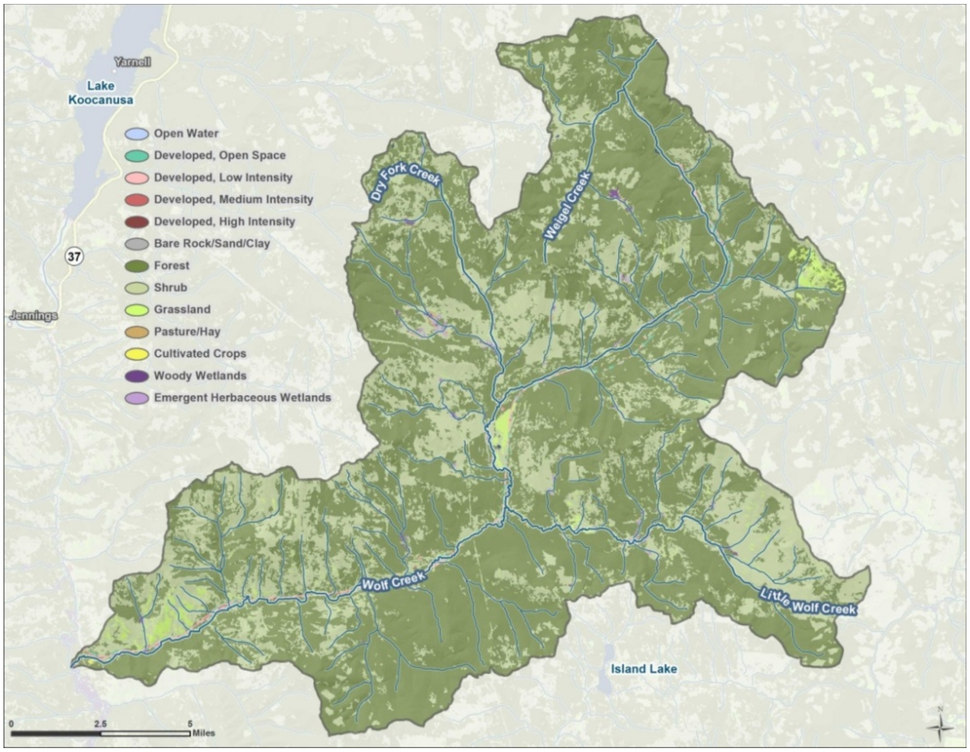
G1-3.0 LAND OWNERSHIP AND LAND USE

Plum Creek Timber Company and the U.S. Forest Service are the primary land owners in the watershed (**Figure G1-3**) . The landscape is typical of timber harvest conditions, with patches of mature forest interspersed with selective harvests and clearcuts at various stages of regrowth (**Figure G1-4** and **Figure G1-5**). Forest roads are located throughout the watershed and a railroad runs along the mainstem of Wolf Creek.



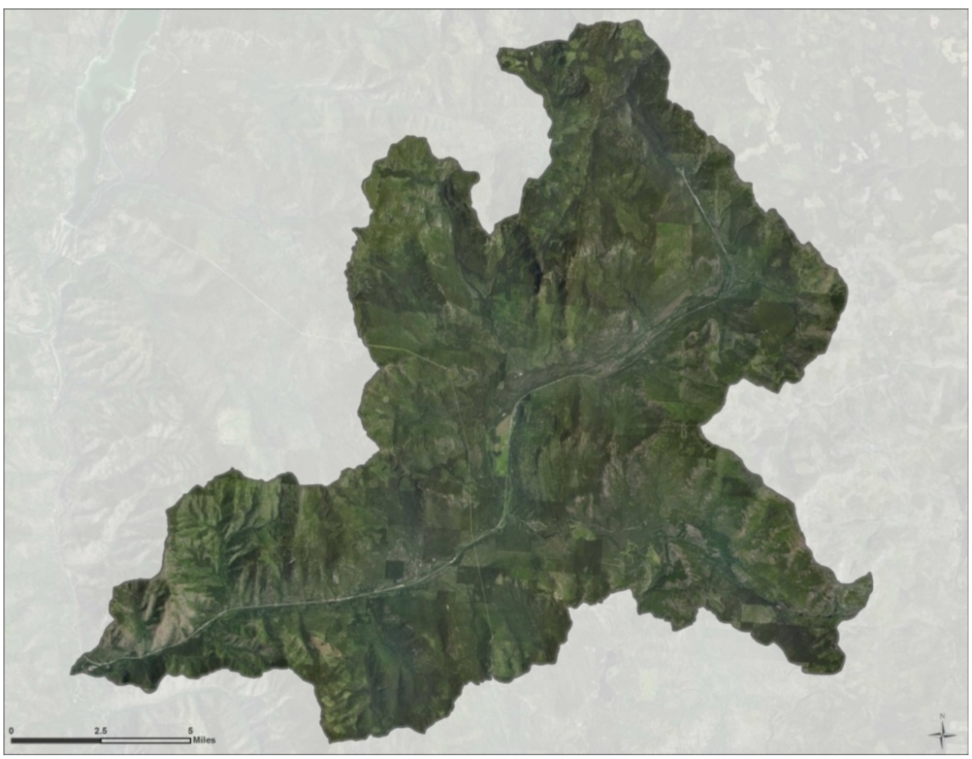
Source of land ownership: NRIS 2012.

Figure G1-3. Land ownership in the Wolf Creek watershed.



Source of land cover: 2006 National Land Cover Dataset (Multi-Resolution Land Characteristics Consortium, 2006).

Figure G1-4. Land cover and land use in the Wolf Creek watershed.



Source of aerial Imagery: 2009 NAIP (NRIS 2012).

Figure G1-5. Aerial imagery of the Wolf Creek watershed.

G1-4.0 Existing Riparian Vegetation

Vegetation communities between the shade monitoring sites were visually characterized based on aerial imagery (Google Earth, 2012) with qualitative field verification conducted during a September 11, 2012 shade monitoring event. Observed vegetative communities within 150 feet of the stream centerline were classified as trees, shrubs, herbaceous. Areas without vegetation, such as bare earth or roads, were also identified. Trees were further divided into the following classes based on percent canopy cover derived from the 2001 NLCD (**Figure G1-6**):

- High density (75 to 100 percent cover)
- Medium density (51 to 74 percent cover)
- Low density (25 to 50 percent cover)
- Sparse density (less than 24 percent cover)

Herbaceous and shrubs are the most common cover types along Wolf Creek, followed by medium and high density trees (**Table G1-1**). Sparse trees, roads, and bare ground comprise only a small percentage of the riparian area.

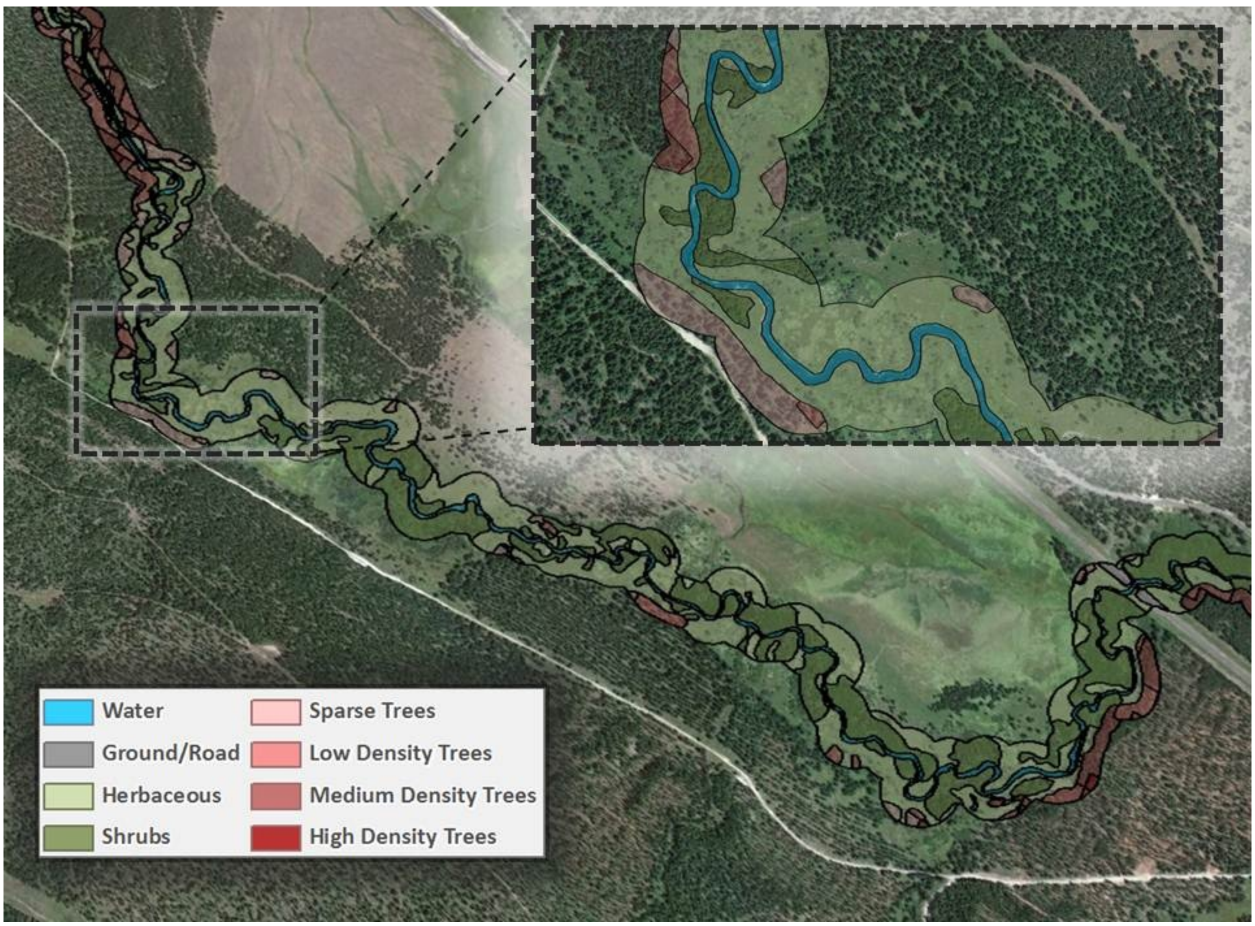


Figure G1-6. Vegetation mapping example for Wolf Creek.

Table G1-1. Land cover types in the Wolf Creek riparian zone

Land cover type	Area Within 150ft buffer (acres)	Relative area Within 150ft buffer (percent)	Relative area Within 50ft buffer (percent)
Bare ground/road	82.4	6.0%	3.4%
Herbaceous	351.9	25.6%	27.9%
Shrub	276.0	20.0%	34.2%
Sparse trees	84.1	6.1%	2.6%
Low density trees	144.2	10.5%	5.9%
Medium density trees	262.2	19.0%	16.6%
High density trees	176.4	12.8%	9.4%

G1-5.0 Shade

Shade is one of several factors that control instream water temperatures. Shade is defined as the fraction of potential solar radiation that is blocked by topography and vegetation.

G1-5.1 Measured Shade

DEQ and Tetra Tech collected shade characterization data on September 11, 2012, at seven monitoring locations along Wolf Creek using a Solar Pathfinder^{TM} (**Figure G1-7**). The data are summarized in **Table G1-2**. Field notes and hourly shade estimates based on the Solar Pathfinder^{TM} measurements are available by request from DEQ or EPA but are not attached to this document due to file size.

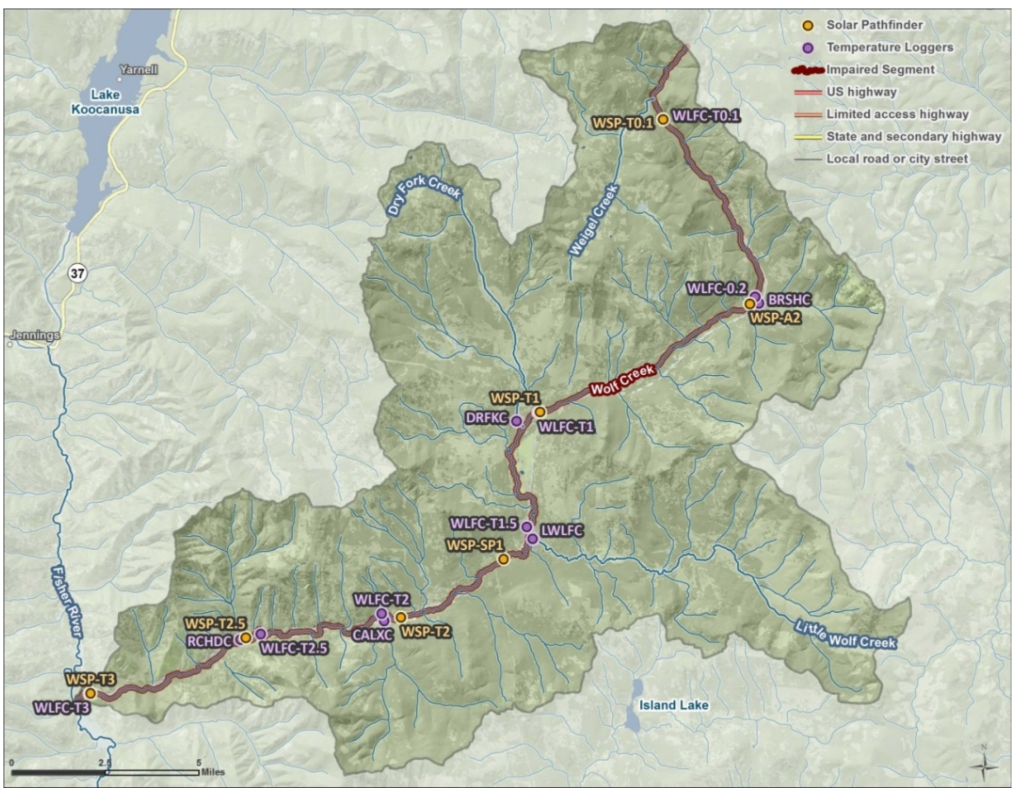


Figure G1-7. EPA flow, shade, and continuous temperature monitoring locations.

Table G1-2. Average shade per reach from Solar Pathfinder™ measurements

Site ID	Average daily shade (averaged across daylight hours)
WSP-T0.1	59%
WSP-A2	61%
WSP-T1	48%
WSP-T1.5	20%
WSP-T2	45%
WSP-T2.5	41%
WSP-SP1	36%
WSP-T3	45%

G1-5.2 SHADE MODELING

An analysis of aerial imagery and field reconnaissance showed that shading along Wolf Creek was highly variable. Therefore, shade was also evaluated using the spreadsheet Shadev3.0.xls. Shade version 3.0 is a riparian vegetation and topography model that computes the hourly effective shade for a single day (Stuart, 2012). Shade is an Excel/Visual Basic for Applications program. The model uses the latitude and longitude, day of year, aspect and gradient (the direction and slope of the stream), solar path, buffer width, canopy cover, and vegetation height to compute hourly, dawn-to-dusk shade. The model input variables include channel orientation, wetted width, bankfull width, channel incision, topography, and canopy cover. Bankfull width in the shade calculations is defined as the near-stream disturbance zone (NSDZ), which is the distance between the edge of the first vegetation zone on the left and right bank.

G1-5.2.1 Available Data

The application of the Shade Model to Wolf Creek relied upon field data collected during a 2012 field study and the interpretation of these data. The results of the study included: tree/shrub height, overhang, wetted channel width, and bankfull width.

G1-5.2.2 GIS Pre-Processing

TTools version 3.0 is an ArcView extension to translate spatial data into Shade Model inputs (Oregon Department of Environmental Quality, 2001). TTools was used to estimate the following values: elevation, aspect, gradient, distance from the stream center to the left bank, and topographic shade. Elevation was calculated using a 10 meter (33 foot) digital elevation model (DEM) and a stream centerline file digitized from aerial imagery in GoogleEarth™. Aspect was calculated to the nearest degree using TTools with the stream centerline file.

Although the field study report provided an estimate of the wetted width, an assessment along the entire stream was obtained by digitizing both the right and left banks from aerial imagery in GoogleEarth™. TTools then calculates wetted width based on the distance between the stream centerline and the left and right banks. Topographic shade was calculated using TTools with the stream centerline file and a DEM.

G1-5.2.3 Riparian Input

The Shade Model requires the description of riparian vegetation: a unique vegetation code, height, density, and overhang (OH). The results in the field study report and the above described vegetation mapping were used to develop a riparian description table (**Table G1-3**). Vegetation descriptions used the average value for tree/shrub height and overhang from field observation.

Table G1-3. Vegetation input values for the Shade Model

Attribute	Value	Basis
Trees		
Height	20.9 meters (69 feet)	Average of field values across all Solar Pathfinder™ sites.
Density	Variable	2006 NLCD.
Overhang	2.1 meters (6.9 feet)	Estimated as 10% of height (Stuart 2012).
Shrubs		
Height	4.9 meters (16 feet)	Average of field values across all Solar Pathfinder™ sites.
Density	90%	Ocular estimate based on aerial imagery.
Overhang	1.2 meter (3.9 feet)	Estimated as 25% of height (Shumar and de Varona 2009)
Herbaceous		
Height	1 meter (3.3 feet)	Estimated average based on site reconnaissance (September 2012).
Density	100%	Estimated average based on site reconnaissance (September 2012).
Overhang	0 meters	Estimated based on site reconnaissance (September 2012).

G1-5.2.4 Shade Input

The Shade Model inputs are riparian zones, reach length, channel incision, elevation, aspect, wetted width, near-stream disturbance zone width, distance from the bank to the center of the stream, and topographic shade. Input for the riparian zone is presented above in **Table G1-3**. The Shade Model requires reach lengths be an equal interval. The reaches in the field study report were not at an equal interval and were very widely spaced. A uniform reach length interval of 30 meters (98 feet) was used. Channel incision was estimated from an examination of field photos. Incision is the vertical drop from the bankfull edge to the water surface, and was estimated at 0.3 meter (1 foot). The remaining variables were computed as part of the GIS pre-processing described above.

G1-5.3 Shade Model Results

The current longitudinal effective shade profile generated from the Shade Model and the Solar Pathfinder™ measurements are presented in **Figure G1-8**.

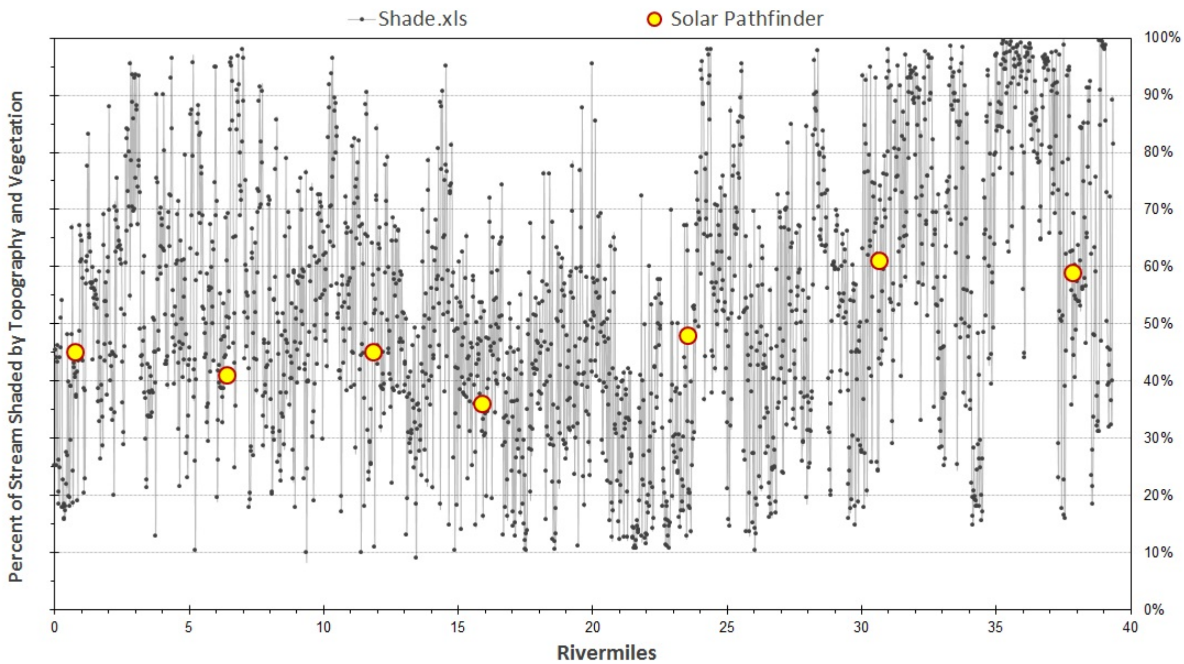


Figure G1-8. Longitudinal estimates of observed and simulated effective shade along Wolf Creek.

The goodness of fit for the Shade Model was summarized using the mean error (ME), average absolute mean error (AME), and root mean square error (RMSE) as a measure of the deviation of model-predicted shade values from the measured values. These model performance measures were calculated as follows:

$$ME = \frac{1}{N}\sum_{n=1}^{n} P_n - O_n$$

$$AME = \frac{1}{N}\sum_{n=1}^{n} \left|P_n - O_n\right|$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{n=1}^{n} \left(P_n - O_n\right)^2}$$

where

P = model predicted values
O = observed values
n = number of samples

Model error statistics are provided in **Table G1-4** and suggest a good fit between observed and predicted average effective shade values. The average absolute mean error is 10 percent. (i.e., the average error from the Shade Model output and Solar Pathfinder™ measurements was 10 percent daily average shade; see **Table G1-4**).

Table G1-4. Shade model error statistics

Error Statistic	Formula	Result	Units
Mean Error (ME)	$(1/N)*\Sigma(P_n-O_n)$	3%	percent of percent shade
Average Absolute Mean Error (AME)	$(1/N)*\Sigma\|(P_n-O_n)\|$	7%	percent shade
Root Mean Square Error (RMSE)	$[(1/N)*\Sigma(P_n-O_n)^2]^{1/2}$	8%	percent of percent shade

G1-6.0 HYDROLOGY

No active U.S. Geological Survey (USGS) continuously recording gages are located on Wolf Creek. USGS gage 12301999 (Wolf Creek near Libby, MT) on Wolf Creek at Fisher River Road operated from water years 1968 through 1977. EPA collected instantaneous flow measurements in 2012, during temperature data logger deployment and retrieval (**Table G1-5** and **Table G1-6**). DEQ observed that Wolf Creek was dry on September 27, 2006 at site K02WOLFC02, which is near site WLFC-T0.1 that was dry on September 19, 2012. Flow data were collected by EPA in support of other water qualities studies in 2010 (**Table G1-7**); data show that Wolf Creek had less flow in 2010 and the changes in flow between sites were similar to those in 2012. Locations of the flow measurements are shown in **Figure G1-9**.

Table G1-5. EPA instantaneous flow measurements (cfs) on Wolf Creek in support of modeling

Date	WLFC-T0.1	WLFC-T0.2	WLFC-T1	WLFC-T1.5	WLFC-T2	WLFC-T2.5	WLFC-T3
July 13, 2012	4.61	13.61	19.91	37.59	36.20	38.78	42.91
August 9-10, 2012	0.28	4.13	5.11	14.34	13.79	15.60	17.62
September 17-19, 2012	dry	2.48	2.13	7.27	7.27	7.91	7.29

Table G1-6. EPA instantaneous flow measurements (cfs) on tributaries to Wolf Creek in support of modeling

Date	BRSHC	DRFKC	LWLFC	CALXC	RCHDC
June 26, 2012	27.29	21.06	29.51	3.04	6.22
August 9-10, 2012	0.52	dry	0.23	dry	1.35
September 17, 2012	0.17	dry	0.01	dry	0.80

Table G1-7. EPA instantaneous flow measurements (cfs) in support of other water quality studies

Date	WLFC-T1	WLFC-T2	WLFC-T3
August 8, 2010	3.16	10.19	12.72
October 5, 2010	1.58	6.51	7.85

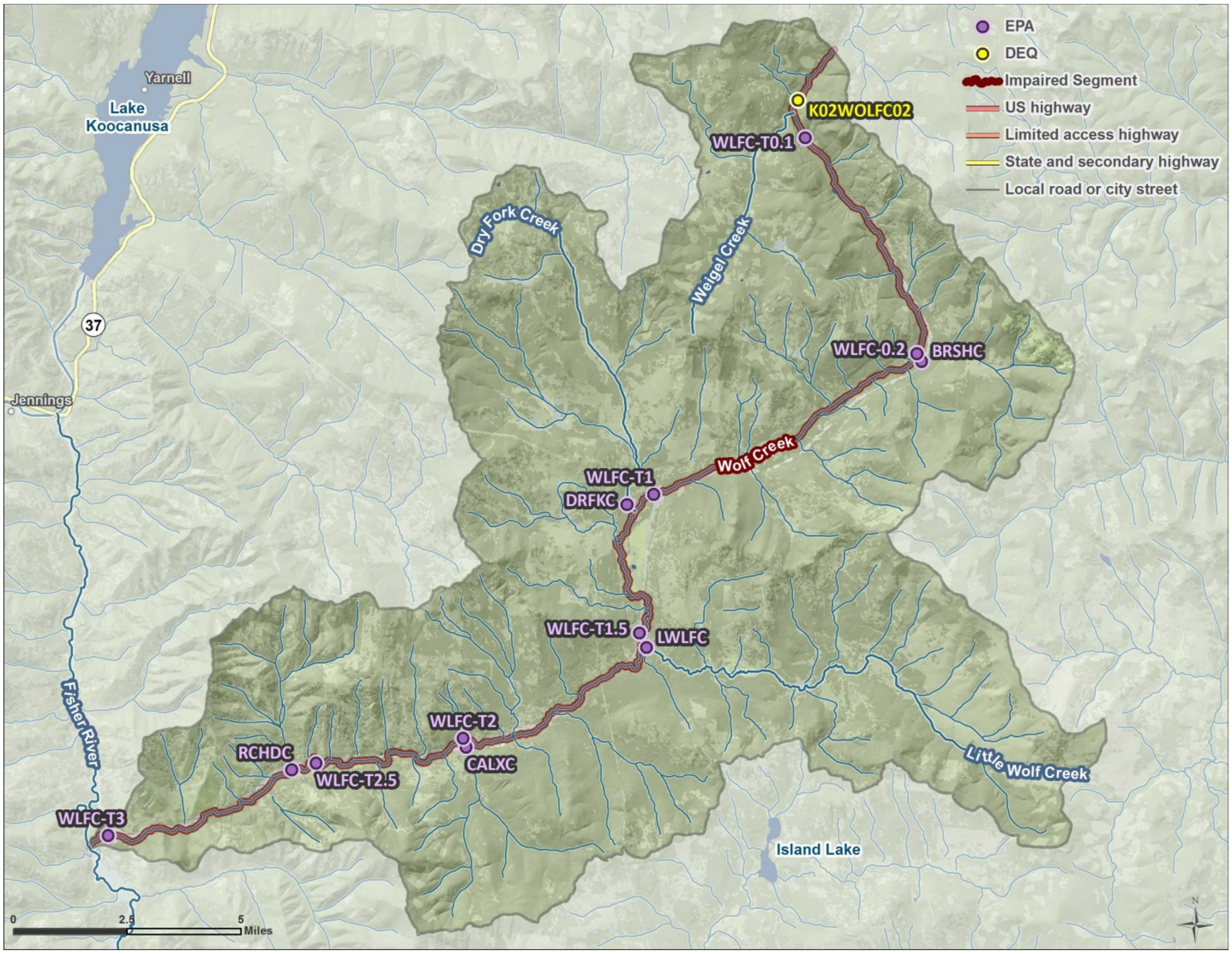
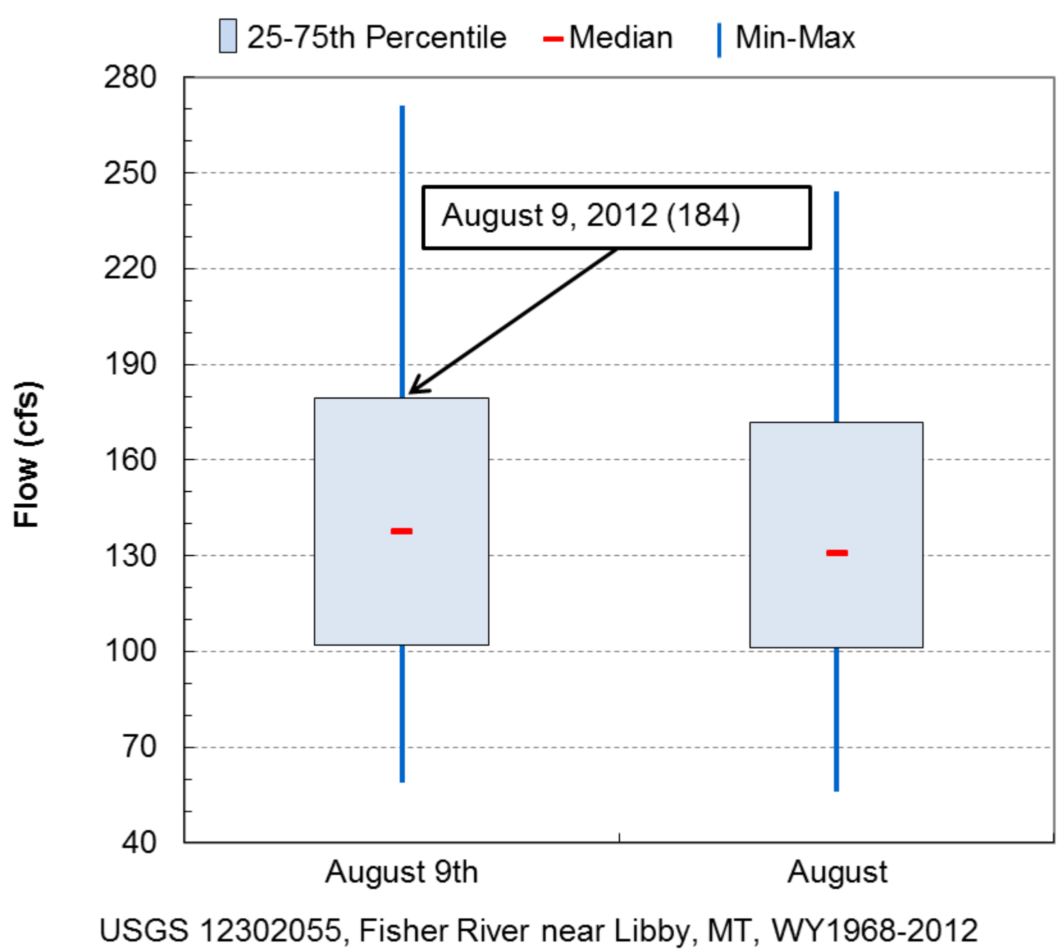


Figure G1-9. Flow monitoring locations.

Continuous flow data monitored at on the Fisher River at USGS gage 12301990 were evaluated with instantaneous discharge data from Wolf Creek to assess the hydrologic conditions of Wolf Creek during the summer of 2012. USGS gage 12301990 was used as a surrogate to represent regional hydrologic conditions. Statics were calculated for the average daily flows (per year) for the month of August and for August 9th from water years 1968 through 2012 at the gage (**Figure G1-10**).

The flow at gage 12301990 on August 9, 2012 (the calibration date for the QUAL2K model) was 184 cfs, which is equivalent to the 77th percentile of flows on August 9th across the period of record. Thus, August 9, 2012 was wetter than the average August 9th and was wetter than the average daily average flow for the month of August.

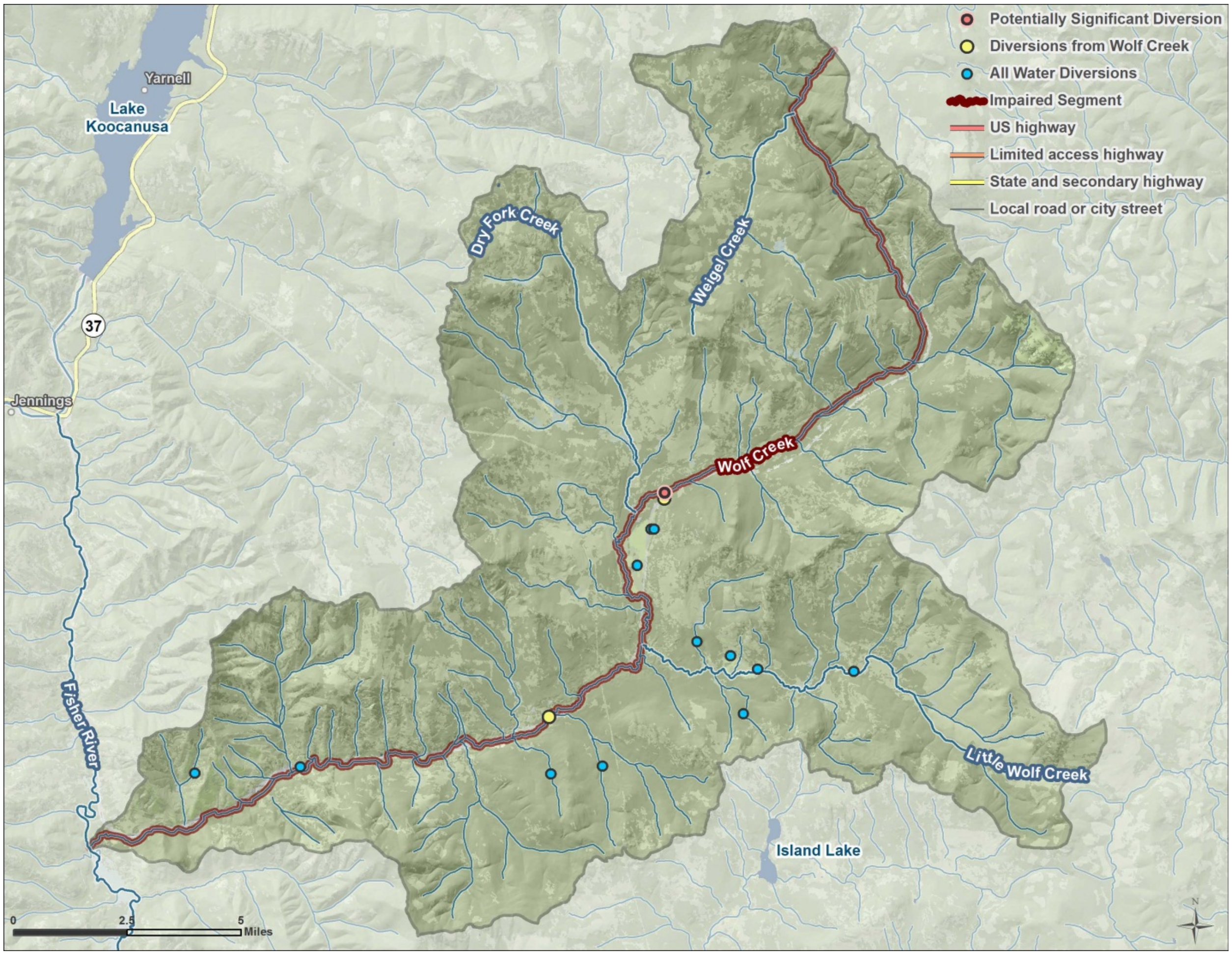


Note: "August" represents the daily average flow for the month of August per year (i.e., the average of 31 daily average flows)

Figure G1-10. Flow analysis with USGS gage 12302055 (Fisher River near Libby, MT).

G1-7.0 Flow Modification

Based on review of aerial photographs and online water rights data (ftp://nris.mt.gov/dnrc), there are surface and groundwater diversions in the Wolf Creek watershed that support a variety of uses (**Figure G1-11**). "Points of diversion" and "places of use" spatial data were obtained from the Montana Natural Resource Information System (Natural Resources Information System, 2012). Of the 17 diversions in the Wolf Creek watershed, 3 were directly from Wolf Creek. The permit for the mining water diversion has been terminated. Of the remaining permits, one is used for livestock and the other is used for flood irrigation (**Figure G1-11** and **Table G1-8**). It is estimated that up to 1.78 cfs may be withdrawn from Wolf Creek on a daily basis during July and August (**Table G1-8**).



Source of "points of diversion" data: NRIS 2012.

Figure G1-11. Surface and groundwater diversions in the Wolf Creek watershed.

Table G1-8. Points of diversion from Wolf Creek

WRNUMBER	Purpose	Irrigation type	Means of withdrawal	Max area (acres)	Max flow rate (cfs)	Volume (acre-ft/yr)	Est. daily volume applied [a] (cf)	Est. daily flow rate [b] (cfs)
76C 215024 00	Irrigation	F	H	151	4.27	--	150,223	1.78
76C 52184 00	Stock	--	D	0	--	--	--	--

Source: NRIS 2012

F = flood; H = headgate; Pf = fueled pump; D = dam.

[a.] The daily volume applied was estimated using the Irrigation Water Requirements (IWR) program developed by the USDA to estimate crop requirements. This method assumes application over the maximum acres reported.
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/irrigation/?cid=stelprdb1044890

[b]. A constant flow rate across a 24 hour period was assumed. Shaded cells assume maximum reported flow rate.

G1-8.0 Point Sources

There are no permitted point sources in the Wolf Creek watershed.

Appendix H - Cleanup/Restoration And Funding Options For Mine Operations Or Other Sources Of Metals Contamination

There are several approaches for cleanup of mining operations or other sources of metals contamination in the state of Montana. Most of these are discussed below, with focus on abandoned or closed mining operations.

H1.0 The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA 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. Petroleum related products and associated raw materials are not covered under CERCLA. Other federal regulations such as Resource Conservation and Recovery Act and associated Leaking Underground Storage Tank cleanup requirements tend to address petroleum.

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 approach 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. Cleanup of metals-contaminated soils in the Town of Superior was performed as a removal action.

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.

H2.0 The Montana Comprehensive Cleanup and Restoration Act (CECRA)

The 1985 Montana Legislature passed the Environmental Quality Protection Fund Act. This Act created a legal mechanism for the Department to investigate and clean up, or require liable persons to investigate and clean up, hazardous or deleterious substance facilities in Montana. The 1985 Act also established the Environmental Quality Protection Fund (EQPF). The EQPF is a revolving fund in which all penalties and costs recovered pursuant to the EQPF Act are deposited. The EQPF can be used only to fund activities relating to the release of a hazardous or deleterious substance. Although the 1985 Act established the EQPF, it did not provide a funding mechanism for the Department to administer the Act. Therefore, no activities were conducted under this Act until 1987.

The 1989 Montana Legislature significantly amended the Act, changing its name to the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA) and providing the Department with similar authorities as provided under the federal Superfund Act (CERCLA). With the passage of CECRA, the state Superfund program became the CECRA Program. Major revisions to CECRA did not occur until the 1995 Legislature, when the Voluntary Cleanup and Redevelopment Act (VCRA), a mixed-funding pilot program, and a requirement to conduct a collaborative study on alternative liability schemes were added and provisions related to remedy selection were changed. Based on the results of the collaborative study, the 1997 Legislature adopted the Controlled Allocation of Liability Act, which provides a voluntary process for the apportionment of liability at CECRA facilities and establishes an orphan share fund. Minor revisions to CECRA were also made by the 1999 and 2001 Legislatures.

CECRA facilities are ranked maximum, high, medium, low and operation and maintenance priority based on the severity of contamination at the facility and the actual and potential impacts of contamination to public health, safety, and welfare and the environment. The Department maintains database narratives that explain contamination problems and status of work at each state Superfund facility.

H2.1 The Controlled Allocation of Liability Act (CALA)

The Montana Legislature added the Controlled Allocation of Liability Act (CALA; §§ 75-10-742 through 752, Montana Code Annotated (MCA)) to the Comprehensive Environmental Cleanup and Responsibility Act (CECRA; §§ 75-10-701 through 752, MCA), the state Superfund law, in 1997. The department administers CALA including the orphan share fund it establishes.

CALA is a voluntary process that allows Potentially Responsible Parties (PRP) to petition for an allocation of liability as an alternative to the strict, joint and several liability scheme included in CECRA. CALA provides a streamlined alternative to litigation that involves negotiations designed to allocate liability among persons involved at facilities requiring cleanup, including bankrupt or defunct persons. Cleanup of these facilities must occur concurrently with the CALA process and CALA provides the funding for the orphan share of the cleanup. Since CECRA cleanups typically involve historical contamination, liable persons often include entities that are bankrupt or defunct and not affiliated with any viable person by stock ownership. The share of cleanup costs for which these bankrupt or defunct persons are responsible is the orphan share. Department represents the interests of the orphan share throughout the CALA process.

The funding source known as the orphan share fund is a state special revenue fund created from a variety of sources. These include an allocation of 8.5 percent of the metal mines license tax, certain penalties and additional funds from the resource indemnity trust fund and 25 percent of the resource indemnity and groundwater assessment taxes (which will increase to 50 percent when the reach indexing tool reaches $100 million). The current balance of the Orphan Share Fund is around $4 million and revenues projected for the rest of this biennium are about $2 million.

In the absence of a demonstrated hardship, claims for orphan share reimbursement may not be submitted until the cleanup is complete. This ensures that facilities are fully remediated before reimbursement. The result is that a PRP could be expending costs it anticipates being reimbursed for some time before the PRP actually submits a claim.

CALA was designed to be a streamlined, voluntary allocation process. For facilities where a PRP does not initiate the CALA process, strict, joint and several liability remains. Any person who has been noticed as being potentially liable as well as any potentially liable person who has received approval of a voluntary cleanup plan can petition to initiate the CALA process. CALA includes fourteen factors to be considered in allocating liability. Based on these factors causation weighs heavily in allocation but is not the only factor considered.

H2.2 The Voluntary Cleanup and Redevelopment Act (VCRA)

The 1995 Montana Legislature amended the Comprehensive Environmental Cleanup and Responsibility Act (CECRA), creating the Voluntary Cleanup and Redevelopment Act (VCRA) (Sections 75-10-730 through 738, MCA). VCRA formalizes the voluntary cleanup process in the state. It specifies application requirements, voluntary cleanup plan requirements, agency review criteria and time frames, and conditions for and contents of no further action letters.

The act was developed to permit and encourage voluntary cleanup of facilities where releases or threatened releases of hazardous or deleterious substances exist, by providing interested persons with a method of determining what the cleanup responsibilities will be for reuse or redevelopment of existing facilities. Any entity (such as facility owners, operators, or prospective purchasers) may submit an application for approval of a voluntary cleanup plan to the Department. Voluntary Cleanup Plans (VCPs) may be submitted for facilities whether or not they are on the CECRA Priority List. The plan must include (1) an environmental assessment of the facility; (2) a remediation proposal; and (3) the written consent of current owners of the facility or property to both the implementation of the voluntary cleanup plan and access to the facility by the applicant and its agents and Department. The applicant is also required to reimburse the Department for any costs that the state incurs during the review and oversight of a voluntary cleanup effort.

The act offers several incentives to parties voluntarily performing facility cleanup. Any entity can apply and liability protection is provided to entities that would otherwise not be responsible for site cleanup. Cleanup can occur on an entire facility or a portion of a facility. The Department cannot take enforcement action against any party conducting an approved voluntary cleanup. The Department review process is streamlined: the Department has 30 to 60 days to determine if a voluntary cleanup plan is complete, depending on how long the cleanup will take. When the Department determines an application is complete, it must decide within 60 days whether to approve or disapprove of the application; these 60 days also includes a 30-day public comment period. The Department's decision is based on the proposed uses of the facility identified by the applicant and the applicant conducts any necessary risk evaluation. Once a plan has been successfully implemented and Department costs have been paid, the applicant can petition the Department for closure. The Department must determine whether closure conditions are met within 60 days of this petition and, if so, the Department will issue a closure letter for the facility or the portion of the facility addressed by the voluntary cleanup.

The act is contained in §§ 75-10-730 through 738, MCA. Major sections include: § 75-10-732 - eligibility requirements; § 75-10-733 and § 75-10-734 - environmental property assessment and remediation proposal requirements; § 75-10-735 - public participation; § 75-10-736 - timeframes and procedures for Department approval/disapproval; § 75-10-737 - voluntary action to preclude remedial action by Department of Environmental Quality (DEQ); and § 75-10-738 - closure process. Section 75-10-721, MCA of CECRA must also be met.

The Department does not currently have a memorandum of agreement (MOA) with the Environmental Protection Agency (EPA) for its Voluntary Cleanup Program. However, the Department and EPA are in the process of negotiating one. EPA has indicated that Montana's Voluntary Cleanup Program includes the necessary elements to establish the MOA. Currently, EPA is reviewing the latest draft of the MOA.

The Department has produced a VCRA Application Guide to assist applicants in preparing a new application; this guide is not a regulation and adherence to it is not mandatory.

As of 2012, the Department has approved 31 voluntary clean plans, including mining, manufactured gas, wood treating, dry cleaning, salvage, pesticide, fueling, refining, metal plating, defense, and automotive repair facilities. Applicants have expressed interest and/or submitted applications for voluntary cleanup at fifteen other facilities. The Department maintains a registry of VCRA facilities.

H3.0 Abandoned Mine Lands Cleanup

The purpose of the Abandoned Mine Lands Reclamation (AML) Program is to protect human health and the environment from the effects of past mining and mineral processing activities. Funding for cleanup is via the Federal Abandoned Mine Fund, which is distributed to the State of Montana via a grant program. The Abandoned Mine Fund is generated by a per ton fee levied on coal producers and the annual grant it based on coal production. There are no collections or contributions to the Abandoned Mine Fund from mineral production beyond coal production fees. Expenditures under the abandoned mine program can only be made on “eligible” abandoned mine sites. For a site to be eligible, mining must have ceased prior to August 4, 1977 (private lands, other dates apply to federal lands). In addition, there must be no continuing reclamation responsibility under any state or federal law. No continuing reclamation responsibility can mean no mining bonds or permits have been issued for the site, however, it has also been interpreted to mean that there can be no viable responsible party under State or Federal laws such as CERCLA or CECRA. While lands eligible for the Abandoned Mine Funds include hard rock mines and gravel pits (collectively categorized as “non-coal”), abandoned coalmines have the highest priority for expenditures from the Fund. As part of the approved plan for Montana, abandoned coal mines are required to be prioritized and funded for reclamation ahead of eligible non-coal mine sites. . Cleanup of any eligible site is prioritized based primarily on human health, which can include health risks such as open shafts, versus risks only associated with hazardous substances, as is the case under CERCLA.

Montana's AML Program maintains an inventory of all potential cleanup sites, and also has a list of non-coal priority sites from which to work from. The DEQ conducts cleanups under the Abandoned Mine

Funds as public works contracts utilizing professional engineers for design purposes and private construction contractors to perform the actual work.

Limited scoping and ranking of water pollution from discharging abandoned coal mines has been completed and Montana's AML program is evaluating how to proceed with funding water treatment and stream quality restoration at the highest priority abandoned coal mine sites. In cases of non-coal cleanups, mitigating impacts associated with discharging adits can be included within the cleanup, although ongoing water treatment is not pursued as a reclamation option to avoid long-term operational commitments, which are outside the scope of the program and funding source. Therefore, even after cleanup, an abandoned non-coal mine site could still represent a source of contaminant loading to a stream, especially if there is a discharging adit associated with the site. Where discharging adits are not of concern, cleanup of either coal or non-coal mines may generally represent efforts to achieve all reasonable land, water, and soil conservation practices for that site.

A Guide to Abandoned Mine Reclamation (Noble and Koerth, 1996) provides further description of the Abandoned Mine Lands Program and how cleanup activities are pursued.

H4.0 Cleanup on Federal Agency Lands

A Federal land management agency may pursue cleanup actions outside of any requirements under CERCLA or CECRA where such activities are consistent with overall land management goals and funding availability. This is the anticipated solutions for United States Forest Service (USFS) lands within the Flat Creek watershed.

H5.0 Permitted or Bonded Sites

Newer mining sites that are or have been in recent operation are required to post bonds as part of their permit conditions. These bond and permit conditions help ensure cleanup to levels that will satisfy Montana Water Quality Standards during operation and after completion of a mining operation. Such sites also include larger placer mines greater than 5 acres in size. There are no permitted or bonded sites in the Kootenai-Fisher Total Maximum Daily Load (TMDL) project area.

H6.0 Voluntary Cleanup Agreement

At least one location within Montana (the Upper Blackfoot Mining Complex) is being addressed via a voluntary cleanup approach based on an agreement between the responsible person and the State of Montana. Although similar in nature to the goals of CECRA, this cleanup effort is currently not considered a remedial action under CECRA. The responsible person is responsible for cleanup costs in this situation.

H7.0 Landowner Voluntary Cleanup Outside of a State Directed or State Negotiated Effort

A landowner could pursue cleanup outside the context of CECRA or other state negotiated cleanup approaches. Under such conditions, liability would still exist since there is presumably a lack of professional oversight and assurance of meeting appropriate environmental and human health goals. Regulatory requirements such as where waste can be disposed, stormwater runoff protection, and multiple other environmental conditions would still need to be followed to help ensure that the cleanup activity does not create new problems. This approach can be risky since the potential for additional future work would likely make it more cost effective to pursue cleanup under CECRA or some other state negotiated approach where PRP liability can be resolved.

H8.0 State Emergency Actions

Where a major emergency exists, the State can undertake remedial actions and then pursue reimbursement from a responsible party. This situation does not exist within the Kootenai-Fisher project area.

H9.0 References

Noble, Cassandra and John Koerth. 1996. Montana ... Bringing the Land Back to Life: A Guide to Abandoned Mine Reclamation. Helena, MT: Montana Department of Environmental Quality.

APPENDIX I – RESPONSE TO PUBLIC COMMENTS

As described in **Section 12.0**, the formal public comment period for the Kootenai-Fisher Project Area Metals, Nutrients, Sediment, and Temperature TMDLs extended from February 3, 2014 to March 4, 2014. Formal written comments were received from three organizations and two individuals. DEQ evaluates all comments and related information to ensure no critical information was excluded from the document. Particularly for stakeholders selected to help advise the TMDL development process, early and active involvement and feedback with DEQ enhances the ability for collaboration and dialogue about the process. All three organizations submitting comments were involved in the stakeholder advisory group for the project, and the comments/concerns provided by two of the three organizations were not shared until the public comment period. This made it difficult to fully collaborate with these two organizations; whereas, early and timely input and feedback from Plum Creek Timber, particularly Brian Sugden, provided numerous opportunities for collaborating and discussing concerns.

Excerpts of the public comments received are organized by category, with most comments pertaining to a specific pollutant (i.e., nutrients, temperature, metals, and sediment). The original comment letters are located in the project files at DEQ and may be reviewed upon request. Responses follow each comment, and because this project was a joint effort between DEQ and the EPA Region 8 Montana Office, the responses were jointly prepared.

In addition to the general and specific comments presented in this appendix, several general grammatical and typographical comments were provided. Changes were made to the final document to reflect those comments but they are not summarized below.

I.1 GENERAL COMMENTS

Comment 1.1: Non-Pollutant Impairments Section 9.0
"For streams that do not have a TMDL in this document, the non-pollutant causes were not investigated. They are being summarized in this section to increase awareness of the non-pollutant impairment definitions and typical sources." Will the non-pollutant causes be investigated in the future and is there the potential for streams listed for non-pollutant impairments being delisted?

> **Response 1.1**: The non-pollutant causes will be investigated in the future as part of the monitoring and assessment process, and if updated assessment information indicates those causes are no longer causing impairment, they will be delisted. For instance, Quartz Creek was previously listed for physical substrate habitat alterations, and as a result of habitat data collected to assist with TMDL development, that cause is being removed within the 2014 Integrated Report.

Comment 1.2: Why wasn't a TMDL assessment for sediment done on the Fisher River? Why wasn't the Fisher River assessed for temperature impairments?

> **Response 1.2**: The scope of TMDLs within this document is based on the 2012 303(d) List and the Fisher River is not on that list as being impaired by sediment or temperature. The Fisher River was last formally assessed for beneficial-use support in 2003. Information about that assessment is available at the Clean Water Act Information Center

(http://deq.mt.gov/wqinfo/CWAIC/default.mcpx). For each 303(d) listing cycle, DEQ solicits stakeholders throughout the state for recent data. All data received as a result of the solicitation are added to the assessment file, but they must be screened to make sure they constitute sufficiently credible data to proceed with an assessment. Additionally, because of time and resource constraints, not all waterbodies with recent data are able to be formally evaluated within that listing cycle. More information about this process is described in the Reports section of the CWAIC website (listed above). If you have specific questions regarding the assessment decision for the Fisher River or would like to follow up with DEQ regarding recent data you think may assist with an assessment, you should contact the DEQ Monitoring and Assessment staff.

Comment 1.3: Point sources figure in Appendix A, Figure A-18. This may be correct, just something we are not currently aware of or it could be an error on the map. It appears that one of the MPDES permits for suction dredging is off of the main stem of Libby Creek up Crazyman Creek. Like I said, could be a mapping error.

Response 1.3: The suction dredge permit was incorrectly plotted on Crazyman Creek. **Figure A-18** has been revised with the correct location for that permit. On a related note, there is a suction dredge permit that is plotted on Libby Creek but the permittee is also authorized to suction dredge on Crazyman Creek.

Comment 1.4: Clarify reference to "*North Fork*" as North Fork Keeler Creek. Correction: North Fork Keeler Creek flows into main Keeler Creek, not South Fork Keeler Creek.

Response 1.4: The correction was made.

Comment 1.5: Page 8-18; 2nd paragraph: What is a "devil" deposit?

Response 1.5: The text was changed to the following: "developed deposits."

Comment 1.6: I believe that the TMDL work was done in too big of a hurry due to lawsuit. The people working on the TMDL should have spent more time in the field. A good example is the new TMDL for Nitrate/Nitrite on upper lake creek. This TMDL was attributed to the Troy Mine tailing dam. However the sample that triggered the new TMDL was taken from sample site (Lake Creek 4) which is way below the tailings facility. In the public meeting we were told that the new TMDL's were not new rules. This is not the truth as the new limits preclude new activity on National Forest Land. I see the environmental groups using their lawsuit as a hammer and the clean water act as the nail to restrict new activity anywhere in the national forest. Very Sad!!!

Response 1.6: Spending more time in the field is always desirable, but DEQ feels that staff spent adequate time in the field during the project. Regarding the example, Lake Creek has been identified as impaired for nitrate/nitrate since the 2000 303(d) List, and recent algal data from multiple locations on the stream confirmed it is still impaired. The allocation for the tailings impoundment was based on the trend in water quality data and literature documenting elevated nitrate concentrations going into the groundwater from the impoundment. However, we agree that more data is needed to refine the source assessment. Given this uncertainty, the allocations in **Section 6.5.4** were changed into a single composite allocation to all human sources and more detailed recommendations for refining the source assessment have been added to **Section 11.3.1**. We disagree with the statement that the TMDL precludes new activity on USFS land. Sources permitted under the MPDES program must adhere to their permits, but this document sets no restrictions on activities on USFS land. We did mention in the public meeting that implementing the TMDLs is voluntary, and in most cases, using all reasonable best management practices is what is recommended. For instance, if all BMPs are implemented during timber harvest on USFS land, that is meeting the intent of the TMDL. In general, this is already being adhered to for activities on USFS land.

Comment 1.7: In general, we believe that DEQ/EPA has done a good job in developing the draft TMDLs, and involving stakeholders in the process. Clearly there was a huge amount of effort put into this draft document. There was good communication with the EPA project manager throughout this process, and as a stakeholder, we felt like our input was heard.

Response 1.7: Thank you for the positive feedback.

Comment 1.8: We made a request in early 2013 that DEQ should conduct additional monitoring of Raven Creek in order to obtain sufficient credible data to resolve the nutrient impairments. We thank DEQ for collecting this additional data during your already busy 2013 monitoring season.

Response 1.8: DEQ is glad this request could be accommodated.

Comment 1.9: SC-15 is marked incorrectly on this map in the Draft K-F TMDL. The correct location for SC-15 is above SC-17A (48°14’33.78”N 115°54’26.90”W). This should also answer the concern later in the document about the lack of location information for SC-15 (8-18). If there are any other sample locations needing location clarification the Troy Mine is available to assist the MTDEQ.

Response 1.9: We have updated document maps to reflect the coordinates provided. The Troy Mine water quality database did not have site coordinates. We noticed that site names had changed some over the years with the addition of sites 15a, 15b, and 15c and had trouble discerning the location of site 15.

Comment 1.10: While many watersheds throughout Montana have very little data concerning the health and history of streams, this is not the case for those streams surrounding the Troy Mine. Over the 30 year life of the Troy Mine, there has been continuous surface water quality sampling and monitoring in Lake Creek, Stanley Creek, and other nearby lakes and streams in the watershed, as well as extensive groundwater sampling. These water sampling efforts have been conducted by mine operators, third-party consultants, and governmental agencies and have produced an extensive amount of baseline data and water quality related reports that provide a detailed analysis of the watershed.
The following are important sources of publically available water quality data and information for Lake and Stanley Creeks:

1. An especially helpful resource with pre-mining water quality data collected as far back as the 1970s is a 1984 report by the Montana Bureau of Mines and Geology prepared in cooperation with the U.S. Geological Survey entitled Water Resources of Lake Creek Valley, Northwestern Montana, Memoir 56 by G.W. Levings, R.F. Ferreira and J.H. Lambing, 1984.
2. Baseline water quality data for Lake Creek is available in a 1983 report by the Montana Bureau of Mines and Geology entitled Hydrochemical Baseline Studies, Lake Creek Drainage, Lincoln County, Montana, Open-File Report 111.

3. Water Quality data gathered by third-party consultants from the Lake Creek and Stanley Creek watershed has been submitted to MT DEQ by the mine operators on an annual basis for over thirty years. This data is compiled and referenced in the Troy Mine Water Quality Monitoring Program Reports, years 1-28; by Paramatrix, Anchor QEA, (et. al.)
4. Excellent work on metals-related water quality impacts performed by third-party consultants in the watershed is available in a 2004 report by Scott Mason entitled Assessment of Fate and Transport of Copper in Decant Pond Disposal System-Troy Mine (Land & Water Consulting, Inc. Kalispell, Montana) and his 2010 report entitled Assessment of Natural Attenuation of Metals in a Decant Pond Disposal System (Hydrometrics, Inc. Helena, Montana).
5. The 2012 report entitled Troy Mine Revised Reclamation Plan: Final Environmental Impact Statement (MT DEQ and US Forest Service, June 2012) includes in its appendices relevant water quality data and analytical reports about water quality in the watershed. Significantly, the Record of Decision for this FEIS does not require construction of water treatment facilities at Troy Mine because of natural attenuation of metals within the tailings impoundment.

The data and reports referenced above provide important information regarding pre-mining and operating conditions. We also have extensive documentation during our care and maintenance period from 1993 until 2005, during a time when mining operations were suspended. Some of the determinations and conclusions in the Draft K-F TMDL suggest that this extensive available data were not referenced by MT DEQ during preparation of the document. The process of listing Lake and Stanley Creeks as impaired waterways and the subsequent Draft K-F TMDL analyses employed by MT DEQ for these creeks are based on a very limited set of data points which do not consider the depth and breadth of publically available data sources. We trust that the MT DEQ will consider these overlooked data resources to improve the analysis and conclusions of the TMDL process for Lake Creek and Stanley Creek.

Response 1.10: Thank you for summarizing this information. Information from Sources 3 and 5 are referenced in the document. We were unaware of the other sources, or else we would have consulted them during development of this document. Since receiving these comments, we located a copy of Source 1, and reviewed that to determine if and how it should be incorporated into the source assessments for Lake and Stanley Creeks. We also obtained the 2013 Final Annual Report for the Comprehensive Water Quality Monitoring Program for Streams Adjacent to the Troy Mine submitted to DEQ's Hardrock Mine Bureau and located the reports in Source 4 in the appendices of the Troy Mine Revised Reclamation Plan Final Environmental Impact Statement. We had previously obtained the electronic database of the water quality data but did not have the macroinvertebrate summary provided in the annual report. Please note, for assessment purposes DEQ only considers data from the previous 10 years.

The sources mentioned above that we were not aware of have been incorporated into revisions in **Section 6** to the extent possible, but they cannot be incorporated in great-depth at this time because we were not made aware of them until this late in the project. As shown in **Appendix F**, the nutrient water quality data through 2011 from the mine were incorporated into the impairment assessments. It is too late to add macroinvertebrate data to the assessment file for the 2014 Integrated Report cycle, but they can be added to the file for inclusion into future assessments if it meets data quality requirements. However, the 2013 Annual Report (Troy Mine and DEQ, 2013) only has a graph of the HBI scores – additional information such as the sample locations, sample dates, and corresponding HBI scores will need to be submitted to DEQ's Monitoring and Assessment Section. As a side note, based on the other available nutrient-related data, additional HBI scores would not have changed the outcome of the nutrient impairment determinations for Lake and Stanley creeks.

DEQ strives to obtain all relevant information during project development, including solicitations for data in meetings and e-mails, as well as pre-public review drafts for project stakeholders (which include the entity that provided this comment). DEQ initiated these efforts starting in early 2012 and extending throughout the life of the project, to help ensure information and data would not be overlooked and available information could be incorporated into the document. Specifically, nutrient-related data was requested in April 2012, and assessment results with updated impairment determinations were presented to the stakeholder group in March 2013. At either of those times and extending until late 2013, additional data could have been incorporated to update the assessment for the 2014 Integrated Report. Nevertheless, as noted above, these new data do not modify any impairment determinations and are not critical to the primary TMDL components.

Comment 1.11: Page 2-12 states "Operations for the Rock Creek Mine are based on the west side of the Cabinet Mountains just outside the Kootenai-Fisher Project Area, but depending on how underground workings are developed the mine could potentially extend into the project area." The inclusion of the Rock Creek Project within the project area for this TMDL is erroneous and may represent a fundamental misunderstanding of the physiography of the watershed. All planned or potential mining operations at Rock Creek will be conducted within the Clark Fork River watershed. There is no potential for the Rock Creek Project to impact water quality in the Kootenai River watershed.

Response 1.11: The reference was intended to convey the hydrological complexity of underground mine workings, but the statement was erroneous and has been removed from the document. Additionally, all discussion of Rock Creek Mine has been removed from the TMDL document and it been removed from **Figure A-17** in **Appendix A**.

Comment 1.12: Did the TMDL development for Raven Creek account for the potential sale and subsequent development of Plum Creek land into smaller land holdings (subdivisions)? What water quality protection practices were identified to mitigate potential sediment and phosphorus sources given the potential for land development? Given that application of water quality improvement practices is a landowner's decision is the State of Montana going to be proactive in TMDL listed watersheds that undergo intensive development as Plum Creek sells its inholdings?

Response 1.12: TMDL development did not explicitly account for subdivision of Plum Creek land. Forecasting changes in land ownership are outside the scope of the TMDL process and unnecessary. Land ownership and/or use within a particular watershed could change at any given time and as long as that owner applies all reasonable land, soil, and water conservation practices for a given use, it will be meeting the intent of the TMDL. **Section 10.5** discusses best management practices for most land uses (i.e., potential source categories), and also includes subsections on Residential/Urban Development (**Section 10.5.4**) and Bank Hardening/Riprap/Revetment/Floodplain Development (**Section 10.5.5**). Based on these concerns additional language regarding best management practices and DEQ recommendations has been added to subsections mentioned above. DEQ is concerned about development within riparian areas and floodplains, and Montana DEQ's strategies for dealing with this concern are detailed on p. 3-16 of its Nonpoint Source Management Plan (DEQ 2012).

Comment 1.13: Adaptive management comments were provided relative to nutrients and temperature (sections 6.8 and 7.8, respectively) - How would adaptive management address the potential development of Plum Creek lands in the ongoing TMDL implementation and evaluation? Are there identified BMP's for subdivisions or lands being transformed from timber to rural development?

Understandably there are uncertainties in regards to the potential development of Plum Creek lands in the Wolf Creek watershed; they own the vast majority of land in Wolf Creek and it is evident that they are rapidly selling off their inholdings in the Kootenai area. Was any of this considered when developing the adaptive management?

> **Response 1.13**: It is not evident to DEQ that Plum Creek is rapidly selling off its inholdings in the Kootenai-Fisher Project Area, and this concern was not brought up by stakeholders during the TMDL development process. Regardless, as discussed in Response 1.12, predicting effects from changes in land ownership is outside the scope of the TMDL process and unnecessary, but BMPs for most potential sources (including residential development) are included in **Section 10.0**.
>
> As discussed in **Sections 5.0** through **8.0** and **11.2**, adaptive management means that TMDL implementation and reassessment of the impairment status of streams is flexible and will change from circumstances such as new information becoming available, land management and uses changing, and standards and/or assessment procedures changing. Because these changes cannot be foreseen and are case-specific, the concept of adaptive management is discussed but no specific details are provided in the document. **Section 7.8** does mention that as part of adaptive management changes in land and water management that affect stream temperatures should be tracked. Using land conversion as an example, this would mean that different BMPs would be necessary, project prioritization for TMDL implementation would change as a result of ownership changes, and monitoring locations may need to be changed as a result of new potential sources and/or access issues.

Comment 1.14: Neither the NHCP nor the TMDL address the potential sale and development of Plum Creek land in the Kootenai-Fisher TMDL Project Area. The progressive sale and development of Plum Creek land has the potential to preclude improvements to watershed conditions.

> **Response 1.14**: See Responses 1.12 and 1.13 for information regarding the TMDL and sale and redevelopment of land. DEQ is not familiar with the details of the NHCP and recommends that interested parties contact Plum Creek Timber Company for additional information, but Section 5 of the NHCP discusses Land Use Planning in the context of working to be compatible with native fish conservation by providing incentives for conservation land sales, protecting fish-bearing streams during private sales through deed restrictions, and transferring the NFHCP to new owners where possible (Plum Creek Timber Co., 2000).

I.2 Nutrients Comments

Comment 2.1: A visual inspection of Stanley Creek is a subjective evaluation for nutrient impairment. In addition, Troy Mine consultants have been conducting macroinvertebrate sampling in Stanley Creek and submitting annual reports to MT DEQ (Troy Mine Water Quality Monitoring Program, years 1-28;) for nearly thirty years. None of this data was referenced as being used in evaluating Stanley Creek for impairment nor was referenced as being analyzed during the TMDL process.

Response 2.1: Algal sampling is time and resource intensive, and in streams where algal biomass is well below the target, a visual determination that algal biomass is <50mg/m^2 is made to conserve resources. For assessment purposes, the target threshold is 125mg/m^2 for chlorophyll-*a* and 35g/m^2 for AFDM. Our field personnel are highly trained, the field protocol has photographs with varying levels of algae, and we are confident that the visual assessment threshold is sufficiently below the target so that physical samples are collected if algal levels are anywhere close to the target.

As discussed in Response 1.10, the macroinvertebrate data collected by Troy Mine was not included because the DEQ Water Quality Planning Bureau was not aware of it. It is submitted via hard copy to a different bureau and is not uploaded electronically to STORET, which is the EPA water quality monitoring database DEQ routinely uses to check for macroinvertebrate data to assist with assessments. Also, as discussed in Response 1.10 macroinvertebrate results would not have affected the outcome of either impairment determination (i.e., Lake or Stanley creeks). The assessment method considers HBI scores over 4.0 to be indicative of nutrient enrichment (when there are other indicators), and a review of the summer HBI scores in the graphs in the 2013 Annual Report shows several samples in both Stanley and Lake creeks have exceeded 4.0 within the past 10 years (Anchor QEA, LLC., 2013).

Comment 2.2: Pre-mining water quality data gathered in the watershed by governmental agencies shows that the Troy Mine is not the source of the nitrate/nitrite in Stanley Creek. Significantly, in 1984, the Montana Bureau of Mines and Geology and the US Geologic Survey jointly published a report entitled *Water Resources of Lake Creek Valley, Northwestern Montana* (Levings et al. 1984) that documented pre-Troy Mine nitrate/nitrite levels are similar to those described in the draft TMDL report. Further, the conclusion that the upper part of Stanley Creek is impacted by the mine fails to take into account the virtually identical values found in the control creek (Fairway Creek, located away from mine operations). Pre-mining water quality data and subsequent water quality data show that Stanley Creek would have the same nitrate/nitrite values with or without the Troy Mine.

Response 2.2: We reviewed *Water Resources of Lake Creek Valley* (Levings et al., 1984) and *Relation between Troy Project and the Hydrology of the Vicinity, Lincoln County, Montana* (Halpenny and Greene, 2014), which both evaluate surface and groundwater conditions prior to Troy Mine being in full production. However, we disagree that the data represent pre-mining water quality. In 1973, exploration drilling was being conducted at Troy Mine and nitrate concentrations in Fairway Creek, Thicket Creek, and Stanley Creek downstream of Fairway Creek were below detection (0.5 mg/L), whereas the concentration in the North adit and upper Stanley Creek (west of the N adit) were 1.86 mg/L and 0.48 mg/L, respectively (Halpenny and Greene, 2014). This indicates that even the exploration activities were affecting nitrate concentrations, and that data from this time period are not representative of pre-mining conditions. Additionally, as described below, other human activities occurred in the watershed prior to exploration drilling associated with the Troy Mine that could have affected background nitrate concentrations.

As stated on the Revett Minerals website (http://www.revettminerals.com/projects/troy-mine), "The Troy ore body was discovered by Bear Creek Mining (Kennecott) in the early 1960's, and was later optioned to ASARCO to develop and operate." The 2005 SRK report titled, "Independent Technical Report on the Troy Cu-Ag Project, Montana" also states that, "In the vicinity of the project area, several small mineral occurrences were found during the 1920's and 1930's. During the 1960's and through to the early 1980's, three major copper/silver deposits – Spar Lake (Troy), Rock Creek and Rock Lake (Montanore) – and numerous smaller deposits were discovered within the Revett Formation inside a narrow belt extending from the Coeur d'Alene Mining District north to approximately the Kootenai River. The ensuing drilling programs, between 1964 and 1967, resulted in the delineation of the Troy deposit." As stated in the EIS, there were also historic timber harvest and road construction activities in the Stanley Creek watershed in the 1960s.

DEQ does not consider Fairway Creek to be a control creek, as there are numerous potential nutrient sources in the watershed including timber harvest, campgrounds, abandoned mines, etc. DEQ has changed the text in the document to recommend additional water quality monitoring in the watershed to (1) identify natural background conditions for Stanley Creek, and (2) identify and better quantify source loads for Fairway Creek.

Comment 2.3: The assertion that the Troy Mine impacts nutrient levels in Lake Creek is also incorrect. If the tailings impoundment were a source of nitrate/nitrite to Lake Creek, then the levels should be high at sampling location K01LAKEC06 as well, as this site is downstream of the impoundment. For a complete assessment of loadings downstream of the impoundment at sampling location LC04 (referenced in the Draft TMDL), the loadings from Porcupine Creek and Twin Creek need to be accounted for. Also, the fate of the mine water at the tailing impoundment has been extensively studied (Scott Mason, 2004). Hydrogeological study has shown that the general direction of ground water flow is cross-valley (Ebasco Environmental, 1990). None of the studies to date have found any evidence of an impact on Lake Creek due to the water from the Troy Mine tailing impoundment. Lastly, the suggestion later in the document that the water quality in wells MW-1 and MW95-4 are indicators of the source of the nutrients detected at LC-4 fails to take into account water sampling done by the Montana Bureau of Mines and Geology prior to the establishment of the impoundment. Levings et al. (1984) found higher levels of nitrate/nitrite in wells adjacent to the impoundment 0.27 ppm, 0.33 ppm, and 0.4 ppm in wells 30N33W30DAAD01, 30N33W30DAAD02, and 30N33W30DCAD01 respectively.

Response 2.3: The groundwater well data cited from Levings et al. (1984) are actually total nitrogen concentrations. The nitrate concentrations at those sites and at the wells in 30N33W20, which is where Lake Creek site LC-04 is located, were below 0.1 mg/L with the exception of one sample at 0.12 mg/L. Additionally, the concentrations that the comment referenced in the TMDL document represent the mean concentration, whereas the maximum shallow well concentration cited the Final EIS and also referenced in Section 6 of this document was 1.19 mg/L (MW95-4). The final EIS states that "if nutrients in shallow groundwater, as measured at MW95-4, discharge locally to surface water (as they may at the toe ponds) nuisance algal growth could occur." Although the data in Levings et al. (1984) do indicate variable groundwater nitrate concentrations in the Lake Creek watershed, we do not feel this negates the evidence that the tailings impoundment is elevating nitrate concentrations in groundwater, and is a probable source to Lake Creek. However, we do agree that based on the distance and other potential sources between monitoring locations, there is insufficient information to retain a separate load allocation to the impoundment (as was proposed in the draft TMDL). The load allocation has been revised to include all potential human sources.

In regards to groundwater flow and loading to Lake Creek, the studies have focused on metals fate and transport and not nitrate, but the groundwater flow information may be helpful for making inferences. **Appendix H** from the Final EIS (U.S. Forest Service and Montana Department of Environmental Quality, 2012) – Mine Water Plume Location and Identification Phase 1 Results and Phase 2 & 3 states the following: "it is hypothesized that a shallow gravel unit may provide the primary flowpath for transport of water from the decant ponds." **Appendix H** also states, "Although the general directions of groundwater movement in the area are likely towards the north (in the general direction of flow in Lake Creek) and towards the west (toward Lake Creek), local groundwater flow directions are likely controlled primarily by the location and orientation of permeable water bearing zones within the glaciolacustrine and alluvial deposits." Based on these statements, it appears that shallow groundwater flow from the tailings ponds does flow towards Lake Creek but the flowpath from the decant ponds is not well understood. Therefore, it is possible that the ponds are contributing nitrate to the groundwater and manifesting at site LC-04 and not Site K01LAKEC06.

DEQ added a recommendation in the document for additional groundwater studies in the area to better understand movement of nitrate from the tailings ponds. The current studies focus on metals movement and attenuation; the Assessment of Natural Attenuation of Metals in a Decant Pond Disposal System, Troy Mine in **Appendix I** of the Final EIS (U.S. Forest Service and Montana Department of Environmental Quality, 2012) concludes that "concentrations of chemically conservative parameters such as nitrate are similar between the mine/decant water and the underlying groundwater…indicating that mine water is not appreciably diluted in the groundwater close to the pond." DEQ has also changed the text in the document to acknowledge that other sources (e.g., Porcupine Creek, Twin Creek, etc.) may be contributing excess nitrate loads from unknown sources. Further monitoring should be conducted to better quantify these other potential sources.

Comment 2.4: The Document Summary, Page DS-2 states "mining-related BMPs are the principle method needed to meet the TMDLs." BMPs are and have been used at the Troy Mine as documented by the decades of inspections and monitoring conducted by Montana DEQ and the US Forest Service.

Response 2.4: The comment about BMPs is not intended to imply that no BMPs have been used but that additional BMPs are necessary because under current practices, water quality standards are still being exceeded. Based on the uncertainties in the source assessment discussed in Response 2.3, this language has been broadened to include more than mining sources and a recommendation that additional monitoring and refinement of the source assessment be conducted.

Comment 2.5: Stanley and Lake Creeks are listed for Nitrate-Nitrite (Nitrate), and TMDLs are proposed for this parameter. DEQ has provided mixed signals on Nitrate, and the need for it to be included as a numeric water quality standard. In Suplee and Watson, they note in the Executive Summary that "Total Nitrogen and TP provide better overall correlation to the eutrophication response than soluble nutrients…" As such, Nitrate was excluded as a proposed numeric nutrient standard for Montana. This was accepted by peer reviewers that evaluated Montana's proposed nutrient criteria. However, later in 2013, DEQ issued a Technical Memorandum (dated 11/14/2013) that recommends that Nitrate be evaluated as a "…benchmark for assessment purposes…." The proposed benchmark level is 0.1 mg/L. In this draft TMDL, DEQ/EPA developed Nitrate TMDLs using the 0.1 mg/L benchmark value. It is unclear to us why - if Nitrate is not suitable as a numeric water quality standard for Montana - that TMDLs are being written for Nitrate using a one-size-fits all benchmark value of 0.1 mg/L.

<u>Response 2.5</u>: DEQ does not agree that mixed signals have been given regarding elevated levels of nitrate is surface waters. While it is true that DEQ is proposing total nutrients as standards, Suplee and Watson (2013) state on pages 1-3 and 1-4:

> "Rapid uptake of soluble nitrogen compounds by aquatic organisms (mainly algae and plants) makes these compounds' concentrations highly variable, and difficult to use as ambient surface water criteria. Total nitrogen and TP have been shown to provide better overall correlation to eutrophication response than soluble nutrients (Dodds et al., 1997; Dodds et al., 2006; Dodds et al., 2002) and, in terms of water quality criteria, total nutrients are more practical than soluble forms for river monitoring and assessment, total maximum daily loads, etc. (Dodd and Welch, 2000). However, the Department <u>strongly</u> encourages the collection of nitrate + nitrite when collecting TN and TP data. The soluble data can often point to specific types of nutrient sources, for example. The Department's Water Quality Monitoring Section will continue to include nitrate + nitrite alongside TN and TP for routine monitoring for nutrients and may use some general guidelines from the scientific literature for determining when measured concentrations are clearly too high."

As was made clear in the last sentence above, DEQ intended that guidance be used to evaluate nitrate data when it has been collected by Monitoring Section staff. The technical memorandum dated November 14, 2013 provided that guidance.

The rationale for not adopting nitrate standards for eutrophication control is that nitrate only provides useful information in one direction (when it is present), but its absence does not necessarily mean there are no issues. A stream might well be choked with *Cladophora* and have no measurable nitrate because the algae have drawn the concentration down. As a water quality standard, this is problematic, because a water quality standard works best when decisions can be made on either side of a threshold. For eutrophication control, numeric nutrient standards will be used for surface water assessment and MPDES permits, and total nutrients were selected as the best measurement for both purposes while nitrate is better addressed in ambient surface water assessment. That is, if monitoring staff are finding elevated nitrate levels in ambient surface waters outside of an MPDES mixing zone, there is reason to be concerned.

The 11/13/2014 technical memo outlines the means by which nitrate data —when it is in fact measured— can be evaluated by monitoring staff. The recommended benchmark is scientifically defensible and DEQ has demonstrated significant eutrophication impacts at concentrations just slightly higher than the benchmark of 0.1 mg/L. And it should be emphasized that the nitrate data is always evaluated alongside the effect variable of concern, excess algal growth, for the reasons outlined above.

<u>Comment 2.6</u>: The use of the nitrate+nitrite threshold does not seem to be appropriate as Montana Department of Environmental Quality (MDEQ) does not plan on using nitrate+nitrite as a method to measure eutrophication (Suplee and Watson, 2013). This issue needs to be discussed in the Kootenai-Fisher TMDL, or the use of nitrate+nitrite needs to be dropped from the process.

<u>Response 2.6</u>: See response to Comment 2.5.

Comment 2.7: The nitrate+nitrite threshold is cited as being from McCarthy (2013). The McCarthy value for nitrate+nitrite is contrary to what is said in Suplee and Watson (2013). Suplee and Watson state that nitrate+nitrite levels are too variable in streams to be used to evaluate eutrophication; however, McCarthy implies it is useful based on a study from a stream in the Eastern Plains of Montana. Which opinion takes precedence in this report? It seems that the nitrate+nitrite threshold may be applicable to the Eastern Plains but not applicable to the Rocky Mountain region of Montana.

> **Response 2.7**: Please see the detailed discussion of this topic under Response 2.5. Regarding the idea that the nitrate threshold is only applicable to eastern MT plains streams, the Department would like to point out that the half-saturation constant used to derive the 0.1 threshold was identified after giving consideration to a collection of studies carried out in many different stream types and locations around the U.S.

Comment 2.8: This report and Appendix B are in error if MDEQ means to cite Suplee and Watson (2013) (Appendix B) as a source for the nitrate+nitrite threshold. Nitrate+nitrite criteria are not defined in the Suplee and Watson report (2013). The source for the threshold is from McCarthy (2013). Furthermore, in Suplee and Watson (2013) it is specifically stated that nitrate+nitrite will not be used to evaluate eutrophication.

> **Response 2.8**: The commenter is correct that nitrate + nitrite criteria or thresholds are not presented in Suplee and Watson (2013), and that the nitrate benchmark used to make assessments is actually found in a technical memo. However, the commenter is not correct in asserting the Suplee and Watson (2013) state that nitrate+nitrite will not be used to evaluate eutrophication. Rather, Suplee and Watson (2013) say "…the Department will not be recommending nitrate (or nitrate + nitrite) criteria ***for adoption*** for the control of eutrophication at this time." (emphasis added). The point they were making is that nitrate will not be proposed for adoption by the Board of Environmental Review, not that nitrate is unimportant to eutrophication. To the contrary, Suplee and Watson (2013) clearly state on page 1-4 that nitrate measurement is very important in ambient surface water monitoring and should continue. But there are specific reasons why DEQ is only intending at this time to adopt standards for total nutrients; please see the discussion of this topic under Response 2.5. On a side note, the TMDL document erroneously cited the memo to McCarthy when it should have been M.W. Suplee – references in the document have been corrected.

Comment 2.9: The nitrate/nitrite target value listed in Table 6.2 originates from a study conducted on the Box Elder Creek. Box Elder Creek is located in the Northwestern Great Plaines ecoregion and is not an appropriate steam to use to establish a target value for developing TMDLs for steams in a wooded intermontane valley (Northern Rockies Level III Ecoregion). At the core of the nitrate/nitrite target value as described in the McCarthy (2013) memo is the assumption that all watersheds in the diverse state of Montana are homogenous. Within an ecoregion the MTDEQ recognizes that variation can be expected. In Suplee et al. (2013) it is stated, "The Department recognizes that within each ecoregional zone there are likely to be some streams with unique characteristics that could render the ecoregional criteria inappropriate."

The Box Elder Creek study showed an increase in the amount of algae to "near-nuisance" levels and an impact to the dissolved oxygen concentration, which exceeded state standards, with dosing rates of 0.119 mg/L. The draft TMDL states that in Stanley Creek there isn't a nuisance algae population (page 6-

6, table 6-4). The bloom detected in Lake Creek (failure of the AFDM test) is likely attributable to *D. geminate*.(see other comments on this topic) In both Levings et al. (1984) and Troy Mine data, it has been shown that the dissolved oxygen content in both creeks is saturated, with nutrient levels virtually identical and in some cases greater than the nitrate + nitrite values tested at the Box Elder Creek sites. The use of nitrate/nitrite for detecting impairment isn't congruent with the Suplee et al. (2013) where it says, "The other major change, relative to the 2008 document, is that the Department will not be recommending nitrate (or nitrate + nitrite) criteria for adoption for the control of eutrophication at this time." In light of Suplee et al. (2013) a target value of 0.1 mg/L nitrate/nitrite is inappropriate for evaluating the health of the streams in the Kootenai-Fisher project area.

The scientific standing for impairment determinations would be enhanced if MT DEQ would investigate the dissolved oxygen level in each stream. In conclusion, it is inappropriate, at least with regards to Lake and Stanley Creek, to use a target value from a Northwestern Great Plains ecoregion steam when developing TMDLs for streams in a wooded intermontane valley.

> **Response 2.9**: See Responses 2.5 and 2.7.

Comment 2.10: In Section 9 there is reference to a Chlorophyll-*a* non-pollutant impairment for Raven Creek (see Table 9-1). Was this not addressed by the Chl-*a* data that DEQ collected on the stream, which showed median values of <20 mg/m^2? If so, can Raven Creek be delisted for this non-pollutant impairment?

> **Response 2.10:** Because of the additional Raven Creek data collected in 2013, the assessment was completed very close to completion of the draft TMDL document. All pollutant listings were updated within the document to reflect the impairment determinations but we forgot to update the non-pollutant status change for Raven Creek. Based on all chlorophyll-*a* and AFDM values being below the target, chlorophyll-*a* will be delisted as an impairment cause for Raven Creek for the 2014 303(d) List. The text in **Sections 6** and **9** has been edited to reflect the delisting.

Comment 2.11: More detail needs to be provided on how the diatom (Didymosphenia geminata; rock snot) is taken into account for all of the Ash Free Dry Matter (AFDM) samples. This is relevant for all of the streams evaluated in this report. Didymosphenia geminata has been observed in Lake Creek up to LC01 (my observations). The biomass provided by D. geminata would likely bias any AFDM measurements made at any location. D. geminata occurs most frequently in waters with low total phosphorus (less than 2 micrograms per liter [µg/L]) and low nitrate (less than 1 milligram per liter [mg/L]; Spaulding and Elwell 2007); however, it can also be found where both of these nutrients are present at very high concentrations (Spaulding and Elwell 2007). Spaulding and Elwell (2007) also suggest that where D. geminata is present, there is no clear indication that the biomass or growth rate for the diatom is in association with nutrient concentrations. Furthermore, it is not known if the diatom is limited by either nitrate or phosphorus in any streams in North America (Spaulding and Elwell 2007). Therefore, if the AFDM measurements are biased by this diatom, the AFDM measurements may not be directly correlated to nutrient levels in the stream.

> **Response 2.11**: In locations where *D. geminata* is not the major benthic growth, DEQ considers the collective measurement of benthic algae, fungus, and bacteria via AFDM to be a reasonable approach for quantifying bottom-attached biomass. Growth of lotic benthic algae typically follows a general pattern of colonization, exponential growth, and autogenic sloughing and loss. During colonization and exponential growth, chlorophyll-*a* and AFDM of algae track one another

fairly well. But with age, the algae begin to be colonized with other algae, bacteria, and fungi, forming the collective periphytic community referred to as *aufwuchs*. The loss phase in late fall is generally followed by repetition of the process the following summer. Leaves, pine needles, macrophytes, and moss are not considered appropriate to sample when sampling *aufwuchs.* DEQ field staff knows not to include them in routine sampling of stream benthic biomass. Thus, AFDM—as measured by DEQ—provides a means of quantifying stream biomass even if the peak of algal chlorophyll-*a* has passed. This gives DEQ more flexibility in sampling (otherwise, field staff would always have to be on the stream at the peak of algal growth, which is not practicable). DEQ does assume, when carrying out these analysis, that the streamflow associated with spring runoff largely resets the *aufwuchs* community each year.

At streams where *D. geminata* has dominated the stream bottom, the commenter has a point in noting that AFDM measurements collected there may lead to false positives using the Nutrient Assessment Methodology. DEQ's use of AFDM in accompaniment with benthic chlorophyll-*a* is predicated on the assumption that what DEQ is measuring is largely green algae and diatoms, and associated *aufwuchs*, and not big mats of *D. geminata.* Large mats of *D. geminata* can occur in waters with very low total P and their ability to do proliferate under these conditions is still under study. It should be noted that high N:P ratios in stream water may be a contributing factor. Field testing assessment methods are a critical component of method development. DEQ will be revising its nutrient assessment methodology over the next couple of years and will take this comment into consideration at that time.

Comment 2.12: Section 6.4.3.1, Page 6-6; "Eight chlorophyll-a and seven AFDM samples were collected from Lake Creek between 2011 and 2012. Chlorophyll-a values ranged from 5.5 to 38.9 mg/m² with none exceeding the target of 125 mg/m². The AFDM samples ranged from 18.5 to 69.5 g/m2 with four of the observations exceeding the target of 35 g/m2."

If the AFDM for Lake Creek were relevant, then the Chlorophyll-a would be closer to the target; however, the highest Chlorophyll-a was less than one-third of the target. The AFDM was likely affected by other sources of organic matter. MDEQ uses AFDM collected from stream-sediment surfaces as a way to estimate algal biomass (Suplee and de Suplee 2011). The method for AFDM analysis is based on oxidizing all material in the sample and reporting back the mass of all organic material in the sample (American Public Health Association 1998). It is used to provide an additional means of assessing accumulated algal biomass independent of Chlorophyll-a (Suplee and de Suplee 2011). The U.S. Environmental Protection Agency exemplifies this in the Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition (Barbour et al. 1999): "Periphyton biomass can be estimated with Chlorophyll-a, ash-free dry mass (AFDM), cell densities, and biovolume, usually per cm2 (Stevenson 1996). Each of these measures estimates a different component of periphyton biomass (see Stevenson 1996 for discussion)." In the Stevenson report (1996), it is stated that AFDM can be biased high due to non-algal sources (e.g., detritus, fungi and bacteria).

This leads to the question: how are the AFDM measurements, which should be measuring periphyton biomass, controlled for the added mass coming from bacteria, fungi, and the diatom (D. geminata)? Are all of the AFDM measurements in this report biased high due to other sources of organic matter? Also, all locations with the AFDM exceedance of the threshold are downstream of LC04, the most downstream location on Lake Creek monitored by the Troy Mine. If the impoundment is affecting Lake Creek at LC04, then the AFDM should fail to be a reliable metric there as well.

<u>Response 2.12</u>: See response to comment 2.11. DEQ does not believe that the AFDM measurements in Lake Creek are biased due to other sources of organic matter. Because algae and other primary producers consume nutrients and alter instream concentrations, and other factors such as sunlight, macroinvertebrate densities, and water depth and velocity affect algal growth, occurances of high levels of algal growth will not necessarily correspond to locations where nutrient concentrations are elevated.

<u>Comment 2.13</u>: Section 6.4.3, Page 6-5, mentions a shift in analytical method from Total Kjehldahl Nitrogen (TKN) to Total Persulfate Nitrogen because of a bias associated with TKN. What bias does this passage refer to? There needs to be more detail why the switch between the methods was implemented. Are there studies that back up this statement?

<u>Response 2.13</u>: The "bias" referred to in the TMDL document pertains to the TKN measurement, which can give higher results than simultaneously-collected total persufate nitrogen measurements (i.e., total N). Since TKN (organic N plus ammonia) should be a subcomponent of total N (TN), it should in theory never be higher than TN, but this was found to occur. This high bias was observed during review of in-house data undertaken by DEQ's QA officer some years ago, and for this reason the Water Quality Monitoring Bureau switched to total persulfate N around 2006.

The USGS recently completed an analysis of calculating TN via different methods, including the persulfate method and the TKN +nitrate +nitrite method (see Assessing Total Nitrogen in Surface-Water Samples—Precision and Bias of Analytical and Computational Methods, USGS Scientific Investigations Report 2012-5281, Rus et al., 2012) . Results are best summarized in Figure 17 of that document. Total N calculated using TKN tends to be biased high and is quite variable, whereas total persulfate N has a somewhat low bias and is fairly precise as long as total suspended sediments are not too high. Streams in the TMDL area in question tend to have low suspended sediments, therefore the total persulfate N method is a good fit. The text has been clarified to state that TKN can have a high bias and a citation for the USGS report has been added.

<u>Comment 2.14</u>: Section 6.5.3.1 - In general, it seems that MDEQ is conducting a TMDL on what it perceives is groundwater. It needs to be described in this document that it is unusual for a small intermittent tributary such as upper Stanley Creek to have intermittently high nutrient levels.

<u>Response 2.14</u>: Many streams are groundwater-dominated, particularly during the summer growing season, but this does not preclude human sources from causing impairment. The TMDL for Stanley Creek applies to all portions of the creek, from the headwaters to the mouth. As stated in the report, reductions in loads vary depending on site-specific conditions. No specific statement was made regarding nutrient concentrations in intermittent streams because the nutrient targets are set at concentrations that are not typically exceeded by natural sources in all streams in the Northern Rockies level 3 ecoregion.

<u>Comment 2.15:</u> The historic level of nitrate/nitrite has been well documented in Stanley Creek (Levings et al., 1984). Levings et al. (1984) stated, "Ross and Stanley Creeks ordinarily had larger nitrite plus nitrate concentrations than did Lake Creek." Using a nitrate/nitrite target value of 0.1 mg/L for impairment, Stanley was impaired from 1976-1978 (prior to the development of Troy Mine) with 42% of the samples exceeding the 0.1 mg/L nitrate/nitrite benchmark. The use of nitrate/nitrite for detecting impairment isn't congruent with Suplee et. al. (2013) where it says, "The other major change, relative to the 2008 document, is that the Department will not be recommending nitrate (or nitrate + nitrite) criteria for adoption for the control of eutrophication at this time." In light of Suplee et al. (2013) a target value of 0.1 mg/L nitrate/nitrite is inappropriate for evaluating the health of Stanley Creek.

Response 2.15: See Responses 2.2 and 2.5.

Comment 2.16: Section 6.5.3.1, Page 6-6: "NO3+NO2 concentrations at the site just downstream of Fairway Creek (K01STNLC01/SC-02) are typically close to those upstream of Fairway Creek, as evidenced by the median at that site and the upper site (K01STNLC05/SC-15) being similar (Figure 6-4). Particularly given the substantial flow from Fairway Creek, this indicates Fairway Creek is also a source of NO3+NO2 to Stanley Creek. Fairway Creek originates from Spar Springs (which are fed by Spar Lake in the upper watershed) approximately 0.5 miles upstream of its confluence with Stanley Creek (KNF 2010)." This statement does not make sense if Stanley Creek upstream of Fairway Creek is the source of nitrate+nitrite to the system.

Response 2.16: The text in the document has been changed and now acknowledges that unknown sources in Fairway Creek are also contributing to the nitrate load in Stanley Creek.

Comment 2.17: The impairment reported during this evaluation of Lake Creek is likely the result of a sampling or measurement false positive. The likely source of the higher than expected AFDM values is due to the presence of *D. geminate* (rock snot) in Lake Creek (see supporting comments herein). The presence of rock snot has been mentioned in the Comprehensive Water Quality Monitoring Program for Streams Adjacent to the Troy Mine report provided to the MTDEQ. Did the MTDEQ look for the presence of *D. geminate*? If so, what proportion of the sample was rock snot and was an adjustment made to the AFDM results?

D. geminate is known to skew the AFDM test. In Spaulding and Elwell (2007) it is stated, "The AFDM biomass of *D. geminate* was measured to be 250 times greater than the chlorophyll α biomass." Spaulding and Ewell go on to say, "blooms of *D. geminate* are unlike other algal blooms, because they are associated with nutrient-poor waters. Notably, many *D. geminate* blooms have occurred in stream habitats generally considered pristine or with limited ecological disturbance."

Response 2.17: See Response 2.12. DEQ did not specifically look for *D. geminata* in Lake Creek when sampling. Four periphyton samples are available for Lake Creek (available in STORET, 2006-2011). The dominant species in each of the four samples was *Achnanthidium minutissimum*, *Achnanthidium pyrenaicum,* and/or *Encyonema silesiacum. Didymosphenia geminata* was present in all four samples, but was less than 1% of each sample. No adjustment was made to the results.

Comment 2.18: Page 6-9 states that no monitoring data could be used to estimate natural background nutrient loading and natural background loading was estimated by using the median concentration from the reference nutrient dataset for each pollutant in the Level III Northern Rockies ecoregion. However, independent data is in fact available for Stanley Creek dating back to at least 1976 (Levings et al., 1984).

Response 2.18: See Response 2.2.

Comment 2.19: Given MT DEQ's recognition about the uncertainty regarding the non-mining related sources of NO3+NO2 what is the scientific basis for the MT DEQ conclusion that Troy Mine is the source for nitrates/nitrites in Stanley Creek?

> **Response 2.19**: DEQ concluded that the mine and Fairway Creek are sources of excess nitrate but did not adequately and consistently clarify this in the Draft document. The source assessment conclusions and load allocation rationale have been clarified regarding the uncertainty in loading from the mine and Fairway Creek.

Comment 2.20: The loading evaluation for Stanley Creek took place outside the preferred MT DEQ evaluation period (July 1st- September 30th) (Suplee et al. 2013). The historic pre- mining record and much of the data from the ongoing 28 years of monitoring wasn't examined by MT DEQ in the development of the draft TMDL. The use of nitrate/nitrite for detecting impairment isn't congruent with the Suplee et al. (2013) where it says, "The other major change, relative to the 2008 document, is that the Department will not be recommending nitrate (or nitrate + nitrite) criteria for adoption for the control of eutrophication at this time." In light of Suplee et al. (2013) a target value of 0.1 mg/L nitrate/nitrite is inappropriate for evaluating the health of Stanley Creek.

> **Response 2.20**: Suplee et al. (2013) allows a ten day window on either side of the evaluation period, and all samples fell within that allowable timeframe. This clarification has been added to the document. See Responses 1.10, 2.5, and 2.8.

Comment 2.21: Two commenters made this point - Refer to the previous comments concerning Lake and Stanley creek. Based on data reported by the Montana Bureau of Mines and Geology prior to the establishment of the mine, under the current definition of impairment, Stanley Creek was impaired with 42% of the samples exceeding the 0.1 mg/l nitrate+nitrite threshold (Levings et al. 1984). Furthermore, during the same time period, Ross Creek had almost 79% of the samples above 0.1 mg/l nitrate+nitrite (Levings et al. 1984). Clearly, nitrate+nitrite levels have been above the present threshold in the past and before the Troy Mine existed.

The suggestion in the TMDL document that the water quality in wells MW-1 and MW95-4 is consistent with the source of the nutrients detected at LC04 assumes an overly simplistic and incorrect model for nutrients in this watershed. The Montana Bureau of Mines and Geology prior to the establishment of the tailing impoundment (Levings et al. 1984) found higher levels of nitrate/nitrite in wells adjacent to the proposed impoundment 0.27 ppm, 0.33 ppm, and 0.4 ppm in wells 30N33W30DAAD01, 30N33W30DAAD02, and 30N33W30DCAD01, respectively. While this only represents a single year of testing, it points to pre-tailings historic local variation in the nitrate-nitrite levels in the ground water.

If the tailings impoundment were a source of nitrate-nitrite to Lake Creek, then the levels should be high at sampling location K01LAKEC06 as well, as this site is immediately downstream of the impoundment and upstream of the cited LC04 sampling location. For a compete assessment of loadings downstream of the impoundment at LC04, the loadings from Porcupine Creek and Twin Creek need to be accounted for, both of which have residential septic systems and other sources of nutrients. Furthermore, the measurements were made during periods of harvest in this assessment. As stated in the draft MTDEQ TMDL report, it takes 2 to 3 years for nitrate levels to drop to normal. It was also stated in the MDEQ report that harvests did occur during the time period in question **(Section 6.5.4.2, Page 6-21: "Harvests occurred on 1,354 acres of Kootenai National Forest land in 2012 (KNF 2012). Harvests units were**

spread throughout the Lake Creek watershed"). Therefore, loadings from these harvests should be considered as likely sources in this report.

> **Response 2.21**: See Responses 2.2 and 2.3. Additionally, as noted in Comment 2.30, the time period for timber harvest was incorrectly stated in the draft document, and the sampling associated with this project did not overlap with timber harvest on USFS land. The decision authorizing the Sparring Bulls Timber harvest was made in 2012, but the harvest occurred (and will be occurring) in 2013-2015. The text has been corrected.

Comment 2.22: Page 6-26: "For Stanley and Lake Creeks, most of the source assessment uncertainty is regarding the non-mining related loading. For both streams, a substantial amount of NO3+NO2 loading is attributable to Troy Mine, so implementation of BMPs to address mining-related loading will also help refine the source assessment by indicated if other sources are also causes exceedances of the water quality standard."

Refer to the previous comments concerning Lake and Stanley creek.

> **Response 2.22**: The referenced text has been deleted from the document, and the source loading and uncertainty discussions have been updated to reflect the uncertainty in the source assessment for Lake and Stanley creeks.

Comment 2.23: The plot in Figure 6-2 implies little difference in nitrate+nitrite concentrations between Stanley Creek upstream of Fairway Creek as compared to downstream of the confluence with Fairway Creek. Data for nitrate+nitrite results for samples collected between 2005 and 2012 (during the growing season, July to September) are presented on Figure 1. The data on Figure 1 imply that there is no difference in nitrate+nitrite concentrations when comparing Stanley Creek upstream of Fairway Creek, Fairway Creek, and Stanley Creek downstream of the confluence with Fairway Creek. Fairway Creek must be evaluated as a part of the TMDL process for nitrate+nitrite loadings to Stanley Creek.

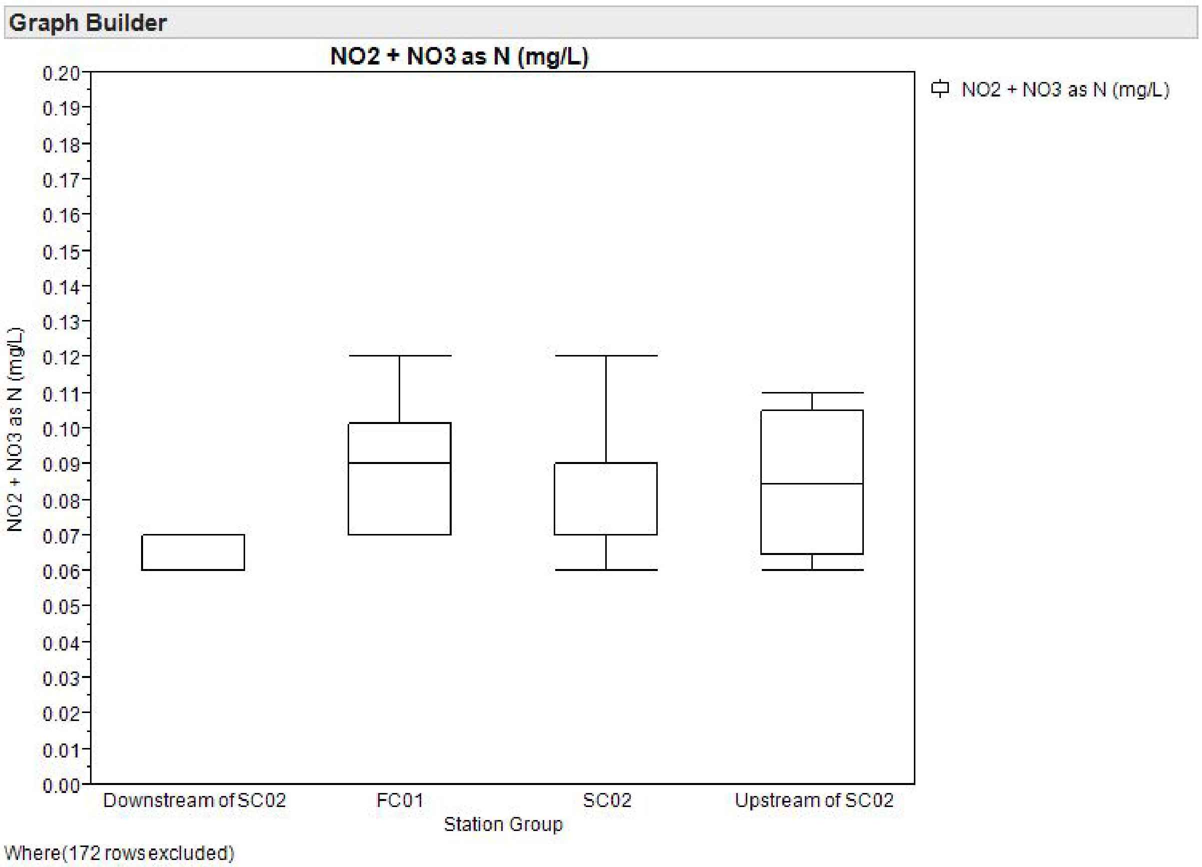


Figure 1 Nitrate+Nitrite Concentrations in the Stanley-Fairway System

Response 2.23: The box plots indicate the overall concentrations at the monitoring locations but do not indicate changes within a single sampling event. Synoptic data where samples were collected on the same day were somewhat limited but a time series plot is shown in **Figure 6-6**, and does show nitrate concentrations (and particularly the peaks) to be consistently greater upstream of Fairway Creek. However, concentrations in Fairway Creek are higher than anticipated and the text has been updated to reflect the uncertainty in nitrate loads from Fairway Creek.

Comment 2.24: Given the location of the underground workings it seems highly unlikely that Fairway Creek is influenced by the mine in which case Fairway should be a good reference stream for nitrite/nitrates. Is this what the natural background value is based on?

Response 2.24: Fairway Creek has a number of possible anthropogenic sources and cannot be used as a reference stream. As stated in **Section 6.5.1**, "Natural background loading was estimated by using the median concentration from the reference nutrient dataset for each pollutant in the Level III Northern Rockies ecoregion (as described in Suplee and Watson, 2013; Suplee et al., 2008)".

Comment 2.25: Two commenters made this point **-** The historic record agrees with your assessment that Fairway Creek is also a source of nitrate/nitrite to Stanley Creek. Based on this fact we question the flawed conclusion in the draft TMDL that the Troy Mine is the source of impairment for Stanley Creek. Fairway Creek is not impacted by mine operations yet it is a source of nitrate/nitrite to Stanley Creek.

> **Response 2.25:** See Response 2.19. The text has been updated to reflect the uncertainty in the source loads.

Comment 2.26: Two commenters made this point - It seems that DEQ concludes that upper Stanley Creek is the major source of nutrients to Stanley Creek downstream of its confluence with Fairway Creek; however, Fairway Creek must be accounted for with this loading analysis. The additional loading from Stanley Creek will be minor relative to that of Fairway Creek.

> **Response 2.26:** DEQ concluded that loading to upper Stanley Creek is causing target exceedances in upper Stanley Creek but that Fairway Creek is contributing most of the load downstream of its confluence with Stanley Creek. The text has been updated to reflect this comment and better clarify loading upstream and downstream of Fairway Creek.

Comment 2.27: At this point, it is not possible to know which samples from Appendix F are used for the assessment on page 6-6, as there are 25 sample results presented in Appendix F.

> **Response 2.27:** There are 24 growing season samples for Stanley Creek in **Appendix F**, and all 24 were used in the assessment. The text erroneously stated 22 samples, and this had been corrected.

Comment 2.28: "Figure 6-8. Synoptic growing season NO3+NO2 data for Lake Creek[1]**"**
[1]Some sites in the above figures are collocated with multiple sites including: K01LAKEC05, LKC-280, LC01; K01LAKEC06, LKCA; LKC-279, K01LAKEC02; K01LAKEC07, LKC-278; K01LAKEC01, LKC-276." This footnote is confusing. Please clarify

> **Response 2.28:** The text has been updated to clarify which sites are collocated.

Comment 2.29: P. 6-19; Paragraph 4: The Final EIS for the Troy Mine concluded that the tailings impoundment does contribute to nitrate loading in Lake Creek (p. 3-79). Explain why you have reached a different conclusion as compared to this document.

> **Response 2.29**: The measured data in Lake Creek suggest that there is a significant and consistent nitrate source in the segment of Lake Creek downstream of the tailings ponds impoundment that has persisted for decades. Multiple documents have also documented that water in the tailings impoundment has high nitrate concentrations (as described in the EIS) and has a documented seepage rate into localized groundwater. These factors and the long-term presence of the tailing ponds versus a short-term potential source such as timber harvest strongly suggest that the tailings pond is the primary source of the excess nitrate load observed in Lake Creek. However, DEQ acknowledges that there are still uncertainties regarding the magnitude of impacts to Lake Creek and impacts from other localized sources. The text and load allocation have been updated to reflect this uncertainty. DEQ also recommends further groundwater study in the vicinity of the tailings pond to accurately describe transport of nitrate from the pond through the groundwater.

Comment 2.30: P. 6-21 states "*Harvests occurred on 1,354 acres of Kootenai National Forest land in 2012 (KNF, 2012)"*. The decision authorizing the harvest for Sparring Bulls was in 2012. However, the timber sale did not begin until 2013, and probably will continue until 2015.

> **Response 2.30**: The text on p. 6-21 has been edited to reflect the correct harvest years.

Comment 2.31: The document summary on page DS-2 states "Nutrient and biological data in these streams indicate nutrients are present in concentrations that can cause algal growth that harms recreation and aquatic life beneficial uses." This implies that there are biological data that indicate effects due to nitrate+nitrite in Stanley Creek; however, in Section 6, Stanley Creek was determined to meet all biological thresholds. Therefore, this statement is not correct. Furthermore, in Lake Creek all biological measures are satisfactory except AFDM, where AFDM measurements are likely affected by D. geminata and other sources of organic matter.

> **Response 2.31**: The statement referenced from the document summary is intended to be a general statement that those streams are not meeting all beneficial uses because of nutrients and that collectively that is due to nutrient and biological data. You are correct in that the impairment determination for Stanley Creek was based on water quality data and the determination for Lake Creek was based on biological data. The statement in the document summary has been revised to state "Nutrient and/or biological data…" Regarding the D. geminata portion of the comment, refer to Responses 2.11, 2.12, and 2.17.

I.3 Temperature Comments

Comment 3.1: Temperature Section 7.2.1.2, Are there no special temperature considerations for western pearlshell mussels? Are there no special temperature considerations for other aquatic organisms?

> **Response 3.1**: In 2012 during the temperature TMDL planning stage, DEQ corresponded with the Montana Natural Heritage Program, which has monitored western pearlshell mussel populations in Montana. Dave Stagliano, the aquatic ecologist who conducted much of the monitoring, responded that "they can withstand temperatures greater than 25 degrees (C°), but obviously those high temperatures will quickly kill their salmonid host fish species and the mussel population will eventually die with no recruitment. So, for temperature models, use the most temperature sensitive organisms expected in the aquatic community (salmonids: westslope cutthroat or Columbia redbands, not the pearshells)." Based on this information and no literature values to the contrary regarding temperature tolerances of western pearlshell mussels, only salmonids were discussed relative to the temperature levels of concern in Wolf Creek (see **Section 7.2.1.1**). In the public review document, the western pearlshell mussels in Wolf Creek were discussed in the sediment TMDL section on p. 5-37 because the mussels are sensitive to excess siltation as well. Although literature indicates salmonids are likely the most sensitive aquatic organisms in regard to elevated stream temperatures in Wolf Creek and focusing on temperature thresholds important for their survival should also protect less sensitive species, you make a good point that the mussel should be mentioned in the temperature section. Additional text been added to **Section 7.2.1** and **7.2.1.1**.

Comment 3.2: In our opinion, the only notable lapse in obtaining stakeholder input in this process was with regard to the stream temperature modeling for Wolf Creek. DEQ/EPA failed to involve stakeholders in perhaps the most critical step of this process, which was helping evaluate the physical attainability of the Naturally Occurring Shade Scenario. With the exception of one willow complex in the middle of the drainage and the railroad and paved roads, DEQ/EPA assumed a 50-foot buffer of medium-density trees along the remaining length of Wolf Creek. This included many areas that are natural sedge meadows, or areas that are otherwise not capable of supporting 50-foot tall medium-density vegetation. Additionally, this ecoregion is naturally frequented by periodic wildfires that prevent long distances of tall riparian vegetation. It cannot be overstated how sensitive the TMDL is to this modeling assumption. We raised this concern to DEQ/EPA in the stakeholder review process, but it was apparently too late to make corrections. DEQ/EPA did note the limitations of this assumption in the analysis, and this has also been noted in the adaptive management and uncertainty sections of the TMDL, as well as the “Surrogate Allocation” portion of the TMDL shown in Table 7-5. We strongly encourage DEQ/EPA to involve local experts in this most critical step in future stream temperature TMDLs.

> **Response 3.2:** We did solicit stakeholder input and feedback regarding the shade scenario at the onset of model development, and did receive positive feedback, but do apologize there were not additional opportunities for stakeholder feedback prior to model finalization. In general though, the nature of the model, field-scale information, and level-of-detail of the project necessitated a fairly coarse approach to scenario development for the QUAL2K model. DEQ realizes that not all areas have the same potential for effective shade, which is why we included the extensive discussion on the intent of the shade scenario and potential limitations to achieving the shade target you referenced in your comment.
>
> After receiving these concerns during the stakeholder review process, we communicated with the USFS, who had been supportive of the shade scenario initially but had reviewed aerial photos from 1932 and conducted extensive vegetation surveys in the watershed in 2013. The botanist/silviculturist with the Kootenai National Forest, Debra Bond, said that after her review of the photos and recent work in the watershed, she feels the shade scenario applied in the model is generally applicable (Bond, Debra, personal communication 3/7/2014). Given that a large part of defining the naturally occurring condition within the model relies on best professional judgment, DEQ works hard to incorporate local expert knowledge into scenario development, but particularly where stakeholders disagree on the endpoint, DEQ must make the final determination. We are confident in the applicability of the shade scenario for the Wolf Creek watershed scale but agree that for reassessment of the Wolf Creek temperature impairment and future TMDLs, more technical stakeholder involvement on scenarios and a higher level of detail on the achievable condition is preferable.

Comment 3.3: Temperature Section 7.5.1-Why were human influences on tributary water temperatures considered outside of the scope of this project? The tributaries to Wolf Creek account for a substantial area of the overall Wolf Creek watershed.

> **Response 3.3**: We agree that tributaries are an important consideration, and data were collected for temperature and flow at the mouth of major tributaries to help identify tributaries that may have a warming or cooling effect on Wolf Creek temperatures. However, to evaluate human influences on tributaries would have required more resources than were available for this project and is not a typical part of the source assessment process for temperature TMDLs. Including tributaries would have required a similar effort of data collection as Wolf Creek, which

included temperature loggers, flow measurements, and shade measurements dispersed from the headwaters to the mouth. DEQ strongly believes in the watershed approach but must prioritize resources during TMDL development to waterbodies that are already identified as impaired. However, during implementation and future monitoring, the tributaries definitely could and should be included when possible. Clarification on this topic was added to **Section 7.5.1**. In the discussion of strengthening the source assessment within the Monitoring Strategy and Adaptive Management Section (**11.3.1**), identifying areas for improvement in shading along tributaries is noted.

Comment 3.4: Were future climatic projections incorporated into the QUAL2K model to assess water temperature in Wolf Creek?

Response 3.4: No, as stated in the Uncertainty and Adaptive Management Section on p. 7-22, future climate projections were not incorporated into the model. DEQ acknowledges that climate change could affect both the baseline condition and naturally occurring condition, but developing projections and applying them to a new baseline and alternative scenarios was outside the scope of the model and TMDL.

Comment 3.5: Temperature Section 7.5.1.1 states "The calibrated and validated model was set up entirely on measured conditions and corresponding weather data, but because long-term flow data at the nearby Fisher River gage indicated Wolf Creek summer flows were likely higher than usual (which could result in cooler water temperatures), flow and climate data were adjusted to represent more critical (i.e., hotter and drier) conditions for the baseline scenario." Why wasn't flow data for Wolf Creek used?

Response 3.5: There is no long-term continuous flow record for Wolf Creek, so the Fisher River gage was used to get a sense of how flows measured in Wolf Creek in 2012 likely fit into the long-term flow regime for Wolf Creek. Flow data from Wolf Creek was used but it was reduced by 45% based on the relative difference (i.e., 45%) between the 2012 August flow at the Fisher River gage and the 25th percentile flow at the gage. **Appendix G** contains more detail than **Section 7.5.1.1**.

Comment 3.6: For the temperature TMDL, were future temperature predictions associated with climate change incorporated into the allowable temperature change? Were future climatic changes and impact to riparian vegetation incorporated into the assessment of riparian shade?

Response 3.6: By representing the 25th percentile flow conditions and more extreme meteorological conditions than were observed in 2012 in the baseline scenario (hotter, drier), the baseline is likely representative of conditions that could occur with greater frequency in the future (under climate change). The allowable change uses the naturally occurring scenario as the starting point, and because that scenario is built on a baseline scenario representing more critical conditions than observed in a typical year. Therefore, it incorporates climate change to a certain extent but it was not explicitly included as part of the model. The potential effective shade from the riparian vegetation was based on an estimate of the existing potential and does not account for climate change; if climate change is sufficient enough to alter the vegetation, it would also likely alter the aquatic species that could inhabit the watershed - the naturally occurring condition would need to be redefined as part of the adaptive management process.

Comment 3.7: How were the potential climatic changes projected for this area incorporated into the margin of safety?

> **Response 3.7**: As discussed in Response 3.6, future predictions associated with climate change were not explicitly incorporated into the TMDL process and would be incorporated into the adaptive management process. **Section 7.7** of the document discusses how the margin of safety was incorporated into the temperature TMDL.

Comment 3.8: Did the TMDL development for temperature in Wolf Creek account for the potential development of Plum Creek land and subsequent increases in water diversions, irrigation, and withdrawals? The potential subdivision of Plum Creek land in Wolf Creek could significantly alter surface water flow paths, water availability, and influence water temperature. Consumptive water use could significantly increase with the sale of Plum Creek land.

> **Response 3.8**: As stated relative to nutrients in Responses 1.12 and 1.13, potential changes in land ownership and the ramifications of that are outside the scope of TMDL development. Forecasting land ownership changes is speculative and would not affect the outcome or allocations for the temperature TMDL, as the surrogate allocation to consumptive water use is to apply all reasonable water conservation practices. Therefore, regardless of land ownership, and even if consumptive water use does become more significant, the temperature standard is narrative and following the surrogate allocation will meet the intent of the TMDL and contribute towards meeting the water quality standard.

Comment 3.9: Why wasn't the potential development of Plum Creek lands and water resources included in the water use scenario to assess the effect on instream flow and water temperatures? If Plum Creek lands are sold off and developed there is the potential for increased flood irrigation and decreased instream flow. How much water development potential is in Wolf Creek before stream temperatures would be impacted? Given the high probability of Plum Creek land being developed, what levels of consumptive water usage would cause the allowable temperature change to be exceeded?

> **Response 3.9**: See Response 3.8.

I.4 Metals Comments

Comment 4.1: In Section 2.3.5, the document refers to the Montanore Mine and the Rock Creek Mine projects as being located in the wilderness and therefore controversial with the future of the projects described as unclear. A better description of the status of these projects is as follows:

In compliance with NEPA and MEPA, the KNF and DEQ released the Montanore draft EIS (2009) and Supplemental draft EIS (2011) for public comment, and responses to comments will be included in the Final EIS which is due to be completed in 2014. The USFWS is completing the formal consultation with the release of the Final BO targeted for Spring of 2014. If approved the project would be administered under an Approved Plan of Operations (KNF) and a modification to the existing DEQ Operating Permit. There are no facilities or other surface disturbances proposed within the wilderness for the Montanore or Rock Creek projects. In response to the US District Court Opinion in 2010, the KNF is completing a Supplemental EIS to address deficiencies in the 2001 Rock Creek FEIS, as outlined in the Court Opinion. The release of the Rock Creek Project Supplemental EIS for public comment is estimated for 2014.

Rather than the description above, if a more succinct description is necessary, it would be better to state that: *The KNF and DEQ are completing the Final EIS for the Montanore Mine project, and the KNF is completing a Supplemental EIS for the Rock Creek project. Both projects have undergone formal consultation under ESA. Neither project proposes surface facilities or other surface disturbances within the wilderness.*

Concerning the Troy Mine,
The DEQ and the KNF completed an EIS which analyzed Troy Mine, Inc.'s revised reclamation plan as well as agency-proposed modifications concerning adit closure, mine water management, water treatment and monitoring, reclamation and road closures. The 2012 ROD approved the amendment to the reclamation plan for the Troy Mine and selected the Agency Mitigated alternative. The agencies are developing bond calculations and the revised reclamation plan.

> **Response 4.1:** Because Rock Creek Mine is outside of the project area and all references to Rock Creek Mine have been removed from the TMDL document (see Response 1.11), none of the suggested text regarding the mine used. The reference to the wilderness area was also removed and a general summary of the Troy Mine and Montanore Project NEPA/MEPA status was added based on the comments provided.

Comment 4.2: The biotic ligand model (BLM) for copper should be used in any evaluation of copper in Montana (USEPA 2007a). An evaluation of copper with the BLM should be provided as an addition to the Kootenai-Fisher TMDL. The use of total recoverable metal analysis to evaluate divalent metals has the potential to over-estimate effects on aquatic life (USEPA 2007b).

> **Response 4.2:** The water chemistry targets for metals are based on numeric human health standards and both chronic and acute aquatic life standards as defined in DEQ Circular DEQ-7. Most of the metals pollutants have numeric water quality criteria defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2008). These criteria include values for protecting human health and for protecting aquatic life, and apply as water quality standards for all streams. Although Montana DEQ does not use biological indicators to assess metals impairments to waterbodies, it is important to note that the chronic and acute water quality standards apply toward the protection of multiple forms of aquatic life, including fish.
>
> Montana water quality standards for metals (except aluminum) in surface water are based upon the analysis of samples following a "total recoverable" digestion procedure (Martin et al., 1994). TMDLs must be based on the applicable water quality standards.

Comment 4.3: My comment for the TMDL Document is that it seems the Big Cherry Millsite Reclamation that took place during the summer of 2007 under CERCLA has not been included. The mining history/reclamation section where it should likely be listed in in section 2-11, this is where the Snowshoe Reclamation is discussed. The Big Cherry metals section is in 8-6, and the metals source assessment for Big Cherry is in 8-14 – the reclamation also seems relevant here.

The Big Cherry Millsite is located approximately three miles below the confluence of Snowshoe Creek and Big Cherry Creek on the east side of Big Cherry Creek (T.29 N., R.31 W., Section 27, MPM). The lowest portion of the millsite was built on a terrace above Big Cherry Creek and contained several flotation tailings impoundments of small to moderate size.

The Big Cherry Mill site contained approximately 3,600 bank cubic yards of waste that was high in arsenic and lead. Downstream of the Mill site and adjacent to Big Cherry Creek another mine waste deposit area contained approximately 3,900 bank cubic yards of contaminated material which originated at the Snowshoe Mine. In 2007, a total of about 10,455 bcy of material (including 6 -12 inches of native underlying material) was excavated from these areas and securely placed in an onsite repository. Clean soil was obtained from a local source on NFS land to backfill and blend the area with surrounding topography. The area has been reclaimed with native vegetation and seedlings. In 2010, approximately 700 cyd of amended material was brought to the Mill site location to improve vegetation, the area was again seeded and mulched.

More information can be found in the Engineering Evaluation Cost Analysis EECA for the Snowshoe Mine, Snowshoe Creek and Big Cherry Mill site.

> **Response 4.3: Section 2.3.6** Mining, on pages 2-11 and 2-12 was updated with the following language: "*The Big Cherry mill site has undergone significant reclamation. The Big Cherry Mill site originally contained approximately 3,600 bank cubic yards (bcy) of waste that was a significant source of metals pollution. Downstream of the Mill site and adjacent to Big Cherry Creek another mine waste deposit area contained approximately 3,900 bcy of contaminated material which originated at the Snowshoe Mine. Reclamation activities include excavation of a total of about 10,455 bcy of material (including 6 -12 inches of native underlying material) that was excavated from these areas and securely placed in an onsite repository. Clean soil was obtained from a local source on NFS land to backfill and blend the area with surrounding topography. The area has been reclaimed with native vegetation and seedlings. In 2010, approximately 700 bcy of amended material was brought to the Mill site location to improve vegetation, the area was again seeded and mulched.*"
>
> A reference to the mine reclamation activities included in **Section 2.3.6**, detailed above, have been added to **Section 8.5.1**.

Comment 4.4: 8.5.2 Stanley Creek -This section states that historical mining activities contribute metals to Stanley Creek. This is not the case in Stanley Creek and this section needs to be revised. Please review and reference Montana Bureau of Mines and Geology "Abandoned-Inactive MInes of the Kootenai National Forest Administered Land (Open-file Report MBMG 395) by Hargrave et al. in December 1999. The source of metals in Stanley Creek is from naturally occurring sources and the Troy Mine. The evidence (1996 road failure that overwhelmed mill site containment system, two tailings spills into the stream, and ongoing mill sidecast issues) indicates that the mining and road operations have continued to lead to an introduction of metals and sediment to Stanley Creek.

> **Response 4.4:** There are a number of small mines, and ongoing active mining in the upper portions of the Stanley Creek watershed. Given the limited amount of data available to the DEQ, during the TMDL development process (particularly upgradient), we were unable to differentiate metals sources that would be considered natural background, existing or historical mining. Review of *"Abandoned-Inactive Mines of the Kootenai National Forest Administered Land"* (Open-file Report MBMG 395) by Hargrave et al. December 1999 did not produce a direct reference to the source of metals in Stanley Creek as being from naturally occurring sources and the Troy Mine. DEQ has associated the metals loading to Stanley Creek with sediment

production in the Stanley Creek basin (**Section 8.5.2** paragraph 2). Those activities that produce sediment are the likely sources of metals pollution in Stanley Creek.

Comment 4.5: Page 8-33; 2nd paragraph: "The source assessment for the Stanley Creek watershed indicates that historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources." This conclusion is incorrect. The MBMG 395 report indicates historic mining activities have no effect on Stanley Creek. There are known sources of contamination from the current mining operation (tailings spills and ore containing material sidecast directly next to the stream at the mill site), and there may be elevated natural background levels as well.

Response 4.5: The TMDL document has been updated to read as follows: "The source assessment for the Stanley Creek watershed indicates that active and historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources."

Comment 4.6: P. 8-16; last paragraph: Add information regarding the second (October 2011) spill into Thicket and Stanley creeks. Although smaller than the October 2009 spill, this spill also resulted in tailings being deposited in Thicket and Stanley creeks. Both spill reports are on file with the DEQ.

Response 4.6: The DEQ Hard Rock Program Operating Permit Field Inspection Report form was reviewed and additional language has been added to **Section 8.5.2**. The following language was added: *"In October of 2011 another tailings pipeline spill occurred in Thicket Creek. Again tailings flowed down Thicket Creek and were deposited in Stanley Creek. Tailings deposits in Stanley Creek were visibly larger than those observed during the 2009 Spill, as noted in the October 26, 2011 DEQ Hard Rock Program Operating Permit Field Inspection Report. Water quality data collected at the time of the inspection indicated levels of copper in exceedance of the chronic aquatic life standard. Total recoverable copper was reported at 0.017 mg/L, at a hardness of 86 mg/L."*

Comment 4.7: P.8-16 - Add information regarding sidecast material at mill site and related water quality sampling results. Runoff from this sidecast ore material on steep slopes immediately above Stanley Creek enters the stream during any period with substantial runoff. The material has elevated metals concentrations (see DEQ site inspection report from 2012).

Response 4.7: The following language was added to **Section 8.5.2**: *"That being said, water quality samples collected upstream and downstream of the sidecast area during a July 2012 Hard Rock Program Operating Permit field inspection showed elevated copper concentrations. The upstream sample was reported as 0.004 mg/L, and increased to 0.006 mg/L downstream of the sidecast area. Both samples were above the chronic aquatic life standard. Soils samples collected during the inspection from the sidecasting area contained elevated concentrations of copper, lead, and antimony."*

Comment 4.8: Section 8.5.3 Lake Creek - Please review and reference Montana Bureau of Mines and Geology "Abandoned-Inactive Mines of the Kootenai National Forest Administered Land (Open-file Report MBMG 395) by Hargrave et al. in December 1999. Note that most of the historic mines in this area are small prospecting developments or are on dry upland slopes and do not have surface water connections downstream. The only small abandoned mines found in this report to have potential water quality impacts are the Giant (Montana) Sunrise/Sunrise Mill in Copper Creek watershed and the Iron Mask/Grouse Mountain mines in NF Keeler watershed. The MBMG report found that the environmental risks posed by these sites were very low.

Response 4.8: The MBMG report *"Abandoned-Inactive Mines of the Kootenai National Forest Administered Land"* (Open-file Report MBMG 395) by Hargrave et al does not indicate that the Giant Sunrise, Iron Mask and Grouse Mountain mines contribute metals pollution directly to surface waters, however it does indicate they have the potential to contribute metals pollution to nearby surface waters, that flow into Lake Creek. The following quotes are from MBMG Open- file Report 395:

The Giant Sunrise Mine waste is in the flood plain of the unnamed tributary to Copper Creek. Several seeps emanate from the toe of the main waste dump. This may be the result of the infiltration of the standing water in the adit at the top of the waste dump.

The Iron Mask had a small adit discharge on private land that flowed into the waste dump and exited on KNF-administered land. The drainage that came from the mine flowed only intermittently before entering into the North Fork of Keeler Creek.

The Grouse Mountain mine waste dumps were in contact with the small tributary to Carr Draw. The stream was flowing in October 1997 and showed signs of having a larger flow earlier in the year.

Given the limited amount of data that is available for source assessment on tributaries to Lake Creek, the Department must take a conservative approach in designating contributing sources, and account for all potentially contributing sources in wasteload allocations (WLAs).

Comment 4.9: Page 8-18; 2nd paragraph: Need to delete most of these references to specific small mines based on lack of evidence of water quality impacts per MBMG report.

Response 4.9: MBMG and DEQ acknowledge the presence of a high density of inactive or abandoned mines in Keeler Creek, Copper Creek and Iron Creek. While there are no data necessarily supporting potential contributions from these small mines, there is no water quality data refuting the potential for these mines to be contributing metals pollution to tributaries of and subsequently the mainstem of Lake Creek. See response to comment 4.8, as the Iron Mask, Grouse Mountain, and Giant Sunrise mines are within the Keeler Creek and Copper Creek watersheds, which contribute to Lake Creek.

Comment 4.10: Page 8-18; 3rd paragraph: Delete or modify "there are likely other unidentified abandoned mines and waste rock piles acting as contributing sources." Based on extensive field review in the Lake Creek watershed by Forest Service employees for recent timber sale and watershed projects additional sources are federal land highly unlikely.

Response 4.10: See Response 4.8.

Comment 4.11: P. 8-33; Second paragraph - "The source assessment for the Lake Creek watershed indicates that historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources." As discussed previously the historical mining sites themselves are probably not a measurable source, however since the limits are exceeded at high flows it is possible that contaminated sediment from these streams is a contributing factor and should be evaluated. Since the current Troy Mine is a known source of metals to Stanley Creek, a discussion of the effect of dilution in Lake Creek should be addressed.

> **<u>Response 4.11:</u>** The TMDL document text was updated to read as follows: "*The source assessment for the Lake Creek watershed indicates that active and historical mining sources contribute the most human-caused metals loading; load reductions should focus on limiting and controlling metals loading from these sources".*
>
> *DEQ agrees that metals bound in sediment dose contribute to metals loading during some high flow events. Sediment sources in Lake Creek are likely a result of active and historical mining activities that have occurred in Lake Creek as well as in Stanley Creek. Differentiating between these two sediment sources can be quite difficult.*
>
> *The specific loading rate from the Troy mine was not determined as a part of this TMDL. A discussion of the effects of dilution in Lake Creek is beyond the scope of this document. Nevertheless, any effects of dilution during both high and low conditions in Stanley Creek are inherently incorporated within the sampling results.*

<u>Comment 4.12:</u> Page 8-18; First paragraph: *"Likely sources of metals pollution include the aforementioned tailings pond".* This conclusion is not consistent with Troy Mine Reclamation EIS (p. 3-79). A lot of analysis occurred for the Troy Mine Reclamation DEIS so a different conclusion must be well supported. Also this statement is not internally consistent with paragraph on page 8-20 which says that monitoring wells indicated limited metals as a result of seepage. Why wouldn't the active Troy Mine operations be a possible source given contamination to Stanley Creek? Need to explain why or why not.

> **<u>Response 4.12:</u>** DEQ has taken into consideration the DEIS conducted by the USFS. DEQ has not defined the tailings impoundment as a sole source of metals pollution to Lake Creek. Given that DEQ identified elevated metals concentrations in water quality data below the tailings impoundment, the impoundment should not be neglected as a potential source. Clarifying language has been added to the TMDL document (**Section 8.5.3**) to identify active mining in Stanley Creek, historical mining throughout the watershed, as well as the tailings pond as potential metals sources. The wasteload allocation (WLA) in Lake Creek is to all mining source including all active and historical mining in Lake Creek and Stanley Creek.

<u>Comment 4.13:</u> In Table 8-6, MDEQ states they had 38 copper samples, but in Appendix F, there are 34 results for detected and non-detected copper collected from Stanley Creek. It is not clear where the other four samples came from. Of the 34 results, 26 are non-detect (24 at 1 µg/L, 1 at 0.5 µg/L, and 1 at 3 µg/L). Therefore, between 2005 and 2012, there were only eight samples where copper was detected—seven upstream of Fairway Creek and only one in Stanley Creek downstream of its confluence with Fairway Creek. During this same time period, 24 samples were collected by the Troy Mine from Fairway Creek; all but one sample was non-detect at 1 µg/L, and the single detected copper sample had 1 µg/L copper. If the system was adding a significant load of copper to Stanley Creek downstream of its confluence to Fairway Creek, then there should be more than one sample with detectable copper. Finally, if copper was affecting the aquatic macroinvertebrates in Stanley Creek, then those effects would be apparent. A discussion on aquatic macroinvertebrate communities as they relate to metals in Stanley Creek and Lake Creek is presented in the comment regarding copper in Lake Creek.

Response 4.13: Table F-2 in **Appendix F** has been updated to show a total of 38 samples for copper. The assessment and impairment determination for copper in Stanley Creek was based on the 38 samples. **Table F-2** did not originally show the 38 samples the assessment was based on. Any assessment or impairment determinations made in the text of the main document will not change as a result of the addition of these data points to the **Table F-2** in **Appendix F**.

The DEQ agrees that fairway Creek is not a significant source of metals loading, and that the majority of elevated copper loading may be coming from the upper portions of Stanley Creek. The TMDL document does not indicate Fairway Creek as a source of metals pollution contributing to Stanley Creek. Regardless of a contributing load from Fairway Creek, Stanley Creek was still found to be impaired. The DEQ determines impairment by assessing a waterbody as a whole. Stanley Creek, from its head waters to the mouth is one assessment unit (AUID MT76D002_010). In the case of Stanley Creek, the if impairment was found to be in the upper portions of the stream or the lower portions of the stream, the stream as a whole would be listed as impaired. Six samples listed in **Table F-2** in **Appendix F** were above twice the acute aquatic life target (AAL). The assessment methodology dictates that if one sample is above twice the AAL target, it is considered impaired, and TMDL development shall take place.

The water chemistry targets for metals are based on numeric human health standards and both chronic and acute aquatic life standards as defined in DEQ Circular DEQ-7. Most of the metals pollutants have numeric water quality criteria defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2008). These criteria include values for protecting human health and for protecting aquatic life, and apply as water quality standards for all streams. Although Montana DEQ does not use biological indicators to assess metals impairments to waterbodies, it is important to note that the chronic and acute water quality standards apply toward the protection of multiple forms of aquatic life, including fish.

Comment 4.14: In Table 8-6, MDEQ states they had 18 lead sample results, but in Appendix F, there are 20 results for detected and non-detected lead collected from Stanley Creek. It is not clear why two of the sample results were not used. Of the 20 results, 17 are non-detect (16 at 0.5 µg/L and 1 at 0.3 µg/L); therefore, between 2005 and 2012, there were only three samples where lead was detected—all three upstream of the confluence with Fairway Creek. From 2009 to 2012, 12 samples were collected by the Troy Mine from Fairway Creek, and samples were non-detect at either 0.3 or 0.5 µg/L. If Stanley Creek upstream of Fairway Creek was adding a significant load of lead to Stanley Creek downstream of its confluence to Fairway Creek, then lead should have been detected in Stanley Creek. Furthermore, any exceedance of chronic threshold for lead is based on total recoverable concentrations for this metal. Using total recoverable lead measurements is conservative as the dissolved bioavailable fraction is less than the total recoverable concentration; conversion factors are typically used to convert from a total recoverable concentration to a dissolved concentration (USEPA 2013). Finally, if lead was affecting the aquatic macroinvertebrates in Stanley Creek, then those effects would be apparent. A discussion on aquatic macroinvertebrate communities as they relate to metals in Stanley Creek and Lake Creek is presented in the comment regarding copper in Lake Creek.

Response 4.14: Table 8-6 correctly identifies 19 lead samples used for assessment purposes, versus 20 mentioned in the comment. There were 19 non-detect samples that were within detection limits at levels above either AAL, the chronic aquatic life (CAL) or the human health standard. Samples reported as non-detect cannot be compared to the standard if the detection level is below the AAL, CAL or the human health standard.

The assessment and impairment determination for lead in Stanley Creek was based on the remaining 19 samples with reporting limits below the AAL, CAL, and the human health standard. Assessment or impairment determinations made in the text of the main document will not change as a result of the addition of data points to the table in **Appendix F**.

Clarifying language has been added to **Section 8.4.3.2** describing the data set, and the samples that could not be used. **Table F-2** in **Appendix F** has been updated to show a total of 38 samples for lead.

The DEQ determines impairment by assessing a waterbody as a whole. Stanley Creek, from its headwaters to the mouth is one assessment unit (AUID MT76D002_010). In the case of Stanley Creek, if the impairment was found to be in the upper portions of the stream or the lower portions of the stream, the stream as a whole would be listed as impaired. Data from the whole assessment unit for Stanley Creek (upstream and downstream of Fairway Creek) indicated a 15.79% exceedance rate of the CAL. This is above the 10% exceedance rate for impairment determination.

Montana water quality standards for metals (except aluminum) in surface water are based upon the analysis of samples following a "total recoverable" digestion procedure (Martin et al., 1994). TMDLs must be based on the applicable water quality standards.

Comment 4.15: In Table 8-6, MDEQ states it had 34 zinc sample results, and in Appendix F, there are 34 results for detected and non-detected zinc collected from Stanley Creek. Of the 34 results, 30 are non-detect (29 at 10 µg/L and 1 at 5 µg/L); therefore, between 2005 and 2012 there were only four samples where zinc was detected—three upstream of the confluence with Fairway Creek and one downstream of its confluence. From 2005 to 2012, 24 samples were collected by the Troy Mine from Fairway Creek, and samples were all non-detect at either 5 or 10 µg/L. If Stanley Creek upstream of Fairway Creek was adding a significant load of zinc to Stanley Creek downstream of its confluence to Fairway Creek, then zinc should have been detected in Stanley Creek at 20 µg/L more than once.

Response 4.15: There is significant difficulty in making source determinations based a limited data set, with a limited number of exceedances. Given the low flow in the upper portions of Stanley Creek and the increased flow contributed from Fairway Creek, there is a significant chance that there is some dilution occurring downstream of the confluence of Stanley and Fairway Creeks, thereby masking the occurrence of zinc in the lower portions of Stanley Creek.

Impairment determination for zinc in Stanley Creek was based on one sample collected by the mine on 10/7/2005 that was 2 times the AAL. DEQ considers a waterbody with one sample above 2 times the AAL as impaired.

Comment 4.16: The high exceedance of the zinc acute life threshold for Stanley Creek may be an outlier. The sample from Stanley Creek upstream of Fairway Creek had 230 µg/L total recoverable zinc. Using recent (2005 to 2012) data for the Troy Mine, the level of zinc in that sample is not exceeded by any water sample collected from the mine adit or from the decant pond (Table 1). The adit water and decant water samples reflect water quality in the mine. Furthermore, the 75th percentile zinc concentration in

Stanley Creek is 10 µg/L; this emphasizes the nature of the outlier concentration. Therefore, the zinc levels measured in Stanley Creek in 2005 do not reflect levels measured in mine water and are likely not directly related to the mine. Finally, if zinc was affecting the aquatic macroinvertebrates in Stanley Creek, then those effects would be apparent. A discussion on aquatic macroinvertebrate communities as they relate to metals in Stanley Creek and Lake Creek is presented in the comment regarding copper in Lake Creek.

> **Response 4.16:** *The sample result of 230 ug/L was reported to DEQ by the Troy Mine. This sample was 2 times the AAL, DEQ considers a waterbody with one sample above 2 times the AAL as impaired.*
>
> The water chemistry targets for metals are based on numeric human health standards and both chronic and acute aquatic life standards as defined in DEQ Circular DEQ-7. Most of the metals pollutants have numeric water quality criteria defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2008). These criteria include values for protecting human health and for protecting aquatic life, and apply as water quality standards for all streams. Montana DEQ does not use biological indicators to assess metals impairments to waterbodies.

Comment 4.17: In **Table 8-9**, MDEQ states it had 77 copper samples, but in Appendix F, there are 73 results for detected and non-detected copper collected from Stanley Creek. It is not clear where the other four samples came from. Of the 73 results, 59 are non-detect (56 at 1 µg/L and 3 at 0.5 µg/L); therefore, between 2005 and 2012, there were 14 samples where copper was detected—two upstream of the tailing impoundment at LC01, four near the tailings impoundment at LC02, one between LC02 and LC04, four at LC04, and three downstream of LC04. When using the measured hardness at the time of sample collection, the acute threshold was exceeded in two of the 14 detected samples, one at LC01 and one at LC02. Therefore, this is an exceedance with 2 of 73 samples. As noted in the Troy Mine annual monitoring reports, there are no signs of any effects of copper on the aquatic macroinvertebrates at LC01, LC02, or LC04 (Anchor QEA 2013).

An important metric for the Fairway-Stanley Creek and Lake Creek systems is the metal-intolerant taxa metric. This metric, using a set of the most metal-sensitive species, is essential in determining whether a macroinvertebrate community is affected by metals (Clements et al. 2000; Fore 2000). For the past 27 years, the number of metal-intolerant taxa has been nearly equal for all seasons (at the median and 75th percentile) when comparing Fairway Creek and Stanley Creek (Anchor QEA 2013). In 2012, the average number of metal-intolerant taxa was the same—one taxa higher or one taxa lower in Stanley Creek when compared to Fairway Creek (Anchor QEA 2013). In the Lake Creek system, the metal-intolerant taxa have nearly always been higher at LC02 in the summer and fall compared to LC01 (comparing medians; Anchor QEA 2013), and nearly the same at LC04 in the summer and fall compared to the upstream site, LC01 (Anchor QEA 2013). For all seasons in 2012, the number of metal-intolerant taxa at LC01 were less than, equal to, or greater than the number found at LC02 and LC04 (Anchor QEA 2013). As with Fairway and Stanley creeks, the standard deviations are high enough to indicate no difference between the sites. Based on this metric, no metal-related effects on the stream macroinvertebrates have been identified (Parametrix 2007; Anchor QEA 2013).

> **Response 4.17:** **Table 8-9** specifies water quality data for Lake Creek, not Stanley Creek. **Table F-2** in **Appendix F** has been updated to show a total of 77 samples for copper in Lake Creek. The assessment and impairment determination for copper in Lake Creek was based on the 77 samples in the updated **Table F-2**. Any assessment or impairment determinations made in the

text of the main document will not change as a result of the addition of these data points to the table in **Appendix F**. Copper in Lake Creek was reported to be above 2 times the AAL, as such DEQ considers the waterbody impaired.

The water chemistry targets for metals are based on numeric human health standards and both chronic and acute aquatic life standards as defined in DEQ Circular DEQ-7. Most of the metals pollutants have numeric water quality criteria defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2008). These criteria include values for protecting human health and for protecting aquatic life, and apply as water quality standards for all streams. Although Montana DEQ does not use biological indicators to assess metals impairments to waterbodies it is important to note that the chronic and acute water quality standards apply toward the protection of multiple forms of aquatic life, including fish.

Comment 4.18: In Table 8-9, MDEQ states they had 43 lead sample results and in Appendix F there are 43 results for detected and non-detected2 lead collected from Lake Creek. Of the 43 samples, 36 are non-detect (33 at 0.5 µg/L and 3 at 0.3 µg/L); therefore, between 2005 and 2012, there were only seven samples where lead was detected—two were near the tailings impoundment at LC02, two at LC04, and three were downstream of LC04. However, as noted earlier with copper, there are no measureable effects on the aquatic macroinvertebrate community using a set of the most metal-sensitive species. Furthermore, any exceedance of chronic threshold for lead is based on total recoverable concentrations for this metal. Using total recoverable lead measurements is conservative as the dissolved bioavailable fraction is less than the total recoverable concentration; conversion factors are typically used to convert from a total recoverable concentration to a dissolved concentration (USEPA 2013). As noted above, if lead was affecting the aquatic macroinvertebrates in Lake Creek, then those effects would be apparent. A discussion on aquatic macroinvertebrates communities as they relate to metals in Stanley Creek and Lake Creek is presented in the comment regarding copper in Lake Creek.

Response 4.18: As stated in this comment, 43 sample results were reported in **Table 8-9** of the TMDL document, and 43 sample results were in **Table F-2** in **Appendix F**. The data results summary provided is consistent with the document data summary. Impairment determination was based on methods identified within the TMDL document. See response to comment 4.17 regarding the effects on macroinvertebrate communities.

DEQ agrees that the use of total recoverable measurement is a conservative approach. Montana's water quality standards for metals (except aluminum) in surface water are based upon the analysis of samples following a "total recoverable" digestion procedure (Martin et al., 1994). TMDLs must be based on the applicable water quality standards.

See the above comments pertaining to similar comments (Comment 4.17). Montana DEQ does not use biological indicators to assess metals impairments to waterbodies.

Comment 4.19: The reports listed in this section of the TMDL document are interesting and confirm there has been no degradation to Lake Creek by the Troy Mine tailing impoundment. There are other studies that provide an even greater examination of the attenuation and fate of the metals in the Troy Mine tailing impoundment (Mason 2004; Mason 2010; & CDM 2010). In these aforementioned studies it is shown that the metals are fully attenuated within the tailing impound. In Mason (2010) it is stated, "The mineral precipitation and co-precipitation mechanisms are expected to last indefinitely or in perpetuity as long as geochemical conditions remain similar to current conditions. The adsorption mechanisms are conservatively estimated to last a minimum of 600 years." It is unclear why the Troy Mine is listed as a source of metal impairment to Lake Creek. It is clear from numerous reports, field mapping, and stream sediment sampling that the source of metals in both Lake and Stanley Creeks is due to the natural erosion of the ore outcrop in Stanley Creek. A consideration of the natural history of the streams in question should be evaluated prior to a determination of impairment.

> **Response 4.19:** The DEQ has reviewed those studies mentioned above and agrees that there is metal attenuation that takes place at the Troy mine tailings impoundment. That being said, the DEQ also acknowledges that the Troy mine and its associated activities are a potential source of metals pollution. The metals load allocations to Lake Creek and Stanley Creek are related to active, inactive, and abandoned mining in the watershed. **Section 8.6.2** describes the basic approach DEQ used to allocated loads. At no place in the TMDL document does it state that Troy Mine and the associated tailings impoundment are the sole sources of metals pollution to Stanley or Lake Creeks.

I.5 SEDIMENT COMMENTS

Comment 5.1: Attachment A, Page 41, 4.1 methods- paragraph 2 and table 4.1: The Colorado dataset for streambank retreat rates isn't applicable to this study area. These rates underestimate known rates in the Kootenai drainage. The dataset developed in the Blackfoot drainage would be more realistic.

> **Response 5.1**: Dave Rosgen has told DEQ that the Colorado dataset is applicable where there is sedimentary and metamorphic geology (like in this project area), and that the curve from that dataset has been tested against measured data for various streams in Montana and been working well (Rosgen, Dave, personal communication 7/17/2011). Given Dave Rosgen's extensive experience measuring streambank erosion in Montana and the fact that the TMDL focuses on a relative change/percent reduction from the existing load based on implementing all reasonable land, soil, and water conservation practices, DEQ feels our approach was sound, and therefore no modifications were made to the existing retreat rates provided within the document. As stated in Section 5.5, EPA guidance for sediment TMDLs suggests determining the relative magnitude of loading (U.S. Environmental Protection Agency, 1999).
>
> DEQ is open to using other datasets to estimate streambank erosion, particularly if there is evidence to indicate it may be more applicable than the Colorado or Lamar curves typically used to support TMDL development, but as noted in Response 1.10, repeated data requests and numerous review drafts of document components were provided to stakeholders (including the party who provided this comment) for review. For the reasons described above, the data from the Blackfoot drainage have not been incorporated into the streambank erosion source assessment. However, DEQ strives to use the most applicable retreat rates and is interested in obtaining this information as it may be relevant for other project areas and could prove useful regarding adaptive management concepts discussed within the document.

Comment 5.2: Appendix D Section 2.1.2.2 - "No evidence of sediment loading from these segments was observed, and based on the condition and composition of the vegetative buffer throughout the Project Area, unpaved parallel road segments were determined to be an insignificant sediment source (**Figure 2-4**). Thus, no field data was collected along parallel road segments in the Kootenai-Fisher Project Area." This is a very broad generalization given the mile of roads in the Kootenai-Fisher Project Area.

Response 5.2: It is a broad generalization but we feel confident in it given the miles of road driven and the buffers observed in watersheds of sediment-impaired streams in the project area. However, we acknowledge that there may be some near-stream parallel segments that are hotspots or areas where problems could develop, and language regarding BMP implementation on parallel road segments was added to the road allocation discussion in **Section 5.6.2.3**.

Comment 5.3: Appendix C, Section 2.2.4.2-"Land cover types identified as 'grasslands/ herbaceous' and 'hay/pasture' were conservatively adjusted to reflect a 10% improvement in ground cover over existing conditions based on input from the local Natural Resources Conservation Service representative as depicted in **Table 2-3** (Don Feist, personal communication)." Given the substantial cattle grazing that occur in Wolf Creek and the propensity of the cattle to congregate in the riparian area a more comprehensive assessment of existing conditions may be warranted.

Response 5.3: Based on DEQ observations along Wolf Creek at the field sites and driving throughout the watershed, as well as communication with the major landowner in the watershed about its practices, current grazing management practices are facilitating recovery of the riparian vegetation. As stated in Response 5.1 relative to streambank erosion, the assessment of upland erosion was a coarse assessment that had to make assumptions at the watershed scale and was intended to estimate the relative loading. If there are significant problems in grazing management that were not identified as part of this process, DEQ encourages you to share that information with the Kootenai River Network, so that those areas and/or landowners can be approached during TMDL implementation. In some instances, the modeled improvement in upland and riparian vegetation will be an underestimate of what is achievable and in others it will be an overestimate – in both instances, the allocation will be met if the landowner is applying all reasonable BMPs.

Comment 5.4: Appendix C, Section 4.0 - "There is uncertainty associated with classifying riparian health into such broad categories because vegetation type and health can vary greatly over small distances." Given this level of uncertainty and the heavy cattle grazing impacts in Wolf Creek additional criteria may be needed to assess existing conditions.

Response 5.4: See Response 5.3.

Comment 5.5: Page 5-7, table 5-2- If the width/depth ratio or entrenchment ratio falls out of the assigned value the channel can no longer be described as a B, C, or E channel type. There are no parameters for A, G, or F channel types. How are adjusting channel types viewed with the parameters of this table?

Response 5.5: Other channel types were not mentioned because B, C, and E channels are either the primary existing or potential channel type in low gradient sections of the streams of concern, which is where the effects of excess sediment from human sources are most likely to be observed. For other channel types, the Rosgen delineative criteria apply (Rosgen, 1996). Channel types can evolve naturally or as a result of human changes to the landscape, and channel type adjustments should be evaluated in the context of the potential cause(s) and whether human sources are causing channel instability or if the channel is recovering. The information in this response has been added to the target discussion (**Section 5.4.1.2**).

Comment 5.6: In Section 5.4.2, a summary of Stanley Creek conditions as compared to targets is missing except for a couple of comments in the Lake Creek section.

> **Response 5.6**: There is no summary for Stanley Creek because as mentioned in **Section 5.2**, it is not on the 303(d) for sediment impairment.

Comment 5.7: 5.4.2.2 Lake Creek; Page 5-21; Paragraph 1: The wording implies that Stanley Creek no longer supports bull trout due to degradation. *"At one time, Stanley Creek supported bull trout, but channel sediment is now highly embedded and does not provide suitable habitat (KNF 2002)."* Double check this information with FWP. The evidence that Stanley Creek "supported" bull trout in the recent past is weak. Also, the cobble embeddedness appears to be largely natural due to the channel type, low gradient and lack of scouring flows because of the natural flow regulation due to Spar Springs. There has been documented increased sediment delivery due to mining and road related disturbances, but the effect on the fisheries as compared to the natural conditions in Stanley Creek is unclear. There may be other reasons why Stanley Creek is not supporting native fish.

The BMP work on the haul roads for the timber sales was implemented for both projects. However, most of the road storage and decommissioning work proposed in the Spar/Lake Decision that was not deemed "critical" has not been implemented. Some of this work was determined to be low priority due to lack of downstream connection (such as in the Spar Lake watershed). None of the road storage and decommissioning work proposed in the Sparring Bulls Decision (Madge and Keeler watersheds) has been implemented. The Madge Creek work could be implemented at any time if there was funding. The Keeler Creek work cannot be implemented until the Sparring Bulls timber sale activities are completed (mitigation for grizzly bear security).

> **Response 5.7**: DEQ did not intend to imply that Stanley Creek does not support bull trout due to degradation and agrees that despite the source cited in the document that you reference, FWP sources cannot confirm this statement. Therefore, it has been removed from the document.
>
> Thank you for the additional details regarding road work – that information has been added to the Lake Creek discussion in **Section 5.4.2**.

Comment 5.8: Page 5-21; 2nd paragraph: There is an active landslide on private land that periodically produces substantial sediment that may be worth noting. It is located in T30N, R33W, Section 7, SE ¼ of NE ¼ which is upstream of the lower Lake Creek monitoring site (Lake 03-03). In 2012 the slide caused turbid water in Lake Creek for weeks. Road construction and riparian vegetation removal may have contributed to activating this slide area. It is not currently stable. The Lincoln County Conservation District would be a source of information on this slide.

> **Response 5.8**: This information is helpful for DEQ from a source assessment perspective and may be useful when additional information is collected for Lake Creek. Particularly if the additional information recommended in the TMDL document to refine the impairment status indicates more BMPs are needed to meet the Lake Creek sediment TMDL, this information may also be useful to the Kootenai River Network and other stakeholders.
>
> We followed up on this issue with Mike Hensler, FWP fish biologist, who has worked extensively with the Conservation District, and learned that the slide initiated in the early 1990s and has progressed to the point that it is a mass wasting site that extends several hundred feet up the

hillslope. Additionally, he stated that the stream is actively migrating upstream of the slide area and is putting more pressure on the streambank. He echoed the statements in the Lake Creek discussion in **Section 5.4.2.2** that residential development and removal of riparian vegetation has exacerbated streambank erosion. Some of this additional information has been added to the discussion in **Section 5.4.2.2**.

Comment 5.9: Two commenters made this point - Section 5.4.2.2, Page 5-21 states "The streambanks are fine-grained glacial till, glacial outwash, and lacustrine material that is highly erodible if not well vegetated, particularly by perennial plants and trees (KNF 2002; USFS 2010). Erosion of the fine-grained streambanks is a chronic source of sediment at high flows (J. Dunnigan, pers. comm., 2013). Even at lower flows, fine sediment can sometimes be observed in suspension for several miles (M. Hensler, pers. comm., 2013)." This is an important statement; it implies that sources of fine sediment to Lake Creek are ongoing throughout the drainage.

Response 5.9: We agree that it is very important to recognize the susceptibility of soils, particularly along the stream channel, to disturbance and increased erosion and that there are sources of excess fine sediment dispersed throughout the Lake Creek drainage.

Comment 5.10: We agree that additional data regarding human sediment sources and instream conditions should be collected from Lake Creek prior to TMDL finalization and implementation.

Response 5.10: DEQ appreciates your support of additional data collection on Lake Creek.

Comment 5.11: For Lake Creek, a sediment TMDL is proposed. In the beneficial use assessment for Lake Creek, DEQ/EPA construct a rationale for listing the stream as impaired based on only isolated excedances of habitat data in comparison with reference conditions. The primary rationale for the listing is that there are threats to water quality, sensitive soils in the watershed, and some verbal consultation with local experts (no data brought to bear). This causes us significant concern. It is our belief that sediment – as a narrative criteria – must have some biological impact demonstrated. However, the only biological data provided – for macroinvertebrates and periphyton - both indicate full support. No other biological data demonstrating biological impairment has been provided, and the physical data provided are far from overwhelming evidence. How is the sediment assessment method valid if the hard data collected are disregarded in favor of opinion and conjecture?

Response 5.11: We disagree that the rationale was based solely on the habitat data or that biological impact must be demonstrated. There is extensive literature documenting the harmful effects of excess sediment on fish and other aquatic life – particularly because biological indicators can be affected by other stressors besides excess sediment and biological communities can change rapidly, DEQ uses biological metrics as supporting information but primarily uses other metrics that are not response variables but indicate harm to the aquatic life use. In regards to the data at the two Lake Creek sites, sampling sites are selected to be representative. However, particularly on such a large stream as Lake Creek, a holistic review of management practices, sources, and instream conditions throughout the watershed is used when evaluating sediment impairment. As described in the target summary (**Section 5.4.1**), "the target parameters are a combination of measurements of instream siltation, channel form, biological health, and habitat characteristics that contribute to loading, storage, and transport of sediment, or that demonstrate those effects." Particularly because the standard for sediment is narrative, evaluating sediment impairment is not as straightforward as comparing stream data to target values. **Section 5.4.1** also describes how target exceedances and other factors are considered: “The exceedance of one or more target values does not necessarily equate to a determination that the information supports impairment; the degree to which one or more targets are exceeded are taken into account (as well as the current 303(d) listing status), and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition.”

Updates have been made to the document, however, that resulted in revision of the impairment determination language for Lake Creek: the O/E metric used to evaluate impairment to macroinvertebrates was recalibrated in 2011 to reflect sampling protocol changes and scores from the revised metric were not included in the public comment draft. Although we disagree that biological impact must be demonstrated, the updated scores have been incorporated into the document and both samples from Lake Creek fail to meet the target. We stand by the original TMDL development determination for Lake Creek, which was made considering the threats to water quality and sensitive soils, the existing listing status, the numerous remaining sediment sources, and the pool tail target exceedance. Additionally, as described in **Section 5.4.2.2**, the input from two local professionals regarding stream conditions and observations of elevated suspended sediment that persists for extended periods of time and is associated with streambank erosion that has been exacerbated by human sources. Additional information has been added to the text about the elevated suspended sediment and the potential for harm to aquatic life. The updated O/E scores add further supporting evidence that excess sediment is likely limiting aquatic life use support. However, because of the management actions that have been conducted to address sediment sources in the watershed and the pool tail target being marginally exceeded, the language suggesting additional data collection regarding remaining human sediment sources and instream conditions prior to TMDL implementation to determine if additional restoration measures are necessary has been retained in the document.

Comment 5.12: Based on the information you provided for Lake Creek, sediment in Lake Creek is not an issue and no TMDL should be developed.

Response 5.12: See Response 5.11.

Comment 5.13: Page 5-5, paragraph 2: Suspended sediment data can be useful to define sediment budgets or daily loads.

Response 5.13: Suspended sediment data can be useful to define sediment budgets or daily loads, but this approach was not used for sediment TMDLs in this document. Additional details are provided below in Response 5.14.

Comment 5.14: Appendix E, E.1.2 - Paragraph 1 (stakeholder review version of the document)
The Fisher River is not a reasonable proxy for suspended sediment loads of Wolf Creek, or Libby Creek. Using the fisher river sediment curve will misrepresent daily loads for the listed streams. Actual data collected at the mouth of Wolf Creek would be more realistic as would sediment data collected on Libby Creek. These data could be used to generate more realistic loads for the listed streams.

What percentage of the Fisher River sediment budget was applied to Wolf Creek and Libby Creek?

Sediment budgets based on the Fisher River might not be the most realistic method as it has excessively high loads; more than any stream in the middle Kootenai. The actively eroding unstable banks in this basin have produced excessive sediment loads as high as 1500-2000 mg/l under less than bankfull stages.

Response 5.14: The sediment loads for the Fisher River were not used as a proxy for any of the streams of concern and the daily loads were not based on a sediment budget for the Fisher River. Because most sediment tends to enter streams from the landscape and streambanks during high flows and runoff, the rating curve for the Fisher River was used to establish the general relationship between suspended sediment and streamflow in the project area. **Appendix E** explains how that information was used to calculate the percentage of sediment in the Fisher River on a daily basis relative to the annual load. The daily percentage was multiplied by the annual load for Wolf Creek to show the daily load, and the daily percentage and annual load for all other streams with sediment TMDLs was shown so that the daily loads could be calculated if desired.

As stated in **Appendix E**, the percent reduction based on average annual loading is the primary approach for expressing sediment TMDLs and they are only presented on a daily basis because it is an EPA requirement. If the daily loads presented in **Appendix E** are summed, they will equal the annual load for Wolf Creek presented for the TMDL in **Section 5.6.3**. Particularly since the annual loads presented in the document represent relative loads and the daily loads are based on the annual load, it is not necessary to use data specific to each stream to calculate the daily loads.

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Attachment A – Kootenai-Fisher TMDL Project Area: Sediment and Habitat Assessment

Kootenai-Fisher TMDL Project Area: Sediment and Habitat Assessment

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ATTACHMENTS

1.0 INTRODUCTION

A detailed sediment and habitat assessment of streams in the Kootenai-Fisher TMDL Project Area (Project Area) was conducted to facilitate development of sediment TMDLs. The Kootenai-Fisher Project Area encompasses an area of approximately 2,511 square miles in Lincoln and Flathead counties in northwestern Montana. The Kootenai-Fisher Project Area includes both the Kootenai TMDL Planning Area (TPA) (1,667 square miles) and the Fisher TPA (844 square miles). The Kootenai TPA encompasses the majority of the Upper Kootenai River HUC8 (17010104), while the Fisher TPA aligns with the Fisher River HUC8 (17010101). Within the Kootenai-Fisher Project Area, there are six water body segments listed on the 2012 303(d) List for sediment-related impairments (**Table 1-1**). Bristow Creek, Libby Creek, Lake Creek and Quartz Creek are listed as impaired due to sediment in the Kootenai TPA, while Wolf Creek and Raven Creek are listed as impaired due to sediment in the Fisher TPA. In addition, Granite Creek, which is a tributary to Libby Creek, was included to provide reference data.

Table 1-1. Waterbody Segments Addressed during the Sediment and Habitat Assessment

TPA	List ID	Waterbody Description
Kootenai/Fisher	MT76C001_020	WOLF CREEK, headwaters to mouth (Fisher River)
Kootenai/Fisher	MT76C001_030	RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)
Kootenai/Fisher	MT76D002_110	BRISTOW CREEK, the headwaters to mouth at Lake Koocanusa
Kootenai/Fisher	MT76D002_062	LIBBY CREEK, from the highway 2 bridge to mouth (Kootenai River)
Kootenai/Fisher	MT76D002_070	LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)
Kootenai/Fisher	MT76D002_090	QUARTZ CREEK, headwaters to confluence with the Kootenai River

The goal of this assessment is to collect data to evaluate the existing condition of sediment impaired streams and to estimate the relative existing sediment load from eroding streambanks and the sediment load reductions that will occur with the application of all appropriate riparian best management practices (BMPs). Sediment from eroding streambanks is commonly a major contributing sediment source to streams throughout western Montana. Estimated sediment loads from eroding streambanks will be used to assist Montana DEQ and EPA with development of sediment TMDLs, which are expressed as a percent reduction in annual loading. Estimated sediment loads should not be considered absolute loads, but instead are used to indicate the relative amount of loading from streambank erosion, as well as the percent reduction in loading that could be achieved via the improvement of riparian management practices. In addition to estimating sediment loads from eroding streambanks, stream channel morphology, in-stream habitat, and riparian vegetation assessments were also performed to further examine sediment dynamics within the streams of interest. The Kootenai-Fisher Project Area sediment and habitat assessment included three main components, which are presented in the following sections: aerial assessment reach stratification, sediment and habitat assessment, and streambank erosion assessment.

2.0 AERIAL ASSESSMENT REACH STRATIFICATION

Prior to field data collection, an aerial assessment of streams in the Kootenai-Fisher Project Area was conducted in GIS to stratify streams into distinct reaches based on landscape and land-use factors following procedures described in the document *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (DEQ 2008). The reach stratification process involved dividing each stream segment into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement resulting in a series of "reach types" specific to the streams within the Kootenai-Fisher Project Area.

2.1 METHODS

An aerial assessment of streams in the Kootenai-Fisher Project Area was conducted using National Agricultural Imagery Program (NAIP) color imagery from 2009 in GIS along with other relevant data layers, including the National Hydrography Dataset (NHD) 1:100,000 stream layer and United States Geological Survey 1:24,000 Topographic Quadrangle Digital Raster Graphics. GIS data layers were used to stratify streams into distinct reaches based on landscape and land-use factors. The reach stratification methodology involves breaking a water body **stream segment** into **stream reaches** and **sub-reaches**. Each of the stream segments in the Kootenai-Fisher Project Area was initially divided into distinct stream reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Stream reaches classified by these four criteria were then further divided into sub-reaches based on the surrounding vegetation and land-use characteristics, including predominant vegetation type, riparian health, adjacent land-use, level of development, and potential anthropogenic influences on streambank erosion. This resulted in a series of stream reaches and sub-reaches delineated based on landscape and land-use factors which were compiled into an Aerial Assessment Database for the Kootenai-Fisher Project Area.

2.1.1 Reach Types

The aerial assessment reach stratification process involved dividing each stream segment into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Each individual combination of the four landscape factors is referred to as a **reach type** in this report based on the following definition:

Reach Type - *Unique combination of ecoregion, gradient, Strahler stream order and confinement*

Reach types were described using the following naming convention based on the reach type identifiers presented in **Table 2-1**:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Table 2-1. Reach Type Identifiers

Landscape Factor	Stratification Category	Reach Type Identifier
Level III Ecoregion	Northern Rockies	NR
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
Confinement	unconfined	U
	confined	C

Thus, a stream reach identified as NR-0-3-U is a low gradient (0-<2%), 3rd order, unconfined stream in the Northern Rockies Level III ecoregion.

2.2 Results

A total of 84 reaches were delineated during the aerial assessment reach stratification process covering 103.1 miles of stream, excluding Granite Creek, which was assessed for potential reference conditions (**Table 2-2**). This assessment includes the entire mainstem of Libby Creek, though only the lower segment, which extends 14.8 miles from the highway 2 bridge crossing to the confluence with the Kootenai River is listed as impaired for sediment. Based on the level III ecoregion, there were a total of 19 distinct reach types delineated in the Kootenai-Fisher Project Area. The complete Aerial Assessment Database is provided in **Attachment A**.

Table 2-2. Aerial Assessment Stream Segments

Stream Segment	Number of Reaches	Number of Reaches and Sub-Reaches	Length (Miles)
Bristow Creek	5	8	6.4
Lake Creek	8	11	17.6
Libby Creek	10	21	26.0
Quartz Creek	10	11	11.3
Raven Creek	6	7	2.6
Wolf Creek	11	26	39.3
Total	**50**	**84**	**103.1**

3.0 Sediment and Habitat Assessment

Substrate character and stream habitat conditions were evaluated by performing a stream channel assessment in the listed tributaries within the Kootenai-Fisher Project Area. Longitudinal surveys including pebble counts, grid toss, cross sections, pool data collection, riparian greenline surveys, and eroding streambank measurements were performed at each of the selected monitoring sites during July and August of 2011 following methods presented in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (DEQ 2011).

Field assessment reaches were selected in relatively low-gradient portions of the listed streams to facilitate the evaluation of sediment loading impacts. At least two monitoring reaches were selected per listed stream. The monitoring locations were chosen to represent various reach characteristics, land-use categories, and human-caused influences, but their representativeness relative to other reaches of the same slope, order, confinement and ecoregion, as well as ease of access, were also considered. There was a preference toward sampling those reaches where human influences would most likely lead to impairment conditions, since it is a primary goal of sediment TMDL development to further 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 303(d) listed waterbody with potential sediment impairment conditions are incorporated into the overall evaluation.

3.1 Methods

Sediment and habitat assessments were performed at 15 field monitoring sites, which were selected based on the aerial assessment in GIS and on-the-ground reconnaissance using the factors discussed above. Sediment and habitat data was collected within six reach types, with the complete sediment and habitat assessment performed at 13 monitoring sites and only the streambank erosion portion of the assessment performed at two sites (**Table 3-1**, **Figures 3-1** and **3-2**). Field monitoring sites were assessed progressing in an upstream direction and the length of the monitoring site was based on the bankfull channel width. A monitoring site length of 500 feet was used at three sites in which the bankfull width was less than 10 feet, a monitoring site length of 1,000 feet was used at nine sites in which the bankfull width was between 10 feet and 50 feet, and a monitoring site length of 2,000 feet was used at three sites in which the bankfull width exceeded 50 feet. Each monitoring site was divided into five equally sized study cells in which a series of sediment and habitat measurements were performed. Study cells were numbered 1 through 5 progressing in an upstream direction. The following sections provide brief descriptions of the various field methodologies employed during the sediment and habitat assessment. A more in-depth description of the methods is available in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (DEQ 2011).

Table 3-1. Reach Types and Monitoring Sites

Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
NR-0-3-C	4		
NR-0-3-U	12	1	QRTZ10-01
NR-0-4-U	29	8	GRNT13-01, LAKE02-01, LAKE03-03, LIBY09-03, LIBY09-05, WOLF08-03*, WOLF09-02, WOLF11-03
NR-0-5-U	1		
NR-10-1-C	1		
NR-10-1-U	3		
NR-10-2-C	1		
NR-2-1-C	1		
NR-2-1-U	2		
NR-2-2-C	1	1	QRTZ03-01
NR-2-2-U	7	1	RAVN07-01
NR-2-3-C	1		
NR-2-3-U	9	2	BRST04-02, BRST04-04
NR-2-4-C	1		
NR-2-4-U	2		
NR-4-1-U	1	1	RAVN04-01*
NR-4-2-C	2		
NR-4-2-U	4	1	RAVN06-01
NR-4-3-U	2		

*Streambank erosion assessment only

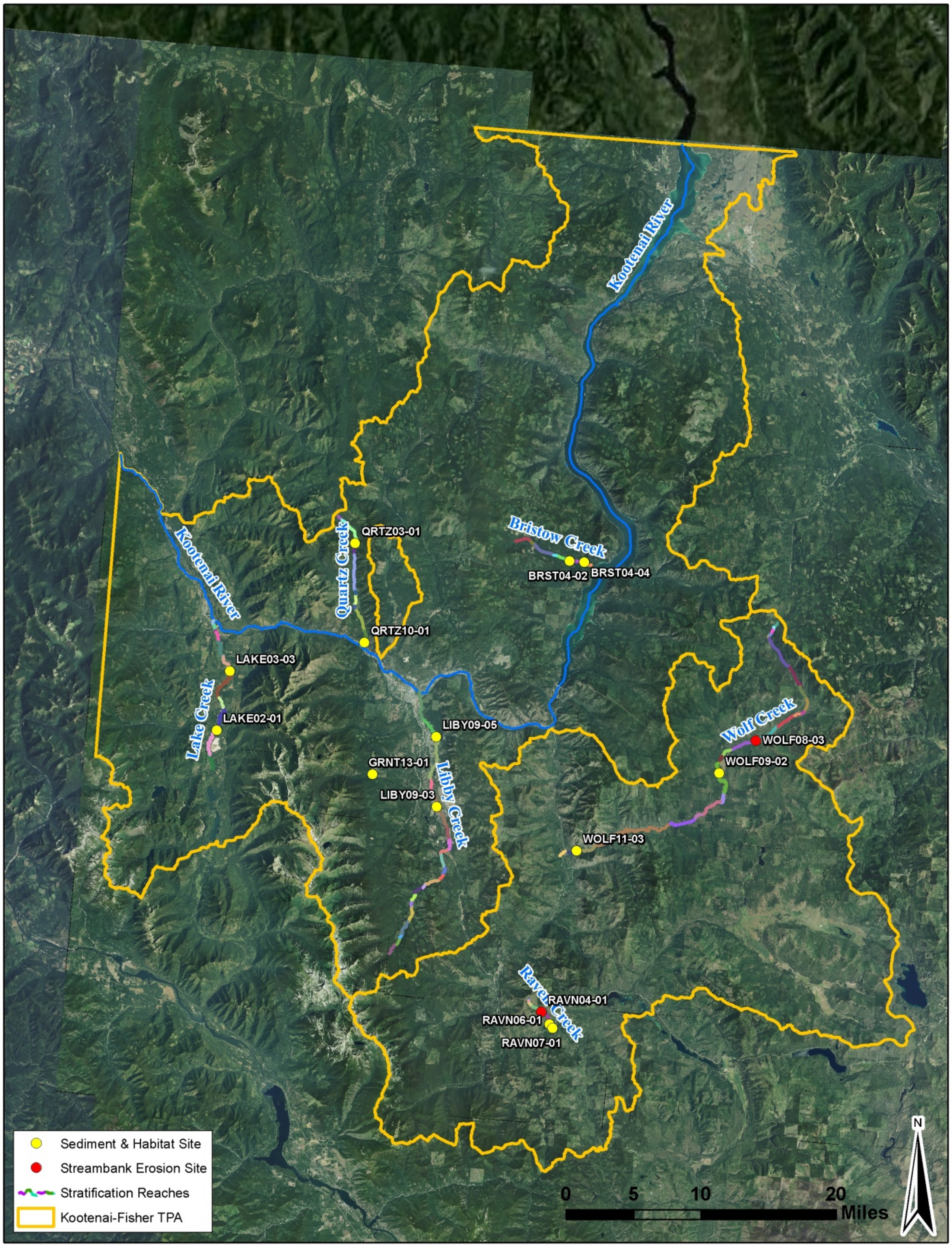


Figure 3-1. Aerial Assessment Reach Stratification

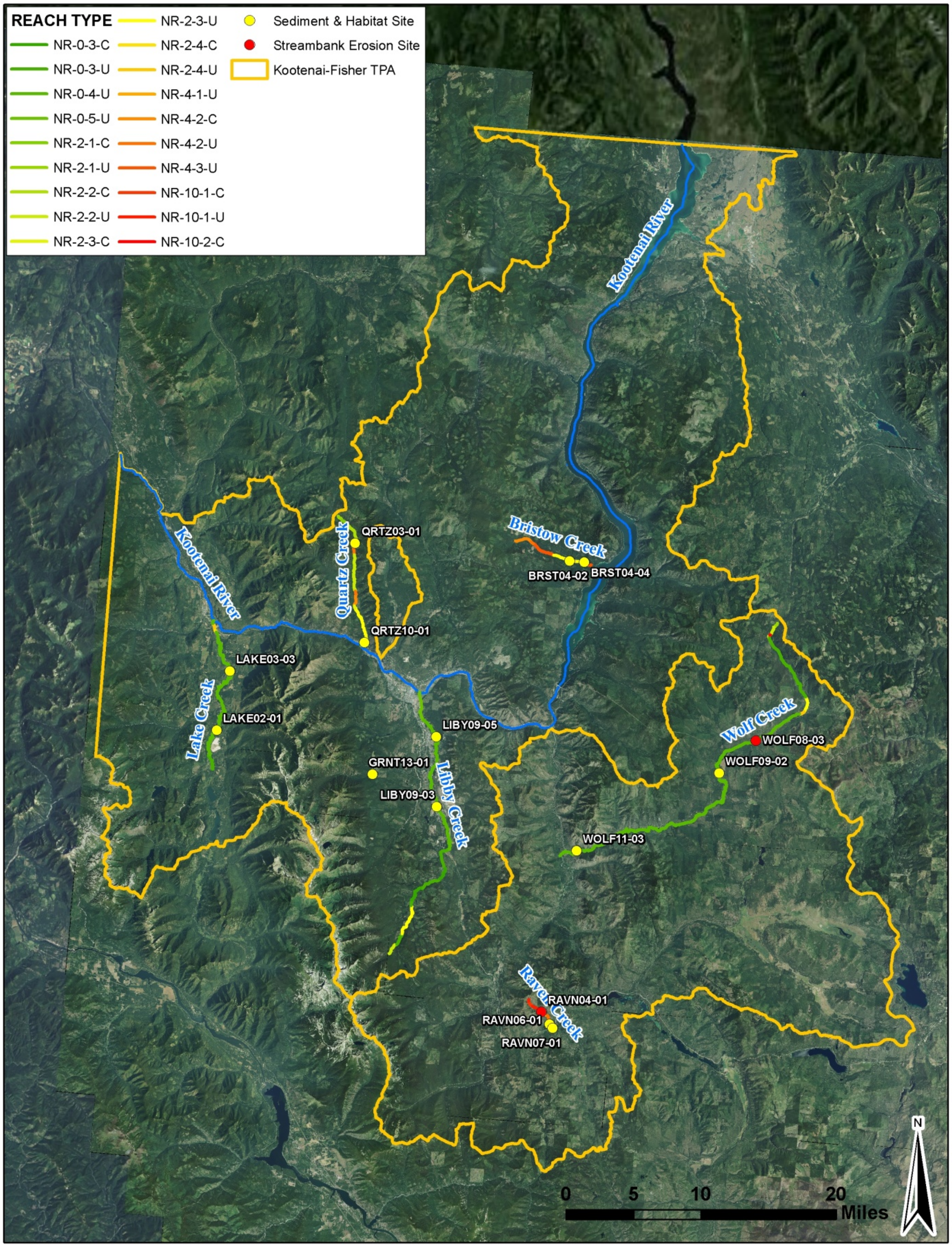


Figure 3-2. Aerial Assessment Reach Types

Field measurements conducted during the sediment and habitat assessment include channel form and stability measurements, fine sediment measurements, in-stream habitat measurements, and riparian health measurements, as summarized below:

Channel Form and Stability Measurements
- Field Determination of Bankfull
- Channel Cross-sections
- Floodprone Width Measurements
- Water Surface Slope

Fine Sediment Measurements
- Riffle Pebble Count
- Riffle Grid Toss
- Pool Tail-out Grid Toss
- Riffle Stability Index

In-stream Habitat Measurements
- Channel Bed Morphology
- Residual Pool Depth
- Pool Habitat Quality
- Woody Debris Quantification

Riparian Health Measurements
- Riparian Greenline Assessment

3.1.1 Channel Form and Stability Measurements

Channel form and stability measurements include the field determination of bankfull, channel cross-sections, floodprone width, and surface water slope.

3.1.1.1 Field Determination of Bankfull

The bankfull elevation was determined for each monitoring site. 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."

Indicators that were used to estimate the bankfull elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, staining of rocks, and inundation features. Multiple locations and bankfull indicators were examined at each site to determine the bankfull elevation, which was then applied during channel cross-section measurements.

3.1.1.2 Channel Cross-sections

Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. These measurements allowed for the calculation of the cross sectional area, the average bankfull depth, and the [bankfull] width/depth ratio. The thalweg depth (i.e., maximum depth) was recorded at the deepest point of the channel independent of the regularly spaced intervals.

3.1.1.3 Floodprone Width Measurements

The floodprone elevation was determined by multiplying the maximum depth value by two (Rosgen 1996). The floodprone width was then measured by stringing a tape from the bankfull channel margin on both the right and left banks until the tape (pulled tight and "flat") touched the ground at the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, the floodprone width was estimated by pacing or making a visual estimate. The floodprone width divided by the bankfull width of the channel is the entrenchment ratio, which is typically within a certain range by stream type and is an indicator of a stream's ability to access it floodplain.

3.1.1.4 Water Surface Slope

Water surface slope measurements were performed using a transit level and stadia rod. This measurement was used to evaluate the slope assigned in GIS based on the aerial assessment. The field measured slope was used when evaluating the Rosgen stream type at each monitoring site.

3.1.2 Fine Sediment Measurements

Fine sediment measurements include the riffle pebble count, riffle grid toss, pool tail-out grid toss, and the riffle stability index. The pebble count and grid toss measurements were used to identify if excess fine sediment was accumulating in areas important for the reproduction and survival of aquatic life. The riffle stability index measures the dominant size of mobile particles in a riffle and is an indicator of excess sediment supply.

3.1.2.1 Riffle Pebble Count

One Wolman pebble count (Wolman 1954) was performed at the first riffle encountered in cells 1, 2, 3 and 5, providing a minimum of 400 particles measured within each assessment reach. Particle sizes were measured along their intermediate length axis (b-axis) and results were grouped into size categories. The pebble count was performed from bankfull to bankfull using the "heel to toe" method.

3.1.2.2 Riffle Grid Toss

The riffle grid toss was performed at the same location as the pebble count measurement. The riffle grid toss measures fine sediment accumulation on the surface of the streambed. Riffle grid tosses were performed prior to the pebble count to avoid disturbances to surface fine sediments.

3.1.2.3 Pool Tail-out Grid Toss

A measurement of the percent of fine sediment in pool tail-outs was taken using the grid toss method at each pool in which potential spawning gravels were identified. Three measurements were taken in each pool with appropriate sized spawning gravels using a 49-point grid. The spawning potential was recorded as “Yes” (Y) or “Questionable” (Q). No grid toss measurements were made when the substrate was observed to be too large to support spawning. Pool tail-out grid toss measurements were performed when the substrate was observed to be too fine to support spawning since the goal of this assessment is to quantify fine sediment accumulation in spawning areas.

3.1.2.4 Riffle Stability Index

In streams that had well-developed point bars, a Riffle Stability Index (RSI) evaluation was performed. For streams in which well-developed point bars were present, a total of three RSI measurements were conducted, which consisted of intermediate axis (b-axis) measurements of 15 particles determined to be among the largest size group of recently deposited particles that occur on over 10% of the point bar (Kappesser 2002). During post-field data processing, the riffle stability index was determined by calculating the geometric mean of the dominant bar particle size measurements and comparing the result to the cumulative particle distribution from the riffle pebble count in an adjacent or nearby riffle.

3.1.3 Instream Habitat Measurements

Instream habitat measurements include channel bed morphology, residual pool depth, pool habitat quality and woody debris quantification.

3.1.3.1 Channel Bed Morphology

The length of each monitoring site occupied by pools and riffles was recorded progressing in an upstream direction. The upstream and downstream stations of “dominant” riffle and pool features were recorded. Features were considered “dominant” when occupying over 50% of the bankfull channel width.

3.1.3.2 Residual Pool Depth

At each pool encountered, the maximum depth and the depth of the pool tail crest at its deepest point was measured. The difference between the maximum depth and the tail crest depth is considered the residual pool depth. It is basically a measure of the water depth that will remain in a pool if the channel is drained. No pool tail crest depth was recorded for dammed pools.

3.1.3.3 Pool Habitat Quality

Qualitative assessments of each pool feature were undertaken, including pool type (i.e., scour or dammed), size (i.e., small or large), formative feature (i.e., lateral scour, plunge, boulder, woody debris), and cover type (i.e., overhanging vegetation, depth, undercut, boulder, woody debris, none). The total number of pools was also quantified.

3.1.3.4 Woody Debris Quantification

The amount of large woody debris (LWD) within each monitoring site was recorded. Large pieces of woody debris located within the bankfull channel that were relatively stable so as to influence the channel form were counted as either single, aggregate or "willow bunch". A single piece of large woody debris was counted when it was greater than 9 feet long or spanned two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton et al. 1997). Two or more single pieces that are touching each other and collectively influencing channel morphology were considered an aggregate, and the number of pieces per aggregate was recorded. A "willow bunch" could be a dead or living willow, or other riparian shrub, that was in the channel and influencing channel morphology.

3.1.4 Riparian Health Measurements

Riparian health measurements include the riparian greenline assessment.

3.1.4.1 Riparian Greenline Assessment

An assessment of riparian vegetation cover was performed along both streambanks at each monitoring site. Vegetation types were recorded at 10 to 20-foot intervals, depending on the bankfull channel width. The riparian greenline assessment described the general vegetation community type of the groundcover, understory and overstory. The vegetation options on the field forms for groundcover were wetland, grasses/rose/snowberry, disturbed/bare ground, rock, and riprap; the options for understory and overstory were coniferous, deciduous, and mixed coniferous/deciduous. At 50-foot intervals, the riparian buffer width was estimated on either side of the channel. The riparian buffer width corresponds to the belt of vegetation buffering the stream from adjacent land uses.

3.2 RESULTS

In the Kootenai-Fisher Project Area, sediment and habitat parameters were assessed at 13 monitoring sites. Out of the 19 reach types delineated on the sediment impaired stream segments in GIS, sediment and habitat assessments were performed in six reach types, with a focus on low gradient reach types. A statistical analysis of the sediment and habitat data is presented by reach type and for individual monitoring sites in the following sections. The complete sediment and habitat dataset is presented in **Attachment B**.

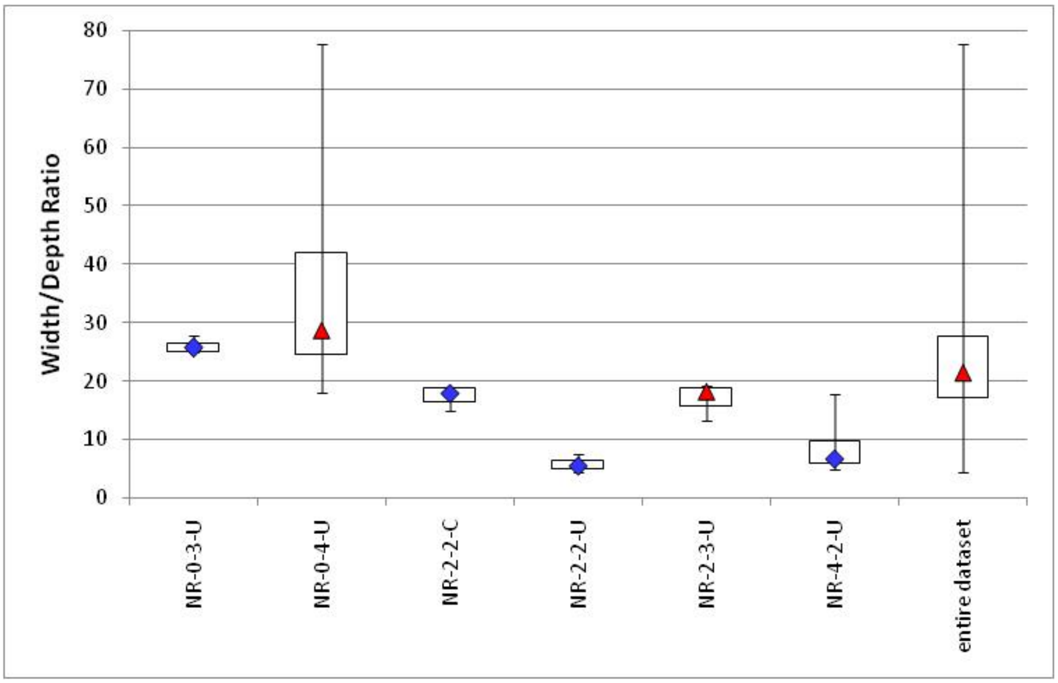
3.2.1 Reach Type Analysis

This section presents a statistical analysis of sediment and habitat base parameters for each of the reach types assessed in the Kootenai-Fisher Project Area. Reach type discussions are based on median values, while summary statistics for the minimum, 25th percentile, 75th percentile, and maximum values are also provided since these may be more applicable for developing sediment TMDL criteria. Sediment and habitat base parameter analysis is provided by reach type for the following parameters:

- width/depth ratio
- entrenchment ratio
- riffle pebble count <2mm
- riffle pebble count <6mm
- riffle grid-toss <6mm
- pool tail-out grid toss <6mm
- residual pool depth
- pool frequency
- LWD frequency
- greenline understory shrub cover
- greenline bare ground

3.2.1.1 Width/Depth Ratio

The channel width/depth ratio is defined as the channel width at bankfull 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 between reaches with the same stream type (Rosgen 1996). A comparison of observed and expected width/depth ratios is also an indicator of channel over-widening and aggradation, which are often linked to excess streambank erosion and/or sediment inputs from sources upstream of the study reach. Channels that are over-widened are often associated with excess sediment deposition and streambank erosion, contain shallower and warmer water, and provide fewer deepwater refugia for fish. Median width/depth ratios for assessed reach types ranged from 5.5 in NR-2-2-U to 28.6 in NR-0-4-U (**Figure 3-3** and **Table 3-2**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.
Figure 3-3. Width/Depth Ratio

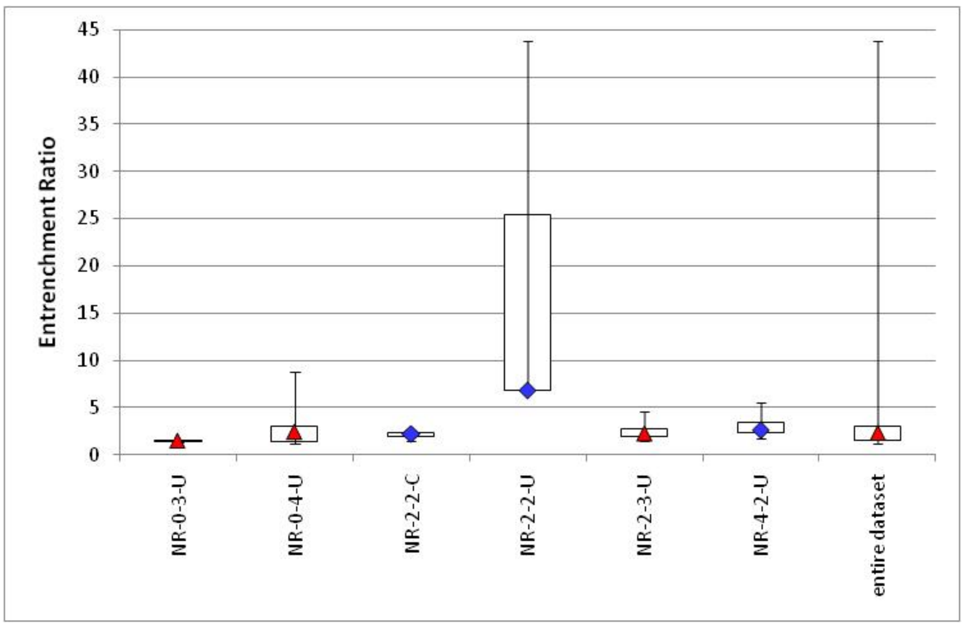
Table 3-2. Width/Depth Ratio

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	1	6	1	1	2	1	12
Sample Size	4	17	4	3	6	4	38
Minimum	24.9	18.0	14.8	4.5	13.2	5.0	4.5
25th Percentile	25.1	24.6	16.4	5.0	15.8	5.9	17.1
Median	25.7	28.6	17.9	5.5	18.2	6.7	21.4
75th Percentile	26.5	41.9	18.8	6.5	18.8	9.8	27.7
Maximum	27.8	77.8	18.9	7.4	19.2	17.8	77.8
Monitoring Sites	QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.2 Entrenchment Ratio

A stream's entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen 1996). The entrenchment ratio is used to help determine if a stream shows departure from its natural stream type and is an indicator of stream incision that describes how easily a stream can access its floodplain. Streams can become incised due to detrimental land management activities or may be naturally incised due to landscape characteristics. A stream that is entrenched is more prone to streambank erosion due to greater energy exerted on the streambanks during flood events, which results in higher sediment loads. The entrenchment ratio is an important measure of channel conditions since it relates to sediment loading and habitat condition. Rosgen (1996) defines an entrenched channel as having a ratio less than 1.4, a moderately entrenched channel having a ratio between 1.4 and 2.2, and a slightly entrenched channel as having a ratio greater than 2.2. Therefore, as the entrenchment ratio increases, floodplain access increases. The median entrenchment ratio for assessed reach types ranged from 1.5 in NR-0-3-U to 6.9 in NR-2-2-U (**Figure 3-4** and **Table 3-3**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.
Figure 3-4. Entrenchment Ratio

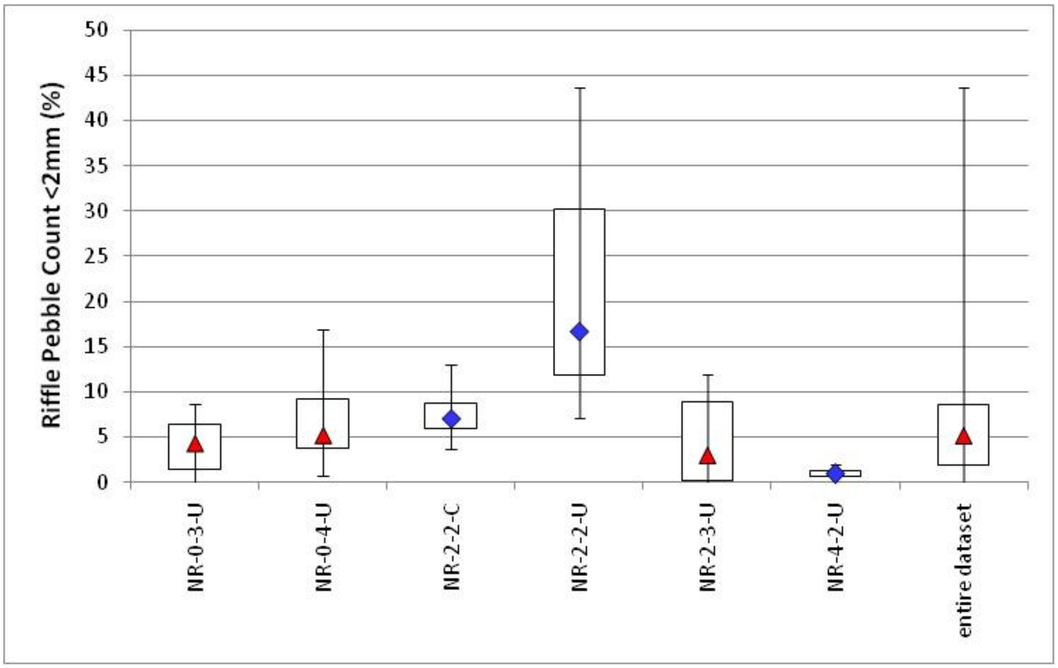
Table 3-3. Entrenchment Ratio

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	1	6	1	1	2	1	12
Sample Size	4	17	4	3	6	4	38
Minimum	1.3	1.2	1.4	6.9	1.4	1.7	1.2
25th Percentile	1.4	1.4	2.0	6.9	1.9	2.4	1.5
Median	1.5	2.4	2.2	6.9	2.2	2.6	2.3
75th Percentile	1.5	3.0	2.3	25.4	2.8	3.4	3.0
Maximum	1.6	8.7	2.4	43.9	4.6	5.5	43.9
Monitoring Sites	QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.3 Riffle Pebble Count <2mm

Percent surface fine sediment measures the amount of siltation occurring in a river system. Surface fine sediment measured using the Wolman (1954) pebble count method is one indicator of aquatic habitat condition and higher values can signify excessive sediment loading. The Wolman pebble count 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. Median values for the percent of fine sediment <2mm based on riffle pebble counts ranged from 1% in NR-4-2-U to 17% in NR-2-2-U (**Figure 3-5** and **Table 3-4**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.
Figure 3-5. Riffle Pebble Count <2mm

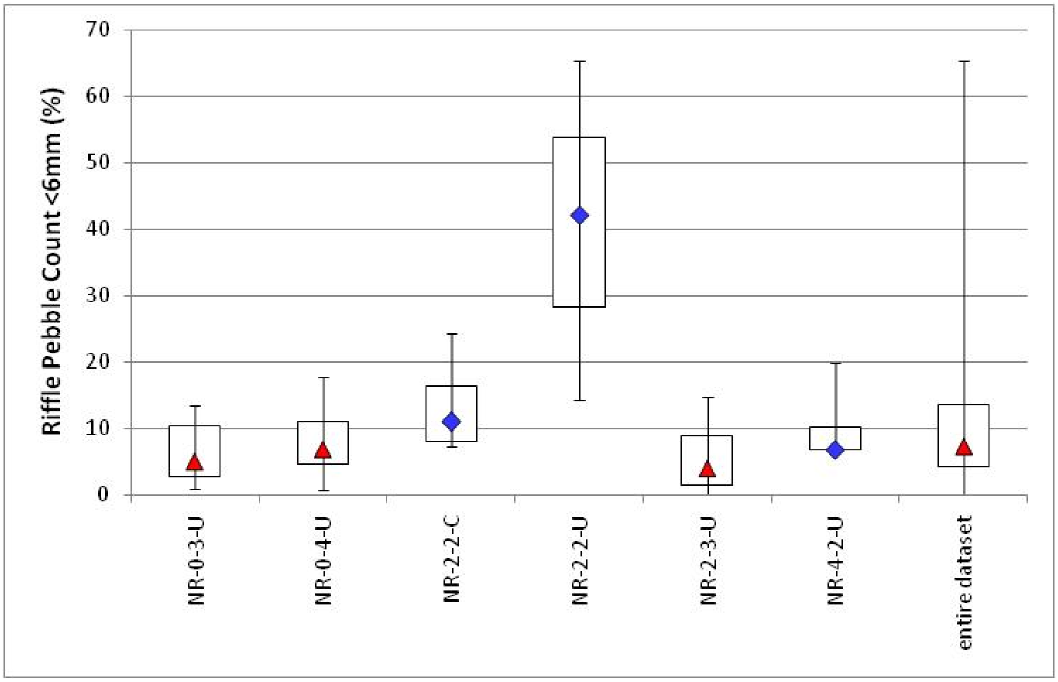
Table 3-4. Riffle Pebble Count <2mm

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	2	6	1	1	2	1	13
Sample Size	8	20	4	3	6	4	45
Minimum	0	1	4	7	0	0	0
25th Percentile	1	4	6	12	0	1	2
Median	4	5	7	17	3	1	5
75th Percentile	6	9	9	30	9	1	9
Maximum	9	17	13	44	12	2	44
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.4 Riffle Pebble Count <6mm

As with surface fine sediment <2mm, an accumulation of surface fine sediment <6mm may indicate excess sedimentation. Median values for the percent of fine sediment <6mm based on pebble counts conducted in riffles ranged from 4% in NR-2-3-U to 42% in NR-2-2-U (**Figure 3-6** and **Table 3-5**). The percent of fine sediment <6mm followed the same general trend as the percent of fine sediment <2mm.



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.
Figure 3-6. Riffle Pebble Count <6mm

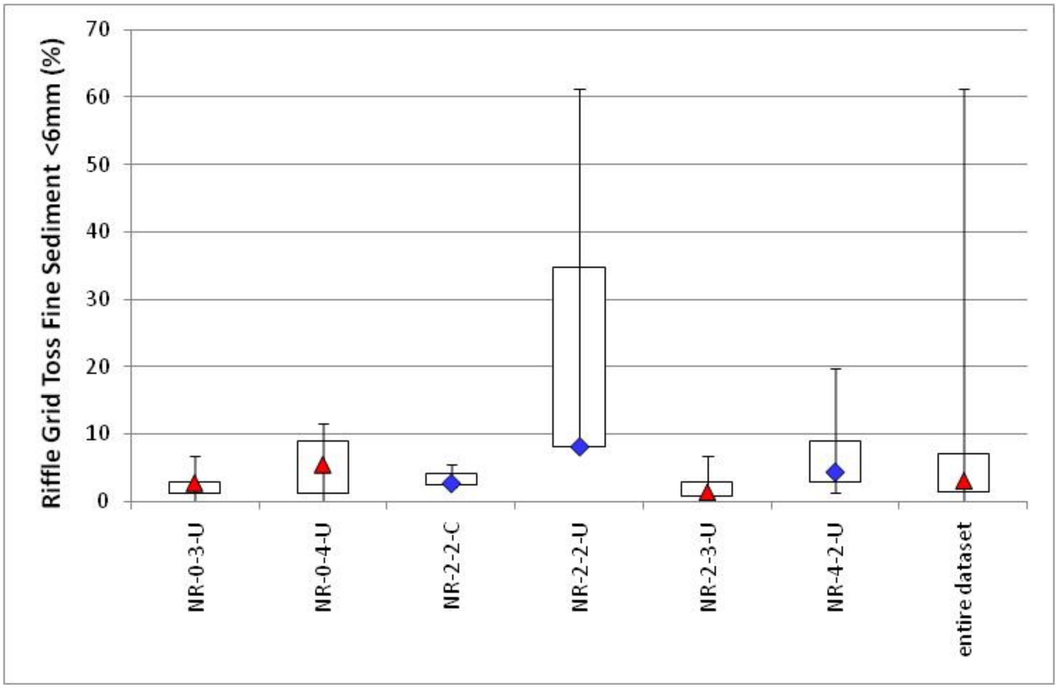
Table 3-5. Riffle Pebble Count <6mm

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	2	6	1	1	2	1	13
Sample Size	8	20	4	3	6	4	45
Minimum	1	1	7	14	0	6	0
25th Percentile	3	5	8	28	1	7	4
Median	5	7	11	42	4	7	7
75th Percentile	10	11	16	54	9	10	13
Maximum	13	18	24	65	15	20	65
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.5 Riffle Grid Toss <6mm

The riffle grid toss is a standard procedure frequently used in aquatic habitat assessments that provides complimentary information to the Wolman pebble count. Median values for riffle grid toss fine sediment <6mm in the Kootenai-Fisher Project Area range from 1% in NR-2-3-U to 8% in NR-2-2-U (**Figure 3-7** and **Table 3-6**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.
Figure 3-7. Riffle Grid Toss Fine Sediment <6mm

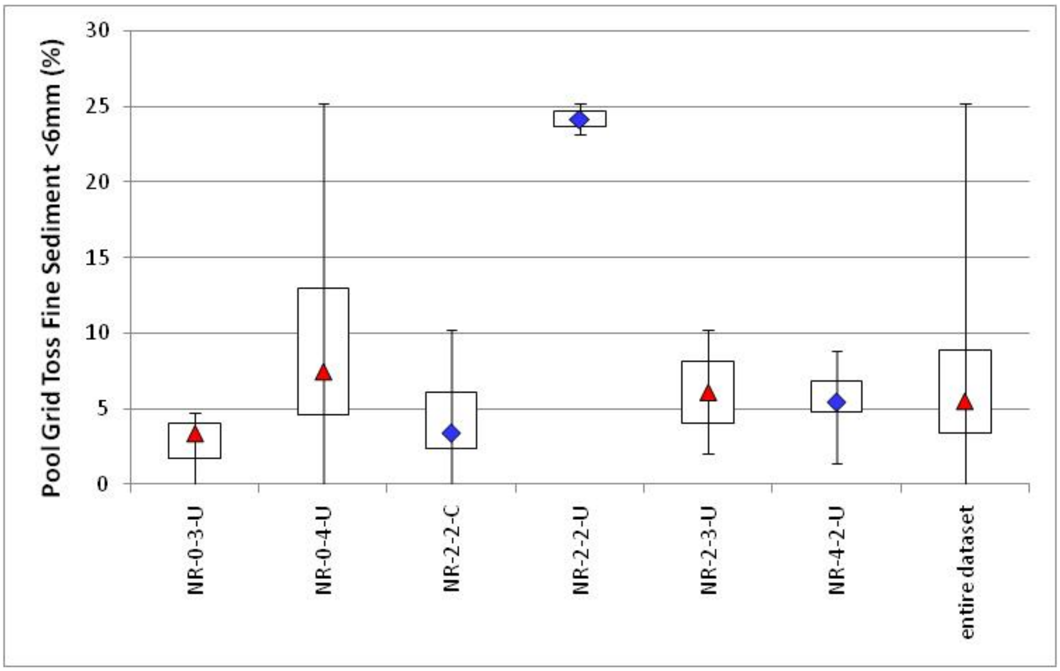
Table 3-6. Riffle Grid Toss Fine Sediment <6mm

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	2	6	1	1	2	1	13
Sample Size	8	20	3	3	6	4	44
Minimum	0	0	2	8	0	1	0
25th Percentile	1	1	2	8	1	3	1
Median	3	5	3	8	1	4	3
75th Percentile	3	9	4	35	3	9	7
Maximum	7	12	5	61	7	20	61
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.6 Pool Tail-out Grid Toss <6mm

Grid toss measurements in pool tail-outs provide a measure of fine sediment accumulation in potential fish spawning sites, which may have detrimental impacts on aquatic habitat by cementing spawning gravels, 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, both of which are present in the Kootenai-Fisher Project Area. Median values for pool tail-out grid toss fine sediment <6mm range from 3% in NR-0-3-U and NR-2-2-C to 24% in NR-2-2-U (**Figure 3-8** and **Table 3-7**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.

Figure 3-8. Pool Tail-out Grid Toss <6mm

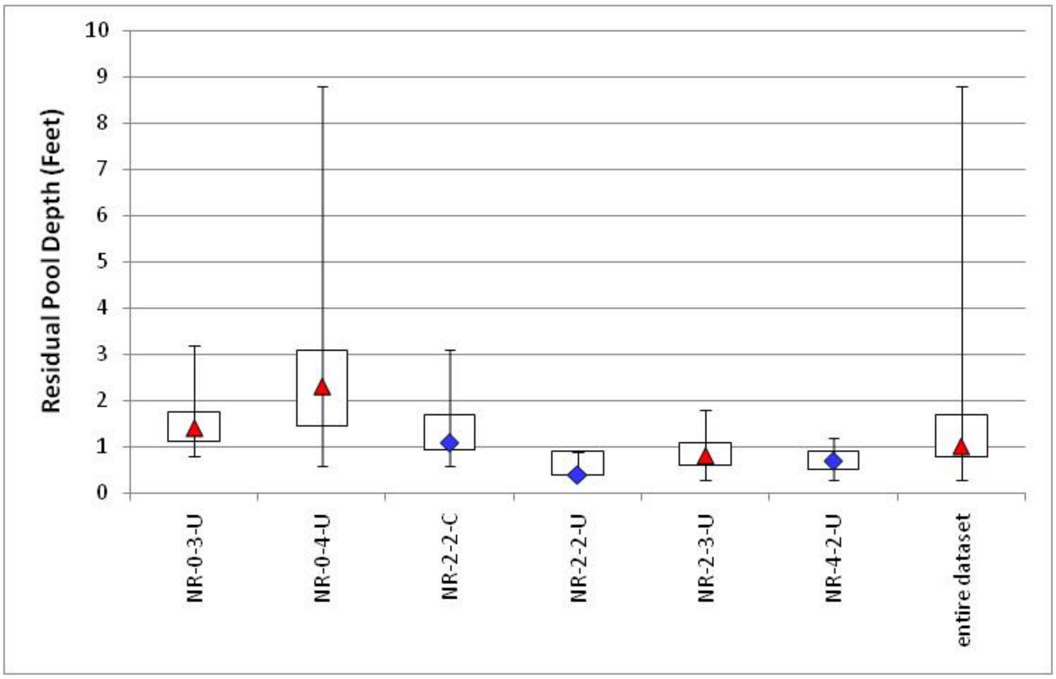
Table 3-7. Pool Tail-out Grid Toss <6mm

Statistical Parameter	Reach Type						
	NR-0-3-U	**NR-0-4-U**	**NR-2-2-C**	**NR-2-2-U**	**NR-2-3-U**	**NR-4-2-U**	**Entire Dataset**
# of Monitoring Sites	2	6	1	1	2	1	13
Sample Size	3	28	15	2	2	7	57
Minimum	0	0	0	23	2	1	0
25th Percentile	2	5	2	24	4	5	3
Median	3	7	3	24	6	5	6
75th Percentile	4	13	6	25	8	7	9
Maximum	5	25	10	25	10	9	25
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.7 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 the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes. Residual pool depth is also an indirect measurement of sediment inputs to streams since an increase in sediment loading can cause pools to fill, thus decreasing residual pool depth over time. Median residual pool depths ranged from 0.4 feet in NR-2-2-U to 2.3 feet in NR-0-4-U (**Figure 3-9** and **Table 3-8**). This analysis indicates that the deepest pools are found in low gradient 4th order streams and that residual pool depth tends to increase as stream order increases in the Kootenai-Fisher Project Area.



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.

Figure 3-9. Residual Pool Depth

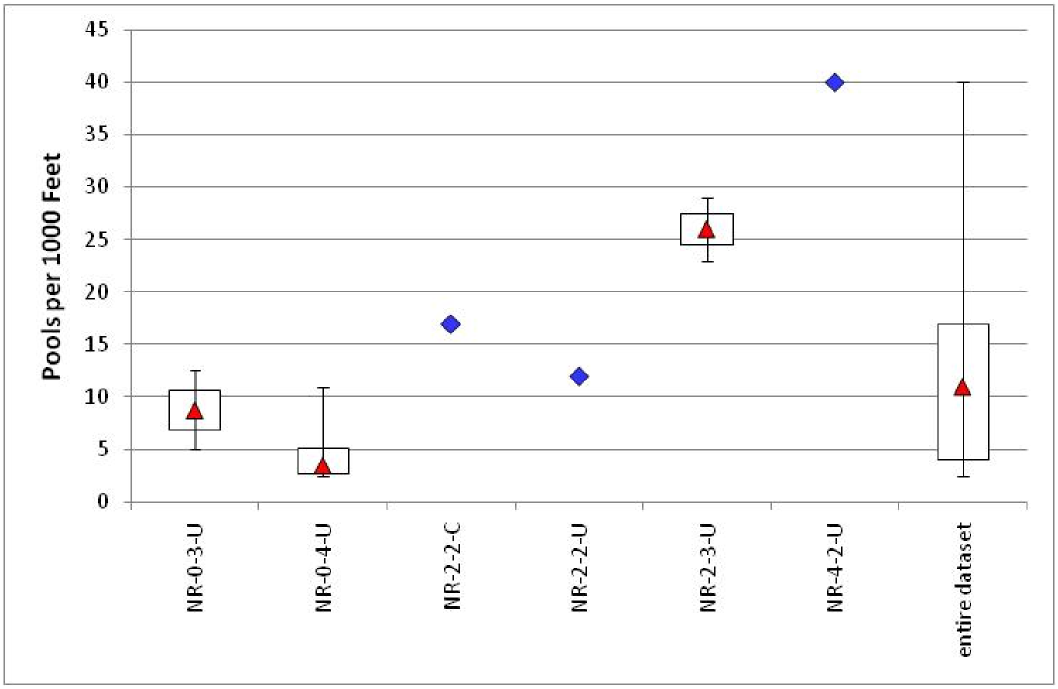
Table 3-8. Residual Pool Depth

Statistical Parameter	Reach Type						
	NR-0-3-U	**NR-0-4-U**	**NR-2-2-C**	**NR-2-2-U**	**NR-2-3-U**	**NR-4-2-U**	**Entire Dataset**
# of Monitoring Sites	2	6	1	1	2	1	13
Sample Size	14	39	15	5	52	16	141
Minimum	0.8	0.6	0.6	0.4	0.3	0.3	0.3
25th Percentile	1.1	1.5	1.0	0.4	0.6	0.5	0.8
Median	1.4	2.3	1.1	0.4	0.8	0.7	1.0
75th Percentile	1.8	3.1	1.7	0.9	1.1	0.9	1.7
Maximum	3.2	8.8	3.1	0.9	1.8	1.2	8.8
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions.

3.2.1.8 Pool Frequency

Pool frequency is a measure of the availability of pools 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 adversely affected by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks. Excluding reach types with only one monitoring site, the median value for the number of pools per 1,000 feet ranged from four (NR-0-4-U) to 26 (NR-2-3-U) (**Figure 3-10** and **Table 3-9**). Pool frequency tends to decrease as gradient decreases and stream order increases in the Kootenai-Fisher Project Area.



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.
Figure 3-10. Pools per 1000 Feet

Table 3-9. Pools per 1000 feet

Statistical Parameter	Reach Type					
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	2	6	*1*	*1*	2	*1*	13
Sample Size	2	6	*1*	*1*	2	*1*	13
Minimum	5	3	*17*	*12*	23	*40*	3
25th Percentile	7	3	*17*	*12*	25	*40*	4
Median	9	4	*17*	*12*	26	*40*	11
75th Percentile	11	5	*17*	*12*	28	*40*	17
Maximum	13	11	*17*	*12*	29	*40*	40
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 2-1 for reach type descriptions. Reach types with only one monitoring site denoted in blue italics.

Pool frequency data is also provided as pools per mile in **Table 3-10** for future TMDL applications.

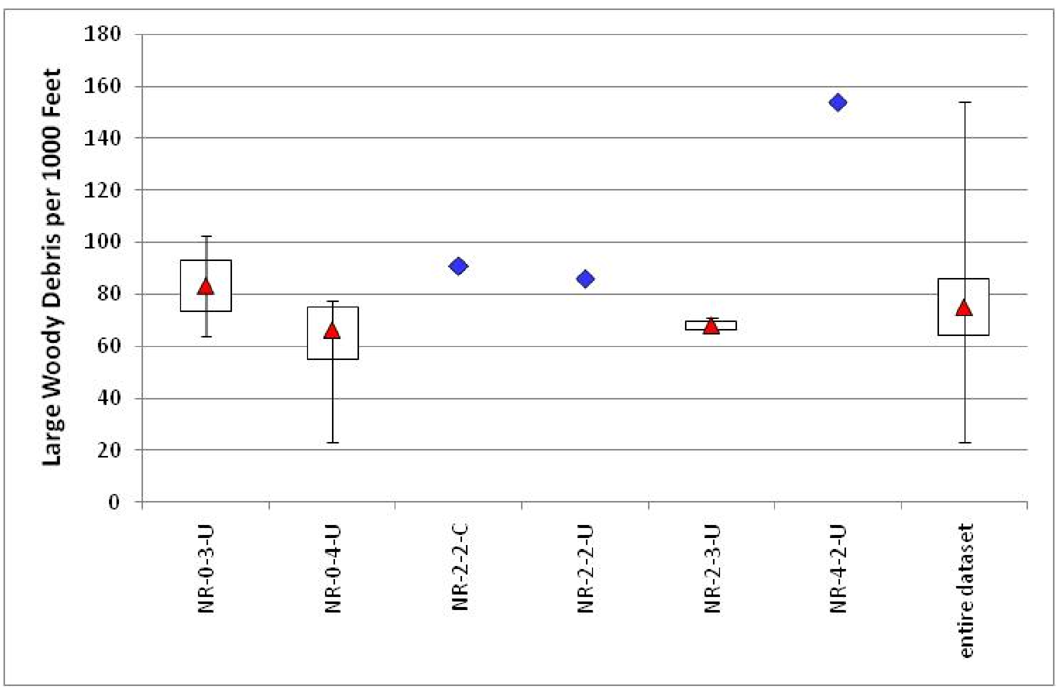
Table 3-10. Pools per Mile

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
Minimum	26	13	*90*	*63*	121	*211*	13
25th Percentile	36	14	*90*	*63*	129	*211*	21
Median	46	18	*90*	*63*	137	*211*	58
75th Percentile	56	27	*90*	*63*	145	*211*	90
Maximum	66	58	*90*	*63*	153	*211*	211

Note: See Table 2-1 for reach type descriptions. Reach types with only one monitoring site denoted in blue italics.

3.2.1.9 Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of high-quality salmonid habitat, providing habitat complexity, quality 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 optimal conditions. Excluding reach types with only one monitoring site, the median value for the amount of large woody debris (LWD) per 1,000 feet ranged from 66 in NR-0-4-U to 83 in NR-0-3-U (**Figure 3-11** and **Table 3-11**). Note that "willow bunches" assigned in the field were tallied as large woody debris. Thus, this analysis makes no distinction as to the size of the woody material.



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site.

Figure 3-11. Large Woody Debris per 1000 Feet

Table 3-11. Large Woody Debris per 1000 Feet

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	2	6	*1*	*1*	2	*1*	13
Sample Size	2	6	*1*	*1*	2	*1*	13
Minimum	64	23	*91*	*86*	65	*154*	23
25th Percentile	74	55	*91*	*86*	67	*154*	64
Median	83	66	*91*	*86*	68	*154*	75
75th Percentile	93	75	*91*	*86*	70	*154*	86
Maximum	103	78	*91*	*86*	71	*154*	154
Monitoring Sites	GRNT13-01, QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01	BRST04-02, BRST04-04	RAVN06-01	

Note: See Table 1-1 for reach type descriptions. Reach types with only one monitoring site denoted in blue italics.

Data is also provided as large woody debris per mile in **Table 3-12** for future TMDL applications.

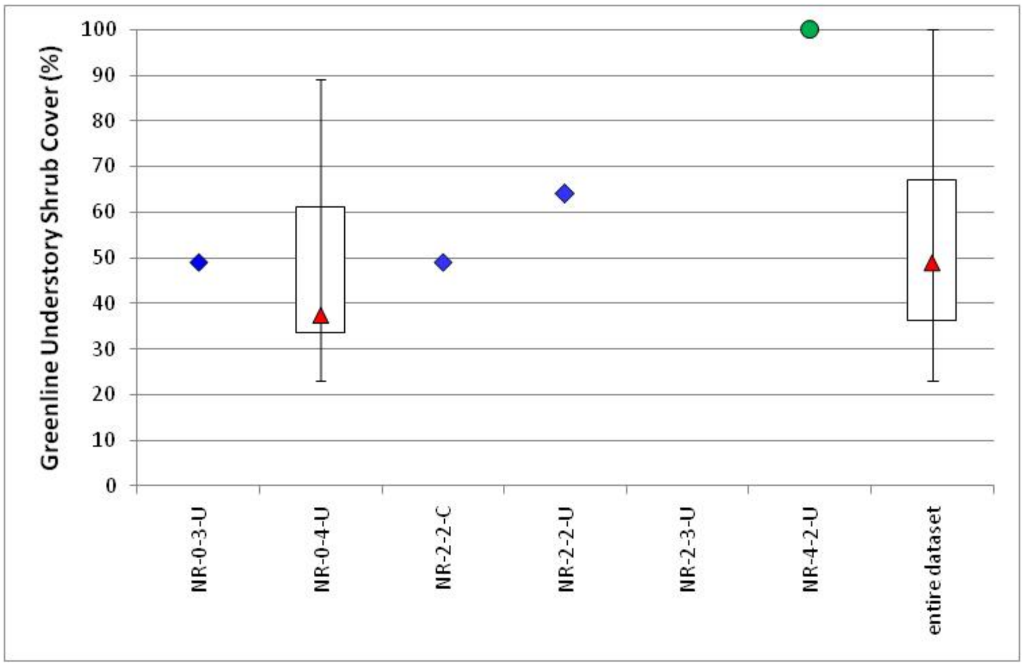
Table 3-12. Large Woody Debris per Mile

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
Minimum	338	121	*480*	*454*	343	*813*	121
25th Percentile	389	290	*480*	*454*	351	*813*	338
Median	440	350	*480*	*454*	359	*813*	396
75th Percentile	490	396	*480*	*454*	367	*813*	454
Maximum	541	409	*480*	*454*	375	*813*	813

Note: See Table 2-1 for reach type descriptions. Reach types with only one monitoring site denoted in blue italics.

3.3.1.10 Greenline Understory Shrub Cover

Riparian shrub cover is an important influence 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, reducing solar inputs and increases in water temperature. 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. Excluding reach types with only one monitoring site, the median value for greenline understory shrub cover was 38% in NR-0-4-U (**Figure 3-12** and **Table 3-13**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site; and the green circle indicates the results of a qualitative visual estimate.

Figure 3-12. Greenline Understory Shrub Cover

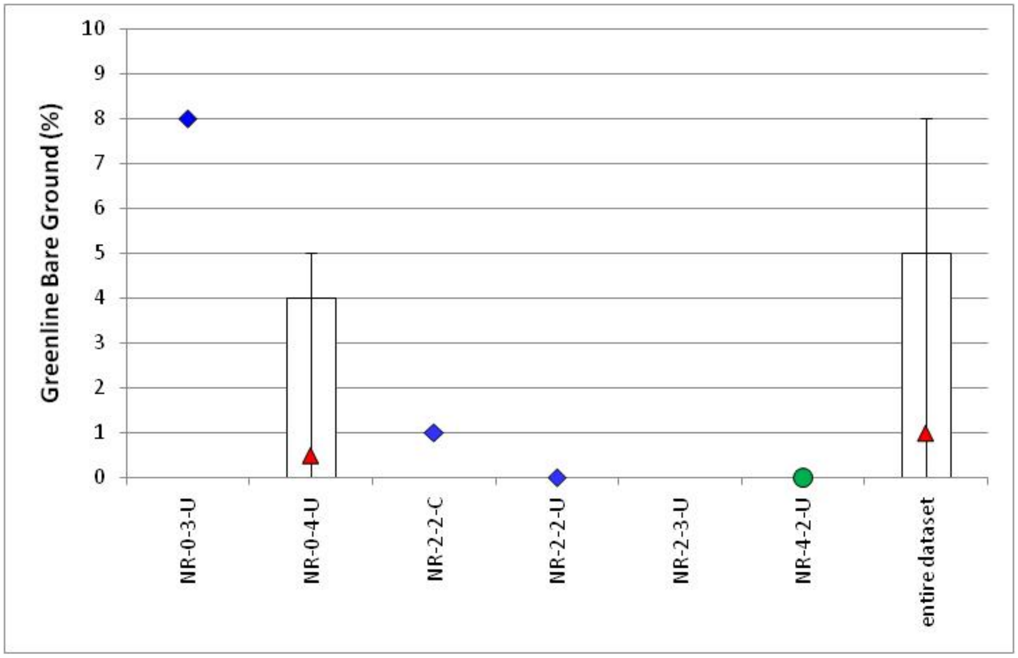
Table 3-13. Greenline Understory Shrub Cover

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	*1*	6	*1*	*1*	0	*1*	10
Sample Size	*1*	6	*1*	*1*	0	*1*	10
Minimum	*49*	23	*49*	*64*		*100*	23
25th Percentile	*49*	34	*49*	*64*		*100*	36
Median	*49*	38	*49*	*64*		*100*	49
75th Percentile	*49*	61	*49*	*64*		*100*	67
Maximum	*49*	89	*49*	*64*		*100*	100
Monitoring Sites	QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01		RAVN06-01	

Note: See Table 2-1 for reach type descriptions. Reach types with only one monitoring site denoted in blue italics.

3.2.1.11 Greenline Bare 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 where recent disturbance has resulted in exposed bare soil. 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 since sediment can wash in from unprotected areas during snowmelt, storm runoff and flooding. Bare areas are also more susceptible to erosion from hoof shear. Excluding reach types with only one monitoring site, the median value for greenline bare ground was 1% in NR-0-4-U (**Figure 3-13** and **Table 3-14**).



Blue diamonds denote reach types with one monitoring site; red triangles denote more than one monitoring site; and the green circle indicates the results of a qualitative visual estimate.

Figure 3-13. Greenline Bare Ground

Table 3-14. Greenline Bare Ground

Statistical Parameter	Reach Type						
	NR-0-3-U	NR-0-4-U	NR-2-2-C	NR-2-2-U	NR-2-3-U	NR-4-2-U	Entire Dataset
# of Monitoring Sites	*1*	6	*1*	*1*	0	*1*	10
Sample Size	*1*	6	*1*	*1*	0	*1*	10
Minimum	*8*	0	*1*	*0*		*0*	0
25th Percentile	*8*	0	*1*	*0*		*0*	0
Median	*8*	1	*1*	*0*		*0*	1
75th Percentile	*8*	4	*1*	*0*		*0*	5
Maximum	*8*	5	*1*	*0*		*0*	8
Monitoring Sites	QRTZ10-01	WOLF09-02, WOLF11-03, LIBY09-03, LIBY09-05, LAKE02-01, LAKE03-03	QRTZ03-01	RAVN07-01		RAVN06-01	

Note: See Table 2-1 for reach type descriptions. Reach types with only one monitoring site denoted in blue italics.

3.2.2 Monitoring Site Analysis

Sediment and habitat data collected at each monitoring site was reviewed individually in the following sections. Monitoring site discussions are based on median values. Summary statistics for the minimum, 25th percentile, 75th percentile and maximum values are presented graphically, since these may be more applicable for developing sediment TMDL criteria.

3.2.2.1 Width/Depth Ratio

The highest median width/depth ratio was observed in LIBY09-05 (**Figure 3-14**). Extensive mid-channel gravel bar deposits indicate Libby Creek is aggrading in this reach, while a review of color aerial imagery in GIS indicates this condition extends along the entire lower segment of Libby Creek. It appears that the mobile bedload is the primary source of sediment to Libby Creek, along with additional inputs from streambank erosion as the stream actively meanders across the floodplain.

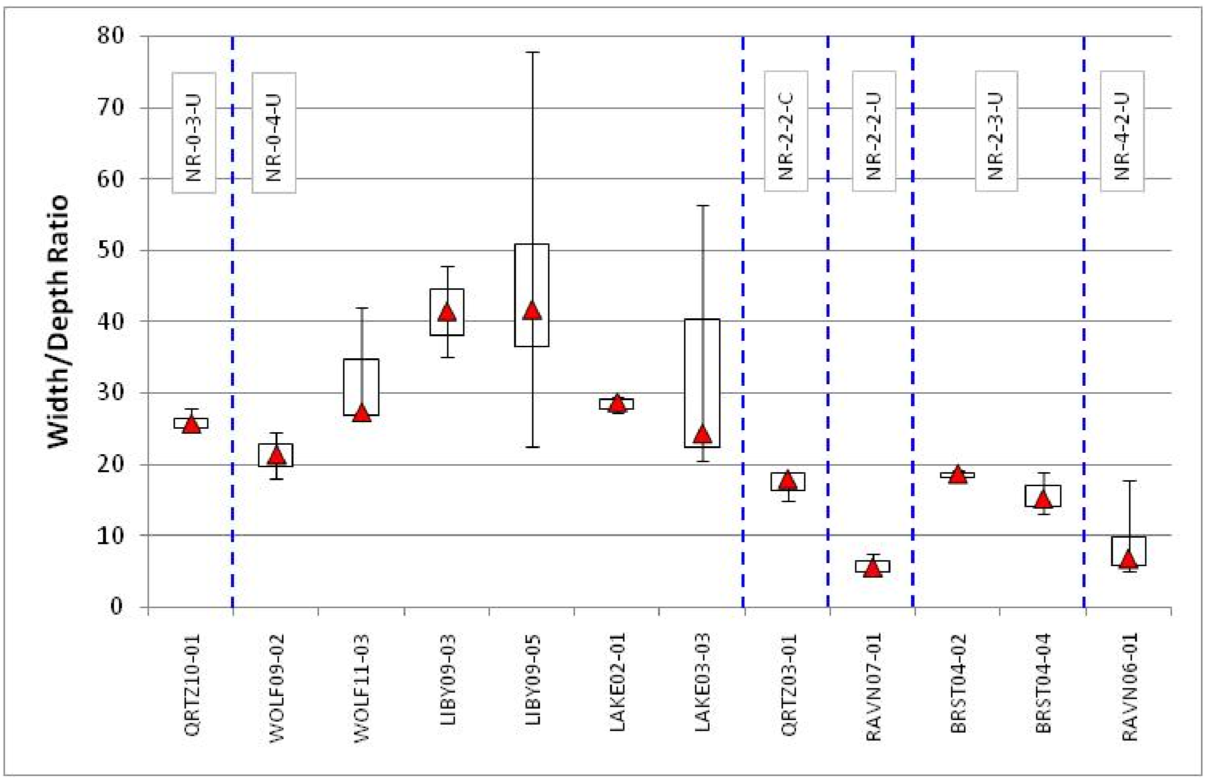


Figure 3-14. Width/Depth Ratio

3.2.2.2 Entrenchment Ratio

Entrenchment ratio data collected within the Kootenai-Fisher Project Area indicates the following (**Figure 3-15**):

1. RAVN07-01 on Raven Creek has the greatest amount of floodplain access out of the sites assessed. This site was located near the confluence of Raven Creek and the Fisher River on the Fisher River floodplain.
2. Entrenched conditions (entrenchment ratio <1.4) were documented in WOLF11-03 as a result of historic channelization due to road and railroad construction.
3. Moderately entrenched conditions (entrenchment ratio 1.4-2.2) were documented in QRTZ10-01 and LIBY09-03 as the result of channelization due to road construction, while moderately entrenched conditions in WOLF09-02 appear to be the result of historic grazing and timber harvest throughout the upper watershed.

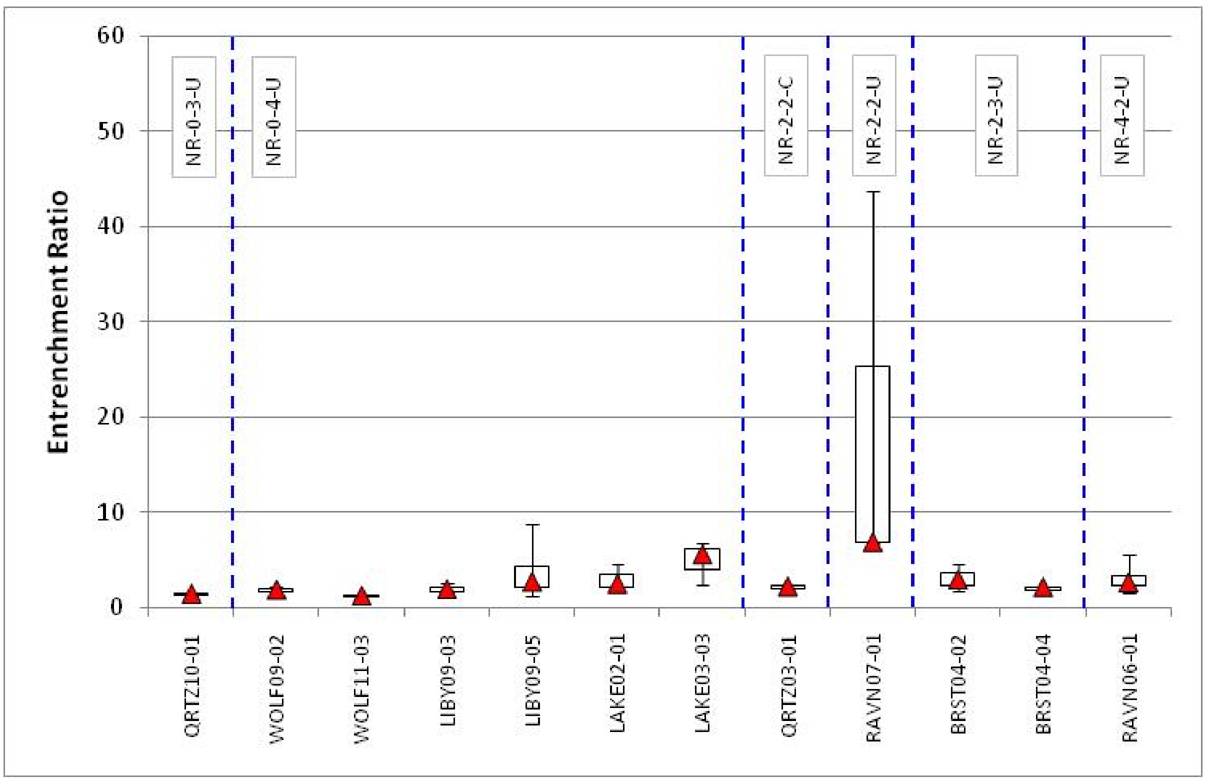


Figure 3-15. Entrenchment Ratio

3.2.2.3 Riffle Pebble Count <2mm

The median percent of fine sediment in riffles <2mm as measured by a pebble count was highest in RAVN07-01, followed by WOLF09-02 (**Figure 3-16**).

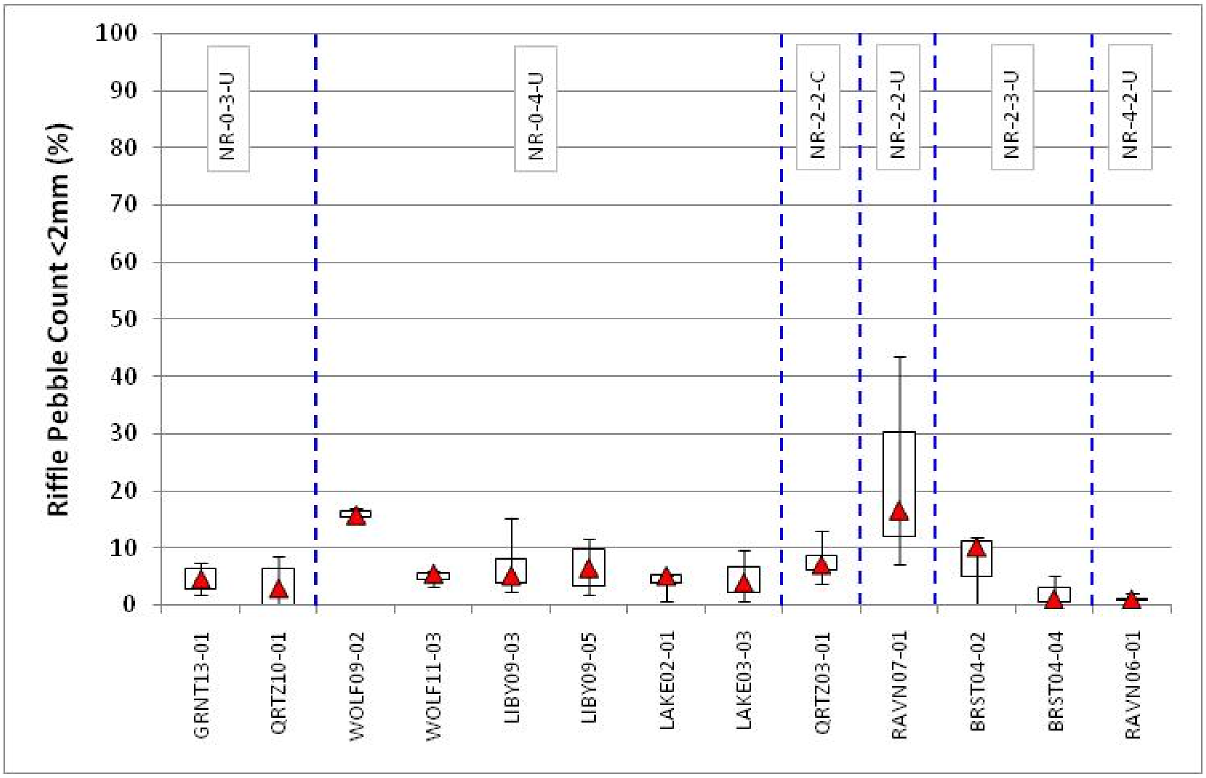


Figure 3-16. Riffle Pebble Count <2mm

3.2.2.4 Riffle Pebble Count <6mm

The percent of fine sediment in riffles <6mm as measured by a pebble count followed a similar trend as the percent of fine sediment <2mm, with the highest median values in RAVN07-01, followed by WOLF09-02 (**Figure 3-17**).

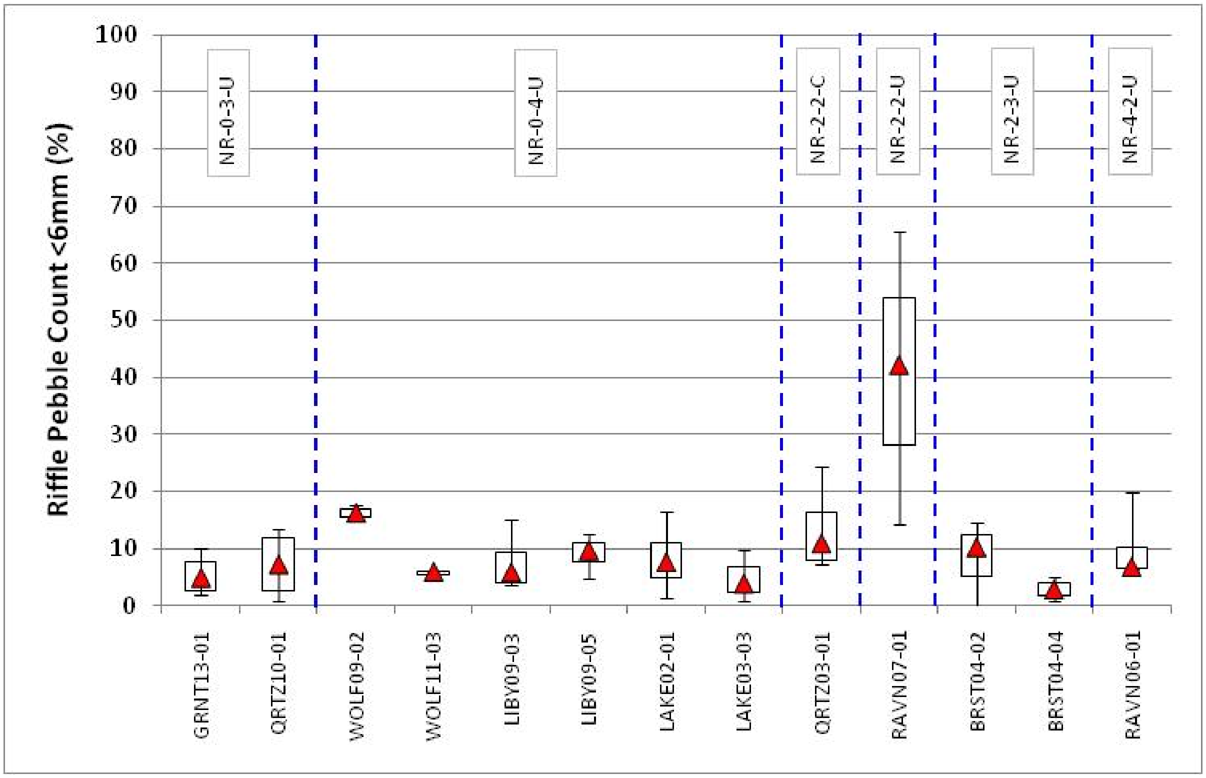


Figure 3-17. Riffle Pebble Count <6mm

3.2.2.5 Riffle Grid Toss <6mm

The median percent of fine sediment in riffles <6mm as measured by a grid toss was highest in LAKE03-03, followed by LIBY09-03 and RAVN07-01 (**Figure 3-18**).

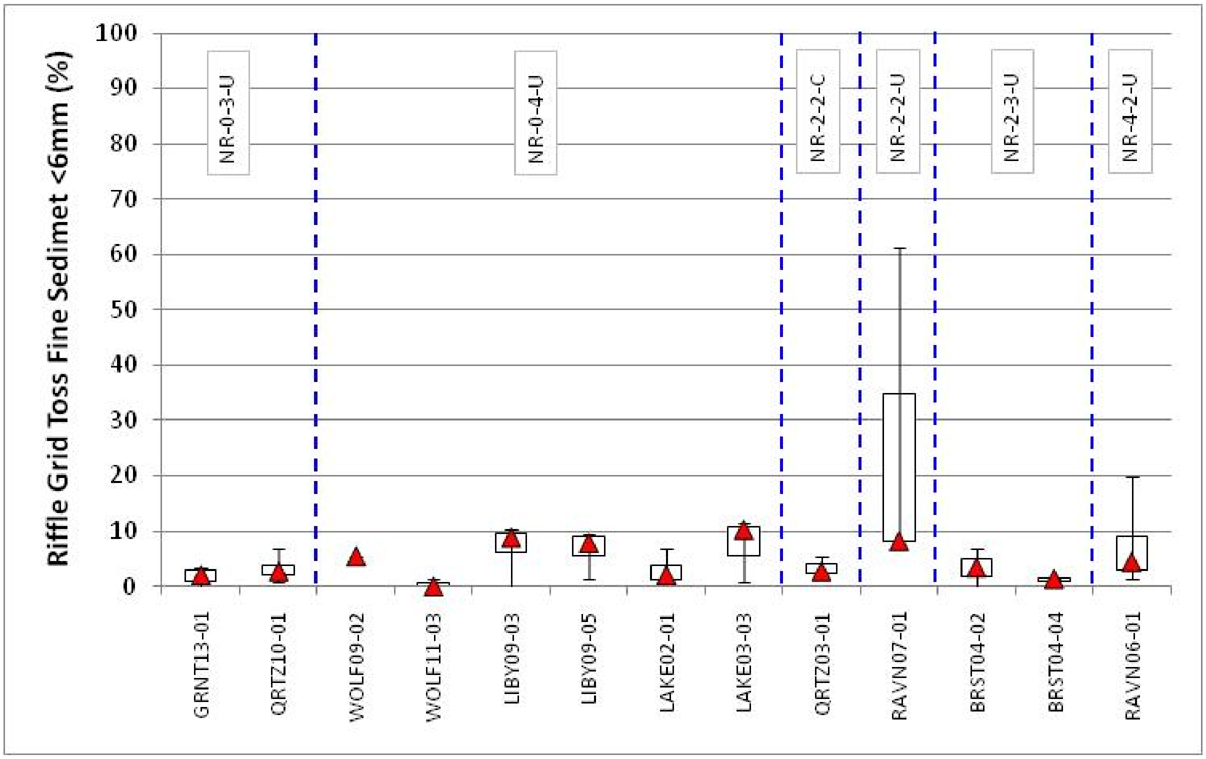


Figure 3-18. Riffle Grid Toss <6mm

3.2.2.6 Riffle Stability Index

The mobile percentile of particles on the riffle is termed "Riffle Stability Index" (RSI) and provides a useful estimate of the degree of increased sediment supply to riffles. The RSI addresses situations in which increases in gravel bedload from headwater activities is depositing material on riffles and filling pools, and it reflects qualitative differences between reference and managed watersheds. Although the expected range varies some by stream type, increasing RSI values above 40-70 generally indicate increased sediment supply to riffles (Kappesser 2002). In the Kootenai-Fisher Project Area, RSI evaluations were performed in BRST04-02, BRST04-04, LIBY09-03, LIBY09-05, and LAKE03-03. (**Table 3-15**).

Table 3-15. Riffle Stability Index Summary

	Mobile Particle Analysis		Pebble Count Analysis		RSI
Site	Cell	Geometric Mean (mm)	Cell	D50 (mm)	
BRST04-02	1	112	1	93	58
BRST04-04	1	114	1	114	50
LIBY09-03	1	182	1	64	95
LIBY09-03	4	166	4	55	90
LIBY09-05	1	185	1	44	97
LAKE03-03	1	166	1	62	94
LAKE03-03	4	155	4	59	96

3.2.2.7 Pool Tail-out Grid Toss <6mm

Fine sediment in pool tail-outs as measured by the grid toss followed a similar pattern as the riffle grid toss. The median percent of fine sediment in pool tail-outs as measured with the grid toss was highest in LAKE03-03, followed by RAVN07-01 (**Figure 3-19**).

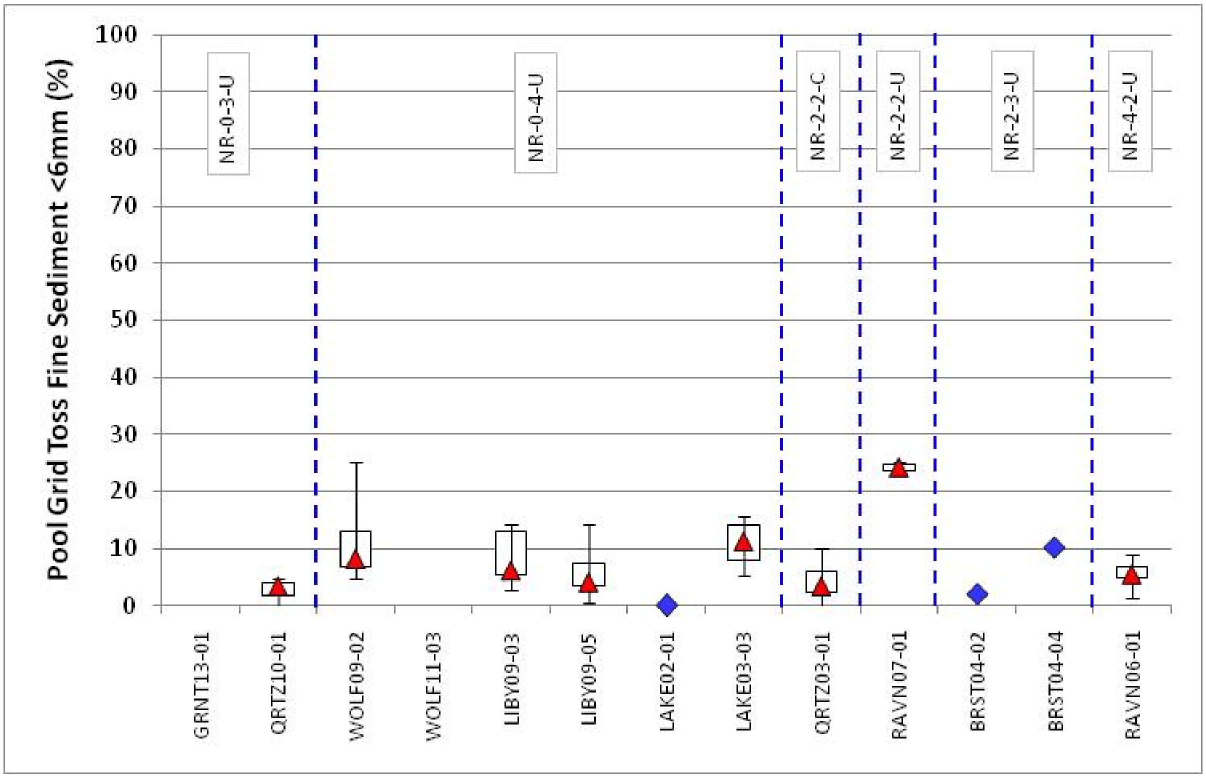


Figure 3-19. Pool Tail-out Grid Toss <6mm

3.2.2.8 Residual Pool Depth

The greatest median residual pool depth was measured in LAKE03-03, followed by LAKE02-01, both of which contained very deep pools in which the maximum depth was estimated (**Figure 3-20**). Maximum depths were also estimated in a portion of the pools in both Libby Creek monitoring sites. The lowest residual pool depth was found in RAVN07-01, which is a small stream flowing across the Fisher River floodplain. In general, residual pool depths increase in the downstream direction within the assessed streams.

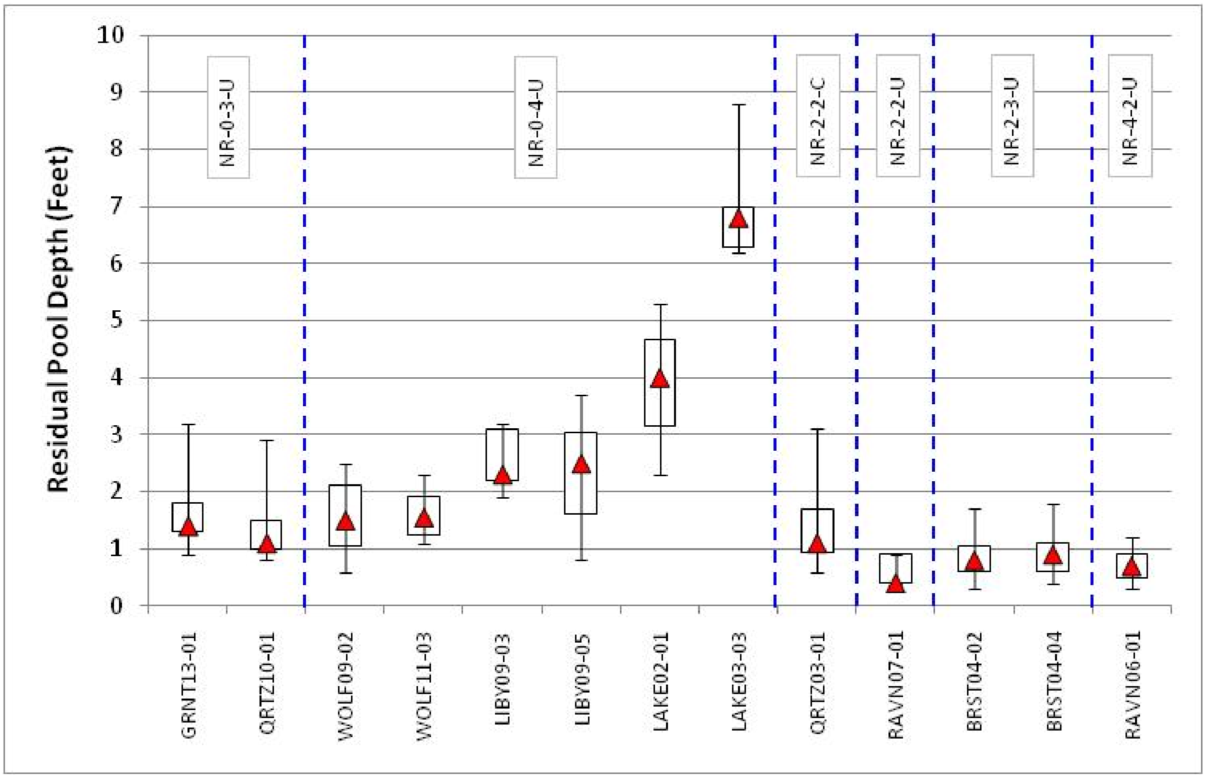


Figure 3-20. Residual Pool Depth

3.2.2.9 Pool Frequency

RAVN06-01 had the greatest number of pools per 1000 feet, followed by BRST04-04 (**Figure 3-21**). Numerous small pools in RAVN06-01 on Raven Creek were formed by interactions with coarse woody debris inputs along this narrow alder-lined stream channel. Pools in BRST04-04 were typical of a cobble and boulder dominated step-pool mountain stream with frequent small pools and large substrate.

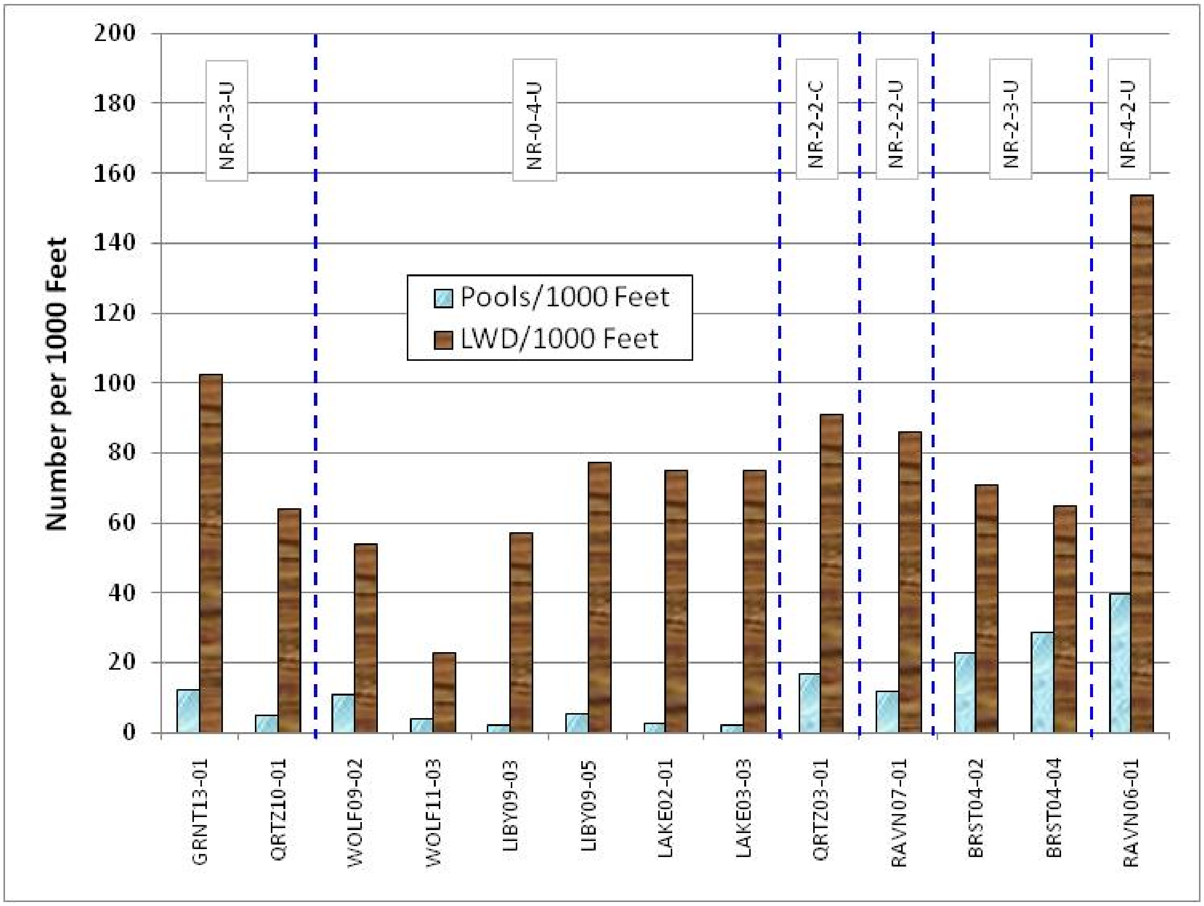


Figure 3-21. Pool and Large Woody Debris Frequency

3.2.2.10 Large Woody Debris Frequency

RAVN06-01 had the greatest amount of large woody debris per 1000 feet, followed by GRNT13-01, which was assessed for potential reference conditions (**Figure 3-21**). Small woody debris inputs from the alder-lined streambanks along Raven Creek comprised the majority of the large woody debris total at RAVN06-01. In GRNT13-01, the channel was lined by large cedar trees with pools formed primarily by large woody debris, which occurred both individually and in several large woody debris aggregates.

3.2.2.11 Greenline Understory Shrub Cover

Mean understory shrub cover exceeded 50% in WOLF11-03, LAKE02-01, and RAVN07-01, while mean shrub density was less than 50% in QRTZ10-01, WOLF09-01, LIBY09-03, LIBY09-05, and LAKE03-03, and QRTZ03-01 (**Figure 3-22**). No greenline measurements were performed in GRNT13-01, BRST04-02, or BRST04-04 since these monitoring sites were located in dense coniferous forests in which dense understory shrub cover was not an expected component of the riparian ecosystem. The greenline understory shrub cover was visually estimated as 100% along RAVN06-01 since the entire reach was lined with dense alders.

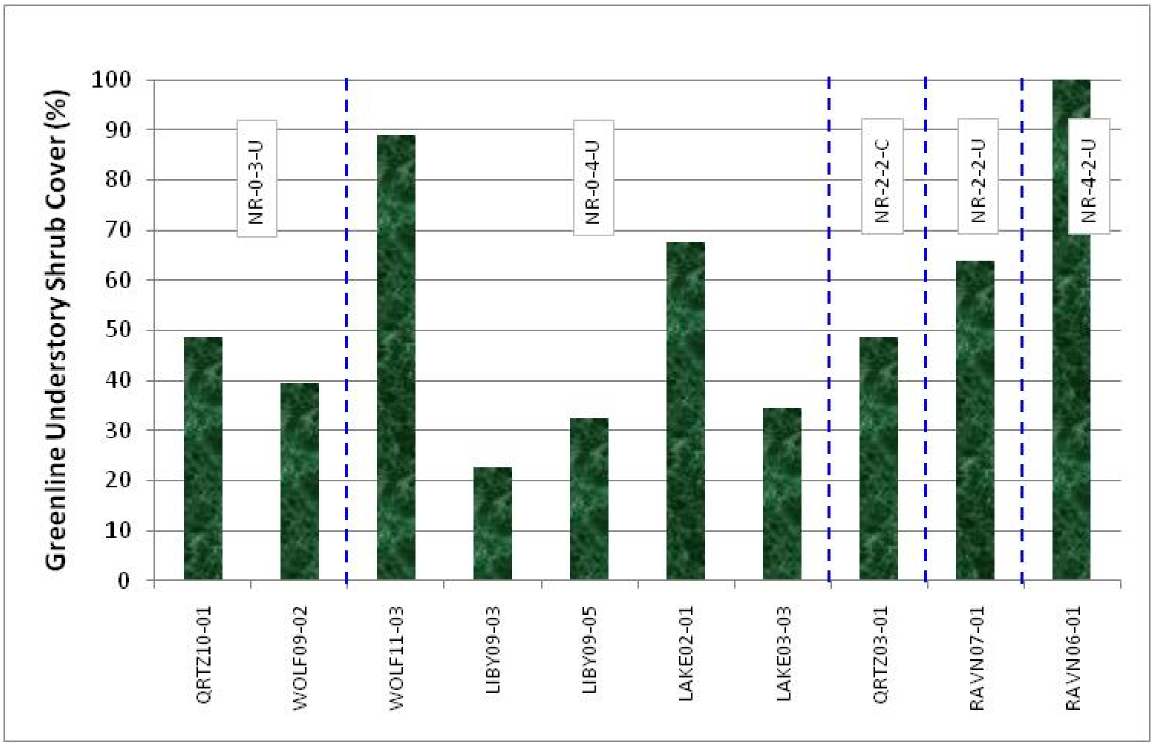


Figure 3-22. Greenline Understory Shrub Cover

3.2.2.12 Greenline Bare Ground

Mean bare ground values equaled or exceeded 5% in QRTZ10-01, LIBY09-03, and LIBY09-05, with all other monitoring sites remaining below 5%, including RAVN06-01 in which bare ground was visually estimated (**Figure 3-23**).

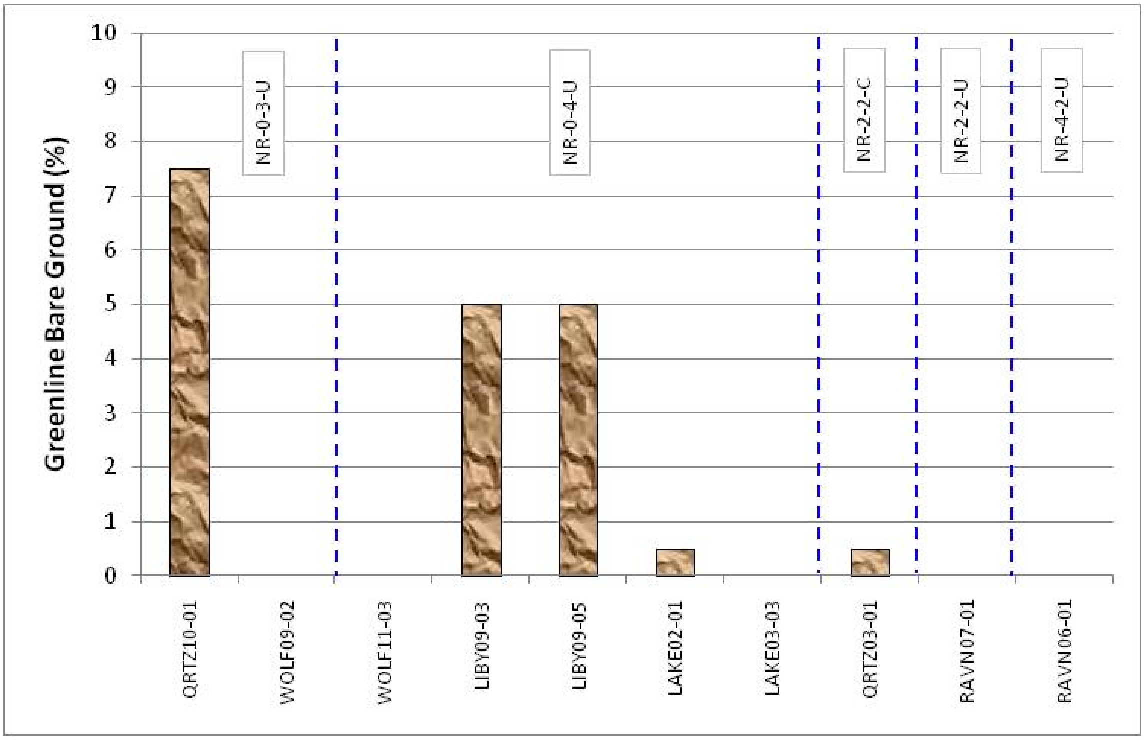


Figure 3-23. Greenline Bare Ground

3.2.3 Site Visit Notes

Following field data collection, field notes were recorded describing conditions observed in the field. Field notes were recorded for four categories and are summarized in the following sections:

- Description of human impacts and their severity
- Description of stream channel conditions
- Description of streambank erosion conditions
- Description of riparian vegetation conditions

3.2.3.1 Bristow Creek – BRST04-02

BRST04-02 was located along a forested reach of Bristow Creek that did not appear to have been logged historically, though logging has occurred in the watershed upstream of the monitoring site and along the stream channel corridor downstream of the monitoring site. The riparian corridor along the monitoring site contained large old cedar trees, though streamside management zone (SMZ) flagging was observed on several streamside trees. Ferns covered the forest floor and large conifers in the overstory limited the amount of understory shrub cover in this reach. Channel conditions were typical of a lower gradient mountain stream with LWD aggregates forming pools and relatively large substrate limiting potential spawning sites. Streambanks were comprised of coarse material and limited erosion was occurring where the flow was directed toward the streambank. The potential for this reach is a B3 stream type, while conditions at the monitoring site ranged from B3 to C3b. The restoration potential for this reach is low as it is in a natural condition.

3.2.3.2 Bristow Creek – BRST04-04

BRST04-04 was located along a forested reach of Bristow Creek downstream of the Koocanusa West Side road crossing. The riparian corridor did not appear to have been logged historically, though logging has occurred in the watershed upstream of the monitoring site. Ferns covered the forest floor and large conifers in the overstory limited the amount of understory shrub cover in this reach, though some alders were present along the channel margin at the upstream end of the reach. Channel conditions were typical of a cobble and boulder dominated step-pool mountain stream with frequent small pools and large substrate limiting potential spawning sites. Streambanks were comprised of coarse material and streambank erosion was limited. The potential for this reach is a B3 stream type, while conditions at the monitoring site ranged from B3a to C3a. The restoration potential for this reach is low as it is in a natural condition.

3.2.3.3 Granite Creek – GRNT13-01

GRNT13-01 was located near the trailhead leading up Granite Creek and the end of the Granite Creek road. This monitoring site was selected to document potential reference conditions and no land use activities beyond the trailhead parking area were observed during a review of 2009 color aerial imagery in GIS. Timber harvest was observed downstream of the monitoring site. This channel was lined by large cedar trees with infrequent alder in the understory. There was very little streambank erosion. The substrate was comprised of large cobbles and small boulders, with pools formed primarily by large woody debris. This reach is at its potential stream type, which is estimated as a B3.

3.2.3.4 Lake Creek – LAKE02-01

LAKE02-01 was located in an area of limited rural residential development along Lake Creek. This reach contained one very deep pool formed by large woody debris at a meander bend. The channel transitioned from a meandering channel to more of a riffle dominated channel progressing upstream through the monitoring site. Naturally eroding streambanks occurred at the outsides of meander bends, with alders along the channel margin and conifers on the floodplain. The potential for this reach is a C4 stream type, with conditions at the monitoring site ranging from C3 to C4 to B3c. The restoration potential for this reach is low as the majority of the reach is in a natural condition.

3.2.3.5 Lake Creek – LAKE03-03

LAKE03-03 was located upstream of the Lake Creek/Spar Lake road crossing. The road encroached the river left bank at the downstream end of the reach and the streambank was lined with riprap. Immediately upstream of the riprap, this streambank has not been stabilized and is actively eroding. The landowner along this streambank estimated it has retreated 10 feet over the past 7 years. Continued erosion is threatening a structure on the property. The opposite streambank progressing upstream is also riprapped along a field, likely leading to the accelerated rate of erosion at the next meander bend downstream. Lake Creek is a meandering channel with a well defined riffle-pool sequence and gravel bars at the insides of meander bends. Fine sediment was observed in the interstitial spaces of the coarse gravel substrate. This reach contained several very deep pools, which were estimated at 8-10 feet deep. These pools were typically formed by large woody debris accumulating at meander bends. Riparian vegetation removal for agricultural activities has occurred and the channel margin was noted to generally lack overstory vegetation at the downstream end of the reach. Progressing upstream, conifer forests occur at the outside of meander bends, with cottonwood galleries at the inside of meander bends. This reach is a C4 stream type, which is the potential stream type. The restoration potential for this reach is moderate and could include revegetation of the stream channel margin along the field and stabilization of the eroding streambank upstream of where the road abuts the channel.

3.2.3.6 Libby Creek – LIBY09-03

LIBY09-03 was located downstream of the Farm to Market – Hammer Cutoff road. The Stimson Haul Road was situated along the river left bank at the upstream end of the reach, including a stretch of riprap lined streambank. Extensive mid-channel gravel bar deposits indicate Libby Creek is aggrading in this reach, while a review of 2009 color aerial imagery in GIS indicates this condition extends along the entire sediment impaired segment of Libby Creek (which extends from the Highway 2 crossing to the mouth). It appears that the mobile bedload is the primary source of sediment to Libby Creek, along with additional inputs from streambank erosion as the stream actively meanders across the floodplain. The large gravel bars contained numerous pieces of large woody debris. Streambanks were primarily comprised of coarse gravel and small cobbles of similar size to the stream substrate. A layer of fine sediment, likely of lacustrine origin, overlay the gravel layer in some of the eroding banks. Fine sediment was observed in the interstitial spaces of the coarse gravel substrate found in the long glides downstream of pools, which typically formed at the outsides of meander bends and in association with large woody debris. Relatively large substrate in the pool tail-outs likely limits spawning potential for all but the largest fish. Even-aged mid-seral cottonwood stands along the river suggest riparian clearing at one point in time. One local resident indicated that Libby Creek was historically lined with large cedar trees, which were logged. Since that time, the stream has been actively meandering, becoming overwidened, and transporting large quantities of bedload sediment. Understory shrub cover was sparse and extensive patches of knapweed were observed. The potential for this reach given the historic disturbances is a C3/4 stream type, with existing conditions ranging from C3 to C4 to B3c. The restoration potential for this reach is moderate given the constraints of the extreme channel over-widening and the large mobile bedload stored in gravel bars.

3.2.3.7 Libby Creek – LIBY09-05

LIBY09-05 was located downstream of LIBY09-03 and shared many of the same characteristics of the upstream reach, though the substrate was slightly finer. The Stimson Haul Road was situated along the river right bank and encroached upon the stream channel upstream of the reach, including a stretch of riprap lined streambank and a flow deflection feature extending into the channel. Extensive mid-channel gravel bar deposits indicate Libby Creek is aggrading in this reach, while a review of 2009 color aerial imagery in GIS indicates this condition extends along the entire lower segment of Libby Creek (which extends from the Highway 2 crossing to the mouth). It appears that the mobile bedload is the primary source of sediment to Libby Creek, along with additional inputs from streambank erosion as the stream actively meanders across the floodplain. The large gravel bars contained numerous pieces of large woody debris. Streambanks were primarily comprised of coarse gravel and small cobbles of similar size to the stream substrate, though one large eroding streambank along the river left side of the channel where Libby Creek was eroding into the terrace was a source of finer material, as well as large woody debris. A small side channel along this eroding terrace had a dynamic series of pools formed by recent large woody debris inputs. Even aged mid-seral cottonwood stands along much of this reach suggest riparian clearing at one point in time. Understory shrub cover was sparse and extensive patches of knapweed were observed. The potential for this reach given the historic disturbances is a C4 stream type, with existing conditions ranging from C4 to F4. The restoration potential for this reach is moderate given the constraints of the extreme channel over-widening and the large mobile bedload stored in gravel bars.

3.2.3.8 Quartz Creek – QRTZ03-01

QRTZ03-01 was located along the upper portion of Quartz Creek approximately five miles upstream of the West Fork Quartz Creek confluence. While a road parallels this portion of Quartz Creek, it is situated high up on the hillslope and does not appear to influence the stream channel. Timber harvest has occurred in the watershed upstream of this reach. The QRTZ03-01 monitoring site was lined by large cedar trees, with infrequent alder in the understory. The streambed was comprised of gravel and small cobble substrate, with pools formed by large woody debris. It appeared that the substrate size, pool frequency, and pool quality would provide ideal spawning conditions. Streambank erosion was limited. Excluding potentially elevated sediment inputs from the upper watershed, conditions within this reach likely approximate reference conditions. The potential for this reach is a B4c stream type, with conditions at the monitoring site ranging from B4c to C4. The restoration potential for this reach is low as it is at a natural condition.

In addition to the assessment conducted on QRTZ03-01, the field crew also examined Quartz Creek above (QRTZ07-01) and below (QRTZ08-01) the confluence with the West Fork Quartz Creek accompanied by the Kootenai National Forest Libby Ranger District hydrologist. An erosive hillslope along river left was observed just downstream of the confluence and upstream of a small bedrock canyon. While anthropogenic disturbances appeared absent along the stream channel in this area, timber harvest has occurred on the adjacent hillslopes and may be leading to increased sediment inputs from hillslope erosion.

3.2.3.9 Quartz Creek – QRTZ10-01

QRTZ10-01 was located near the mouth of Quartz Creek. Anthropogenic disturbances that have influenced this site include timber harvest in the upper watershed, riparian harvest along the monitoring site, road encroachment, and large woody debris aggregate removal. This monitoring site was essentially comprised of one long riffle, with a couple of pools at the upper end of the monitoring site formed by large woody debris aggregates. One large eroding streambank was observed where the stream channel abuts a hillslope. Riparian vegetation along the channel margin includes conifers, cottonwoods, and alder. It appears that a large woody debris aggregate at the upstream end of the reach was partially removed as evidenced by saw marks in the logs on both sides of the channel margin. Quartz Creek is one of the primary bull trout spawning tributaries to the Kootenai River between the Libby Dam and Kootenai Falls, particularly West Fork Quartz Creek (Jim Dunnigan, personal communication). A fish counter was observed just upstream of the QRTZ10-01 monitoring site. The potential for this reach is a B3 stream type, with conditions at the monitoring site ranging from B3 to F3. The restoration potential for this reach is moderate and could include the addition of large woody debris jams to enhance channel complexity.

3.2.3.10 Raven Creek – RAVN04-01

A streambank erosion assessment was performed at RAVN04-01, which was located on a dry ephemeral reach of Raven Creek upstream of a road crossing. Logging and fire appear to be the primary landscape scale disturbances along this site. The low streambanks were generally comprised of cobble and streambank erosion was likely limited by the relatively straight cascading stream channel. Grass, small shrubs, and knapweed lined the channel margin of this ephemeral reach. **Figure 3-24** shows Raven Creek in May 1994 following the fire compared to July 2011 looking downstream from the road crossing that the monitoring site was located upstream of.

Figure 3-24. Raven Creek in May 1994 (left) and July 2011 (right), photos courtesy of Plum Creek

3.2.3.11 Raven Creek – RAVN06-01

The RAVN06-01 monitoring site was located in the lower portion of a heavily logged and roaded watershed. Raven Creek contains surface flow in RAVN03-01 before going subsurface in RAVN04-01; arising from springs in RAVN05-01 upstream of the monitoring site in RAVN06-01. The channel is entrenched with numerous small pools formed by small woody debris inputs. Streambank erosion was limited by the small channel size, the degree of entrenchment, and dense woody vegetation along the stream channel margin. The substrate was comprised of gravel and small cobbles and free of fine sediment accumulations due to the high transport capacity of this reach. Alders formed a narrow band of vegetation along the channel margin, while the uplands were comprised of weeds and small conifers. The potential for this reach is a B4 stream type, with an existing condition of B4a/C4a along the monitoring site. The restoration potential for this reach is low due to channel entrenchment.

3.2.3.12 Raven Creek – RAVN07-01

RAVN07-01 was located near the mouth of Raven Creek, where it joins the Pleasant Valley Fisher River. Historic logging has occurred along this transitional reach where Raven Creek flows across the Fisher River floodplain. Stream substrate became finer in a downstream direction toward the mouth. The channel was small with grass lined streambanks that limited streambank erosion. Alders were also present along the channel margin. The potential for this reach is an E4 stream type, which is the existing condition. The restoration potential for this reach is low since it is in a relatively natural condition.

3.2.3.13 Wolf Creek – WOLF08-03

A streambank erosion assessment was performed at WOLF08-03. Extensive logging has occurred in the Wolf Creek watershed upstream of this monitoring site. Grazing appears to be the primary land-use activity along the monitoring site, though overall grazing pressure appears relatively light. Streambanks were comprised primarily of clay and silt and most streambank erosion appeared to be due to historic grazing activity and the loss of riparian vegetation, though historic logging and changes in water yield may also play a role. A fine layer of silt was observed on the streambed. The channel was slightly entrenched at this site and streambanks were lined with grass and alders in the understory along the channel margin.

3.2.3.14 Wolf Creek – WOLF09-02

WOLF09-02 was located in a meadow area that has been grazed historically, though a recently constructed fence appears to exclude grazing. In addition, extensive logging has occurred in the Wolf Creek watershed upstream of this monitoring site. Historic land use activities upstream and along the site appear to be the source of the current channel entrenchment, though the channel is still relatively sinuous and comprised of long runs and slow moving pools, punctuated by an occasional short riffle. The streambed is comprised of relatively fine material with a layer of fine silt noted on the substrate. Streambanks were comprised primarily of clay and silt and most streambank erosion appeared to be due to historic grazing activity and the loss of riparian vegetation, though historic logging and changes in water yield may also play a role. Streambanks were lined with wetland sedges and grasses, with alders in the understory along the channel margin and very little overstory. The riparian vegetation appeared to be in a state of recovery. The potential for this reach is a C4 stream type, with an existing condition of B4c due to the slight channel entrenchment. The restoration potential for this reach is moderate due to slight channel entrenchment. The riparian vegetation is currently in a state of recovery and beaver activity was observed, though sediment contributions from eroding streambanks remain significant.

3.2.3.15 Wolf Creek – WOLF11-03

WOLF11-03 was located along the main road heading up the valley. The monitoring site was situated so that the lower portion was located in a channelized area, while the upper portion was along a meander bend situated away from the road. Extensive channelization has occurred along Wolf Creek due to the construction of the road and railroad. It appears that several grade control structures were added to Wolf Creek as well. During a review of 2009 color aerial imagery using GIS, 31 bridge crossings of Wolf Creek were identified, most of which were associated with the railroad. The streambed at the monitoring site was comprised of large cobbles and small boulders, with riprap lining a portion of the reach, while natural streambanks generally contained large cobbles. Pools were relatively shallow and lacked spawning sized gravels. Alder and red osier dogwood lined the channel margin with conifers and a few cottonwoods in the overstory. The potential for this reach is a C3 stream type, with an existing condition of F3 due to channel entrenchment. The restoration potential for this reach is low due to the large channel material and extensive channelization along the Wolf Creek mainstem. Habitat enhancement projects utilizing large woody debris jams may be beneficial.

4.0 STREAMBANK EROSION ASSESSMENT

4.1 METHODS

In the Kootenai-Fisher Project Area, streambank erosion data was collected at 13 monitoring sites in which the complete sediment and habitat assessment was performed. An additional assessment of streambank erosion was conducted at two sites to increase the representativeness of the assessment. At each of the 15 monitoring sites, eroding streambanks were assessed for erosion severity and categorized as either "actively/visually eroding" or "slowly eroding/vegetated/undercut". At each eroding streambank, **Bank Erosion Hazard Index (BEHI)** measurements were performed and the **Near Bank Stress (NBS)** was evaluated (Rosgen 1996, 2006). Bank erosion severity was rated from "very low" to "extreme" based on the BEHI score, which was determined based on the following six parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. Near Bank Stress was also rated from "very low" to "extreme" depending on the shape of the channel at the toe of the bank and the force of the water (i.e. "stream power") along the bank. In addition, the source, or underlying cause, of streambank erosion was evaluated at each eroding streambank based on observed anthropogenic disturbances within the riparian corridor, as well as current and historic land-use practices observed within the surrounding landscape. The source of streambank instability was identified based on the following near-stream source categories: transportation, riparian grazing, cropland, mining, silviculture, irrigation, natural, and "historic or other". Naturally eroding streambanks were considered the result of "natural sources" while "historic or other" sources in the Kootenai-Fisher Project Area include dam operations on Lake Creek, rural residential development along Libby Creek, and railroad development along Wolf Creek. Historic removal of riparian vegetation also likely plays a significant role in the existing rate of streambank erosion along streams in the Kootenai-Fisher Project Area, particularly along Libby Creek. If multiple sources were observed, then a percent was noted for each source.

For each eroding streambank, the average annual sediment load was estimated based on the streambank length, mean height, and annual retreat rate. The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between the BEHI and NBS ratings. Annual retreat rates were estimated based on retreat rates developed using Colorado USDA Forest Service (1989) data for sedimentary and metamorphic geologies (Rosgen 2006) (**Table 4-1**). The annual sediment load in cubic feet was then calculated from the field data (annual retreat rate x mean bank height x bank length), converted into cubic yards, and finally converted into tons per year based on the bulk density of streambank material, which was assumed to average 1.3 tons/yard^3 as identified in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS) (EPA 2006, Rosgen 2006). This process resulted in a sediment load for each eroding streambank expressed in tons per year.

Table 4-1. Annual Streambank Retreat Rates (Feet/Year), Colorado USDA Forest Service (adapted from Rosgen 2006)

BEHI	Near Bank Stress					
	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

4.1.1 Monitoring Site Sediment Loads

During field data collection, streambank erosion was assessed at a total of 15 monitoring sites in seven different reach types. For each monitoring site, the streambank erosion sediment load was normalized to 1000 feet. Streambank erosion data was then grouped into two categories for the purpose of analysis and extrapolation, with low gradient (<2% slope) 3rd and 4th order reach types (NR-0-3-U, NR-0-4-U) grouped together and moderate or greater gradient (2-10% slope) 1st, 2nd, and 3rd order reach types (NR-2-2-C, NR-2-2-U, NR-2-3-U, NR-4-1-U, and NR-4-2-U) grouped together. These reach type data groupings result in a total of nine monitoring sites in low gradient 3rd and 4th order reach types and six monitoring sites in moderate gradient 1st, 2nd, and 3rd order reach types (**Table 4-2**).

Table 4-2. Reach Type Data Groupings

Reach Type	Number of Monitoring Sites	Monitoring Sites
NR-0-3-U	2	QRTZ 10-01, GRNT13-01
NR-0-4-U	7	LAKE 02-01, LAKE03-03, LIBY09-03, LIBY09-05, WOLF08-03*, WOLF09-02, WOLF11-03
NR-2-2-C	1	QRTZ 03-01
NR-2-2-U	1	RAVN 06-01
NR-2-3-U	2	BRST 04-02, BRST04-04
NR-4-1-U	1	RAVN 04-01*
NR-4-2-U	1	RAVN 05-01

*Streambank erosion assessment only

4.1.2 Streambank Erosion Sediment Loads for Existing Conditions

Streambank erosion was estimated as predominantly due to natural sources at nine of the 15 assessed monitoring sites, while streambank erosion was estimated as predominately due to anthropogenic sources at six monitoring sites. Erosion from predominantly natural sources is defined as reaches where 75% or more of the causes of streambank erosion influence are attributed to natural sources, whereas anthropogenically influenced reaches attribute streambank erosion to human caused sources for greater than 25% of the reach. For the six monitoring sites with streambank erosion predominately due to anthropogenic sources, five monitoring sites were in reaches of low gradient (<2% slope) and one monitoring site was of moderate or greater gradient (2-10% slope). The average sediment load per year for reaches with erosion predominantly influenced by human sources from these groupings was then used to represent existing conditions for these reach types. For low gradient reach types, the sediment load averaged 22.00 tons/year/1000 feet, while the sediment load at the one site in a moderate or greater gradient reach type was 6.32 tons/year/1000 feet (**Table 4-3**).

Table 4-3. Sediment Loads by Reach Type for Existing Conditions

Field Assessed Reach Type Group	Number of Monitoring Sites	Average Sediment Load per 1000 Feet (Tons/Year)	Standard Error (Tons/Year)	Minimum (Tons)	Maximum (Tons)
NR-0-3-U, NR-0-4-U	5	22.00	3.74	12.67	34.73
NR-2-2-C, NR-2-2-U, NR-2-3-U, NR-4-1-U, NR-4-2-U	1	6.32	n/a	n/a	n/a

Since only one data point was available for moderate or greater gradient reach types, additional analysis was conducted based on streams within the vicinity of the Kootenai-Fisher Project Area, including both the Tobacco TPA streambank erosion assessment from 2008 and the 2011 Thompson Project Area streambank erosion assessment. For the Tobacco TPA, four monitoring sites located in moderate or greater gradient reach types with predominately anthropogenic sources averaged 7.70 tons/year/1000 feet, while for the Thompson Project Area, five monitoring sites located in moderate or greater gradient reach types with predominately anthropogenic sources averaged 6.90 tons/year/1000 feet. This analysis indicates that streambank erosion sediment loads applied to moderate gradient reach types in the Kootenai-Fisher Project Area are similar to those applied in adjacent watersheds.

4.1.3 Reducing Streambank Erosion Sediment Loads through Best Management Practices

The ability to reduce streambank erosion through the application of Best Management Practices (BMPs) was evaluated by comparing the existing conditions sediment load for monitoring sites with predominately human influenced erosion to the sediment load at the nine monitoring sites in which streambank erosion was due to predominately natural sources. Of the nine low gradient monitoring sites, streambank erosion was predominately due to natural sources at four of the sites, while five out of the six moderate or greater gradient monitoring sites had predominately natural sources. The average sediment load per year from these groupings was then used to represent potential bank erosion loading under best management practices. For low gradient reach types, the four monitoring sites with a predominately natural sediment load averaged 9.43 tons/year/1000 feet, while the five monitoring sites in moderate or greater gradient reach types with predominately natural sediment load averaged 2.81 tons/year/1000 feet (**Table 4-4**).

Table 4-4. Sediment Loads by Reach Type with BMPs

Field Assessed Reach Type Group	Number of Monitoring Sites	Average Sediment Load per 1000 Feet with BMPs (Tons/Year)	Standard Error (Tons/Year)	Minimum (Tons)	Maximum (Tons)
NR-0-3-U, NR-0-4-U	4	9.43	4.28	3.64	22.14
NR-2-2-C, NR-2-2-U, NR-2-3-U, NR-4-1-U, NR-4-2-U	5	2.81	1.26	0.12	5.82

4.1.4 Streambank Erosion Sediment Load Extrapolation for Existing Conditions

Streambank erosion data collected at **monitoring sites** were extrapolated to the **stream reach**, **stream segment**, and **sub-watershed** scales based on similar reach type characteristics as identified in the Aerial Assessment Database. Sediment load calculations were performed for monitoring sites, stream reaches, stream segments, and sub-watersheds, which are distinguished as follows:

Monitoring Site - *A 500, 1000, or 2000 foot section of a stream reach where field monitoring was conducted*

Stream Reach -*Subdivision of the stream segment based on ecoregion, stream order, gradient and confinement as evaluated in GIS*

Stream Segment *-303(d) listed segment*

Sub-watershed *-303(d) listed segment and tributary streams based on 1:100,000 NHD data layer*

Streambank erosion sediment loads for the 303(d) listed stream segments were estimated based on the following criteria:

1. Monitoring site sediment loads were extrapolated directly to the stream reach in which the monitoring site was located and the percent contribution from different source categories was based on field observations.

2. Existing conditions data from low gradient (<2% slope) 3rd and 4th order reach types (NR-0-3-U, NR-0-4-U) was applied to all low gradient 3rd, 4th and 5th order reach types in the Kootenai-Fisher Project Area with predominately anthropogenic sources (>25%, based on the aerial assessment) (**Table 4-5**).

3. Existing conditions data from moderate or greater gradient (2-10% slope) 1st, 2nd, and 3rd order reach types (NR-2-2-C, NR-2-2-U, NR-2-3-U, NR-4-1-U, and NR-4-2-U) was applied to all moderate gradient 1st, 2nd, 3rd, and 4th order reach types in the Kootenai-Fisher Project Area with predominately anthropogenic sources (>25%, based on the aerial assessment) (**Table 4-5**).

4. BMP condition sediment loads were assigned to reaches with predominately natural sediment loads (>75%, based on the aerial assessment). One loading rate was applied to low gradient and a different rate was applied to moderate gradient reaches.

5. No streambank erosion sediment load was applied to 1st and 2nd order high gradient (>10%) reach types as these channels tend to be small and well armored and have a very low streambank erosion rate.

6. While a portion of the sediment derived from the Upper Lake Creek watershed is likely retained in Bull Lake, no adjustment was made to sediment loading estimates since this assessment is focused on identifying areas where human sources of sediment loading can be reduced.

Table 4-5. Reach Type Groupings for Extrapolation

Field Assessed Reach Type Group	Un-Assessed Reach Types
NR-0-3-U, NR-0-4-U	NR-0-3-C, NR-0-5-U
NR-2-2-C, NR-2-2-U, NR-2-3-U, NR-4-1-U, NR-4-2-U	NR-2-1-C, NR-2-1-U, NR-2-3-C, NR-2-4-C, NR-2-4-U, NR-4-2-C, NR-4-3-U

At the sub-watershed scale, streambank erosion data from the five monitoring sites in the moderate or greater gradient reach type group with a predominately natural sediment load was used to estimate the streambank erosion sediment load for un-assessed tributaries that were not included in the aerial assessment database. For un-assessed tributaries to the 303(d) listed stream segments, a sediment load of 1.41 tons/year/1000 feet was applied. This value is 50% of the average sediment load from the five monitoring sites in the moderate or greater gradient reach type group with a predominately natural sediment load, which averaged 2.81 tons/year/1000 feet. This value was selected because many of the un-assessed tributaries to the sediment listed streams are 1st and 2nd order streams with high gradients (> 10%) (**Figure 4-1**), and they are assumed to have well-armored streambanks with a low erosion rate.

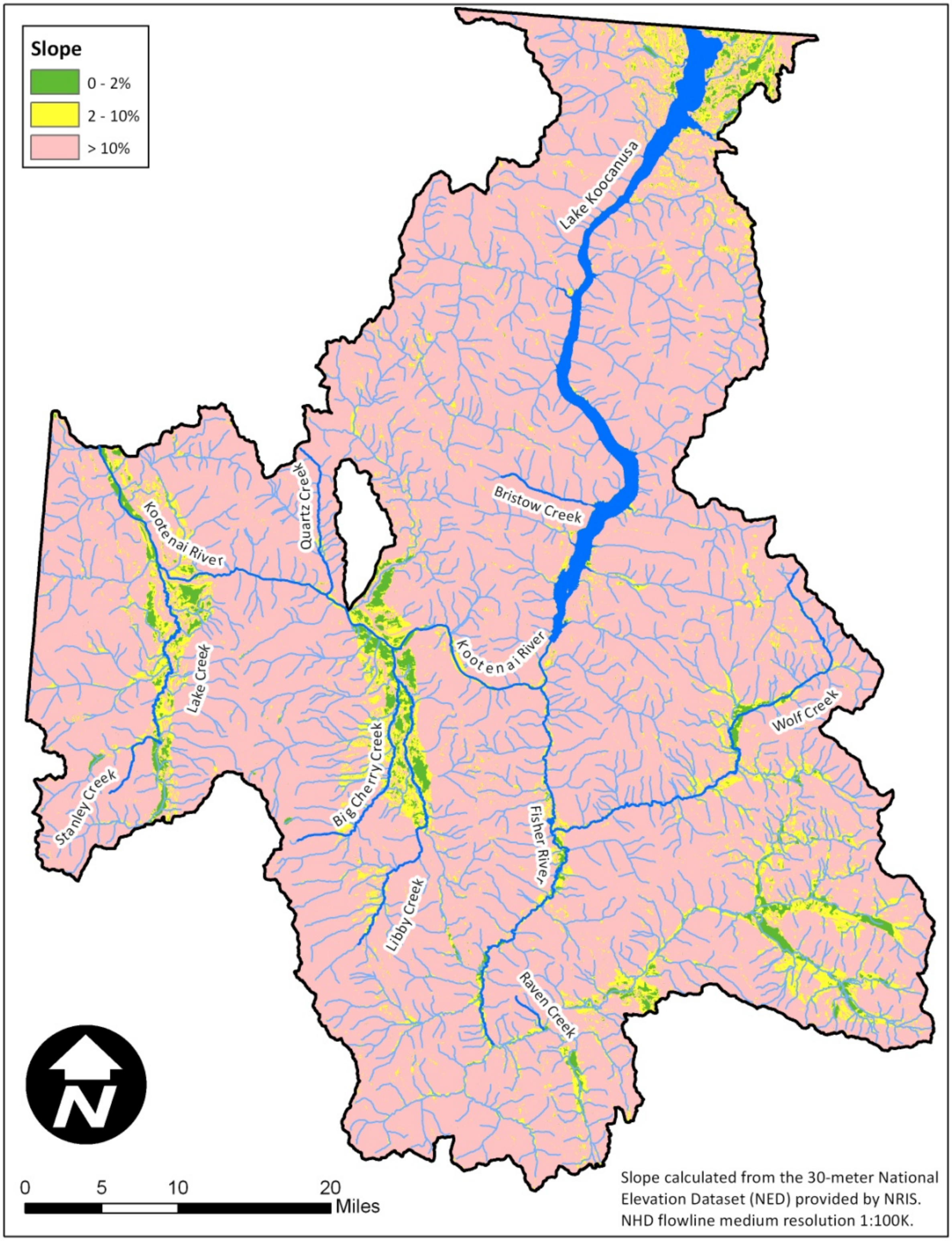


Figure 4-1. Percent Slope in the Kootenai-Fisher Project Area

4.1.5 Streambank Erosion Sediment Load Extrapolation with Best Management Practices

Montana's narrative water quality standards that apply to sediment relate to the naturally occurring condition, which is typically associated with either reference conditions or those that occur if all reasonable land, soil, and water conservation practices are applied. Anthropogenic activities that remove streamside vegetation tend to de-stabilize streambanks and increase the amount streambank erosion. Through the implementation of riparian and streambank BMPs, streambanks can be stabilized and sediment loads can be reduced. The reduction in streambank erosion sediment loads due to anthropogenic sources achievable via the implementation of BMPs was approximated using the estimated streambank erosion rate for monitoring sites in which the sediment load was due to predominately natural sources as discussed in **Section 4.1.3**, along with the following criteria:

1. Because they are assumed to be achieving the naturally occurring condition, no sediment load reductions were applied to reaches with predominately natural sources of erosion (>75%, based on the aerial assessment and observations at monitoring sites). In addition, no load reduction was applied to the natural portion of the sediment load in reaches with <75% natural sources.

2. Percent reductions for monitoring sites with predominately (>25%) anthropogenic sources were based on the difference between the existing conditions streambank erosion sediment load and the BMP sediment load as depicted in **Table 4-6**.

3. BMP sediment loads presented discussed in **Section 4.1.3** were applied to un-assessed reaches on the 303(3) listed stream segments by reach type grouping as shown in **Table 4-6**.

4. No reductions were applied to the un-assessed tributaries to the sediment listed streams (i.e., those not included in the aerial assessment database.

Table 4-6. Percent Reduction in Streambank Erosion Sediment Loads

Field Assessed Reach Type Group	Number of Monitoring Sites	Average Sediment Load per 1000 Feet (Tons/Year)	Average Sediment Load per 1000 Feet with BMPs (Tons/Year)	Percent Reduction
NR-0-3-U, NR-0-4-U	9	22.00	9.43	57%
NR-2-2-C, NR-2-2-U, NR-2-3-U, NR-4-1-U, NR-4-2-U	6	6.32	2.81	56%

4.2 RESULTS

4.2.1 Streambank Erosion Sediment Load Extrapolation

A total average annual sediment load of 246 tons/year was attributed to the 96 assessed eroding streambanks within the 15 monitoring sites. Average annual sediment loads for each monitoring site were normalized to a length of 1,000 feet for the purpose of comparison and extrapolation. Monitoring site sediment loads per 1,000 feet ranged from 0.1 tons/year in RAVN06-01 and RAVN07-01 on Raven Creek to 34.7 tons/year at LIBY09-05 on Libby Creek (**Table 4-7**).

Table 4-7. Monitoring Site Estimated Average Annual Sediment Loads due to Streambank Erosion

Stream Segment	Reach ID	Reach Type	Length of Eroding Bank (Feet)	Monitoring Site Length (Feet)	Percent of Reach with Eroding Streambank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
Bristow Creek	BRST04-02	NR-2-3-U	263	1,000	13%	5.8	5.8
	BRST04-04	NR-2-3-U	154	1,000	8%	2.3	2.3
Granite Creek	GRNT13-01	NR-0-3-U	159	800	10%	2.9	3.6
Lake Creek	LAKE02-01	NR-0-4-U	217	1,000	11%	5.5	5.5
	LAKE03-03	NR-0-4-U	838	2,000	21%	44.3	22.1
Libby Creek	LIBY09-03	NR-0-4-U	1,088	2,000	27%	50.1	25.0
	LIBY09-05	NR-0-4-U	1,789	2,000	45%	69.5	34.7
Quartz Creek	QRTZ03-01	NR-2-2-C	323	1,000	16%	5.6	5.6
	QRTZ10-01	NR-0-3-U	323	1,000	16%	12.7	12.7
Raven Creek	RAVN04-01	NR-4-1-U	216	500	22%	3.2	6.3
	RAVN06-01	NR-4-2-U	6	500	1%	0.1	0.1
	RAVN07-01	NR-2-2-U	4	500	<1%	0.1	0.1
Wolf Creek	WOLF08-03	NR-0-4-U	485	1,000	24%	19.2	19.2
	WOLF09-02	NR-0-4-U	277	1,000	14%	18.4	18.4
	WOLF11-03	NR-0-4-U	219	1,000	11%	6.4	6.4

Monitoring site sediment loads were extrapolated to each 303(d) listed stream segment based on the reach type groups discussed in **Section 4.1.4**. Stream segment sediment loads were estimated for all 103.1 miles of stream included in the Aerial Assessment Database (**Attachment C**). An average annual sediment load of 8,908 tons/year was attributed to eroding streambanks at the stream segment scale (**Table 4-8**). In the Kootenai-Fisher Project Area, streambank erosion sediment loads ranged from 28.8 tons/year in Raven Creek to 3,843.2 tons/year in Wolf Creek (**Attachment C**). Wolf Creek has highest sediment load due to streambank erosion per mile of stream, followed by Libby Creek, while Raven Creek has the lowest streambank erosion sediment load per mile of stream. At the stream segment scale, this assessment indicates that transportation and timber harvest are the greatest anthropogenic contributors of sediment loads due to streambank erosion in the Kootenai-Fisher Project Area, along with removal of riparian vegetation as highlighted in the “other” category (**Figure 4-2**).

Average annual streambank erosion sediment loads at the sub-watershed scale were estimated for the assessed stream segments in the Kootenai-Fisher Project Area based on the total length of stream within each sub-watershed. These sub-watershed sediment loads were estimated from the sum of the average annual streambank erosion sediment loads at the stream segment scale combined with an estimate of streambank erosion sediment loads from un-assessed streams. A total of 103.1 miles of stream were included in the Aerial Assessment Database and there are a total of 877.6 miles of stream in the assessed sub-watersheds based on a modified version of the 1:100,000 NHD stream layer in which ditches were removed (**Table 4-8**). For the purposes of estimating an annual average sub-watershed streambank erosion sediment load, streambank erosion sediment inputs from un-assessed streams was assumed to be 1.41 tons/year/1000 feet. A total sediment load of 14,655 tons per year is estimated at the sub-watershed scale for the Kootenai-Fisher Project Area (**Table 4-8**).

Table 4-8. Sub-watershed Streambank Erosion Sediment Loads

Stream Segment	Stream Length (Miles)	Stream Segment Sediment Load (Tons/Year)	Sub-watershed Stream Length (Miles)	Un-assessed Stream Length (Miles)	Sediment Load Applied to Un-assessed Stream Length (7.42 Tons/Year/Mile)	Sub-watershed Sediment Load (Tons/Year)	Total Load per Mile (Tons/Year)
Bristow Creek	6.4	133.6	22.60	16.2	120.2	253.8	11.2
Lake Creek	17.6	1,625.9	232.15	214.6	1,592.2	3,218.1	13.9
Libby Creek	26.0	3,026.2	283.73	257.7	1,912.1	4,938.3	17.4
Quartz Creek	11.3	250.5	48.24	37.0	274.5	524.9	10.9
Raven Creek	2.6	28.8	6.90	4.3	32.1	60.9	8.8
Wolf Creek	39.3	3,843.2	284.00	244.7	1,816.0	5,659.2	19.9
TOTAL	**103.1**	**8,908**	**877.6**	**774.5**	**5,747**	**14,655**	**16.7**

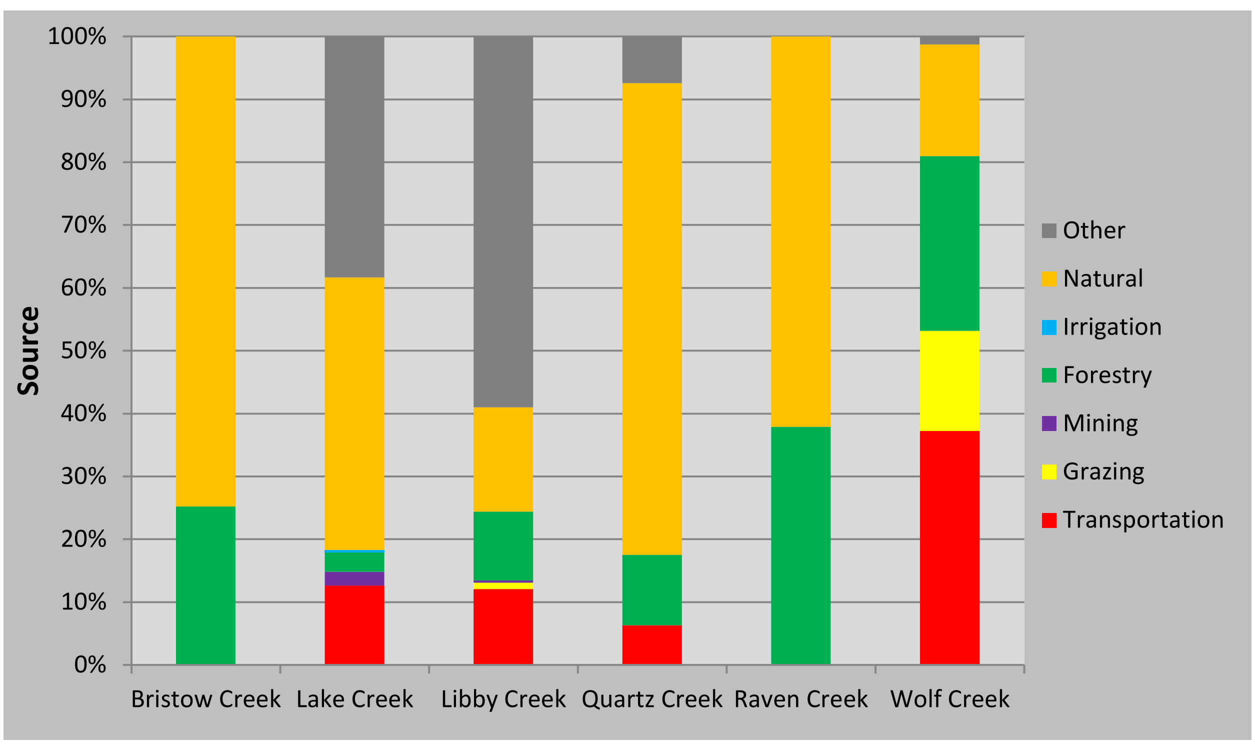


Figure 4-2. Stream Segment and Sub-watershed Streambank Erosion Sources

4.2.1.1 Streambank Composition

The percent of eroding streambank within each particle size category was evaluated for each monitoring site based on the sediment load from each eroding streambank relative to the total sediment load for the monitoring site. Then, the loads per particle size category from the monitoring sites within each impaired stream segment were summed to provide the streambank particle size breakdown for each stream segment (**Table 4-9**). Thus, it is assumed that streambank composition assessed at the field monitoring sites is representative of the overall stream segment. This analysis will help guide implementation activities geared toward reducing sediment loads for specific particle size categories. In the Kootenai-Fisher Project Area, sand/silt generally comprised the greatest portion of the streambank sediment load, comprising greater than 50% of the sediment load in all of the assessed streams except for Libby Creek where coarse gravel comprised the greatest portion of the streambank erosion sediment load.

Table 4-9. Stream Segment Streambank Composition

Stream Segment	Coarse Gravel >6mm (Percent)	Fine Gravel <6mm & >2mm (Percent)	Sand/Silt <2mm (Percent)
Bristow Creek	18%	27%	55%
Lake Creek	28%	15%	57%
Libby Creek	48%	14%	37%
Quartz Creek	28%	20%	52%
Raven Creek	10%	10%	80%
Wolf Creek	6%	3%	92%

4.2.2 Streambank Erosion Sediment Load Reductions

Streambank erosion sediment load reductions for each sediment 303(d) listed sub-watershed in the Kootenai-Fisher Project Area are provided in **Table 4-10**. Potential reductions in anthropogenic loading as a result of the application of BMPs range from 7% in Quartz Creek and Bristow Creek to 32% in Wolf Creek. The loading reductions listed in **Table 4-10** were calculated based on the erosion rates of streambanks predominately influenced by natural sources on the 303(d) listed water body segments, but additional reductions may also be possible from the tributaries to the listed water bodies.

Table 4-10. Sub-watershed Sediment Load Reductions with BMPs

Stream Segment	Existing Sediment Load			Reduced Sediment Load through BMPs			Potential Reduction in Total Sediment Load (Tons/Year)	Percent Reduction in Total Sediment Load
	Total Sub-watershed (Tons/Year)	Anthropogenic Sub-watershed Load (Tons/Year)	Natural Sub-watershed Load (Tons/Year)	Total Sub-watershed (Tons/Year)	Anthropogenic Sub-watershed Load (Tons/Year)	Natural Sub-watershed Load (Tons/Year)		
Bristow Creek	253.8	63.9	189.9	235.1	45.2	189.9	18.7	7%
Lake Creek	3,218.1	1822.9	1395.2	2730.7	1335.5	1395.2	487.4	15%
Libby Creek	4,938.3	4117.6	820.7	3498.1	2677.4	820.7	1440.2	29%
Quartz Creek	524.9	130.8	394.1	490.1	96.0	394.1	34.8	7%
Raven Creek	60.9	23.1	37.8	54.8	17.0	37.8	6.1	10%
Wolf Creek	5,659.2	4652.9	1006.3	3866.7	2860.4	1006.3	1792.5	32%
TOTAL	**14,655**	**10,811**	**3,844**	**10,876**	**7,032**	**3,844**	**3,780**	**26%**

5.0 Assumptions and Uncertainty

The Kootenai-Fisher sediment and habitat assessment assumes reaches with similar reach type characteristics will have similar physical attributes and sediment loads due to streambank erosion. Since only a portion of the streams within the Kootenai-Fisher Project Area were assessed in the field, a degree of uncertainty is unavoidable when extrapolating data from assessed reaches to un-assessed reaches. Although the accuracy of the GIS data may influence the length of each reach type, the largest potential sources of inaccuracy within the project are the small sample size per reach type, the near-stream land uses identified based on aerial images, and the retreat rates used for the extrapolation process. These are minimized by careful selection of representative monitoring sites and only using the near-stream land uses for informational purposes within the TMDL document. Since sediment source modeling may under-estimate or over-estimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each sub-watershed. Instead, the streambank erosion assessment model results should be considered an instrument for estimating existing streambank erosion sediment loads and making general comparisons of streambank erosion sediment loads from various sources.

6.0 Summary

The 2011 sediment and habitat assessment in the Kootenai-Fisher Project Area provides a comprehensive analysis of existing sediment conditions within impaired stream segments and estimated streambank erosion sediment loads for use in TMDL development. A total of 84 reaches were delineated during the aerial assessment reach stratification process covering 103.1 miles of stream. Based on the level III ecoregion, there were a total of 19 distinct reach types and sediment and habitat parameters were assessed at 15 monitoring sites. Statistical analysis of the sediment and habitat data from the 15 monitoring sites will aid in developing sediment TMDL targets that are specific for the Kootenai-Fisher Project Area, while streambank erosion data will be utilized in the sediment TMDL. Within the 15 monitoring sites, an average annual sediment load of 246 tons/year was attributed to the 96 assessed eroding streambanks and average annual sediment load of 8,908 tons/year was estimated for the listed stream segments. Out of the 877.6 miles of stream within the assessed sub-watersheds, a total sediment load of 14,655 tons per year was estimated at the sub-watershed scale. It is estimated that this sediment load can be reduced to 10,876 tons/year, which is a 26% reduction in sediment load from streambank erosion.

7.0 References

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Attachment A

Aerial Assessment Database

STREAM	REACH_ID	REACH	SUBREACH	REACH_TYPE	LENGTH_FT	PRI_ECOREG	SEC_ECOREG	STREAM_ORD	CONFINE	GRADIENT	HB_TRIGGER	SB_TRIGGER	LB_LANDUSE	LB_ANTHRO	LB_RP_VEG	LB_RP_HLTH	RB_LANDUSE	RB_ANTHRO	RB_RP_VEG	RB_RP_HLTH	ANTHRO_TRA	ANTHRO_GRA	ANTHRO_CRO	ANTHRO_MIN	ANTHRO_FOR	ANTHRO_IRR	ANTHRO_NAT	ANTHRO_OTH	ANTHRO_TOT
Bristow Creek	BRST 01-01	01	01	NR-4-2-C	6699	15l		2	C	4-10	Start		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Bristow Creek	BRST 02-01	02	1	NR-4-2-U	1184	15l		2	U	4-10	Confinement		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Bristow Creek	BRST 03-01	03	1	NR-4-3-U	9942	15l		3	U	4-10	Stream Order		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Bristow Creek	BRST 04-01	04	01	NR-2-3-U	1980	15l		3	U	2-<4	Gradient		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	0	0	0	0	70	0	30	0	100
Bristow Creek	BRST 04-02	04	02	NR-2-3-U	5050	15l		3	U	2-<4	Gradient	LULC	Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Bristow Creek	BRST 04-03	04	03	NR-2-3-U	4924	15l		3	U	2-<4	Gradient	LULC	Forest	Yes	Brush	Fair	Forest	Yes	Mature Coniferous	Fair	0	0	0	0	80	0	20	0	100
Bristow Creek	BRST 04-04	04	04	NR-2-3-U	1661	15l		3	U	2-<4	Gradient	LULC	Forest	Yes	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	10	0	90	0	100
Bristow Creek	BRST 05-01	05	1	NR-4-3-U	2344	15l		3	U	4-10	Gradient		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Lake Creek	LAKE 01-01	01	1	NR-0-3-U	8145	15q		3	U	<2	Stream Order		Rural Res./Hobby Farm	No	Brush	Good	Rural Res./Hobby Farm	No	Brush	Good	20	0	0	0	0	0	60	20	100
Lake Creek	LAKE 02-01	02	01	NR-0-4-U	18056	15q		4	U	<2	Tributary		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	10	0	0	0	0	0	70	20	100
Lake Creek	LAKE 02-02	02	02	NR-0-4-U	13006	15q		4	U	<2	Tributary	LULC	Range	Yes	Brush	Good	Forest	No	Brush	Good	0	0	0	0	0	0	50	50	100
Lake Creek	LAKE 03-01	03	01	NR-0-4-U	4515	15q		4	U	<2	Tributary		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Lake Creek	LAKE 03-02	03	02	NR-0-4-U	17510	15q		4	U	<2	Tributary	LULC	Rural Res./Hobby Farm	Yes	Mature Deciduous	Good	Rural Res./Hobby Farm	Yes	Brush	Good	20	0	0	0	0	0	20	60	100
Lake Creek	LAKE 03-03	03	03	NR-0-4-U	11402	15q		4	U	<2	Tributary	LULC	Forest	Yes	Mature Coniferous	Good	Hay/Pasture	Yes	Grass	Poor-Fair	10	20	0	0	20	10	10	30	100
Lake Creek	LAKE 04-01	04	1	NR-0-4-U	11526	15q		4	U	<2	Tributary		Forest	Yes	Mature Coniferous	Good	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair-Good	10	0	0	0	20	0	20	50	100
Lake Creek	LAKE 05-01	05	01	NR-0-4-U	3186	15q		4	U	<2	Impoundment		Forest	No	Mature Deciduous	Good	Urban	Yes	Brush	Fair	50	0	0	50	0	0	0	0	100
Lake Creek	LAKE 06-01	06	1	NR-2-4-C	941	15q		4	C	2-<4	Gradient, Confinement		Forest	No	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Poor	0	0	0	0	0	100	0	0	100
Lake Creek	LAKE 07-01	07	1	NR-2-4-U	2981	15q		4	U	2-<4	Confinement		Urban	Yes	Grass	Fair	Urban	Yes	Brush	Fair	50	0	0	0	0	0	0	50	100
Lake Creek	LAKE 08-01	08	1	NR-0-4-U	1501	15q		4	U	<2	Gradient		Urban	Yes	Grass	Fair	Forest	Yes	Brush	Fair	70	0	0	0	0	0	0	30	100
Libby Creek	LIBY 01-01	01	1	NR-2-2-U	5374	15l		2	U	2-<4	Start		Fores	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	80	0	0	0	0	0	20	0	100
Libby Creek	LIBY 02-01	02	01	NR-0-3-U	3489	15l		3	U	<2	Stream Order		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	0	100	100
Libby Creek	LIBY 02-02	02	02	NR-0-3-U	2065	15l		3	U	<2	Stream Order	LULC	Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Libby Creek	LIBY 03-01	03	01	NR-2-3-U	6032	15l		3	U	2-<4	Gradient		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	30	0	0	30	0	0	10	30	100
Libby Creek	LIBY 03-02	03	02	NR-2-3-U	8130	15l		3	U	2-<4	Gradient	Stream morphology	Forest	Yes	Mature Coniferous	Fair-Good	Forest	Yes	Mature Coniferous	Good	20	0	0	0	20	0	0	60	100
Libby Creek	LIBY 04-01	04	01	NR-0-3-U	2358	15l		3	U	<2	Gradient		Forest	No	Mature Coniferous	Fair-Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	0	100	100
Libby Creek	LIBY 05-01	05	01	NR-0-3-C	3106	15l		3	C	<2	Confinement		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	0	100	100
Libby Creek	LIBY 05-02	05	02	NR-0-3-C	5732	15l		3	C	<2	Confinement	Stream morphoplogy	Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	0	100	100
Libby Creek	LIBY 06-01	06	01	NR-0-3-U	1260	15l		3	U	<2	Tributary, Confinement		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	0	0	0	0	0	0	0	100	100
Libby Creek	LIBY 06-02	06	02	NR-0-3-U	7353	15l		3	U	<2	Tributary, Confinement	Stream morphology	Forest	Yes	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	40	0	0	60	100
Libby Creek	LIBY 07-01	07	01	NR-0-3-C	1931	15l		3	C	<2	Confinement		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	0	0	0	0	50	0	0	50	100
Libby Creek	LIBY 07-02	07	02	NR-0-3-C	4449	15l		3	C	<2	Confinement	LULC	Forest	Yes	Mature Coniferous	Good	Forest	yes	Mature Coniferous	Fair-Good	10	0	0	0	70	0	0	20	100
Libby Creek	LIBY 08-01	08	01	NR-0-3-U	4528	15l		3	U	<2	Confinement		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Fair-Good	20	0	0	0	80	0	0	0	100
Libby Creek	LIBY 08-02	08	02	NR-0-3-U	5162	15l		3	U	<2	Confinement	RD	Forest	Yes	Mature Deciduous	Good	Forest	Yes	Mature Deciduous	Good	30	0	0	0	0	0	0	70	100
Libby Creek	LIBY 09-01	09	01	NR-0-4-U	6475	15l		4	U	<2	Stream Order		Forest	No	Mature Deciduous	Good	Forest	Yes	Mature Deciduous	Fair	0	0	0	0	40	0	0	60	100
Libby Creek	LIBY 09-02	09	02	NR-0-4-U	6077	15l		4	U	<2	Stream Order	LULC	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair	0	10	0	0	0	0	0	90	100
Libby Creek	LIBY 09-03	09	03	NR-0-4-U	14582	15l		4	U	<2	Stream Order	LULC	Rural Res./Hobby Farm	Yes	Shrub	Fair	Rural Res./Hobby Farm	Yes	Mature Deciduous	Poor-Fair	20	10	0	0	0	0	0	70	100
Libby Creek	LIBY 09-04	09	04	NR-0-4-U	6708	15l		4	U	<2	Stream Order	LULC	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair-Good	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair-Good	10	0	0	0	20	0	0	70	100
Libby Creek	LIBY 09-05	09	05	NR-0-4-U	22803	15l		4	U	<2	Stream Order	LULC	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair	Rural Res./Hobby Farm	Yes	Mature Deciduous	Fair	20	10	0	0	0	0	0	70	100
Libby Creek	LIBY 09-06	09	06	NR-0-4-U	7814	15l		4	U	<2	Stream Order	LULC	Forest	Yes	Mature Deciduous	Fair	Forest	Yes	Mature Deciduous	Fair-Good	10	10	0	0	0	0	0	80	100
Libby Creek	LIBY 10-01	10	01	NR-0-5-U	12029	15l		5	U	<2	Stream Order		Urban	Yes	Shrub	Poor	Forest	Yes	Shrub	Poor	20	0	0	0	0	0	0	80	100
Quartz Creek	QRTZ 01-01	01	1	NR-2-1-U	2412	15q		1	U	2-<4	Start		Forest	Yes	Brush	Good	Forest	Yes	Brush	Good	10	0	0	0	0	0	90	0	100
Quartz Creek	QRTZ 02-01	02	1	NR-2-1-C	2226	15q		1	C	2-<4	Start		Forest	Yes	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	30	0	0	0	0	0	70	0	100
Quartz Creek	QRTZ 03-01	03	1	NR-2-2-C	10466	15q		2	C	2-<4	Stream Order		Forest	Yes	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	30	0	0	0	0	0	70	0	100
Quartz Creek	QRTZ 04-01	04	1	NR-4-2-U	3758	15q		2	U	4-10	Gradient, Confinement		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Quartz Creek	QRTZ 05-01	05	1	NR-2-2-U	15428	15q		2	U	2-<4	GRADIENT		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Quartz Creek	QRTZ 06-01	06	1	NR-4-2-U	1180	15q		2	U	4-10	GRADIENT		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Quartz Creek	QRTZ 07-01	07	1	NR-4-2-C	5031	15q		2	C	4-10	Confinement		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Quartz Creek	QRTZ 08-01	08	1	NR-2-3-C	925	15q		3	C	2-<4	Stream Order		Forest	Yes	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	50	0	50	0	100
Quartz Creek	QRTZ 09-01	09	01	NR-2-3-U	11271	15q		3	U	2-<4	Confinement		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Quartz Creek	QRTZ 09-02	09	02	NR-2-3-U	3666	15q		3	U	2-<4	Confinement	LULC	Rural Res./Hobby Farm	Yes	Mature Deciduous	Good	Forest	No	Mature Coniferous	Good	20	0	0	0	0	0	0	80	100
Quartz Creek	QRTZ 10-01	10	1	NR-0-3-U	3042	15q		3	U	<2	Gradient		Rural Res./Hobby Farm	No	Mature Coniferous	Good	Forest	No	Mature Deciduous	Good	10	0	0	0	0	0	90	0	100

STREAM	REACH_ID	REACH	SUBREACH	REACH_TYPE	LENGTH_FT	PRI_ECOREG	SEC_ECOREG	STREAM_ORD	CONFINE	GRADIENT	HB_TRIGGER	SB_TRIGGER	LB_LANDUSE	LB_ANTHRO	LB_RP_VEG	LB_RP_HLTH	RB_LANDUSE	RB_ANTHRO	RB_RP_VEG	RB_RP_HLTH	ANTHRO_TRA	ANTHRO_GRA	ANTHRO_CRO	ANTHRO_MIN	ANTHRO_FOR	ANTHRO_IRR	ANTHRO_NAT	ANTHRO_OTH	ANTHRO_TOT
Raven Creek	RAVN 01-01	01	01	NR-10-1-U	471	15l		1	U	>10	START		Forest	Yes	Mature Coniferous	Fair	Forest	Yes	Mature Coniferous	Fair	0	0	0	0	100	0	0	0	100
Raven Creek	RAVN 01-02	01	02	NR-10-1-U	108	15l		1	U	>10		ROAD	Forest	Yes	Grass	Poor	Forest	Yes	Grass	Poor	100	0	0	0	0	0	0	0	100
Raven Creek	RAVN 02-01	02	1	NR-10-1-C	2667	15l		1	C	>10	CONFINEMENT		Forest	Yes	Grass	Fair	Forest	Yes	Mature Coniferous	Fair	0	0	0	0	100	0	0	0	100
Raven Creek	RAVN 03-01	03	1	NR-10-1-U	2456	15l		1	U	>10	Confinement		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	0	0	0	0	100	0	0	0	100
Raven Creek	RAVN 04-01	04	1	NR-4-1-U	4479	15l		1	U	4-10	Gradient		Forest	Yes	Grass	Fair	Forest	Yes	Grass	Fair	0	0	0	0	100	0	0	0	100
Raven Creek	RAVN 05-01	05	1	NR-4-2-U	2772	15l		2	U	4-10	Stream Order		Forest	Yes	Mature Deciduous	Good	Forest	Yes	Mature Deciduous	Good	0	0	0	0	100	0	0	0	100
Raven Creek	RAVN 06-01	06	01	NR-2-2-U	616	15l		2	U	2-<4	Gradient		Range	Yes	Mature Deciduous	Good	Range	Yes	Mature Deciduous	Good	50	0	0	0	0	0	50	0	100
Wolf Creek	WOLF 01-01	01	1	NR-2-1-U	2271	15l		1	U	2-<4	Start		Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Wolf Creek	WOLF 02-01	02	01	NR-2-2-U	1519	15l		2	U	2-<4	Stream Order		Forest	No	Mature Coniferous	Good	Forest	No	Brush	Good	0	0	0	0	0	0	100	0	100
Wolf Creek	WOLF 02-02	02	02	NR-2-2-U	948	15l		2	U	2-<4	Stream Order	LULC	Forest	No	Grass	Good	Forest	No	Grass	Good	0	0	0	0	0	0	100	0	100
Wolf Creek	WOLF 02-03	02	03	NR-2-2-U	1000	15l		2	U	2-<4	Stream Order	LULC	Forest	No	Mature Coniferous	Good	Forest	No	Mature Coniferous	Good	0	0	0	0	0	0	100	0	100
Wolf Creek	WOLF 03-01	03	1	NR-10-2-C	391	15l		2	C	>10	Gradient		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Good	100	0	0	0	0	0	0	0	100
Wolf Creek	WOLF 04-01	04	1	NR-2-2-U	1476	15l		2	U	2-<4	Gradient		Forest	No	Brush	Good	Forest	No	Brush	Good	0	0	0	0	0	0	100	0	100
Wolf Creek	WOLF 05-01	05	01	NR-0-3-U	14509	15l		3	U	<2	Stream Order		Forest	Yes	Brush	Good	Forest	No	Brush	Good	10	0	0	0	0	0	90	0	100
Wolf Creek	WOLF 05-02	05	02	NR-0-3-U	11032	15l		3	U	<2	Stream Order	RD	Forest	Yes	Brush	Good	Forest	Yes	Brush	Good	80	0	0	0	20	0	0	0	100
Wolf Creek	WOLF 05-03	05	03	NR-0-3-U	5069	15l		3	U	<2	Stream Order	RD	Forest	Yes	Brush	Good	Forest	Yes	Brush	good	50	0	0	0	50	0	0	0	100
Wolf Creek	WOLF 06-01	06	1	NR-2-3-U	6203	15l		3	U	2-<4	Gradient		Forest	Yes	Mature Coniferous	Good	Forest	Yes	Mature Coniferous	Fair	0	0	0	0	100	0	0	0	100
Wolf Creek	WOLF 07-01	07	1	NR-2-4-U	2188	15l		4	U	2-<4	Stream Order		Forest	Yes	Brush	Good	Forest	Yes	Brush	Fair	20	10	0	0	10	0	60	0	100
Wolf Creek	WOLF 08-01	08	01	NR-0-4-U	3318	15l		4	U	<2	Gradient		Forest	Yes	Grass	Good	Forest	Yes	Grass	Fair	10	0	0	0	20	0	70	0	100
Wolf Creek	WOLF 08-02	08	02	NR-0-4-U	6926	15l		4	U	<2	Gradient	LULC	Forest	Yes	Brush	Good	Forest	Yes	Brush	Fair	20	0	0	0	70	0	10	0	100
Wolf Creek	WOLF 08-03	08	03	NR-0-4-U	14108	15l		4	U	<2	Gradient	LULC	Forest	Yes	Brush	Good	Forest	Yes	Brush	Fair	10	0	0	0	90	0	0	0	100
Wolf Creek	WOLF 08-04	08	04	NR-0-4-U	9140	15l		4	U	<2	Gradient	LULC	Forest	Yes	Grass	Good	Forest	Yes	Grass	Fair	10	0	0	0	70	0	20	0	100
Wolf Creek	WOLF 08-05	08	05	NR-0-4-U	4941	15l		4	U	<2	Gradient	LULC	Forest	Yes	Grass	Good	Range	Yes	Grass	Fair	20	40	0	0	30	0	10	0	100
Wolf Creek	WOLF 09-01	09	01	NR-0-4-U	2666	15l		4	U	<2	Tributary	LULC	Range	No	Brush	Good	Forest	No	Brush	Good	0	50	0	0	20	0	30	0	100
Wolf Creek	WOLF 09-02	09	02	NR-0-4-U	25937	15l		4	U	<2	Tributary	LULC	Range	Yes	Brush	Good	Range	Yes	Brush	Good	20	10	0	0	0	10	60	0	100
Wolf Creek	WOLF 10-01	10	01	NR-0-4-U	7326	15l		4	U	<2	Tributary		Range	Yes	Brush	Fair	Range	Yes	Brush	Fair	30	10	0	0	0	0	30	30	100
Wolf Creek	WOLF 10-02	10	02	NR-0-4-U	11468	15l		4	U	<2	Tributary	RD	Forest	Yes	Brush	Fair	Forest	Brush	Yes	Fair	100	0	0	0	0	0	0	0	100
Wolf Creek	WOLF 10-03	10	03	NR-0-4-U	4146	15l		4	U	<2	Tributary	RD	Forest	Yes	Brush	Fair	Forest	Yes	Brush	Fair	50	0	0	0	0	0	50	0	100
Wolf Creek	WOLF 10-04	10	04	NR-0-4-U	12540	15l		4	U	<2	Tributary	RD	Forest	Yes	Brush	Fair	Forest	Yes	Brush	Fair	60	0	0	0	0	0	40	0	100
Wolf Creek	WOLF 11-01	11	01	NR-0-4-U	41193	15l		4	U	<2	Tributary		Forest	Yes	Brush	Fair	Forest	Yes	Brush	Fair	50	0	0	0	50	0	0	0	100
Wolf Creek	WOLF 11-02	11	02	NR-0-4-U	5909	15l		4	U	<2	Tributary	LULC	Forest	No	Mature Deciduous	Good	Forest	Yes	Brush	Fair	70	0	0	0	0	0	30	0	100
Wolf Creek	WOLF 11-03	11	03	NR-0-4-U	7875	15l		4	U	<2	Tributary	RD, LULC	Forest	Yes	Brush	Fair	Forest	Yes	Brush	Fair	40	0	0	0	60	0	0	0	100
Wolf Creek	WOLF 11-04	11	04	NR-0-4-U	3205	15l		4	U	<2	Tributary	RD, LULC	Forest	No	Brush	Fair	Forest	Yes	Brush	Fair	30	0	0	0	70	0	0	0	100

Attachment B

Sediment and Habitat Database

Reach ID	Date	Cell	Reach Type	Existing Rosgen Stream Type	Potential Rosgen Stream Type	GIS Calculated Sinuosity	Field Slope (Percent)	Aerial Assessment Valley Gradient	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index	Number of Pools per 1000 Feet	Mean Residual Pool Depth	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	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
WOLF09-02	8/22/11	1	NR-0-4-U	B4c	C4	1.1	0.6	<2%	35.1	50.1	1.43	24.6	2.4	77.1	2.2	33	17	18	5		11	1.5	18	6	54	40	0	0	14	200	51
WOLF09-02	8/22/11	2	NR-0-4-U					<2%																							
WOLF09-02	8/22/11	3	NR-0-4-U	B4c	C4	1.1	0.6	<2%	24.3	32.8	1.35	18.0	2.2	37.3	1.5	33	15	15	5												
WOLF09-02	8/22/11	4	NR-0-4-U					<2%																							
WOLF09-02	8/22/11	5	NR-0-4-U					<2%																							
RAVN06-01	8/22/11	1	NR-4-2-U	B4a	B4	1.3	4.5	4-<10%	5.7	4.5	0.79	7.2	1.0	9.5	1.7	18	0	7	20		40	0.7	62	28	154						
RAVN06-01	8/22/11	2	NR-4-2-U	C4a	B4	1.3	4.5	4-<10%	10.7	6.5	0.60	17.8	1.0	27.7	2.6	14	1	20	5												
RAVN06-01	8/22/11	3	NR-4-2-U	C4a	B4	1.3	4.5	4-<10%	5.5	6.1	1.11	5.0	1.6	30.5	5.5	32	2	7	1												
RAVN06-01	8/22/11	4	NR-4-2-U	C4a	B4	1.3	4.5	4-<10%	5.4	4.7	0.87	6.2	1.2	14.4	2.7	33	1	6	3												
RAVN06-01	8/22/11	5	NR-4-2-U					4-<10%																							
RAVN07-01	8/22/11	1	NR-2-2-U					2-<4%													12	0.6	62	0	86	64	0	0	18	200	200
RAVN07-01	8/22/11	2	NR-2-2-U					2-<4%																							
RAVN07-01	8/22/11	3	NR-2-2-U	E4	E4	1.6	0.2	2-<4%	5.8	4.5	0.78	7.4	1.3	39.8	6.9	9	17	42	8												
RAVN07-01	8/22/11	4	NR-2-2-U	E4	E4	1.6	0.2	2-<4%	3.5	2.7	0.78	4.5	1.7	153.5	43.9	3	44	65	61												
RAVN07-01	8/22/11	5	NR-2-2-U	E4	E4	1.6	0.2	2-<4%	6.3	7.3	1.15	5.5	1.8	43.3	6.9	30	7	14	8												
WOLF11-03	8/23/11	1	NR-0-4-U	F3	C3	1.4	1.2	<2%	36.4	49.6	1.36	26.7	2.4	43.4	1.2	128	5	6	0		4	1.6	10	4	23	89	0	7	23	85	139
WOLF11-03	8/23/11	2	NR-0-4-U	F3	C3	1.4	1.2	<2%	53.8	68.7	1.28	42.1	1.9	67.3	1.3	118	6	6	1												
WOLF11-03	8/23/11	3	NR-0-4-U	F3	C3	1.4	1.2	<2%	45.2	75.1	1.66	27.2	2.6	58.2	1.3	111	3	5	0												
WOLF11-03	8/23/11	4	NR-0-4-U					<2%																							
WOLF11-03	8/23/11	5	NR-0-4-U					<2%																							
BRST04-02	8/23/11	1	NR-2-3-U	C3b	B3	1.2	3.4	2-<4%	22.5	28.5	1.27	17.8	2.0	102.5	4.6	93	12	15	7	58	23	0.8	29	7	71						
BRST04-02	8/23/11	2	NR-2-3-U					2-<4%																							
BRST04-02	8/23/11	3	NR-2-3-U	B3	B3	1.2	3.4	2-<4%	23.5	28.8	1.23	19.2	2.3	42.5	1.8	75	10	10	3												
BRST04-02	8/23/11	4	NR-2-3-U					2-<4%																							
BRST04-02	8/23/11	5	NR-2-3-U	C3b	B3	1.2	3.4	2-<4%	23.2	28.9	1.25	18.6	2.3	68.2	2.9	97	0	0	0												
BRST04-04	8/23/11	1	NR-2-3-U	B3a	B3	1.1	4.7	2-<4%	19.4	24.9	1.28	15.1	2.2	27.4	1.4	114	5	5	1	50	29	0.9	31	6	65						
BRST04-04	8/23/11	2	NR-2-3-U	C3a	B3	1.1	4.7	2-<4%	21.2	34.0	1.61	13.2	2.2	48.2	2.3	88	1	3	1												
BRST04-04	8/23/11	3	NR-2-3-U					2-<4%																							
BRST04-04	8/23/11	4	NR-2-3-U					2-<4%																							
BRST04-04	8/23/11	5	NR-2-3-U	B3a	B3	1.1	4.7	2-<4%	23.8	30.0	1.26	18.9	2.2	51.3	2.2	72	0	1	1												

Reach ID	Date	Cell	Reach Type	Existing Rosgen Stream Type	Potential Rosgen Stream Type	GIS Calculated Sinuosity	Field Slope (Percent)	Aerial Assessment Valley Gradient	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index	Number of Pools per 1000 Feet	Mean Residual Pool Depth	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	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
LIBY09-03	8/24/11	1	NR-0-4-U	C3/4	C3/4			<2%								64	6	7	8	95	3	2.5	29	6	58	23	5	9	37	97	102
LIBY09-03	8/24/11	2	NR-0-4-U	C3	C3/4			<2%								75	4	4	10												
LIBY09-03	8/24/11	3	NR-0-4-U					<2%																							
LIBY09-03	8/24/11	4	NR-0-4-U	C4	C3/4	1.1	1.0	<2%	90.9	172.7	1.90	47.8	2.7	230.9	2.5	55	15	15	10	90											
LIBY09-03	8/24/11	5	NR-0-4-U	B3c	C3/4	1.1	1.0	<2%	74.1	157.1	2.12	35.0	3.4	100.1	1.4	75	2	4	0												
LIBY09-05	8/24/11	1	NR-0-4-U	C4	C4	1.1	0.5	<2%	86.1	176.8	2.05	41.9	3.1	206.1	2.4	44	12	13	9	97	6	2.3	26	8	78	33	5	0	41	148	115
LIBY09-05	8/24/11	2	NR-0-4-U	F4	C4	1.1	0.5	<2%	78.1	147.6	1.89	41.3	2.7	101.1	1.3	48	4	9	10												
LIBY09-05	8/24/11	3	NR-0-4-U	C4	C4	1.1	0.5	<2%	151.0	293.2	1.94	77.8	3.6	451.0	>3.0	57	9	11	7												
LIBY09-05	8/24/11	4	NR-0-4-U					<2%																							
LIBY09-05	8/24/11	5	NR-0-4-U	C4	C4	1.1	0.5	<2%	56.8	143.9	2.53	22.4	3.5	496.8	8.7	50	2	5	1												
GRNT13-01	8/24/11	1	NR-0-3-U	B3	B3	1.2	0-2%	<2%								125	2	2	0		13	1.7	43	10	103						
GRNT13-01	8/24/11	2	NR-0-3-U	B3	B3	1.2	0-2%	<2%								116	6	7	3												
GRNT13-01	8/24/11	3	NR-0-3-U	B3	B3	1.2	0-2%	<2%								117	7	10	3												
GRNT13-01	8/24/11	4	NR-0-3-U	B3	B3	1.2	0-2%	<2%								90	3	3	1												
QRTZ03-01	8/25/11	1	NR-2-2-C	C4	B4c		1.6	2-<4%	20.3	24.4	1.20	16.9	1.7	48.0	2.4	33	13	24	5		17	1.4	28	15	91	49	1	0	56	200	169
QRTZ03-01	8/25/11	2	NR-2-2-C	B4c	B4c		1.6	2-<4%	16.9	19.2	1.14	14.8	1.8	35.9	2.1	48	7	14	2												
QRTZ03-01	8/25/11	3	NR-2-2-C	B4c	B4c		1.6	2-<4%	18.1	17.4	0.96	18.8	1.8	26.1	1.4	34	4	8	3												
QRTZ03-01	8/25/11	4	NR-2-2-C					2-<4%																							
QRTZ03-01	8/25/11	5	NR-2-2-C	C4	B4c		1.6	2-<4%	19.4	19.9	1.03	18.9	1.5	44.9	2.3	55	7	7													
QRTZ10-01	8/25/11	1	NR-0-3-U	B3	B3	1.1	2.3	<2%	39.7	56.7	1.43	27.8	2.1	64.7	1.6	78	9	13	3		5	1.5	19	8	64	49	8	0	53	200	96
QRTZ10-01	8/25/11	2	NR-0-3-U	F3	B3	1.1	2.3	<2%	39.1	60.6	1.55	25.2	2.0	52.1	1.3	83	6	11	3												
QRTZ10-01	8/25/11	3	NR-0-3-U	B3	B3	1.1	2.3	<2%	35.8	51.6	1.44	24.9	2.2	52.8	1.5	92	0	1	7												
QRTZ10-01	8/25/11	4	NR-0-3-U	B3	B3	1.1	2.3	<2%	39.2	58.8	1.50	26.1	2.2	56.2	1.4	74	0	3	1												
QRTZ10-01	8/25/11	5	NR-0-3-U					<2%																							
LAKE03-03	8/26/11	1	NR-0-4-U	C4	C4	1.4	0.2	<2%	70.0	239.9	3.43	20.4	4.7	470.0	6.7	62	1	1	10	94	3	7.0	12	7	75	35	0	8	5	72	156
LAKE03-03	8/26/11	2	NR-0-4-U	C4	C4			<2%								42	10	10	12												
LAKE03-03	8/26/11	3	NR-0-4-U					<2%																							
LAKE03-03	8/26/11	4	NR-0-4-U	C4	C4	1.4	0.2	<2%	141.4	354.2	2.50	56.5	4.3	351.4	>2.5	59	4	4	1	96											
LAKE03-03	8/26/11	5	NR-0-4-U	C4	C4	1.4	0.2	<2%	87.0	311.7	3.58	24.3	4.4	487.0	5.6																
LAKE02-01	8/26/11	1	NR-0-4-U	C4	C4	2.3	0.9	<2%	71.7	174.5	2.43	29.5	3.0	331.7	4.6	49	5	6	7		3	3.9	24	5	75	68	1	0	14	134	198
LAKE02-01	8/26/11	2	NR-0-4-U					<2%																							
LAKE02-01	8/26/11	3	NR-0-4-U	C3	C4	2.3	0.9	<2%	63.7	141.8	2.23	28.6	3.0	159.7	2.5	67	5	9	1												
LAKE02-01	8/26/11	4	NR-0-4-U	C3	C4			<2%								82	5	16	3												
LAKE02-01	8/26/11	5	NR-0-4-U	B3c	C4	2.3	0.9	<2%	68.0	170.3	2.51	27.1	3.3	118.0	1.7	118	1	2	1												

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
WOLF09-02	NR-0-4-U	1	0.8	Y	25
WOLF09-02	NR-0-4-U	2	1.5	Y	7
WOLF09-02	NR-0-4-U	3	1.5	Y	8
WOLF09-02	NR-0-4-U	4	1.3	Y	5
WOLF09-02	NR-0-4-U	5	0.9		
WOLF09-02	NR-0-4-U	6	1.2		
WOLF09-02	NR-0-4-U	7	2.5	Y	12
WOLF09-02	NR-0-4-U	8	0.6	Y	7
WOLF09-02	NR-0-4-U	9	2.3	Y	14
WOLF09-02	NR-0-4-U	10	2.3	Y	13
WOLF09-02	NR-0-4-U	11	1.9	Y	6
RAVN06-01	NR-4-2-U	1	0.3	Y	5
RAVN06-01	NR-4-2-U	2	0.6		
RAVN06-01	NR-4-2-U	3	0.8	Y	5
RAVN06-01	NR-4-2-U	4			
RAVN06-01	NR-4-2-U	5			
RAVN06-01	NR-4-2-U	6	0.7	Y	5
RAVN06-01	NR-4-2-U	7	1.2	Y	7
RAVN06-01	NR-4-2-U	8	1.0	Y	9
RAVN06-01	NR-4-2-U	9	0.9	Y	7
RAVN06-01	NR-4-2-U	10	0.6		
RAVN06-01	NR-4-2-U	11	0.7	Y	1
RAVN06-01	NR-4-2-U	12	0.9		
RAVN06-01	NR-4-2-U	13	0.8		
RAVN06-01	NR-4-2-U	14			
RAVN06-01	NR-4-2-U	15	0.5		
RAVN06-01	NR-4-2-U	16	0.5		
RAVN06-01	NR-4-2-U	17	0.5		
RAVN06-01	NR-4-2-U	18	1.1		
RAVN06-01	NR-4-2-U	19			
RAVN06-01	NR-4-2-U	20	0.4		
RAVN07-01	NR-2-2-U	1			
RAVN07-01	NR-2-2-U	2	0.4		
RAVN07-01	NR-2-2-U	3	0.9		
RAVN07-01	NR-2-2-U	4	0.9		
RAVN07-01	NR-2-2-U	5	0.4	Y	23
RAVN07-01	NR-2-2-U	6	0.4	Y	25
WOLF11-03	NR-0-4-U	1	2.3		
WOLF11-03	NR-0-4-U	2	1.3		
WOLF11-03	NR-0-4-U	3	1.1		
WOLF11-03	NR-0-4-U	4	1.8		

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
BRST04-02	NR-2-3-U	1	0.7		
BRST04-02	NR-2-3-U	2	0.8		
BRST04-02	NR-2-3-U	3	0.7		
BRST04-02	NR-2-3-U	4	0.5		
BRST04-02	NR-2-3-U	5	0.3		
BRST04-02	NR-2-3-U	6	0.8		
BRST04-02	NR-2-3-U	7	0.6		
BRST04-02	NR-2-3-U	8	1.1	Y	2
BRST04-02	NR-2-3-U	9	0.7		
BRST04-02	NR-2-3-U	10	1.4		
BRST04-02	NR-2-3-U	11	1.4		
BRST04-02	NR-2-3-U	12	1.1		
BRST04-02	NR-2-3-U	13	0.8		
BRST04-02	NR-2-3-U	14	0.7		
BRST04-02	NR-2-3-U	15	0.8		
BRST04-02	NR-2-3-U	16	0.5		
BRST04-02	NR-2-3-U	17	0.8		
BRST04-02	NR-2-3-U	18	0.5		
BRST04-02	NR-2-3-U	19	1.1		
BRST04-02	NR-2-3-U	20	1.7		
BRST04-02	NR-2-3-U	21	1.0		
BRST04-02	NR-2-3-U	22	0.6		
BRST04-02	NR-2-3-U	23	0.6		
BRST04-04	NR-2-3-U	1	0.5		
BRST04-04	NR-2-3-U	2	0.8		
BRST04-04	NR-2-3-U	3	0.8		
BRST04-04	NR-2-3-U	4	1.1		
BRST04-04	NR-2-3-U	5	1.0		
BRST04-04	NR-2-3-U	6	1.0		
BRST04-04	NR-2-3-U	7	0.6		
BRST04-04	NR-2-3-U	8	1.1		
BRST04-04	NR-2-3-U	9	0.9		
BRST04-04	NR-2-3-U	10	1.7		
BRST04-04	NR-2-3-U	11	0.5		
BRST04-04	NR-2-3-U	12	0.8		
BRST04-04	NR-2-3-U	13	0.5		
BRST04-04	NR-2-3-U	14	0.4		
BRST04-04	NR-2-3-U	15	0.9		
BRST04-04	NR-2-3-U	16	0.8		
BRST04-04	NR-2-3-U	17	0.8		
BRST04-04	NR-2-3-U	18	1.0		
BRST04-04	NR-2-3-U	19	0.4		
BRST04-04	NR-2-3-U	20	0.9		
BRST04-04	NR-2-3-U	21	1.8		
BRST04-04	NR-2-3-U	22	0.4		
BRST04-04	NR-2-3-U	23	0.4		
BRST04-04	NR-2-3-U	24	1.1		
BRST04-04	NR-2-3-U	25	1.0		
BRST04-04	NR-2-3-U	26	1.3	Y	10
BRST04-04	NR-2-3-U	27	0.6		
BRST04-04	NR-2-3-U	28	1.2		
BRST04-04	NR-2-3-U	29	1.1		

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
LIBY09-03	NR-0-4-U	1	3.2	Y	6
LIBY09-03	NR-0-4-U	2	2.2	Y	5
LIBY09-03	NR-0-4-U	3	3.1	Y	14
LIBY09-03	NR-0-4-U	4	2.3	Y	3
LIBY09-03	NR-0-4-U	5	1.9	Y	13
LIBY09-05	NR-0-4-U	1	2.5	Y	7
LIBY09-05	NR-0-4-U	2	1.8	Y	7
LIBY09-05	NR-0-4-U	3	3.7	Y	1
LIBY09-05	NR-0-4-U	4	3.1	Y	4
LIBY09-05	NR-0-4-U	5	3.1	Y	7
LIBY09-05	NR-0-4-U	6	2.9	Y	3
LIBY09-05	NR-0-4-U	7	0.8	Y	4
LIBY09-05	NR-0-4-U	8	1.4	Y	3
LIBY09-05	NR-0-4-U	9	3.0	Y	14
LIBY09-05	NR-0-4-U	10	1.0		
LIBY09-05	NR-0-4-U	11	2.2		
GRNT13-01	NR-0-3-U	1	1.8		
GRNT13-01	NR-0-3-U	2	1.4		
GRNT13-01	NR-0-3-U	3	1.4		
GRNT13-01	NR-0-3-U	4	1.6		
GRNT13-01	NR-0-3-U	5	0.9		
GRNT13-01	NR-0-3-U	6	1.2		
GRNT13-01	NR-0-3-U	7	1.3		
GRNT13-01	NR-0-3-U	8	3.2		
GRNT13-01	NR-0-3-U	9			
GRNT13-01	NR-0-3-U	10	2.1		
QRTZ03-01	NR-2-2-C	1	0.6	Y	1
QRTZ03-01	NR-2-2-C	2	3.1	Y	2
QRTZ03-01	NR-2-2-C	3			
QRTZ03-01	NR-2-2-C	4	1.0	Y	5
QRTZ03-01	NR-2-2-C	5	1.9	Y	3
QRTZ03-01	NR-2-2-C	6	0.8	Y	10
QRTZ03-01	NR-2-2-C	7		Y	9
QRTZ03-01	NR-2-2-C	8	1.1	Y	6
QRTZ03-01	NR-2-2-C	9	1.4	Y	0
QRTZ03-01	NR-2-2-C	10	1.0	Y	3
QRTZ03-01	NR-2-2-C	11	2.3	Y	7
QRTZ03-01	NR-2-2-C	12	1.1	Y	3
QRTZ03-01	NR-2-2-C	13	1.5	Y	3
QRTZ03-01	NR-2-2-C	14	1.7	Y	1
QRTZ03-01	NR-2-2-C	15	1.7	Y	5
QRTZ03-01	NR-2-2-C	16	0.9	Y	6
QRTZ03-01	NR-2-2-C	17	0.7		
QRTZ10-01	NR-0-3-U	1	1.1	Y	5
QRTZ10-01	NR-0-3-U	2	1.0		
QRTZ10-01	NR-0-3-U	3	1.5	Y	3
QRTZ10-01	NR-0-3-U	4	0.8		
QRTZ10-01	NR-0-3-U	5	2.9	Y	0

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
LAKE03-03	NR-0-4-U	1	8.8	Y	9
LAKE03-03	NR-0-4-U	2	7.0	Y	14
LAKE03-03	NR-0-4-U	3	6.3	Y	16
LAKE03-03	NR-0-4-U	4	6.8		
LAKE03-03	NR-0-4-U	5	6.2	Y	5
LAKE02-01	NR-0-4-U	1	5.3		
LAKE02-01	NR-0-4-U	2	2.3		
LAKE02-01	NR-0-4-U	3	4.0	Y	0

Attachment C

Streambank Erosion Sediment Loads

Stream Segment	Reach ID	Reach Type	Sediment Load per 1000 Feet (Tons/Year)	Length (Feet)	Reach Sediment Load (Tons/Year)	Transportation (Percent)	Grazing (Percent)	Cropland (Percent)	Mining (Percent)	Silviculture (Percent)	Irrigation (Percent)	Natural (Percent)	Other (Percent)	Transportation (Tons/Year)	Grazing (Tons/Year)	Cropland (Tons/Year)	Mining (Tons/Year)	Silviculture (Tons/Year)	Irrigation (Tons/Year)	Natural (Tons/Year)	Other (Tons/Year)
Bristow Creek	BRST 01-01	NR-4-2-C	2.81	6699	18.8	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0
Bristow Creek	BRST 02-01	NR-4-2-U	2.81	1184	3.3	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
Bristow Creek	BRST 03-01	NR-4-3-U	2.81	9942	27.9	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	27.9	0.0
Bristow Creek	BRST 04-01	NR-2-3-U	6.32	1980	12.5	0	0	0	0	70	0	30	0	0.0	0.0	0.0	0.0	8.8	0.0	3.8	0.0
Bristow Creek	**BRST 04-02**	**NR-2-3-U**	**5.82**	**5050**	**29.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**29.4**	**0.0**
Bristow Creek	BRST 04-03	NR-2-3-U	6.32	4924	31.1	0	0	0	0	80	0	20	0	0.0	0.0	0.0	0.0	24.9	0.0	6.2	0.0
Bristow Creek	**BRST 04-04**	**NR-2-3-U**	**2.34**	**1661**	**3.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.9**	**0.0**
Bristow Creek	BRST 05-01	NR-4-3-U	2.81	2344	6.6	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0
Bristow Creek			**TOTAL**	**33783**	**133.6**								**TOTAL**	**0.0**	**0.0**	**0.0**	**0.0**	**33.7**	**0.0**	**99.9**	**0.0**
Bristow Creek													**PERCENT**	**0.00**	**0.00**	**0.00**	**0.00**	**0.25**	**0.00**	**0.75**	**0.00**
Lake Creek	LAKE 01-01	NR-0-3-U	22.00	8145	179.2	20	0	0	0	0	0	60	20	35.8	0.0	0.0	0.0	0.0	0.0	107.5	35.8
Lake Creek	**LAKE 02-01**	**NR-0-4-U**	**5.48**	**18056**	**98.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**76.2**	**23.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**75.4**	**23.5**
Lake Creek	LAKE 02-02	NR-0-4-U	22.00	13006	286.1	0	0	0	0	0	0	50	50	0.0	0.0	0.0	0.0	0.0	0.0	143.1	143.1
Lake Creek	LAKE 03-01	NR-0-4-U	9.42	4515	42.5	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	42.5	0.0
Lake Creek	LAKE 03-02	NR-0-4-U	22.00	17510	385.2	20	0	0	0	0	0	20	60	77.0	0.0	0.0	0.0	0.0	0.0	77.0	231.1
Lake Creek	**LAKE 03-03**	**NR-0-4-U**	**22.14**	**11402**	**252.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**82.6**	**17.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**208.6**	**43.8**
Lake Creek	LAKE 04-01	NR-0-4-U	22.00	11526	253.6	10	0	0	0	20	0	20	50	25.4	0.0	0.0	0.0	50.7	0.0	50.7	126.8
Lake Creek	LAKE 05-01	NR-0-4-U	22.00	3186	70.1	50	0	0	50	0	0	0	0	35.0	0.0	0.0	35.0	0.0	0.0	0.0	0.0
Lake Creek	LAKE 06-01	NR-2-4-C	6.32	941	5.9	0	0	0	0	0	100	0	0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0
Lake Creek	LAKE 07-01	NR-2-4-U	6.32	2981	18.8	50	0	0	0	0	0	0	50	9.4	0.0	0.0	0.0	0.0	0.0	0.0	9.4
Lake Creek	LAKE 08-01	NR-0-4-U	22.00	1501	33.0	70	0	0	0	0	0	0	30	23.1	0.0	0.0	0.0	0.0	0.0	0.0	9.9
Lake Creek			**TOTAL**	**92768**	**1625.9**								**TOTAL**	**205.8**	**0.0**	**0.0**	**35.0**	**50.7**	**5.9**	**704.9**	**623.5**
Lake Creek													**PERCENT**	**0.13**	**0.00**	**0.00**	**0.02**	**0.03**	**0.00**	**0.43**	**0.38**
Libby Creek	LIBY 01-01	NR-2-2-U	6.32	5374	34.0	80	0	0	0	0	0	20	0	27.2	0.0	0.0	0.0	0.0	0.0	6.8	0.0
Libby Creek	LIBY 02-01	NR-0-3-U	22.00	3489	76.7	0	0	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.7
Libby Creek	LIBY 02-02	NR-0-3-U	9.42	2065	19.5	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	19.5	0.0
Libby Creek	LIBY 03-01	NR-2-3-U	6.32	6032	38.1	30	0	0	30	0	0	10	30	11.4	0.0	0.0	11.4	0.0	0.0	3.8	11.4
Libby Creek	LIBY 03-02	NR-2-3-U	6.32	8130	51.4	20	0	0	0	20	0	0	60	10.3	0.0	0.0	0.0	10.3	0.0	0.0	30.8
Libby Creek	LIBY 04-01	NR-0-3-U	22.00	2358	51.9	0	0	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.9
Libby Creek	LIBY 05-01	NR-0-3-C	22.00	3106	68.3	0	0	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.3
Libby Creek	LIBY 05-02	NR-0-3-C	22.00	5732	126.1	0	0	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	126.1
Libby Creek	LIBY 06-01	NR-0-3-U	22.00	1260	27.7	0	0	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7
Libby Creek	LIBY 06-02	NR-0-3-U	22.00	7353	161.8	0	0	0	0	40	0	0	60	0.0	0.0	0.0	0.0	64.7	0.0	0.0	97.1
Libby Creek	LIBY 07-01	NR-0-3-C	22.00	1931	42.5	0	0	0	0	50	0	0	50	0.0	0.0	0.0	0.0	21.2	0.0	0.0	21.2
Libby Creek	LIBY 07-02	NR-0-3-C	22.00	4449	97.9	10	0	0	0	70	0	0	20	9.8	0.0	0.0	0.0	68.5	0.0	0.0	19.6
Libby Creek	LIBY 08-01	NR-0-3-U	22.00	4528	99.6	20	0	0	0	80	0	0	0	19.9	0.0	0.0	0.0	79.7	0.0	0.0	0.0
Libby Creek	LIBY 08-02	NR-0-3-U	22.00	5162	113.6	30	0	0	0	0	0	0	70	34.1	0.0	0.0	0.0	0.0	0.0	0.0	79.5
Libby Creek	LIBY 09-01	NR-0-4-U	22.00	6475	142.5	0	0	0	0	40	0	0	60	0.0	0.0	0.0	0.0	57.0	0.0	0.0	85.5
Libby Creek	LIBY 09-02	NR-0-4-U	22.00	6077	133.7	0	10	0	0	0	0	0	90	0.0	13.4	0.0	0.0	0.0	0.0	0.0	120.3
Libby Creek	**LIBY 09-03**	**NR-0-4-U**	**25.03**	**14582**	**365.0**	**4.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**48.9**	**46.6**	**16.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**178.3**	**170.2**
Libby Creek	LIBY 09-04	NR-0-4-U	22.00	6708	147.6	10	0	0	0	20	0	0	70	14.8	0.0	0.0	0.0	29.5	0.0	0.0	103.3
Libby Creek	**LIBY 09-05**	**NR-0-4-U**	**34.73**	**22803**	**791.9**	**19.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**37.2**	**43.7**	**151.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**294.5**	**346.2**
Libby Creek	LIBY 09-06	NR-0-4-U	22.00	7814	171.9	10	10	0	0	0	0	0	80	17.2	17.2	0.0	0.0	0.0	0.0	0.0	137.5
Libby Creek	LIBY 10-01	NR-0-5-U	22.00	12029	264.6	20	0	0	0	0	0	0	80	52.9	0.0	0.0	0.0	0.0	0.0	0.0	211.7
Libby Creek			**TOTAL**	**137458**	**3026.2**								**TOTAL**	**365.2**	**30.6**	**0.0**	**11.4**	**330.9**	**0.0**	**502.9**	**1785.1**
Libby Creek													**PERCENT**	**0.12**	**0.01**	**0.00**	**0.00**	**0.11**	**0.00**	**0.17**	**0.59**
Quartz Creek	QRTZ 01-01	NR-2-1-U	2.81	2412	6.8	10	0	0	0	0	0	90	0	0.7	0.0	0.0	0.0	0.0	0.0	6.1	0.0
Quartz Creek	QRTZ 02-01	NR-2-1-C	6.32	2226	14.1	30	0	0	0	0	0	70	0	4.2	0.0	0.0	0.0	0.0	0.0	9.8	0.0
Quartz Creek	**QRTZ 03-01**	**NR-2-2-C**	**5.64**	**10466**	**59.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**59.0**	**0.0**
Quartz Creek	QRTZ 04-01	NR-4-2-U	2.81	3758	10.6	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0
Quartz Creek	QRTZ 05-01	NR-2-2-U	2.81	15428	43.4	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	43.4	0.0
Quartz Creek	QRTZ 06-01	NR-4-2-U	2.81	1180	3.3	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
Quartz Creek	QRTZ 07-01	NR-4-2-C	2.81	5031	14.1	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	0.0
Quartz Creek	QRTZ 08-01	NR-2-3-C	6.32	925	5.8	0	0	0	0	50	0	50	0	0.0	0.0	0.0	0.0	2.9	0.0	2.9	0.0
Quartz Creek	QRTZ 09-01	NR-2-3-U	2.81	11271	31.7	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	0.0
Quartz Creek	QRTZ 09-02	NR-2-3-U	6.32	3666	23.2	20	0	0	0	0	0	0	80	4.6	0.0	0.0	0.0	0.0	0.0	0.0	18.5
Quartz Creek	**QRTZ 10-01**	**NR-0-3-U**	**12.67**	**3042**	**38.5**	**16.3**	**0.0**	**0.0**	**0.0**	**65.2**	**0.0**	**18.5**	**0.0**	**6.3**	**0.0**	**0.0**	**0.0**	**25.1**	**0.0**	**7.1**	**0.0**
Quartz Creek			**TOTAL**	**59403**	**250.5**								**TOTAL**	**15.8**	**0.0**	**0.0**	**0.0**	**28.1**	**0.0**	**188.0**	**18.5**
Quartz Creek													**PERCENT**	**0.06**	**0.00**	**0.00**	**0.00**	**0.11**	**0.00**	**0.75**	**0.07**
Raven Creek	RAVN 01-01	NR-10-1-U	0.00	471	0.0	0	0	0	0	100	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raven Creek	RAVN 01-02	NR-10-1-U	0.00	108	0.0	100	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raven Creek	RAVN 02-01	NR-10-1-C	0.00	2667	0.0	0	0	0	0	100	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raven Creek	RAVN 03-01	NR-10-1-U	0.00	2456	0.0	0	0	0	0	100	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raven Creek	**RAVN 04-01**	**NR-4-1-U**	**6.32**	**4479**	**28.3**	**0.0**	**0.0**	**0.0**	**0.0**	**38.5**	**0.0**	**61.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10.9**	**0.0**	**17.4**	**0.0**
Raven Creek	**RAVN 05-01**	**NR-4-2-U**	**0.14**	**2772**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.4**	**0.0**
Raven Creek	**RAVN 06-01**	**NR-2-2-U**	**0.12**	**616**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**
Raven Creek			**TOTAL**	**13569**	**28.8**								**TOTAL**	**0.0**	**0.0**	**0.0**	**0.0**	**10.9**	**0.0**	**17.9**	**0.0**
Raven Creek													**PERCENT**	**0.00**	**0.00**	**0.00**	**0.00**	**0.38**	**0.00**	**0.62**	**0.00**
Wolf Creek	WOLF 01-01	NR-2-1-U	2.81	2271	6.4	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0
Wolf Creek	WOLF 02-01	NR-2-2-U	2.81	1519	4.3	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
Wolf Creek	WOLF 02-02	NR-2-2-U	2.81	948	2.7	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0
Wolf Creek	WOLF 02-03	NR-2-2-U	2.81	1000	2.8	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
Wolf Creek	WOLF 03-01	NR-10-2-C	0.00	391	0.0	100	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wolf Creek	WOLF 04-01	NR-2-2-U	2.81	1476	4.1	0	0	0	0	0	0	100	0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0
Wolf Creek	WOLF 05-01	NR-0-3-U	9.42	14509	136.7	10	0	0	0	0	0	90	0	13.7	0.0	0.0	0.0	0.0	0.0	123.0	0.0
Wolf Creek	WOLF 05-02	NR-0-3-U	22.00	11032	242.7	80	0	0	0	20	0	0	0	194.2	0.0	0.0	0.0	48.5	0.0	0.0	0.0
Wolf Creek	WOLF 05-03	NR-0-3-U	22.00	5069	111.5	50	0	0	0	50	0	0	0	55.8	0.0	0.0	0.0	55.8	0.0	0.0	0.0
Wolf Creek	WOLF 06-01	NR-2-3-U	6.32	6203	39.2	0	0	0	0	100	0	0	0	0.0	0.0	0.0	0.0	39.2	0.0	0.0	0.0
Wolf Creek	WOLF 07-01	NR-2-4-U	6.32	2188	13.8	20	10	0	0	10	0	60	0	2.8	1.4	0.0	0.0	1.4	0.0	8.3	0.0
Wolf Creek	WOLF 08-01	NR-0-4-U	22.00	3318	73.0	10	0	0	0	20	0	70	0	7.3	0.0	0.0	0.0	14.6	0.0	51.1	0.0
Wolf Creek	WOLF 08-02	NR-0-4-U	22.00	6926	152.4	20	0	0	0	70	0	10	0	30.5	0.0	0.0	0.0	106.7	0.0	15.2	0.0
Wolf Creek	**WOLF 08-03**	**NR-0-4-U**	**19.21**	**14108**	**271.0**	**0.0**	**87.4**	**0.0**	**0.0**	**0.0**	**0.0**	**12.6**	**TOTAL**	**0.0**	**236.9**	**0.0**	**0.0**	**0.0**	**0.0**	**34.1**	**0.0**
Wolf Creek	WOLF 08-04	NR-0-4-U	22.00	9140	201.1	10	0	0	0	70	0	20	**PERCENT**	20.1	0.0	0.0	0.0	140.8	0.0	40.2	0.0
Wolf Creek	WOLF 08-05	NR-0-4-U	22.00	4941	108.7	20	40	0	0	30	0	10	0	21.7	43.5	0.0	0.0	32.6	0.0	10.9	0.0
Wolf Creek	WOLF 09-01	NR-0-4-U	22.00	2666	58.7	0	50	0	0	20	0	30	0	0.0	29.3	0.0	0.0	11.7	0.0	17.6	0.0
Wolf Creek	**WOLF 09-02**	**NR-0-4-U**	**18.36**	**25937**	**476.2**	**0.0**	**59.9**	**0.0**	**0.0**	**23.9**	**0.0**	**16.2**	**0.0**	**0.0**	**285.4**	**0.0**	**0.0**	**113.9**	**0.0**	**76.9**	**0.0**
Wolf Creek	WOLF 10-01	NR-0-4-U	22.00	7326	161.2	30	10	0	0	0	0	30	30	48.4	16.1	0.0	0.0	0.0	0.0	48.4	48.4
Wolf Creek	WOLF 10-02	NR-0-4-U	22.00	11468	252.3	100	0	0	0	0	0	0	0	252.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wolf Creek	WOLF 10-03	NR-0-4-U	22.00	4146	91.2	50	0	0	0	0	0	50	0	45.6	0.0	0.0	0.0	0.0	0.0	45.6	0.0
Wolf Creek	WOLF 10-04	NR-0-4-U	22.00	12540	275.9	60	0	0	0	0	0	40	0	165.5	0.0	0.0	0.0	0.0	0.0	110.3	0.0
Wolf Creek	WOLF 11-01	NR-0-4-U	22.00	41193	906.3	50	0	0	0	50	0	0	0	453.1	0.0	0.0	0.0	453.1	0.0	0.0	0.0
Wolf Creek	WOLF 11-02	NR-0-4-U	22.00	5909	130.0	70	0	0	0	0	0	30	0	91.0	0.0	0.0	0.0	0.0	0.0	39.0	0.0
Wolf Creek	**WOLF 11-03**	**NR-0-4-U**	**6.44**	**7875**	**50.7**	**16.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**83.7**	**0.0**	**8.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**42.5**	**0.0**
Wolf Creek	WOLF 11-04	NR-0-4-U	22.00	3205	70.5	30	0	0	0	70	0	0	0	21.2	0.0	0.0	0.0	49.4	0.0	0.0	0.0
Wolf Creek			**TOTAL**	**207304**	**3843.2**								**TOTAL**	**1431.3**	**612.6**	**0.0**	**0.0**	**1067.6**	**0.0**	**683.4**	**48.4**
Wolf Creek													**PERCENT**	**0.37**	**0.16**	**0.00**	**0.00**	**0.28**	**0.00**	**0.18**	**0.01**