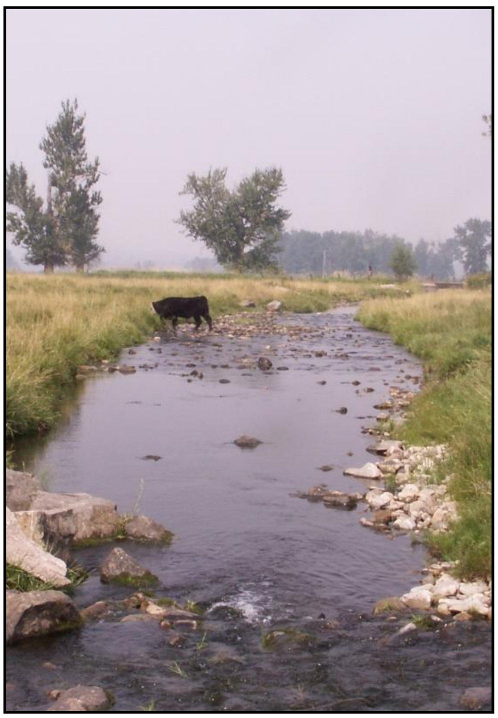
Montana Department of Environmental Quality

Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan



August 17, 2011

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Errata Sheet for the Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan

This TMDL was approved by EPA on August 17, 2011. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version had minor changes that are explained and corrected on this errata sheet. If you have a bound copy, please note the corrections listed below or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet to your disk or download the updated version from our website.

Appropriate corrections have already been made in the downloadable version of the TMDL located on our website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

The following table contains corrections to the TMDL. The first column cites the page and paragraph where there is a text error. The second column contains the original text that was in error. The third column contains the new text that has been corrected for the Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan document. The text in error and the correct text are underlined.

Location in the TMDL	**Original Text**	**Corrected Text**
Page 6-17, Section 6.5.1.2.2, Table 6-7, last cell in the last column	<u>880,054</u>	<u>88,054</u>

ACKNOWLEDGEMENTS

DEQ would like to acknowledge multiple entities for their contributions in the development of the sediment and temperature TMDLs contained in this document. PBS&J (now Atkins) provided significant contributions in the development of the sediment and habitat data collection methods used for this project, the collection of bank erosion and sediment and habitat data, and development of **Appendices D** and **E** (*2007 Sediment and Habitat Data Collection Methods and Summary*, *Stream Bank Erosion Source Assessment,* respectively). Water & Environmental Technologies provided significant contribution in the sediment assessment of the unpaved road network in this TMDL planning area, and in the development of **Appendix G**, *Unpaved Road Sediment Source Assessment*.

Watershed Consulting, LLC conducted flights to capture thermal infrared imagery that assisted in the identification of thermal sources for the temperature TMDLs. Watershed Consulting also authored **Attachment A**, *Bitterroot River FLIR Temperature Analysis and Interpretive Report*. Modeling of water temperature was completed with assistance from HDR Engineering, Inc. (HDR). HDR also co-authored **Attachment B**, *Modeling Streamflow and Water Temperature in the Bitterroot River, Montana*. Additionally, information provided by the Bitter Root Irrigation District aided the development of the temperature model. Project input was provided by the Montana Department of Transportation and the City of Missoula for the assessment of thermal loading from the city's storm sewer system.

Draft versions of these TMDLs were sent to various stakeholders for review and input. The involvement of all reviewers led to improvements in this document and is greatly appreciated. DEQ would like to thank the Lolo and Bitterroot national forests and the Tri State Water Quality Council for their comments and contributions. Additionally, we would like to recognize the support of the Bitter Root Water Forum who provided assistance with identification of stakeholders and public outreach and education.

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ACRONYMS

Acronym	Definition
AFO	Animal Feeding Operation
AOP	Aquatic Organism Passage
ARM	Administrative Rules of Montana
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BER	Board of Environmental Review (Montana)
BFW	Bankfull Width
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practice
BNF	Bitterroot National Forest
BRWF	Bitter Root Water Forum
CAFO	Concentrated (or Confined) Animal Feed Operation
CFR	Code of Federal Regulations
CFS	Cubic feet per second
CMP	Corrugated Metal Pipe
CWA	Clean Water Act
DEM	Digital Elevation Map
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
EC	Electrical Conductance or Electrical Conductivity
EF	East Fork
EPA	Environmental Protection Agency (US)
FWP	Fish, Wildlife, and Parks (Montana)
FWS	Fish & Wildlife Services (US)
GIS	Geographic Information System
GPS	Global Positioning System
GWIC	Groundwater Information Center
HRU	Hydrologic Response Unit
HUC	Hydrologic Unit Code
IB	Idaho Batholith [ecoregion]
INFISH	Inland Native Fish Strategy
ITML	Instantaneous Thermal Maximum Load
KNFLD	Kootenai National Forest Libby District
LA	Load Allocation
LBFT	Lower Blackfoot TMDL Planning Area
LID	Low Impact Development
LNF	Lolo National Forest
LWD	Large woody debris
LWG	Lolo Watershed Group
MCA	Montana Code Annotated
MBMG	Montana Bureau of Mines and Geology
MGWPCS	Montana Ground Water Pollution Control System
MMI	Multi-Metric Index
MOS	Margin of Safety

Acronym	Definition
MPDES	Montana Pollutant Discharge Elimination System
MR	Middle Rockies [ecoregion]
MS4	Municipal Separate Storm Sewer System
MSU	Montana State University
MUSLE	Modified Universal Soil Loss Equation
NBS	Near Bank Stress
N/A	Not Applicable
NC	Not Collected
NHD	National Hydrology Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NR	Northern Rockies [ecoregion]
NRCS	National Resources Conservation Service
NRIS	Natural Resource Information System (Montana)
PIBO	PACFISH/INFISH Biological Opinion
RHCA	Riparian Habitat Conservation Area
RSI	Riffle Stability Index
SAR	Sodium Absorption Ratio
SDWIS	Safe Drinking Water Information System
SMZ	Streamside Management Zone
SNOTEL	Snowpack Telemetry
SOP	Standard Operating Procedure
SSTEMP	Stream Segment Temperature [model]
SSURGO	Soil Survey Geographic Database
SWAT	Soil & Water Assessment Tool
SWPPP	Storm Water Pollution Prevention Plan
TAG	Technical Advisory Group
TIR	Thermal Infrared [flight]
TKN	Total Kjehldahl Nitrogen
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
TSS	Total Suspended Solids
TSWQC	Tri-State Water Quality Council
UAA	Use Attainability Analysis
UILT	Upper Incipient Lethal Temperature
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VFS	Vegetated Filter Strips
WAG	Watershed Advisory Group
WARSSS	Watershed Assessment of River Stability and Sediment Supply
WEPP	Water Erosion Prediction Project
WF	West Fork
WLA	Wasteload Allocation

Acronym	Definition
WQA	Water Quality Act
WQS	Water Quality Standards
WRP	Watershed Restoration Plan
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for 17 stream segments in the Bitterroot TMDL planning Area (TPA) including the Middle and Lower Bitterroot River, Ambrose Creek, Bass Creek, Lick Creek, Lolo Creek (3 segments), McClain Creek, Miller Creek, Muddy Spring Creek, North Burnt Fork Creek, Rye Creek, Sleeping Child Creek, Sweathouse Creek, Threemile Creek, and Willow Creek. 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 all streams and lakes can support and maintain their state-designated beneficial uses.

The Bitterroot River watershed is divided into three separate TMDL planning areas: The Bitterroot Headwaters TPA (TMDLs completed October, 2005), the Upper Lolo Creek TPA (TMDLs completed April, 2003), and the Bitterroot TPA. The Bitterroot TPA includes the Bitterroot River, which begins in Ravalli County at the confluence of the East and West Forks of the Bitterroot River near Conner, MT and flows north 84 miles to its confluence with the Clark Fork River near Missoula, MT in Missoula County; the Bitterroot River tributaries; and also the mainstem of Lolo Creek from just above Lolo Hot Springs to its confluence with the Bitterroot River.

DEQ has performed assessments determining that the above 17 stream segments do not meet the applicable water quality standards. The scope of the TMDLs in this document address sediment (in tributaries) and temperature related problems on the aforementioned streams. A total of 20 TMDLs are included and are shown in **Table E-1**. The document provides an evaluation of existing water quality data, assesses pollutant sources contributing to impairment conditions, and estimates pollutant loading reductions and allocations that will result in attainment of water quality standards. The document should be used as a guide to understanding water-quality related issues in the Bitterroot TPA and developing implementation plans to remedy known water quality problems related to sediment and temperature. Below is a brief synopsis of water quality issues addressed by this document.

Sediment

DEQ identified sediment-related effects as a cause of impairment on the following tributaries to the Bitterroot River: Ambrose Creek, Bass Creek, Lick Creek, Lolo Creek (3 segments), McClain Creek, Miller Creek, Muddy Spring Creek, North Burnt Fork Creek, Rye Creek, Sleeping Child Creek, Sweathouse Creek, Threemile Creek, and Willow Creek. Anthropogenic sources of sediment include upland and bank erosion associated with removal or riparian vegetation, unpaved roads, culvert failure, logging, disturbed ground on small and large acreage ranches, agriculture, and stormwater from construction sites.

Recommended strategies for reducing sediment include applying best management practices to maintain riparian vegetation, improve ground protection in disturbed areas (small acreages and construction sites), develop and implement grazing management plans, reduce the amount of erodible soil and runoff rate from agricultural lands, lessen the risk of culvert failure, and reduce the transport of unpaved road sediment into streams.

Water Temperature

DEQ identified temperature-related effects as a cause of impairment on the Middle and Lower stream segments of the Bitterroot River, Miller Creek, Sleeping Child Creek, and Willow Creek. Anthropogenic sources for temperature include reductions in riparian shade from large and small acreage ranching, crops, suburban land use, and timber harvest. Livestock grazing widens streams which then warm due to larger surface area. Inefficient irrigation systems reduce stream volumetric heat capacity, where less stream water heats more due to the same energy inputs. Irrigation return flow, waste water treatment plants, and urban runoff also provide heated water to certain segments.

Recommended strategies for reducing temperature include applying best management practices to improve shade producing riparian vegetation by reducing browse along streams, provide vegetated riparian buffers to provide shade where crop and suburban lands encroach on stream corridors, limit riparian timber harvest, increase irrigation efficiencies, and reduce water waste in irrigation systems.

Implementation of Water Quality Improvement Plan

Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, the TMDL and associated assessment and evaluation information in this document will be used by a local watershed groups, stakeholders and regulatory agencies as a tool to guide and prioritize local water quality improvement activities. These improvement and mitigation activities should be addressed further within a detailed watershed restoration plan consistent with DEQ and EPA recommendations. Presently, the Lolo Watershed Group is developing a comprehensive watershed restoration plan for Lolo Creek. Both the Lolo Watershed Group and the Bitter Root Water Forum are working on educating the public about water quality in the Bitterroot TPA.

It is recognized that a flexible and adaptive approach to most TMDL implementation activities may become necessary as more knowledge is gained through continued monitoring, assessment and restoration activities. The plan includes a framework strategy for further monitoring and assessment activities that will assist in refining source assessments and allow tracking of progress toward meeting TMDL water quality goals.

Table E-1. List of Waterbodies, Impairment Causes, and Impaired Uses in the Bitterroot TPA with Completed TMDLs Contained in this Document

Waterbody & Location	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use
Ambrose Creek, headwaters to the mouth (Threemile Creek)	MT76H004_120	Sedimentation/Siltation*	Sediment	Aquatic Life, Cold Water Fishery
Bass Creek, Selway-Bitterroot Wilderness boundary to mouth (confluence with the Bitterroot River)	MT76H004_010	Sedimentation/Siltation*	Sediment	Aquatic Life, Cold Water Fishery
Bitterroot River, Eightmile Creek to the mouth (Clark Fork River)	MT76H001_030	Temperature (water)*	Temperature	Aquatic Life, Cold Water Fishery
Bitterroot River, Skalkaho Creek to Eightmile Creek	MT76H001_020	Temperature (water)	Temperature	Aquatic Life, Cold Water Fishery

Table E-1. List of Waterbodies, Impairment Causes, and Impaired Uses in the Bitterroot TPA with Completed TMDLs Contained in this Document

Waterbody & Location	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use
Lick Creek, headwaters to mouth (Bitterroot River)	MT76H004_170	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Lolo Creek, headwaters to Sheldon Creek	MT76H005_013	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
Lolo Creek, Mormon Creek to the mouth (Bitterroot River)	MT76H005_011	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
Lolo Creek, Sheldon Creek to Mormon Creek	MT76H005_012	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
McClain Creek, headwaters to mouth (Bitterroot River)	MT76H004_150	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
Miller Creek, headwaters to the mouth (Bitterroot River)	MT76H004_130	Temperature (water)	Temperature	Aquatic Life, Cold Water Fishery
		Sedimentation/Siltation	Sediment	
Muddy Spring Creek, headwaters to mouth (Gold Creek) T7N, R19W, S2	MT76H004_180	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
North Burnt Fork Creek, confluence with South Burnt Fork Creek to Mouth (Bitterroot River)	MT76H004_200	Bottom Deposits	Sediment	Aquatic Life, Cold Water Fishery
Rye Creek, North Fork to mouth (Bitterroot River)	MT76H004_190	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
Sleeping Child Creek, headwaters to the mouth (Bitterroot River)	MT76H004_090	Temperature (water)	Temperature	Aquatic Life, Cold Water Fishery
		Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Sweathouse Creek, headwaters to mouth (Bitterroot River)	MT76H004_210	Sedimentation/Siltation*	Sediment	Aquatic Life, Cold Water Fishery
Threemile Creek, headwaters to mouth (Bitterroot River)	MT76H004_140	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery
Willow Creek, headwaters to the mouth (Bitterroot River)	MT76H004_110	Temperature (water)	Temperature	Aquatic Life, Cold Water Fishery
		Sedimentation/Siltation	Sediment	

*Waterbody-pollutant combination not on the 2010 303(d) List. TMDL developed based on newly collected data.

1.0 – INTRODUCTION

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

1.1 BACKGROUND

In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA requires each state to set water quality standards to protect designated beneficial water uses and to monitor the attainment of those uses. Fish and aquatic life, wildlife, recreation, agriculture, industrial, and drinking water are all types of beneficial uses designated in Montana. Streams and lakes (also referred to as waterbodies) not meeting the established standards are called impaired waters.

The waterbodies with their associated impairment causes are identified within a biennial integrated water quality report developed by DEQ (**Table 1-1** identifies impaired waters for the Bitterroot TPA). Impairment causes fall within two main categories: pollutant and non-pollutant. Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of total maximum daily loads for impaired waters where a measurable pollutant (for example, sediment, nutrients, metals or temperature) is the cause of the impairment. The waterbody segments with pollutant impairment causes in need of TMDL development are contained within the 303(d) list portion of the state's integrated water quality report. The integrated report identifies impaired waters by a Montana waterbody segment identification, which is indexed to the National Hydrography Dataset.

A TMDL refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. The development of TMDLs and water quality improvement strategies in Montana includes several steps that must be completed for each impaired waterbody and for each contributing pollutant (or "waterbody-pollutant combination"). These steps include:

1. Characterizing the existing waterbody conditions and comparing these conditions to water quality standards. During this step, measurable target values are set to help evaluate the stream's condition in relation to the applicable standards.
2. Quantifying the magnitude of pollutant contribution from the pollutant sources
3. Determining the TMDL for each pollutant, based on the allowable loading limits (or loading capacity) for each pollutant-waterbody combination.
4. Allocating the total allowable load (the TMDL) into individual loads for each source (referred to as the load allocations or wasteload allocations).

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

The above four TMDL steps are further defined in **Section 4.0** of this document. Basically, TMDL development for an impaired waterbody is a problem solving exercise. The problem is excess pollutant loading negatively impacting a designated beneficial use. The solution is developed by identifying the total acceptable pollutant load to the waterbody (the TMDL), characterizing all the significant sources contributing to the total pollutant loading, and then identifying where pollutant loading reductions should be applied to one or more sources to achieve the acceptable load.

Table 1-1. 2010 Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Ambrose Creek, headwaters to mouth (Threemile Creek)	MT76H004_120	Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Bass Creek, Selway-Bitterroot Wilderness boundary to mouth (un-named creek), T9N R20W S3	MT76H004_010	Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery
Bear Creek, Selway-Bitterroot Wilderness boundary to mouth (Fred Burr Creek), T7N R20W S7	MT76H004_031	Low flow alterations	Not Applicable: Non-Pollutant	Primary Contact Recreation
Bitterroot River, East and West Forks to Skalkaho Creek	MT76H001_010	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
Bitterroot River, Skalkaho Creek to Eightmile Creek	MT76H001_020	Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Nitrate/Nitrite (Nitrate + Nitrite as N)	Nutrients	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery
		Temperature (water)	**Temperature**	Aquatic Life, Cold Water Fishery

Table 1-1. 2010 Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Bitterroot River, Eightmile Creek to mouth (Clark Fork River)	MT76H001_030	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery
		Nitrogen (Nitrate)	Nutrients	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery
Blodgett Creek, Selway-Bitterroot Wilderness boundary to mouth (Bitterroot River)	MT76H004_050	Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Kootenai Creek, Selway-Bitterroot Wilderness boundary to mouth (Bitterroot River)	MT76H004_020	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Lick Creek, headwaters to mouth (Bitterroot River)	MT76H004_170	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Chlorophyll-*a*	Not Applicable: Non-Pollutant	Primary Contact Recreation
		Phosphorus (Total)	Nutrients	Primary Contact Recreation
		Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Lolo Creek, Mormon Creek to mouth (Bitterroot River)	MT76H005_011	Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery

Table 1-1. 2010 Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Lolo Creek, Sheldon Creek to Mormon Creek	MT76H005_012	Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Lolo Creek, headwaters to Sheldon Creek	MT76H005_013	Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Lost Horse Creek, headwaters to mouth (Bitterroot River)	MT76H004_070	Low flow alterations	Not Applicable: Non-Pollutant	Primary Contact Recreation
McClain Creek, headwaters to mouth (Sin-tin-tin-em-ska Creek), T11N R20W S23	MT76H004_150	**Sedimentation / Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Mill Creek, Selway-Bitterroot Wilderness boundary to the mouth (Fred Burr Creek), T7N R20W S19	MT76H004_040	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Cold Water Fishery
		Low flow alterations	Not Applicable: Non-Pollutant	Cold Water Fishery, Primary Contact Recreation
		Temperature (water)	**Temperature**	Cold Water Fishery
Miller Creek, headwaters to mouth (Bitterroot River)	MT76H004_130	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Chlorophyll-*a*	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Phosphorus (Total)	Nutrients	Primary Contact Recreation
		Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Temperature (water)	**Temperature**	Aquatic Life, Cold Water Fishery
Muddy Spring Creek, headwaters to mouth (Gold Creek) T7N R19W S2	MT76H004_180	Nitrate / Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	**Sediment**	Cold Water Fishery

Table 1-1. 2010 Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
North Burnt Fork Creek, confluence with South Burnt Fork Creek to mouth (Bitterroot River)	MT76H004_200	**Bottom Deposits**	**Sediment**	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery
North Channel Bear Creek, headwaters to the mouth (Fred Burr Creek), T8N R20W S32	MT76H004_032	Low flow alterations	Not Applicable: Non-Pollutant	Primary Contact Recreation
North Fork Rye Creek, headwaters to mouth (Rye Creek-Bitterroot River, South of Darby)	MT76H004_160	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
Rye Creek, North Fork to mouth (Bitterroot River)	MT76H004_190	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Skalkaho Creek, headwaters to mouth (Bitterroot River)	MT76H004_100	Low flow alterations	Not Applicable: Non-Pollutant	Primary Contact Recreation
		Mercury	Metals	Drinking Water
Sleeping Child Creek, headwaters to mouth (Bitterroot River)	MT76H004_090	Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Sediment / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Temperature (water)	**Temperature**	Aquatic Life, Cold Water Fishery
South Fork Lolo Creek, Selway-Bitterroot Wilderness boundary to mouth (Lolo Creek)	MT76H005_020	Low flow alterations	Not Applicable: Non-Pollutant	Primary Contact Recreation
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery

Table 1-1. 2010 Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Sweathouse Creek, headwaters to mouth (Bitterroot River)	MT76H004_210	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
Threemile Creek, headwaters to mouth (Bitterroot River)	MT76H004_140	Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Sediment / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Tin Cup Creek, Selway-Bitterroot Wilderness boundary to mouth (Bitterroot River)	MT76H004_080	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery
Willow Creek, headwaters to mouth (Bitterroot River)	MT76H004_110	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery
		Chlorophyll-*a*	Not Applicable: Non-Pollutant	Primary Contact Recreation
		Sediment / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Temperature (water)	**Temperature**	Aquatic Life, Cold Water Fishery
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation

This document addresses those waterbody-pollutant combinations identified by **bold text**.

1.2 Water Quality Impairments and TMDLs Addressed by This Plan

Table 1-1 shows there are several different types of impairment causes which fall into different TMDL pollutant categories. For each impairment cause in the Bitterroot TPA, the impaired beneficial uses are also identified and include: aquatic life, coldwater fishery, drinking water, and primary contact recreation. This framework water quality improvement plan addresses the pollutant impairment causes identified by bold text in **Table 1-1**. These pollutant impairment causes fall within the categories of sediment and temperature. TMDL development for each pollutant category will follow a similar process as reflected by the organization of this document and discussed further in **Section 1.3** below.

Table 1-1 identifies a combined total of 17 waterbody-pollutant combinations being addressed in this document: 12 sediment and 5 temperature. TMDLs were completed for all of these combinations, with the exception of the Mill Creek temperature impairment. A temperature TMDL for Mill Creek will be completed during future TMDL work in the TPA (see **Sections 6.1** and **6.5.3**). New data collected during this project justified the development of four additional TMDLs (**Table 1-2**). These 4 TMDLs along with the 16 TMDLs identified above result in a total of 20 TMDLs provided in this document.

Table 1-2. Additional TMDLs Developed in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category
Ambrose Creek, headwaters to mouth (Threemile Creek)	MT76H004_120	Sedimentation/Siltation	Sediment
Bass Creek, Selway-Bitterroot Wilderness boundary to mouth (un-named creek), T9N R20W S3	MT76H004_010	Sedimentation/Siltation	Sediment
Bitterroot River, Eightmile Creek to mouth (Clark Fork River)	MT76H001_030	Temperature (water)	Temperature
Sweathouse Creek, headwaters to mouth (Bitterroot River)	MT76H004_210	Sedimentation/Siltation	Sediment

It is important to note that this document only addresses the sediment causes of impairment for the tributaries of the Bitterroot River. The sediment listings for the mainstem of the Bitterroot River (segments: MT76H001_020 and MT76H001_030) will also be addressed during future TMDL development. DEQ recognizes there are also other pollutant listings for this TPA in the nutrients and metals TMDL pollutant categories. However, this document only addresses those identified in bold in **Table 1-1** and listed above. This is because DEQ sometimes develops TMDLs in a watershed at varying phases with focus on one or a couple of specific pollutant types. Furthermore, there are several non-pollutant related types of impairment. 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 written in this document and the non-pollutant impairment causes is discussed in **Section 7.0**. **Section 8.0** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

1.3 Document Layout

The main body of the document provides a summary of the TMDL components. Additional technical details of these components are contained in the appendices and attachments of this report. In addition to this introductory section which includes the background and identification of TMDLs developed, this document has been organized into the following sections:

Section 2.0 Bitterroot River Watershed Description:
Description of the physical and social characteristics of the watershed

Section 3.0 Montana Water Quality Standards:
Discusses the water quality standards that apply to the Bitterroot River watershed

Section 4.0 Description of TMDL Components:

Defines the components of a TMDL and the process by which they are developed

Sections 5.0 – 6.0 Tributary Sediment and Temperature TMDL Components, sequentially:
Discusses the pollutant category's impact to beneficial uses, the existing water quality conditions and the water quality targets, the quantified pollutant contributions from the identified sources, the TMDLs, and the allocations for each individual TMDL

Section 7.0 Other Identified Issues or Concerns:
Describes other issues that may potentially be contributing to water quality impairment and how the TMDLs in the plan may address some of these concerns.

Section 8.0 Framework Water Quality Restoration and Monitoring Strategy:
Discusses the framework for TMDL implementation. Also presents a monitoring strategy to help ensure successful TMDL implementation and attainment of water quality standards.

Section 9.0 Public Participation & Public Comments:
Describes the involvement of other agencies and stakeholder groups who were involved with the development of the plan, the public participation process used in review of the draft document, and addresses comments received during the public comment period.

2.0 - BITTERROOT RIVER WATERSHED DESCRIPTION

This section contains a summary of the physical and social characteristics of the Bitterroot River watershed that has been excerpted from the “Bitterroot River Watershed Description.” The entire watershed description and corresponding maps is contained in **Appendix B**.

2.1 PHYSICAL CHARACTERISTICS

2.1.1 Location

The Bitterroot TMDL Planning Area encompasses an area of 1,891 square miles, approximately 75% of which lies within Ravalli County, just under 25% in Missoula County, and a small portion in Mineral County. The watershed is bounded by the Bitterroot Mountains on the west and the Sapphire Mountains on the east. The Bitterroot River begins at the confluence of the East and West Forks of the Bitterroot River near Conner, Montana, and flows north to its confluence with the Clark Fork River near Missoula (**Map A-1** in **Appendix A**).

2.1.2 Topography

Elevations in the Bitterroot TPA range from 3,087 – 10,157 feet above mean sea level (**Map A-3** in **Appendix A**). The TPA geography is characterized on the west by glacially sculpted U-shaped alpine valleys draining the Bitterroot Mountains and on the east by dendritic V-shaped valleys draining the Sapphire Mountains. Slopes are generally 10 to 20 percent steeper in the Bitterroot Range than in the Sapphire Range (**Map A-8** in **Appendix A**). The Bitterroot Valley is roughly 10 miles across at the widest.

2.1.3 Geology and Soils

The bedrock of the TPA includes Precambrian metamorphic and metasedimentary rocks, Cretaceous and Tertiary igneous intrusions, and Tertiary volcanic rocks (Ross, et al., 1955). Granitic rocks of the Idaho Batholith and similar igneous bodies dominate the Bitterroot Range and the Sapphire Range south of Skalkaho Creek. Metasedimentary rocks of the Precambrian Belt Series dominate the Sapphire Range north of Skalkaho Creek and most of the Lolo Creek watershed. **Map A-4** in **Appendix A** provides an overview of the geology.

Nearly half (49%) of the TPA has soils with low susceptibility to erosion; another 41% is has low-moderate susceptibility. Nearly all of the moderate-high susceptibility soils (3%) correspond to the Tertiary benches and the foothills of the Sapphire Range. Majority (80%) of the soils in the planning area have moderate infiltration rate and runoff potential (B type soils). Many of the Quaternary sediments along the front of the Bitterroot Range have high infiltration rates and a low runoff potential (A type soils). See **Maps A-5 through A-7** in **Appendix A**.

2.1.4 Hydrography and Climate

The Bitterroot Mountains contribute nearly four times as many tributary streams as the drier Sapphire Mountains (Briar and Dutton, 2000). The Bitterroot Mountains also receive considerably more precipitation than the Sapphire Range. Annual average precipitation ranges from 13 inches in the valley, 32 inches in the Sapphire Mountains, and 83 inches in the Bitterroot Mountains, with the wettest months being May and June. **Map A-11** in **Appendix A** shows the distribution of average annual precipitation.

Stream flow in the TPA generally peaks in late spring, declines in the summer, and remains stable through the winter (Briar and Dutton, 2000). Monthly mean discharges in the mainstem Bitterroot River vary over an order of magnitude. Statistically, flow peaks in June and is lowest in January. Annual peak flows occur almost exclusively (>97%) in May and June. See **Map A-9** for the locations of stream gages and **Figures A-1 through A-4** for streamflow data (**Appendix A**).

Temperature patterns reveal that July is the hottest month and January is the coldest throughout the watershed. Summertime highs are typically in the low eighties (°F) and winter lows are in the upper teens (°F). See **Map A-11** in **Appendix A**.

2.2 Ecological Parameters

2.2.1 Vegetation and Fire History

The primary cover in the TPA is conifer forest. Spruce-Fir communities dominate in the Bitterroot Range. Lodgepole Pines are more common in the Sapphire Range. **Maps A-12 and A-13** in **Appendix A** illustrate land covers found in the TPA. Large areas of the TPA have burned within the last two decades (see **Map A-15**), particularly in the Sapphire Range. The Bear and Coyote fires of 2000 burned much of the southeastern portion of the TPA, an area that includes the headwaters of Skalkaho Creek and much of the drainages of Sleeping Child and North Fork Rye Creeks.

2.2.2 Aquatic Life

Two fish species found in the TPA are of particular note. Bull trout are designated “threatened” by the U.S. Fish and Wildlife Service (USFWS). Westslope cutthroat trout are designated “Species of Concern” by Montana Department of Fish, Wildlife and Parks. Within the planning area, the USFWS has designated 131 miles of stream as bull trout critical habitat. Critical habitat is designated in the Bitterroot River and in Blodgett, Burnt Fork, Fred Burr, Mill, Skalkaho, and Sleeping Child Creeks. Non-native brook, rainbow and brown trout are also present in the TPA. Fish species distribution is shown in **Map A-14** in **Appendix A**.

2.3 Cultural Parameters

2.3.1 Population and Land Ownership

An estimated 68,000 persons lived within the TPA in 2000 (NRIS,2002). Nearly half (33,093) of that population is reported from Missoula County, which includes portions of Missoula and its southern suburbs. Some of the population is concentrated in or near the towns and unincorporated communities: Hamilton, Lolo, Stevensville, Grantsdale, Florence, Victor, Pinesdale, Darby, Corvallis and Woodside. These communities had a cumulative population of 13,584 in the 2000 census. The remaining population is distributed across the valley floor. Much of the TPA is unpopulated. Census data are shown in **Map A-16** in **Appendix A**.

The USFS is the dominant landholder in the Bitterroot TMDL Planning Area., which administers 57% of the TPA, mostly in the higher elevations. Private land is extensive, however. Individual private smallholdings comprise 33.5% of the TPA; Plum Creek Timber Company owns another 7% of the TPA. Land ownership data is shown in **Map A-17** in **Appendix A**.

2.3.2 Land Cover and Land Use

Land cover is dominated by evergreen forest (see **Map A-12**). The valley floor however is a mixture of developed property, grassland, mixed forest, and shrubland. The Bitterroot TPA contains portions of both the Bitterroot and Lolo National Forests. Within the Bitterroot portions of the national forests, 88,228 acres have been harvested between 1906 and 2007. Timber harvests have ranged in size from a low of an acre to a high of 468 acres. **Map A-21** in **Appendix A** shows the majority of timber harvests have occurred in the northeastern and southwestern portions of the planning area.

The principal transportation routes in the TPA are US Highways 93 and 12 (**Map A-19**). Highway 93 runs the length of the Bitterroot Valley, and Highway 12 runs along Lolo Creek. Mining was not prominent in the Bitterroot Valley. Abandoned and inactive mines are present, but at relatively low density (**Map A-20**). A substantial quantity of streamflow within the Bitterroot River watershed is diverted and used for irrigation throughout the valley. **Map A-18** in **Appendix A** shows locations of irrigation diversions and dams within the TPA.

2.3.3 Wastewater

The communities of Hamilton, Lolo, Stevensville, Victor, Darby and Corvallis are sewered. Hamilton, Lolo, Stevensville and Darby systems discharge to surface water. There are multiple groundwater discharge permits for human waste disposal within the TPA as well. **Tables B4-4** and **B4-5** in **Appendix B** contain a list of permitted facilities, including general stormwater permits for industrial and mining activities.

DEQ estimates that the TPA includes ~18,000 residential septic systems. The estimate is based upon a GIS layer of residential structures. The highest densities are clustered south of Missoula, and around Lolo and Hamilton. Other population centers such as Grantsdale, Darby, Woodside, Victor, Stevensville, and Florence corresponded to increased density of septic systems, as compared with the "background" density of 11-50 drain fields per square mile across much of the valley. Septic system density and permitted wastewater discharge locations are shown on **Map A-22** in **Appendix A**.

3.0 - Montana Water Quality Standards

The goal of the federal Clean Water Act is to ensure that the quality of all surface waters is capable of supporting all designated uses. Water quality standards also form the basis for impairment determinations for Montana's 303(d) list, TMDL water quality improvement goals, formation of TMDLs and allocations, and standards attainment evaluations. The Montana water quality standards include four main parts: 1) stream classifications and designated uses, 2) numeric and narrative water quality criteria designed to protect the designated uses, 3) nondegradation provisions for existing high quality waters, and 4) prohibitions of various practices that degrade water quality. The components applicable to this document are reviewed briefly below. More detailed descriptions of the Montana water quality standards that apply to Bitterroot TPA streams can be found **Appendix C**.

3.1 Bitterroot River Watershed Stream Classifications and Designated Beneficial Uses

Classification is the designation of a single use or group of uses to a waterbody based on the potential of the waterbody to support those uses. All Montana waters are classified for multiple beneficial uses. All streams and lakes within the Bitterroot River watershed are classified B-1 which specifies that all of the following uses must be supported: 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. On the "2010 Water Quality Integrated Report", 28 waterbody segments are listed as not supporting or partially supporting one or more beneficial uses (**Table 3-1**). Waterbodies that are not supporting or partially supporting a beneficial use are impaired and require a TMDL.

While some of the Bitterroot River watershed streams might not actually be used for a specific use (e.g. drinking water supply) the quality of the water must be maintained at a level that can support that use to the extent possible based on a stream's natural potential. More detailed descriptions of Montana's surface water classifications and designated beneficial uses are provided in **Appendix C**.

Table 3-1. Impaired Waterbodies and their Beneficial Use Support Status on the "2010 Water Quality Integrated Report" in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Cold Water Fishery	Drinking Water	Industry	Primary Contact Recreation
Ambrose Creek, headwaters to mouth (Threemile Creek)	MT76H004_120	B-1	F	N	N	X	F	P
Bass Creek, Selway-Bitterroot Wilderness boundary to mouth (un-named creek), T9N R20W S3	MT76H004_010	B-1	F	P	P	F	F	F
Bear Creek, Selway-Bitterroot Wilderness boundary to mouth (Fred Burr Creek), T7N R20W S7	MT76H004_031	B-1	F	X	X	X	F	P
Bitterroot River, East and West Forks to Skalkaho Creek	MT76H001_010	B-1	F	P	P	F	F	F

Table 3-1. Impaired Waterbodies and their Beneficial Use Support Status on the "2010 Water Quality Integrated Report" in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Cold Water Fishery	Drinking Water	Industry	Primary Contact Recreation
Bitterroot River, Skalkaho Creek to Eightmile Creek	MT76H001_020	B-1	F	P	P	X	F	P
Bitterroot River, Eightmile Creek to mouth (Clark Fork River)	MT76H001_030	B-1	F	P	P	F	F	F
Blodgett Creek, Selway-Bitterroot Wilderness boundary to mouth (Bitterroot River)	MT76H004_050	B-1	F	P	P	X	F	P
Kootenai Creek, Selway-Bitterroot Wilderness boundary to mouth (Bitterroot River)	MT76H004_020	B-1	F	P	P	X	F	P
Lick Creek, headwaters to mouth (Bitterroot River)	MT76H004_170	B-1	F	P	P	F	F	P
Lolo Creek, Mormon Creek to mouth (Bitterroot River)	MT76H005_011	B-1	F	P	P	X	F	P
Lolo Creek, Sheldon Creek to Mormon Creek	MT76H005_012	B-1	F	P	P	X	F	F
Lolo Creek, headwaters to Sheldon Creek	MT76H005_013	B-1	F	P	P	X	F	F
Lost Horse Creek, headwaters to mouth (Bitterroot River)	MT76H004_070	B-1	F	F	F	X	F	P
McClain Creek, headwaters to mouth (Sin-tin-tin-em-ska Creek), T11N R20W S23	MT76H004_150	B-1	F	P	P	X	F	X
Mill Creek, Selway-Bitterroot Wilderness boundary to the mouth (Fred Burr Creek), T7N R20W S19	MT76H004_040	B-1	X	X	P	X	X	P
Miller Creek, headwaters to mouth (Bitterroot River)	MT76H004_130	B-1	F	P	P	F	F	P
Muddy Spring Creek, headwaters to mouth (Gold Creek) T7N R19W S2	MT76H004_180	B-1	F	P	P	F	F	F
North Burnt Fork Creek, confluence with South Burnt Fork Creek to mouth (Bitterroot River)	MT76H004_200	B-1	F	P	P	F	F	F
North Channel Bear Creek, headwaters to the mouth (Fred Burr Creek), T8N R20W S32	MT76H004_032	B-1	F	X	X	X	F	P
North Fork Rye Creek, headwaters to mouth (Rye Creek-Bitterroot River, South of Darby)	MT76H004_160	B-1	F	P	P	X	F	F
Rye Creek, North Fork to mouth (Bitterroot River)	MT76H004_190	B-1	F	P	P	X	F	X
Skalkaho Creek, headwaters to mouth (Bitterroot River)	MT76H004_100	B-1	F	F	F	N	F	P

Table 3-1. Impaired Waterbodies and their Beneficial Use Support Status on the "2010 Water Quality Integrated Report" in the Bitterroot TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Cold Water Fishery	Drinking Water	Industry	Primary Contact Recreation
Sleeping Child Creek, headwaters to mouth (Bitterroot River)	MT76H004_090	B-1	F	P	P	X	F	P
South Fork Lolo Creek, Selway-Bitterroot Wilderness boundary to mouth (Lolo Creek)	MT76H005_020	B-1	F	P	P	F	F	P
Sweathouse Creek, headwaters to mouth (Bitterroot River)	MT76H004_210	B-1	X	P	P	X	X	N
Threemile Creek, headwaters to mouth (Bitterroot River)	MT76H004_140	B-1	F	N	N	X	F	X
Tin Cup Creek, Selway-Bitterroot Wilderness boundary to mouth (Bitterroot River)	MT76H004_080	B-1	F	P	P	F	F	F
Willow Creek, headwaters to mouth (Bitterroot River)	MT76H004_110	B-1	F	P	P	F	F	P

F = Fully Supporting, P = Partially Supporting, N = Not Supporting, X = Not Assessed

3.2 Bitterroot River Watershed Water Quality Standards

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that are designed to protect the designated uses. **Appendix C** defines each of these. For the sediment and temperature TMDL development in the Bitterroot TPA, only the narrative standards are applicable.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. Narrative standards describe either the allowable condition or an allowable increase of a pollutant over "naturally occurring" conditions or pollutant levels. DEQ uses a reference condition to determine whether or not narrative standards are being achieved.

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

The specific sediment and temperature narrative water quality standards that apply to the Bitterroot TPA are summarized in **Appendix C**.

4.0 - Description of TMDL Components

A TMDL is the pollutant loading capacity for a particular waterbody and refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. Therefore, when a TMDL is exceeded, the waterbody will be impaired.

More specifically, a TMDL is the sum of the allowable loading from all sources to the waterbody. These loads are applied to individual sources or categories of sources as a logical method to allocate water quality protection responsibilities and overall loading limits within the contributing watershed(s). The allocated loads are referred to as wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. Natural background loading is considered a type of nonpoint source and therefore represents a specific load allocation. In addition, the TMDL includes a Margin of Safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. The inclusion of a MOS results in less load allocated to one or more WLAs or LAs to help ensure attainment of water quality standards.

TMDLs are expressed by the following equation which incorporates the above components:

$$\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}$$

The allowable pollutant load must ensure that the waterbody being addressed by the TMDL will be able to attain and maintain water quality standards for all applicable seasonal variations in streamflow, and pollutant loading. **Figure 4-1** is a schematic diagram illustrating 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.

The major components that go into TMDL development are target development, source quantification, establishing the total allowable load, and allocating the total allowable load to sources. Although the way a TMDL is expressed may vary by pollutant, these components are common to all TMDLs, regardless of pollutant. Each component is described in further detail below.

The following two sections of the document (**Sections 5 and 6**) are organized by the two pollutants of concern in the Bitterroot TPA: sediment and temperature. Each section includes a discussion on the waterbody segments of concern, how the pollutant of concern is impacting beneficial uses, the information sources and assessment methods to evaluate stream health and pollutant source contributions, water quality target development along with a comparison of existing conditions to targets, quantification of loading from identified sources, the determination of the allowable loading (TMDL) for each waterbody, and the allocations of the allowable loading to sources.

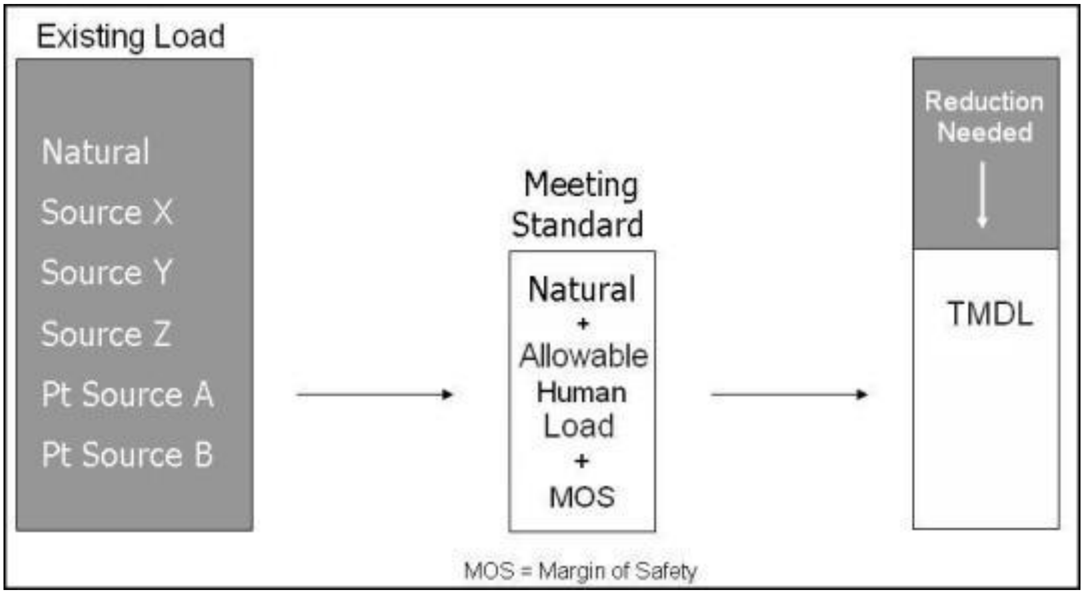

Figure 4-1. Schematic example of TMDL development

4.1 Target Development

Because loading capacity is evaluated in terms of meeting water quality standards, quantitative water quality targets are developed to help assess the condition of the waterbody relative to the applicable standard(s) and to help determine successful TMDL implementation. This document outlines water quality targets for each pollutant of concern in the Bitterroot TPA. TMDL water quality targets help translate the applicable numeric or narrative water quality standards for the pollutant of concern. For pollutants with established numeric water quality standards, the numeric value(s) within the standard(s) are used as TMDL water quality targets. For pollutants with only narrative standards, the water quality targets provide a site-specific interpretation of the narrative standard(s), along with an improved understanding of impairment conditions. Water quality targets typically include a suite of in-stream measures that link directly to the impacted beneficial use(s) and applicable water quality standard(s). The water quality targets help define the desired stream conditions and are used to provide benchmarks to evaluate overall success of restoration activities. By comparing existing stream conditions to target values, there will be 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. Source assessments often have to evaluate the seasonal nature and ultimate fate of the pollutant loading since water quality impacts can vary throughout the year. The source assessment usually helps to further define the extent of the problem by putting human caused loading into context with natural background loading.

A pollutant load is usually quantified for each point source of the pollutant permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Most other pollutant sources, typically referred to as nonpoint sources, are quantified by source categories such as unpaved roads and/or by land uses such as crop production or forestry. These source categories or land uses can be further divided by ownership such as federal, state, or private. Alternatively, a sub-watersheds or tributaries approach can be used, whereby most or all sources in a sub-watershed or tributary are combined for quantification purposes.

The source assessments are performed at a watershed scale because all potentially significant sources of the water quality problems must be evaluated. The source quantification approaches may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading (40CFR 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 and sensible time period necessary to comply with the applicable water quality standard(s). Although the concept of allowable daily load is incorporated into the TMDL term, a daily loading period 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 using a time period consistent with the application of the water quality standard(s) and consistent with established approaches to properly characterize, quantify, and manage pollutant sources in the watershed. For example, sediment TMDLs may be expressed as an allowable yearly load whereas a TMDL for metals may be expressed as a daily average concentration.

Where numeric water quality standards exist for a stream, the TMDL or allowable loading, typically represents the allowable concentration multiplied by the flow of water over the time period of interest. This same approach can be applied for situations where a numeric target is developed to interpret a narrative standard and the numeric value is based on an in-stream concentration of the pollutant of concern.

For some narrative standards such as those relating to sediment, there is often a suite of targets based on stream substrate conditions and other similar indicators. In many of these situations, it is difficult to link the desired target values to highly variable and often episodic in-stream loading conditions. In these situations, 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 Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period as discussed above.

4.4 Determining Allocations

Once the loading capacity (i.e. TMDL) is determined, that total must be divided, or allocated, among the contributing sources. In addition to basic technical and environmental considerations, this step introduces economic, social, and political considerations. The allocations are often determined by quantifying feasible and achievable load reductions associated with the application of reasonable land, soil, and water conservation practices. Reasonable land, soil, and water conservation practices generally include best management practices (BMPs), but additional conservation practices may be required to achieve compliance with water quality standards and restore beneficial uses. It is important to note that implementation of the TMDL does not conflict with water rights or private property rights. **Figure 4-2** contains a schematic diagram of 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.

Under the current regulatory framework for development of TMDLs, flexibility is allowed in the expression of 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, such as a percent increase in canopy density for temperature TMDLs.

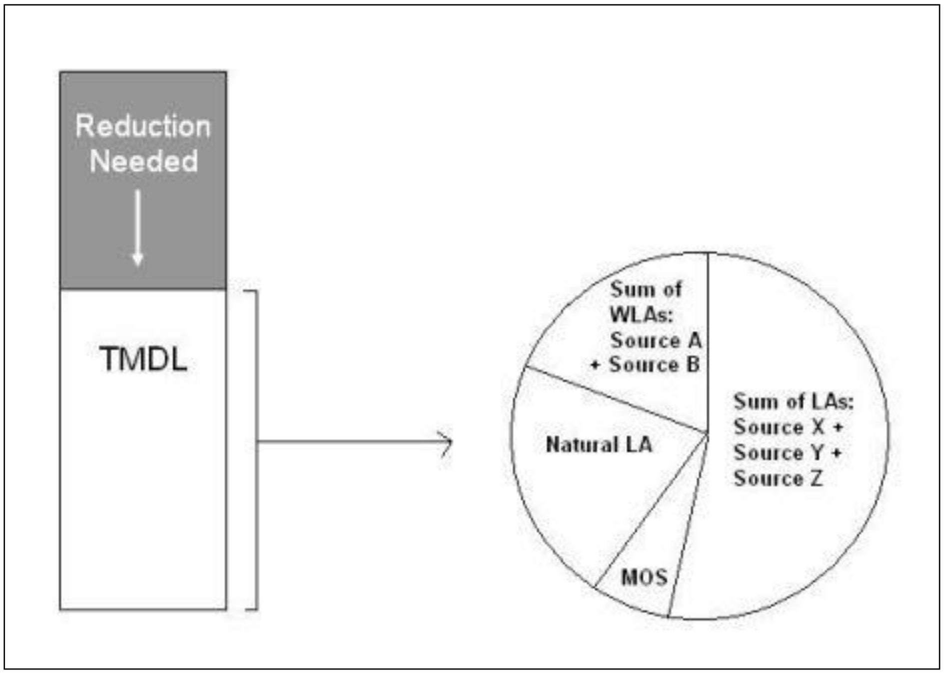

Figure 4-2. Schematic diagram of TMDL and allocations

Incorporating a margin of safety is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (Environmental Research Laboratory-Duluth, 1999).

5.0 - SEDIMENT

This section focuses on sediment as an identified cause of water quality impairments in tributaries in the Bitterroot TMDL Planning Area (TPA). It describes: 1) the mechanisms by which sediment can impair beneficial uses, 2) the specific stream segments of concern, 3) the available data pertaining to sediment impairment characterization in the watershed, 4) quantification of the various contributing sources of sediment based on recent studies, and 5) identification of, and justification for, the sediment TMDLs and the TMDL allocations.

The term “sediment” is used in this document to refer collectively to two pollutant categories: sedimentation/siltation and bottom deposits.

5.1 MECHANISM OF 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 vegetation and natural instream barriers, such as large woody debris, beaver dams, or overhanging vegetation, help trap sediment and build channel and floodplain features. When these barriers are absent, or excessive sediment loading enters the system from increased bank erosion or other sources, it may alter channel form and function. It can also negatively affect fish and other aquatic life by increasing turbidity and causing excess sediment to accumulate in critical aquatic habitats.

More specifically, sediment may block light and cause a decline in primary production of fish. It can also interfere with reproduction and survival of fish and macroinvertebrate. Fine sediment deposition reduces the availability of suitable spawning habitat for salmonid fishes and can smother eggs or fry. 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). 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 effecting recreational use. Excessive sediment can increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 STREAM SEGMENTS OF CONCERN

A total of 12 waterbody segments in the Bitterroot TPA, not including the Bitterroot River, appear on the 2010 Montana 303(d) List because of sediment impairments **(Table 5-1)**; Listing causes are bottom deposits and sedimentation/siltation. The listed waterbodies include Lick Creek, Lolo Creek (3 segments), McClain Creek, Miller Creek, Muddy Spring Creek, North Burnt Fork Creek, Rye Creek, Sleeping Child Creek, Threemile Creek, and Willow Creek. Seven of those waterbodies are also listed for habitat alterations, which are non-pollutants (noted in **Table 5-1**). Ambrose, Bear, Blodgett, Kootenai, Lost Horse, Mill, North Fork Rye, Skalkaho, South Fork Lolo, Sweathouse, Bass, and Tin Cup creeks are also listed for habitat alterations but were not listed for sediment impairments (**Table 5-2**). TMDLs are limited to pollutants; however, streams listed for habitat alterations were also assessed because habitat alterations are frequently associated with sediment impairment.

Table 5-1. Waterbody Segments in the Bitterroot TPA with Sediment Listings and Possible Sediment-related Non-Pollutant Listings on the 2010 303(d) List

Waterbody Name	Waterbody Segment ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Lick Creek	MT76H004_170	Sedimentation/Siltation	Alteration in stream-side or littoral vegetative covers
Lolo Creek (headwaters to Sheldon Creek)	MT76H005_013	Sedimentation/Siltation	Physical substrate habitat alterations
Lolo Creek (Mormon Creek to Mouth)	MT76H005_011	Sedimentation/Siltation	Physical substrate habitat alterations and Low flow alterations
Lolo Creek (Sheldon Creek to Mormon Creek)	MT76H005_012	Sedimentation/Siltation	Physical substrate habitat alterations
McClain Creek	MT76H004_150	Sedimentation/Siltation	
Miller Creek	MT76H004_130	Sedimentation/Siltation	Alteration in stream-side or littoral vegetative covers
Muddy Spring Creek	MT76H004_180	Sedimentation/Siltation	
Rye Creek	MT76H004_190	Sedimentation/Siltation	Alteration in stream-side or littoral vegetative covers
Sleeping Child Creek	MT76H004_090	Sedimentation/Siltation	
Threemile Creek	MT76H004_140	Sedimentation/Siltation	Low flow alterations
Willow Creek	MT76H004_110	Sedimentation/Siltation	Alteration in stream-side or littoral vegetative covers
North Burnt Fork Creek	MT76H004_200	Bottom deposits	

Table 5-2: Waterbody Segments in the Bitterroot TPA in the 2010 Integrated Report with Possible Sediment-Related Non-Pollutant Listings

Waterbody Name	Waterbody Segment ID	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Ambrose Creek	MT76H004_120	Physical substrate habitat alterations
Kootenai Creek	MT76H004_020	Alteration in stream-side or littoral vegetative covers and Low flow alterations
Mill Creek	MT76H004_040	Alteration in stream-side or littoral vegetative covers and Low flow alterations
North Fork Rye Creek	MT76H004_160	Alteration in stream-side or littoral vegetative covers
South Fork Lolo Creek	MT76H005_020	Physical substrate habitat alterations and Low flow alterations
Sweathouse Creek	MT76H004_210	Alteration in stream-side or littoral vegetative covers and Low flow alterations
Tin Cup Creek	MT76H004_080	Alteration in stream-side or littoral vegetative covers
Bass Creek	MT76H004_010	Low flow alterations
Bear Creek	MT76H004_030	Low flow alterations
Blodgett Creek	MT76H004_050	Low flow alterations
North Channel Bear Creek	MT76H004_032	Low flow alterations
Skalkaho Creek	MT76H004_100	Low flow alterations
Lost Horse Creek	MT76H004_070	Low flow alterations

5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions

For TMDL development, information sources and assessment methods fall within two general categories: characterizing overall stream health with focus on sediment and related water quality conditions (discussed in this section) and quantifying sources of sediment loading in the watershed (discussed in **Section 5.6**).

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 2007. The below listed data sources were used to characterize water quality and/or develop TMDL targets. The first three are described in the following sections:

- DEQ assessment files
- DEQ 2007 sediment and habitat assessments
- Relevant local and regional reference data
- GIS data layers and publications regarding historical land use, channel stability, and sediment conditions

5.3.1.1 DEQ Assessment File

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The files include a summary of physical, biological, and habitat data collected by DEQ on most waterbodies between 1991 and 2005, as well as other historical information collected or obtained by DEQ. The files include information on sediment water quality characterization, as well as information on potentially significant sources of sediment. The files also include information on determinations of non-pollutant impairment and associated rationale. Files are available electronically on the DEQ's website: http://cwaic.mt.gov/.

5.3.1.2 DEQ 2007 Sediment and Habitat Assessment Work

To help characterize instream sediment conditions and aid in TMDL development, field measurements of channel morphology and riparian and instream habitat parameters were collected by DEQ in 2007 from 32 monitoring reaches on the listed waterbodies and other tributaries **(Appendix D** and **Map A-23** in **Appendix A)**. To aid in the characterization of bank erosion, an additional 23 reaches were assessed in 2007 for bank erosion severity and source identification (**Appendix E** and **Map A-23** in **Appendix A**).

Initially, all streams of interest were assessed by aerial survey. Four main attributes not linked to human activity were looked at: stream order, valley gradient, valley confinement, and ecoregion. These four attributes represent main factors influencing stream morphology, which in turn influences sediment transport and deposition.

Next, the aerial assessment identified near-stream land uses because land management practices can have a significant influence on stream morphology and sediment characteristics. This process stratifies streams into reaches, allowing reaches with the same natural morphological characteristics to be compared. The process also identifies reaches where land management practices could further influence stream morphology. Along with field reconnaissance, stratifying streams provided the basis for selecting the monitoring reaches. The selected monitoring reaches represent various reach characteristics and anthropogenic influences. Because the primary goal of sediment TMDL development is to further characterize sediment impairment conditions, we tended to sample reaches where human influences would most likely lead to impairment conditions. Thus, the sample is not random and stream reaches do not necessarily represent all potential impairment and non-impairment conditions. Instead, this targeted sampling design aims to assess a representative subset of reach types, while ensuring that reaches in each [sediment] 303(d) listed waterbody with potential impairment conditions are incorporated into the overall evaluation. Typically, the effects of excess sediment are most apparent in low gradient, unconfined streams larger than 1st order (i.e., having at least one tributary); therefore, these stream conditions were the focus of the field effort (**Table 5-3**). Although the TMDL development process necessitates this targeted sampling design, DEQ acknowledges that this approach yields less certainty regarding conditions in 1st order streams and higher gradient reaches, and that conditions within sampled reaches are not necessarily representative of conditions throughout the entire stream.

Ecoregion and geology play an important role in the Bitterroot TPA. There are three level III ecoregions in the planning area: Idaho Batholith, Middle Rockies, and Northern Rockies (Woods, et al., 2002). Most of the 2007 DEQ field work sites were sampled in the Middle Rockies ecoregion; however, streams located at least partially in the Idaho Batholith ecoregion are influenced by its ecoregion's unique geological makeup, which is mountainous, deeply dissected, partially glaciated, and underlain by granitic rocks. The soils derived from these granitic rocks are highly erodible when vegetation is removed (Omernik, 1987). Therefore, streams originating in the Idaho Batholith ecoregion that were assessed in 2007 are considered to be part of that ecoregion. Additionally, McClain Creek and Lolo Creek are split between two ecoregions with similar characteristics: the Northern Rockies and Middle Rockies. Because of the similar nature of these ecoregions, these streams will be assigned an ecoregion based on where the majority of the stream is located. McClain Creek resides partly in the Northern Rockies ecoregion with the majority of the stream located in the Middle Rockies ecoregion. The lowest segment of Lolo Creek is partially situated in the Middle Rockies ecoregion; however, the majority of the stream is located in the Northern Rockies ecoregion. Consequently, streams are sequenced by ecoregion accordingly: Idaho Batholith: Bass, Kootenai, Sweathouse, Bear, Mill, Blodgett, Lost Horse, Lick, Tin Cup, Rye North Fork Rye, Sleeping Child, and South Fork Lolo; Middle Rockies: Miller, McClain, Threemile, Ambrose, North Burnt Fork, Muddy Spring, Willow, and Skalkaho; Northern Rockies: Lolo (3 segments) **(Map A-23** in **Appendix A)**.

Table 5-3. Reach Types Assessed in the Bitterroot TPA

Level III Ecoregion Sequence	Gradient	Strahler Stream Order	Confinement	Reach Type	Number of Monitoring Sites	Monitoring Sites
Idaho Batholith	0-<2%	2	U	IB-0-2-U/M	2	KOOT-52, MILL-50
		3	U	IB-0-3-U/M	5	BEAR-30, LOST-43, NBEAR-08, SWEA-29, TINC 31/32
		4	U	IB-0-4-U/M	3	RYEC-28, RYEC-36, SLEE-43
	2 to <4%	2	U	IB-2-2-U/M	5	BASS-24, BASS-27, BLOD-49, LICK-19, MILL-43
		3	U	IB-2-3-U/M	2	NFRC-22,SFLO-43
Middle Rockies	0-<2%	2	U	MR-0-2-U/M	1	MILR-21
		3	U	MR-0-3-U/M	5	AMBR-30, MILR-33, NFBC-11, NFBC-15, WILL-38
		4	U	MR-0-4-U/M	3	SKAL-33, SKAL-48, THRE-35
	2 to <4%	1	U	MR-2-1-U/M	1	MILR-11
		3	U	MR-2-3-U/M	1	WILL-28
	>4%	2	U	MR-4-2-U/M	1	MCCL-15

Table 5-3. Reach Types Assessed in the Bitterroot TPA

Level III Ecoregion Sequence	Gradient	Strahler Stream Order	Confinement	Reach Type	Number of Monitoring Sites	Monitoring Sites
Northern Rockies	0-<2%	4	U	NR-0-4-U/M	3	LOLO-26, LOLO-34, LOLO-56

The field parameters assessed in 2007 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. To help increase sample sizes and capture variability in assessed streams, reaches ranged from 500 to 2,000 feet (depending on the channel bankfull width) and were broken into five cells. Generally, channel morphology and fine sediment measures were performed in three of the cells, and stream habitat, riparian, and bank erosion measures were performed in all cells. Field parameters are briefly described in **Section 5.4**, and methodology descriptions and summaries of field data are found in **Appendix D**.

5.3.1.3 Relevant Local and Regional Reference Data

Regional reference data was derived from the Bitterroot National Forest (BNF) reference dataset, the Beaverhead Deerlodge National Forest (BDNF) reference dataset, the Kootenai National Forest Libby District (KNFLD) reference dataset, and the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). The BNF data was collected between 1990 and 2006, including 50 reference sites in the Idaho Batholith ecoregion and 27 reference sites in the Middle Rockies ecoregion. The BDNF data was collected between 1991 and 2002, including approximately 260 sites located in the Middle Rockies ecoregion in southwest Montana (Bengeyfield, unpublished 2002). The KNFLD data was collected between 1995 and 2004 and includes 77 reference sites located in the Northern Rockies ecoregion. The PIBO reference dataset includes data collected between 2001 and 2008 from USFS and BLM sites throughout the Pacific Northwest. To increase the comparability of the data to conditions in the Bitterroot TPA, only data collected in the Middle Rockies ecoregion (64 sites), Idaho Batholith ecoregion (23 sites), and Northern Rockies ecoregion (29 sites) in Montana was evaluated.

5.4 Water Quality Targets and Comparison with Existing Conditions

The concept of water quality targets was presented in **Section 4.1**: this section provides the rationale for each sediment-related target parameter. In addition it discusses the basis of the target values and compares those values with available data for the stream segments of concern, as well as the additional stream segments that were monitored in the Bitterroot TPA (**Tables 5-1** and **5-2**). Although placement on the 303(d) list indicates impaired water quality, comparing water quality targets with existing data helps define the level of impairment and establishes a benchmark to evaluate the effectiveness of restoration efforts.

In developing targets, natural variation throughout the river continuum must be considered. 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 to use reference site data: however, modeling, professional judgment, and literature values may also be used. DEQ defines “reference” as the condition of a waterbody such that it supports its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody’s greatest potential for water quality given historic and current land-use activities. Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations due to climate, bedrock, soils, hydrology and other natural physiochemical differences, yet allow differentiation between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology from human activity.

The basis for the value for each water quality target may vary depending on the availability and comparability of reference data to the 2007 DEQ data. Relevant regional and local reference data is preferred for target development. However, if discrepancies exist between the regional reference data and DEQ data because of data collection methods and their application, or because of the type or condition of the investigated streams such that the available reference data is no longer deemed appropriate for comparison, then statistics may be applied to the DEQ data and used for target development. DEQ uses several statistical approaches for target development, including using percentiles of reference data or percentiles of the entire sample dataset, if reference data are limited. For example, if low values reflect desired conditions, the sampled streams are assumed to be severely degraded, and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset or the 25th percentile of the sample dataset (if reference data are not available) is typically used. However, the representativeness and range of variability of the data, the severity of human disturbance to streams , and the dataset size all have a bearing on which percentile to use to reflect the desired condition. For each target, descriptive statistics were generated relative to any available reference data (e.g., BNF, PIBO, or KNFLD), 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 that uses collection methods comparable to those for the waterbody of interest. Additionally, the target value for some parameters may apply to all streams in the Bitterroot TPA, whereas others may be stratified by reach type characteristics (i.e., ecoregion, gradient, stream order, and/or confinement) or by Rosgen stream type. 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 are achievable. MOS is discussed in additional detail in **Section 5.8**.

5.4.1 Water Quality Targets

The sediment water quality targets for the Bitterroot TPA are summarized in **Table 5-4** and described in detail in the following sections. Listed in order of preference, sediment-related targets for the Bitterroot TPA are based on a combination of reference data from the Bitterroot National Forest (BNF) dataset, PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) dataset, Beaverhead Deerlodge National Forest (BDNF) dataset, Kootenai National Forest Libby District (KNFLD) dataset, along with data collected from the Montana DEQ in 2007. Target values from the Upper Lolo TPA were also considered in target development in relationship to the Northern Rockies ecoregion. **Appendix D** provides a summary of the DEQ 2007 sample data, including many of the statistics used to help with target development.

Consistent with EPA guidance for sediment TMDLs (EPA, 1999), water quality targets for the Bitterroot TPA 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 on aquatic life habitat are given the most weight (i.e., fine sediment and biological indices). The water quality targets presented in this section (see **Table 5-4**) are based on the best available science and information at publication. However, during future TMDL review, targets will be examined for their applicability and may be modified under certain situations, such as a better understanding of reference conditions or assessment procedure improvements, including new or modified field methods. In some cases, new targets may be added in the future to better characterize sediment conditions.

For all water quality targets, future surveys should document stable (if meeting target) or improving trends. The exceedance of one target value does not necessarily equate to impairment. Instead, the degree to which one or more targets are exceeded is taken into account; thus, 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 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. A description and justification of the target parameters used in the analysis is included in the sections that follow, and regional reference and DEQ summary statistics considered for target development are included in **Appendix F**.

Table 5-4. Sediment Targets

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of fine surface sediment in riffles < 6mm (reach average via pebble count method)	Idaho Batholith : ≤ 14 Middle Rockies : ≤ 14 Northern Rockies : ≤ 15 E channel type : ≤ 45 for IB and ≤ 36 for MR
	Percentage of fine surface sediment in riffles < 2mm (reach average via pebble count method)	Idaho Batholith : ≤ 8 Middle Rockies : ≤ 10 Northern Rockies : ≤ 7 E channel type : All ecoregions ≤ 20
	Percentage of fine surface sediment <6mm in riffles and pool tails (reach average via grid toss method)	Riffles: All Ecoregions: ≤ 10 Pools: Idaho Batholith : ≤ 10 Middle Rockies : ≤ 6 Northern Rockies : ≤ 8
Channel Form and Stability	Bankfull width/depth ratio (median of channel x-sec measurements)	Bankfull width ≤ 35' : ≤ 16 Bankfull width > 35' : ≤ 29 E channel : 6-11
	Entrenchment ratio (median of channel x-sec measurements)	B channel type: ≥ 1.5 C channel type: ≥ 2.5 E channel type: ≥ 2
Instream Habitat	Residual pool depth (reach average)	< 20' bankfull width : ≥ 0.8 (ft) 20'-35' bankfull width : ≥ 1.1 (ft) > 35' bankfull width : ≥ 1.3 (ft)
	Pools/mile	< 20' bankfull width : ≥ 84 20'-35' bankfull width : ≥ 49 > 35' bankfull width : ≥ 26
	LWD/mile	< 20' bankfull width : ≥ 573 20'-35' bankfull width : ≥ 380 > 35' bankfull width : ≥ 195
Riparian Health	Percent of streambank with understory shrub cover	≥ 57% understory shrub cover

Table 5-4. Sediment Targets

Parameter Type	Target Description	Criterion
Sediment Source	Riffle stability index	<70 for B stream types >45 and <75 for C stream types
	Significant and controllable sediment sources	Identification of significant and controllable anthropogenic sediment sources throughout the watershed
Biological Indices	Macroinvertebrate bioassessment impairment thresholds	Mountain MMI : > 63 Valley MMI : > 48 O/E : > 0.80

5.4.1.1 Fine Sediment

The percent of surface fines less than 6 millimeters (< 6 mm) and 2 millimeters (< 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 Bjorn, 1984; Shepard, et al., 1984; Weaver and Fraley, 1991; Suttle, et al., 2004; Bryce, et al., 2010). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001; Cover, et al., 2008; Bryce, et al., 2010). Literature values for harmful fine sediment thresholds are highly variable because: (1) similar concentrations of sediment can cause different degrees of impairment to different species, and even age classes within a species; (2) the particle size defined as "fine" varies; and (3) some assessment methods measure surficial sediment, while other measures include subsurface fine sediment. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle, et al., 2004); other studies have concluded the most harmful percentage falls within 10% and 40% fine sediment (Bjorn and Reiser, 1991; Relyea, et al., 2000; Mebane, 2001). A recent 5-year study on 557 U.S. western mountain streams indicates that a minimum-effect sediment level (for pebble count fine sediment ≤ 2 mm) for four sediment sensitive salmonid species, including bull trout and cutthroat trout, is 13%. This same study also found a minimum-effect level (for pebble count fine sediment < 2 mm) of 10% for macroinvertebrates (Bryce, et al., 2010). Targets are developed using a conservative statistical approach (consistent with Montana's water quality standard for sediment as described in **Section 3.1)**, particularly in those streams with the potential for salmonid spawning. Literature values are also taken into consideration as increasing concentrations of fine sediment are known to be harmful to salmonid spawning success, including bull trout and cutthroat trout (Kondolf, 1997; Weaver and Fraley, 1991; Bryce, et al., 2010).

Because geology and soils can differ significantly between ecoregions, fine sediment targets were evaluated within the context of the Level III ecoregions in the Bitterroot TPA. Most sediment-listed waterbodies in the Bitterroot TPA are in the Middle and Northern Rockies Level III ecoregions (**Map A-23** in **Appendix A**). The remainder of sediment-listed or evaluated streams in the TPA originate in the Idaho Batholith Level III ecoregion and flow into the Middle Rockies Level III ecoregion (with the exception of South Fork Lolo Creek, which flows into the Northern Rockies Level III ecoregion). Fine sediment values are similar between these ecoregions for 6 mm pebble counts but vary among the other fine sediment target parameters. Therefore, Bitterroot TPA fine sediment targets are broken out by ecoregion.

Riffle Substrate Percent Fine Sediment <6mm and <2mm via Pebble Count
Surface fine sediment measured in riffles by the modified Wolman pebble count (Wolman, 1954) indicates the particle size distribution across the channel width and points to excessive sediment loading in the aquatic habitat. DEQ used a modified Wolman riffle pebble count in the 2007 sediment and habitat assessment.

Several reference datasets were examined during the development of these targets. The BNF reference dataset used a Wolman pebble count method frequently at one representative riffle per reach, instead of an average of pebble counts at multiple riffle sites within each reach, which is used for TMDL related data collection. Additionally, if a riffle was difficult to find, alternate channel forms (glide/run) were used for pebble counts in the BNF data collection, which can result in a higher percentage of fines. The BDNF reference data for pebble count was collected using the "zigzag" method, which includes both riffles and pools. Variances in the BNF and BDNF collection methods likely resulted in a higher percentage of fines than a riffle-only pebble count, the method used for TMDL related data collection, resulting in lower confidence of comparable data (Bunte, et al., 2010). Pebble count reference data from the KNFLD reference dataset were a composite count of riffles and pools. Typically, a composite count can increase the fine sediment percentage values relative to a riffle-only pebble count; however, in a review of the KNFLD field forms, pools did not typically increase the overall percentage of fines, indicating that results between the KNFLD reference dataset and Bitterroot TPA sample dataset are comparable.

Riffle substrate percent fine sediment < 2 mm and < 6 mm targets for the Bitterroot TPA are based on the median of the DEQ 2007 dataset for streams in the Idaho Batholith ecoregion, the 25th percentile of the DEQ 2007 dataset for streams in the Middle Rockies ecoregion, and the 75th percentile of the KNFLD reference dataset for streams in the Northern Rockies ecoregion (**Tables 5-5** and **5-6**). This variable approach used for target value development, as discussed in **Section 5.4** and in detail below, is justified to differing reference methods and varying stream conditions. Most of the streams in the Idaho Batholith ecoregion sequence, sampled in 2007, are listed only for habitat impairments: according to field observations, they appear to be in fair condition and healthier than Middle and Northern Rockies streams, justifying the use of the median. Field observations noted that several of the Middle Rockies streams had significant sources and visible impacts and were comparably unhealthy relative to the Idaho Batholith streams, justifying the use of a 25th percentile. Compared with the reference datasets, it appears the variability in pebble count methods causes problems when relating them to applicable targets, given the statistics in the DEQ collected data, thus justifying the use of the DEQ data over the reference data. On the other hand, the KNFLD reference data compares favorably to the DEQ collected data statistics and the use of the 75th percentile of the KNFLD reference data is therefore an appropriate target choice for this ecoregion, because only a small number of reaches were sampled for the Northern Rockies ecoregion through the 2007 DEQ field effort. These indicators should be assessed based on the reach average pebble count. Due to an inherently high percentage of fines in Rosgen Type E channels, E channel values were excluded from reference data sets and the DEQ sample dataset. E channel targets are based on the applied targets in the Lower Blackfoot TMDL Planning Area (LBFT), which used the 75th percentile of the LBFT dataset for E channels. E channel targets for percent fines < 6 mm are set at ≤ 36 for streams in the Middle Rockies ecoregion and set at ≤ 45 for streams in the Idaho Batholith ecoregion. The latter target is based on similar streams in the LBFT that have granitic geology which can commonly results in a high production of sand-sized sediment. Target values for percent fines < 2 mm are set at ≤ 20, based on applied targets in the LBFT planning area.

Table 5-5. Percentiles of reference data and 2007 Bitterroot sample data for riffle substrate percent fine sediment <6 mm (pebble count) used for target development.
Targets are shown in **bold**.

Level III Ecoregion	Data Source	Summary Statistics			
		n	Median	75th	25th
Idaho Batholith	BNF Reference	49	23	33	
	DEQ 2007	16	**14**		10
Middle Rockies	BNF Reference	26	20	29	
	BDNF Reference	79	11	22.5	
	DEQ 2007	10	23		**14**
Northern Rockies	KNFLD Reference	76	7	**15**	
	DEQ 2007	3	16		15

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

Table 5-6. Percentiles of reference data and 2007 Bitterroot sample data for riffle substrate percent fine sediment < 2 mm (pebble count) used for target development.
Targets are shown in **bold**.

Level III Ecoregion	Data Source	Summary Statistics			
		n	Median	75th	25th
Idaho Batholith	BNF Reference	49	17	24	
	DEQ 2007	16	**8**		5
Middle Rockies	BNF Reference	26	16	24	
	DEQ 2007	10	12		**10**
Northern Rockies	KNFLD Reference	76	4	**7**	
	DEQ 2007	3	5		4

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

In examining the 2007 DEQ data and reference datasets for riffle pebble counts by both ecoregion and Rosgen stream type, data generally show an approximate 10% variation between the "B3/C3's" and "B4/C4's" for 6 mm results and an approximate 6% variation between the "B3/C3's" and "B4/C4's" for 2 mm results. Therefore, when applying target values, an allowance will be considered to adjust the target up or down as much as 5% for 6 mm and as much as 3% for 2 mm, depending on Rosgen channel substrate, if there is a high level of confidence in both the current and potential Rosgen stream type.

Percent Fine Sediment < 6mm in Riffle via Grid Toss
Grid toss measurements in riffles are an alternative measure to pebble counts and assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. Riffle grid toss measurements were not collected for the BNF, BDNF, or KNFLD reference efforts: however, regional riffle grid toss data are available in a report by the Lolo National Forest (Riggers, et al., 1998). Samples were taken at 111 unroaded sites. An interpretation of the distributed data taken at these sites (see Figure 7 in Riggers, 1998) reveals a 75th percentile of approximately 10%. These sites reflect a mix of geologies throughout the Lolo National Forest; however, the values correspond with the 2007 DEQ collected data, with 10% falling between the 75th percentile and median for Idaho Batholith (streams appear healthier), between the 25th and median for Middle Rockies (streams with visible sediment sources), and just above the 25th and median of the Northern Rockies (**Table 5-7**). Grid toss was measured with a 49-point grid and summary statistics were prepared based on the average value of three tosses for each pool and riffle assessed in the Bitterroot TPA in 2007. These indicators should be

assessed based on the reach average grid toss value. Due to an inherently high percentage of fines in Rosgen Type E channels, E channel values were excluded from reference data sets and the DEQ sample dataset, and reaches will be evaluated independently.

Table 5-7. Percentiles of 2007 Bitterroot sample data for riffle substrate percent fine sediment <6mm (grid toss) used for target development.
Targets are shown in **bold**.

Level III Ecoregion	Data Source	Summary Statistics			
		n	Median	75th	25th
Idaho Batholith	DEQ 2007	15	6	14	4
Middle Rockies	DEQ 2007	10	15	23	2
Northern Rockies	DEQ 2007	3	6	7	6
Lolo National Forest report (Riggers)		**10**			

Percent Fine Sediment <6mm in Pool Tails via Grid Toss
A 49-point grid toss was used to estimate the percent surface fine sediment < 6 mm in pool tails in the Bitterroot TPA. Three tosses, or 147 points, were performed and averaged for each riffle and pool tail assessed. Reference values for pool tail grid toss measurements are available through the PIBO reference dataset; however, the PIBO reference values vary substantially from the DEQ data. Although methods are similar, when compared with the DEQ dataset, the PIBO dataset appears to be misrepresentative of typical conditions in a reference type setting for this metric in Idaho Batholith and Middle Rockies streams. As a result, because of the closer familiarity with the methods, site selection, and results from the 2007 DEQ dataset, the DEQ data is focused on for pool-tail target development for Idaho Batholith and Middle Rockies streams. As discussed with pebble count percent fine target development (**Section 5.4.1.1**), most of the 2007 sampled streams in the Idaho Batholith ecoregion appear to be in fair condition and healthier than Middle and Northern Rockies streams, justifying the use of the median for Idaho Batholith streams and the 25th percentile for Middle and Northern Rockies streams. However, only a small number of reaches were sampled from just one stream in the Northern Rockies ecoregion and therefore, the median of the PIBO dataset is the most appropriate target because it dataset most closely correlates with the target values from the DEQ dataset in all ecoregions (**Table 5-8**). These indicators should be assessed based on the reach average grid toss value. Due to an inherently high percentage of fines in Rosgen Type E channels, E channel values were excluded from reference data sets and the DEQ sample dataset, and reaches will be evaluated independently.

Table 5-8. Percentiles of reference data and 2007 Bitterroot sample data for pool tail percent fine sediment <6mm (grid toss) used for target development.
Targets are shown in **bold**.

Level III Ecoregion	Data Source	Summary Statistics			
		n	Median	75th	25th
Idaho Batholith	PIBO Reference	23	17	25	
	DEQ 2007	11	**10**		8
Middle Rockies	PIBO Reference	64	9	16	
	DEQ 2007	8	10		**6**
Northern Rockies	PIBO Reference	29	**8**	16	
	DEQ 2007	3	31		24

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

5.4.1.2 Channel Form and Stability

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are fundamental aspects of channel morphology; each provides a measure of channel stability and indicates a stream's ability to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e., riffles, pools, and near-bank zones). Changes in both the width/depth ratio and entrenchment ratio can be used to indicate change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess coarse sediment load (MacDonald, et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in channel width as the stream attempts to regain a balance between sediment load and transport capacity. Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios signify that stream energy is concentrated in-channel during flood events rather than dissipating energy to the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Knighton, 1998; Rowe, et al., 2003; Rosgen, 1996). Width/depth and entrenchment ratios were calculated for each 2007 assessment reach based on five riffle cross-section measurements.

Width/Depth Ratio Target Development

The 75th percentile of the Bitterroot National Forest dataset was applied as a target for width/depth ratio. The 2007 DEQ Bitterroot dataset is primarily comprised of 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 large streams. Therefore, the 75th percentile values of the BNF reference dataset were split into two groups: bankfull widths ≤ 35 feet and bankfull widths ≥ 35 feet (**Table 5-9**). The target width/depth ratios are set at less than or equal to bolded values indicated by channel type and bankfull width (BFW) in **Table 5-9**.

Table 5-9. Bitterroot TPA tributary targets for width to depth ratio.

Targets are shown in **bold** and are equal to or less than the bolded value.

Bankfull Width	Data Source	Summary Statistics		
		n	Median	75th
≤ 35'	BNF Reference	93		**16**
	DEQ 2007	69	16	
> 35'	BNF Reference	20		**29**
	DEQ 2007	57	31	

Values exclude E channels. E channel targets are set at a range of 6-11 based on a combination of the 75th percentile of the BNF dataset and ranges applied in completed TMDL documents.

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

Width/depth ratio values are comparable between the Bitterroot National Forest dataset and the median of the Montana DEQ 2007 Bitterroot dataset. The values presented in **Table 5-9** exclude E channels. E channel targets are set as a range from 6 to 11 based on the 75th percentile of the BNF dataset and ranges applied in completed TMDL documents including the Lower and Middle Blackfoot TPAs.

Entrenchment Ratio Target Development

The target value for entrenchment ratio is set at ≥ 25th percentile of the BNF reference data (**Table 5-10**). When comparing assessment results with 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). Reaches with multiple potential channel types will be evaluated using the lowest target value (e.g., target for B3/C3 = 1.4). The BNF dataset had limited reference data for E channels, therefore E channels should meet the minimum value as identified in Rosgen literature (> 2).

Table 5-10. Entrenchment targets for the Bitterroot TPA based on BNF reference data

Rosgen Stream Type	Sample Size	25th Percentile of BNF Reference Data
B	32	**1.5**
C	12	**2.5**

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 KNFLD and PIBO reference datasets. 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. Furthermore, their use in evaluating or characterizing impairment should be considered according to whether these measures are linked to fine, course, or total sediment loading impacts.

Residual Pool Depth

Residual pool depth (the difference between the maximum depth and the tail crest depth) is a discharge-independent measure of pool depth and indicates 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 (Sedell, et al., 1990). Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors. Pool depth can be decreased by filling with excess sediment, a reduction in channel obstructions (such as large woody debris), and changes in channel form and stability (Bauer and Ralph, 1999). Residual pool depth is typically greater in larger systems. During DEQ sampling in 2007, pools were defined as depressions in the streambed bounded by a “head crest” at the upstream end and a “tail crest” at the downstream end, with a maximum depth that is 1.5 times the pool-tail depth (Kershner, et al., 2004).

Residual pool depths for the 75th percentile of the 2007 DEQ dataset are comparable with the median of the KNFLD reference dataset and the 25th percentile of the PIBO reference dataset (**Table 5-11**). The definition of “pools” for the PIBO protocol matches the definition used for the 2007 Bitterroot sample dataset (therefore the 25th percentile is appropriate), but that used for the KNFLD reference dataset defines pools as slack water areas occupying at least one-third of the bankfull channel with a scour feature and hydraulic control. Therefore, the KNFLD reference dataset excludes small pools that occupy less than one-third of the bankfull channel but were counted and evaluated as part of the PIBO reference dataset and 2007 Bitterroot sample dataset. The target for residual pool depths is established as ≥ 25th percentile of the PIBO dataset based on bankfull width. The indicator should be assessed based on the reach’s average residual pool depth value. This range of target values is comparable with the target of ≥ 1.5 established for the Bitterroot Headwaters TPA. Future monitoring should document an improving trend (i.e. deeper pools) at sites that fail to meet the target, while a stable trend should be documented at established monitoring sites that are currently meeting the target.

Table 5-11. Percentiles of reference data and 2007 Bitterroot sample data for residual pool depth (ft) used for target development.
Targets are shown in **bold**.

Bankfull Width	Data Source	Summary Statistics			
		n	Median	75th	25th
<20’	KNFLD Reference	57	0.8		0.6
	PIBO Reference	40	1.0		**0.8**
	DEQ 2007	8	0.71	0.8	
20-35’	KNFLD Reference	18	1.4		1.2
	PIBO Reference	50	1.4		**1.1**
	DEQ 2007	11	1.19	1.5	
>35’	PIBO Reference	25	1.7		**1.3**
	DEQ 2007	13	1.5	1.7	

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

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. Excess fine sediment may limit pool habitat by filling in pools. 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 and gradient decreases.

Pool frequency within both the KNFLD and PIBO reference datasets are lower than the 75th percentile of the 2007 DEQ sample data, which may be because of the difference in method/pool definition. Because the median pool frequency values in the PIBO reference dataset compare favorably with both the 25th percentile of the KNFLD reference data and the median of the 2007 Bitterroot TPA sample data, the pool frequency target is greater than or equal to the median of the PIBO dataset (**Table 5-12**). Future monitoring should document an improving trend (i.e., more pools) at sites that fail to meet the target, while a stable trend should be documented at established monitoring sites that are currently meeting the target.

Table 5-12. Percentiles of reference data and 2007 Bitterroot sample data for pool frequency (pools/mile) used for pool frequency target development.
Targets are shown in **bold**.

Bankfull Width	Data Source	Summary Statistics			
		n	Median	75th	25th
<20’	KNFLD Reference	57	114		81
	PIBO Reference	40	**84**		64
	DEQ 2007	8	90	148	
20-35’	KNFLD Reference	18	53		38
	PIBO Reference	50	**49**		36
	DEQ 2007	11	42	69	
>35’	PIBO Reference	25	**26**		17
	DEQ 2007	13	13	29	

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

Large Woody Debris Frequency

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 frequency is sensitive to land management activities, particularly during the long term, and its frequency tends to be greater in smaller streams (Bauer and Ralph, 1999). For DEQ sampling in 2007, 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 2007 DEQ sample dataset. If measurements were conducted in the same reach, the KNFLD LWD count would likely be less than the 75th percentile of the DEQ LWD count because the protocol only counted wood if it was larger than 6 inches in diameter and longer than the BFW. The PIBO median LWD count would likely be greater because it includes pieces 3 feet long and 4 inches in diameter. An analysis of LWD frequency in the Lolo National Forest showed an average of 590 pieces per mile in 2nd order streams in undeveloped watersheds, which is comparable with the 75th percentile of the 2007 DEQ dataset for streams with a bankfull width less than 20 feet (Riggers, et al., 1998). The LWD target, based on the 2007 DEQ protocol, is set at $\geq$ 75th percentile of the DEQ dataset (**Table 5-13**).

Table 5-13. Percentiles of reference data and 2007 Bitterroot sample data for LWD frequency (LWD/mile) used for target development.

Targets are shown in **bold**.

Bankfull Width	Data Source	Summary Statistics			
		n	**Median**	**75th**	**25th**
<20’	KNFLD Reference	57	359		183
	PIBO Reference	40	402		214
	DEQ 2007	8	153	**573**	
20-35’	KNFLD Reference	18	242		92
	PIBO Reference	45	459		293
	DEQ 2007	11	222	**380**	
>35’	PIBO Reference	24	662		387
	DEQ 2007	13	195	**195**	

Summary statistics shown in table were used for target development. Additional summary statistics are available in **Appendix F**.

5.4.1.4 Riparian Health

Greenline Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in supporting the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides food for aquatic organisms and supplies large woody debris that influences sediment storage and channel morphology. Riparian vegetation also helps stabilize streambanks and can provide shading, cover, and habitat for fish. During assessments conducted in 2007, ground cover, understory vegetation and overstory vegetation were cataloged at 10- to 20- foot intervals along the greenline at the bankfull channel margin on both sides of the stream channel for each survey 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. Therefore, when applying target values, an understory shrub cover potential will be considered for each reach.

Greenline measurements were performed in 160 cells at 32 monitoring sites, with an average value of 51% understory shrub cover and a median value of 53% understory shrub cover. Based on this assessment, an target value of ≥ 53% is established for understory shrub cover in the Bitterroot TPA. This indicator should be assessed based on the reach average greenline understory shrub cover value. The selected target value compares favorably with the median value of ≥ 49% in the Middle and Lower Big Hole TMDL based on reference data from the Upper Big Hole River watershed.

5.4.1.5 Sediment Supply and Sources

Riffle Stability Index

The Riffle Stability Index (RSI) is an estimate of sediment supply in a watershed. RSI target values are established based on values calculated by Kappesser (Kappesser, 2002), who found that RSI values between 40 and 70 in B channels indicate that a stream's sediment transport capacity is in dynamic equilibrium with its sediment supply. Values between 70 and 85 indicate that sediment supplies are moderately high, while values greater than 85 suggest that a stream has excessive sediment loads. The scoring concept applies to any streams with riffles and depositional bars. Additional research on RSI values in C streams types was conducted in the St. Regis River watershed and applied in the St. Regis TMDL, for which a water quality target of greater than 45 and less than 75 was established based on Kappesser's research and local reference conditions for least-impacted stream segments. For the Bitterroot TPA an RSI target value of < 70 is established for B streams, while values of > 45 and < 75 are established for C streams. The target should be compared with the mean of measurements within a sample reach. Streams types other than B and C will need to be reviewed on a case-by-case basis.

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 historic or current identified anthropogenic sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared because 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 from aerial imagery and 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 effects to channel form and stability. This is because the historical effects still have the potential to contribute sediment and/or to habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.6**, with additional information in **Appendices B, D**, and **E**.

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. Macroinvertebrates respond predictably to siltation, shifting from natural or expected taxa (those that prefer clean gravel substrates) to a prevalence of sediment-tolerant taxa. Macroinvertebrate bioassessment scores record the macroinvertebrate taxa at a site. DEQ uses two bioassessment methodologies to evaluate impairment condition and aquatic life beneficial-use support. Aquatic insect assemblages may be altered because 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.

Two macroinvertebrate assessment tools are the Multi-Metric Index (MMI) and the Observed/Expected model (O/E). The rationale and methodology for both indices are presented in "Biological Indicators of Stream Condition in Montana Using Benthic Macroinvertebrates" (Jessup, et al., 2006). Unless noted otherwise, macroinvertebrate samples discussed in this TMDL document were collected according to DEQ protocols.

The MMI is organized based on different bioregions in Montana (i.e., mountain, low valley, and plains), and the Bitterroot TPA falls within the Mountain MMI and Valley MMI regions; here, the threshold value is an MMI score less than 63 and 48, respectively. These values are established as sediment targets in the Bitterroot TPA. 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; it is expressed as a ratio of the observed/expected taxa (O/E value). The O/E threshold value for all Montana streams is any O/E value < 0.8. Therefore, an O/E score of > 0.80 is a sediment target in the Bitterroot TPA. For both metrics, 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 non-pollutants such as habitat disturbance, they will be evaluated in consideration of more direct indicators of excess sediment.

5.4.2 Existing Condition and Comparison with Water Quality Targets

This section presents summaries and evaluations of relevant water quality data for Bitterroot TPA waterbodies appearing on the Montana 2010 303(d) list. The weight-of-evidence approach described earlier in **Section 4.2**, using a suite of water quality targets, has been applied to each of the listed water quality impairments. Data presented in the section comes primarily from sediment and habitat assessments performed by DEQ during summer 2007. Results of the 2007 assessment are supported by additional data collected by DEQ in the DEQ Assessment Files and by data supplied by the Bitterroot and Lolo national forests. This section is not intended to provide an exhaustive review of all available data.

5.4.2.1 Ambrose Creek

Ambrose Creek flows through mostly private lands for approximately 12.7 miles, from its headwaters in the Sapphire Mountains on the east side of the Bitterroot Valley to its confluence with Threemile Creek near the Lee Metcalf Wildlife Refuge north of Stevensville, Montana. Ambrose Creek was listed for physical substrate habitat alterations, a non-pollutant commonly linked to sediment impairment. Suspected sources include agriculture and grazing in riparian zones. Although the stream is not currently listed for sediment, it is listed for habitat alterations, and previous assessment studies suggest a potential problem with excess fine sediment accumulation in its channel. Additionally, Ambrose Creek is the largest tributary to Threemile Creek, which is currently listed as impaired by sediment. For these reasons, Ambrose Creek was included in this analysis.

Physical Condition and Sediment Sources

DEQ performed a stream assessment at one site along Ambrose Creek in 2007, using the methodology described in "Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat

Impairments." The monitoring reach, Ambrose 30 (AMBR-30), was located in the lower watershed, a short distance upstream from the confluence with Threemile Creek, and at the time of assessment was classified as a Rosgen E4 stream type, however upon further review of the reach data, the stream is characteristic of a Rosgen B4c channel type and may be transitioning to a Rosgen C4b stream type. Therefore, a Rosgen C4 stream type will be applied to Ambrose Creek when comparing targets to existing conditions. The field assessment team reported that near this reach the stream flowed through a rural-residential area. Young cottonwoods sprouted along the channel and on the floodplain. The low streambanks were well vegetated with grass, which minimized erosion in this low intensity system. Small undercuts at meander bends were associated with cottonwoods, and there was a short section of cobble riprap. The channel was primarily a run, with short riffles and a few pools. The substrate was sand and fine gravel, except in the riffles where small cobbles dominated.

2007 DEQ Data and Comparison with Water Quality Targets
The existing sediment and habitat data compared with the targets for Ambrose Creek are summarized in **Table 5-14**.

Table 5-14. Ambrose Creek Data Compared with Targets

				Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
Reach ID	**Mean BFW (ft)**	**Level III Ecoregion**	**Potential Stream Type**	**% <6mm**	**% <2mm**	**Riffle % <6mm**	**Pool % <6mm**	**W/D Ratio**	**Entrenchment Ratio**	**Residual Pool Depth (ft)**	**Pools / Mile**	**LWD / Mile**	**Greenline % Shrub Cover**	**Riffle Stability Index**
AMBR-30	6.7	MR	C4	**75**	**30**	**57**	**87**	8.6	5	**0.7**	**74**	**11**	**46**	NC

Bold indicates target value was not met. NC = not collected

During the 2007 assessment, the composite riffle pebble count surface fines < 6 mm exceeded the target criteria of ≤ 14% for Middle Rockies streams with a value of 75%. The percent surface fines < 2 mm also exceeded the target criteria of ≤ 10%, with a value of 30%. Percent fines as measured by the grid toss methodology were 57% in riffles and 87% in pool tail-outs, exceeding the target values of ≤ 10% and ≤ 6%, respectively. The median width/depth ratio and entrenchment ratio were meeting the set targets. The mean residual pool depth of 0.7 failed to meet the target value of ≥ 0.8. A pool frequency of 74/mile was observed in the reach, missing the target of ≥ 84/mile. Large woody debris frequency was 11/mile, falling short of the target value of ≥ 573/mile. Along the length of the monitoring reach, 46% of the near-stream riparian vegetation was dominated by deciduous shrubs, falling short of the target of ≥ 57%. RSI data was not collected in Reach AMBR-30 due to a shortage of suitable riffles.

Other Assessments
In October 1995 the Bitterroot National Forest conducted a stream survey approximately 40 feet upstream of the Forest Service boundary (**Table 5-15**). Rosgen stream type was B4. Riffle pebble count percent fines less < 2 mm was 26% and percent fines < 6 mm was 33%, both of which exceed the target values established for Middle Rockies stream types. At this location bankfull width was 9 feet and bankfull depth was 0.84 feet, resulting in a width-to-depth ratio of 10.7, meeting the target value of ≤ 16. The entrenchment ratio was 2.9, meeting the target value of ≥ 1.5.

Table 5-15. Selected BNF Data from Ambrose Creek Mile 9.3

Agency	Location	Year	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
BNF	Mile 9.3	1995	**33**	**26**	11	2.9

In 2005, DEQ collected pebble count data at three sites on Ambrose Creek. At the upper site near the forest boundary, surface fines < 2 mm were 28%, and fines < 6 mm were 64%. At the middle site, surface fines < 2 mm were 15% and fines < 6 mm were 32%. At the lower site, a short distance upstream from the confluence with Threemile Creek, surface fines < 2 mm were 8% and fines < 6 mm were 23%. The surface fines < 2 mm target of ≤ 10% that has been established for all Middle Rockies stream types was met at the lower site, but exceeded at the middle and upper. The surface fines <6mm target of ≤14% that has been established for all Middle Rockies stream types was exceeded at all sites.

In May 1991 DEQ conducted a Nonpoint Source Stream Reach Assessment on the lower three-quarters of Ambrose Creek, which indicated notable sediment production from riparian grazing, livestock bank trampling, silvicultural activities, and roads. Road encroachment was noted in the upper stream reaches. Intensive, poorly managed grazing activities were identified as major sources of habitat alteration and sediment delivery in the lower reach.

During 2003 and 2004 the Tri-State Water Quality Council (TSWQC) conducted an extensive watershed assessment of Ambrose Creek as part of a larger watershed assessment of Threemile Creek and two tributaries (Ambrose and Wheelbarrow creeks). During the assessment, TSWQC delineated Ambrose into four reaches. Progressing downstream, surface fines < 6 mm were reported at 45%, 55%, 69%, and 72%.

TSWQC reported large woody debris densities in the four reaches (proceeding downstream) of 51 pieces per 1,000 feet, 21 pieces per 1,000 feet, 28 pieces per 1,000 feet, and 16 pieces per 1,000 feet, equating to 269, 111, 148, and 84 pieces per mile, respectively. Pool frequency was measured twice and was reported as 136/ mile near the headwaters and 45/mile near the mouth. Width-to-depth ratios were reported as 6.6 near the headwaters, and 13.5 near the mouth of Ambrose Creek.

Biological Data

Macroinvertebrate data samples were collected at two sites on Ambrose Creek in September 2005 (**Table 5-16**). The MMI target values for valley and mountain streams were met at sites AMBR1 and AMBR 2. The O/E target was not met at either site.

Table 5-16. Macroinvertebrate Metrics for Ambrose Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
AMBR1 – near forest boundary	9/15/2005	71	Not applicable	**0.65**
AMBR2 – near mouth	9/15/2005	Not applicable	70	**0.26**

Bold indicates target value was not met.

Summary and TMDL Development Information

These results indicate an increased sediment supply in Ambrose Creek. All of the percent surface fines measures for the 2007 DEQ assessment failed to meet their water quality targets, suggesting increased sediment supply. Low LWD frequency and reduced coverage of woody stream side vegetation all suggest potential negative effects to habitat in Ambrose Creek. Biological data generally indicate potential impairment. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) found that of the 25.4 miles of streambank along Ambrose Creek (double its 12.7-mile length to account for both banks), 12.7 miles (50%) had significant anthropogenic effects within 100 feet of the channel. These anthropogenic effects appeared to be having a negative impact on riparian health. Of the more than 18 miles of its banks rated as poor or fair condition, 17.6 miles (98%) were in areas where anthropogenic effects were observed. In contrast, all but a trace amount of the riparian areas in which no anthropogenic effects were observed as being in good condition.

Overall, the data collected by DEQ in 2007, along with previous studies, suggests a problem with excess fine sediment accumulation in the stream channel. This problem is linked to land-use activities in the watershed. For this reason, a sediment TMDL will be developed.

The 2003-04 TSWQC study reached the same conclusion, stating that "the aquatic habitat of Ambrose Creek…is impaired by sediment, especially 'siltation' or deposition of heavy loads of sediment in stream channels." This same report described the major sediment sources as: 1) excess streambank erosion; 2) gully erosion on tertiary benches; 3) erosion of unpaved roads and crossing structures; and 4) upland sheet and rill erosion, particularly where weeds or livestock have degraded native grasses. Note "impairment" as used by TSWQC is not the same as defined in the Integrated 303(d)/305(b) Water Quality Report because only DEQ has authority to determine whether or not a stream is impaired, thereby including it in the official Integrated Water Quality Report.

5.4.2.2 Bass Creek

Bass Creek begins at Bass Lake in the Bitterroot Mountains on the west side of the Bitterroot Valley, and flows for approximately 10 miles from its headwaters to its confluence with the Bitterroot River near the Lee Metcalf Wildlife Refuge. For approximately 8 miles the creek flows thorough a roadless portion of the Bitterroot National Forest; the lower two miles flow through mostly private agricultural lands. Although the stream is not currently listed for sediment, it is listed for flow alterations, and previous assessment studies suggest a potential problem with excess fine sediment accumulation in the channel of Bass Creek. For this reason, Bass Creek was included in this analysis.

Physical Condition and Sediment Sources

DEQ performed stream assessments at two sites along Bass Creek in 2007. The channel in both reaches was classified as Rosgen B3. Monitoring reach Bass 24 (BASS-24) was located on the Lolo National Forest downstream of a bridge crossing. According to the field assessment crew, there was some indication of historic timber harvest, with stumps along the channel, though channel form appeared essentially intact in this large substrate step-pool system. Scour pools with good LWD cover were observed. There was no streambank erosion observed due to the large cobble substrate and woody vegetation along the channel margin. The riparian zone was a mix of cottonwoods and conifers, with alder in the understory. Assessment reach Bass 27 (BASS-27) was located on private property in the lower watershed a short distance upstream of the creek's confluence with the Bitterroot River. Field crews observed that this site appeared in a state of recovery, though portions were still over-widened in an area that flowed through what appeared to be a former CAFO. The reach was primarily comprised of riffles. Pools were poorly defined and relatively shallow. The substrate was dominated by cobbles, even in the over-widened areas. There was no streambank erosion due to the cobble substrate and dense riparian vegetation, which included cottonwoods, alder, and hawthorn, with grasses and forbs in the understory. The channel in both monitoring reaches was classified as a Rosgen B3 stream type.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for Bass Creek are summarized in **Table 5-17**.

Table 5-17. Bass Creek Data Compared with Targets

Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	Riffle Pebble Count (mean) % <6mm	Riffle Pebble Count (mean) % <2mm	Grid Toss (mean) Riffle % <6mm	Grid Toss (mean) Pool % <6mm	Channel Form (median) W/D Ratio	Channel Form (median) Entrenchment Ratio	Instream Habitat Residual Pool Depth (ft)	Instream Habitat Pools / Mile	Instream Habitat LWD / Mile	Riparian Greenline % Shrub Cover	Sediment Source Riffle Stability Index
BASS-24	24.7	IB	B3	7	3	5	4	**17.9**	1.9	1.1	74	**317**	**39**	52
BASS-27	19.5	IB	B3	**18**	4	**14**	**20**	14.4	1.9	**0.7**	**79**	**158**	60	50

Bold indicates target value was not met.

During the 2007 assessment, the upper reach, Bass 24, was meeting its target values for all four fine sediment target variables. At the lower site, Bass 27, the composite riffle pebble count surface fines < 6 mm exceeded the target of < 14%; while surface fines < 2 mm met the target of < 8%. In Bass 27, percent fines as measured by the grid toss methodology were 14% in riffles and 20% in pool tail-outs, exceeding the target value of <10% for both parameters. The median width-to-depth ratio in Bass 24 exceeded the target value of < 16, and the entrenchment ratios for both reaches met the target value > 1.5. The mean residual pool depth in Bass 27 did not meet the target value of > 0.8. Pool frequency did not meet target values in Bass-27. Large woody debris frequency did not meet target values in either reach. In Bass 24, 39% of the near-stream riparian vegetation contained deciduous shrubs, falling short of the target value of > 57%. The mean RSI values met target values in both reaches.

Other Assessments

DEQ collected data at two sites on Bass Creek in 2004, one near the forest boundary and one on private property in the lower watershed, and the Bitterroot National Forest collected data near the forest boundary in 2003 and 1995. Rosgen B3 channel types were found at all of these locations. Selected results from these studies are presented in **Table 5-18**. The composite riffle pebble count surface fines < 6 mm and < 2 mm exceeded the target values of ≤ 14% and ≤ 10%, respectively, in all sites and time periods, with the exception of the BNF data collected for < 6 mm in 1995. Width-to-depth ratio exceeded the target value in 2004 at the DEQ site near the USFS boundary and the entrenchment ratio was below the target value at the BNF site in 1995.

Table 5-18. Selected DEQ and BNF Data from Bass Creek

Agency	Location	Year	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
DEQ	Near USFS boundary	2004	**30**	**30**	**27.8**	7.57
DEQ	Lower Bass	2004	**17**	**17**	7.28	5.16
BNF	Near USFS boundary	2003	**15**	**15**	14.4	1.5
BNF	Near USFS boundary	1995	14	**11**	15.8	**1.4**

Bold indicates target value was not met.

Biological Data

Macroinvertebrate data samples were collected at two sites on Bass Creek in July 2004. All biological targets were met at both sites (**Table 5-19**).

Table 5-19. Macroinvertebrate Metrics for Bass Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
BASS10 – near forest boundary	7/9/2004	83	Not applicable	1.26
BASS20 – near mouth	7/9/2004	Not applicable	60	1.04

Summary and TMDL Development Information

At the time of the 2007 sampling, many target variables were within reference ranges at Bass 24. Upstream of this reach, there are very limited anthropogenic effects from which excessive sediment loading could result and much of the area is within the Selway-Bitterroot Wilderness. Downstream of the forest boundary at reach Bass 27, excessive surface fines were observed in both the <6mm substrate particle size class, and grid toss-based target value thresholds for riffle and pool tail-out percent fines were also above optimal levels. Land use in the lower reaches of Bass Creek are dominated by agriculture, and the data collected as part of the assessment by DEQ field crew in 2007 suggested that agriculture is having a potentially significant impact on stream health. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) found that of the 20 miles of streambank along Bass Creek (double its 10 mile length to account for both banks) four miles (20%) had significant anthropogenic effects within 100 feet of the channel. In general, the stream appeared to be in good health based on the riparian assessment results. Approximately 16 of the 20 miles of streambank were rated as good condition (80%). However, the remaining 4 miles that were rated as in fair or poor condition were all in areas were near-stream anthropogenic effects were observed, suggesting that while limited in area, human effects were influencing the stream. Those portions of Bass Creek's riparian areas that were rated as good condition were dominated by forest land uses; while those as fair or poor conditions were dominated by agriculture and near-stream roads. Although the impairment for sediment is unclear, the available data indicates that below the USFS boundary, sediment levels in Bass Creek are elevated and it appears that the lower impacted portions of the stream would recover well with riparian plantings and grazing management. For this reason, a sediment TMDL will be developed.

5.4.2.3 Lick Creek

Lick Creek headwaters from north of Lake Como and the stream flows for 6.4 miles mostly through Bitterroot National Forest lands before joining the Bitterroot River just north of Como, Montana. Private lands border the stream for approximately 1 mile before the confluence with the Bitterroot. Lick Creek was placed on the 2010 303(d) List for sedimentation/siltation. Suspected pollutant sources are grazing in riparian areas, livestock (grazing or feeding operations), and silvicultural activities.

Physical Condition and Sediment Sources

DEQ performed a stream assessment at one site along Lick Creek in 2007. The monitoring reach, LICK 19, was located on private land a short distance upstream from Highway 93 and at the time of assessment was classified as a Rosgen E4b stream type, however upon further review of the reach data, the steep valley slope and low sinuosity of the reach indicate that the stream may be in transition from an E4b to a B4 type stream. Therefore, a Rosgen B4 stream type will be applied to Lick Creek when comparing targets to existing conditions. According to the stream survey crew, there appeared to be minimal watershed disturbance upstream of this site, though there was a flood irrigated field along the river left of the reach and signs of historic grazing on the hillslopes. The reach was primarily comprised of runs with small riffles and pools. Some spawning-size gravels were observed. Dense alders along the channel margin minimized streambank erosion.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for Lick Creek are summarized in **Table 5-20**.

Table 5-20. Lick Creek Data Compared with Targets

Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
				% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
LICK-19	11.9	IB	B4	**37**	**20**	**22**	5	10	11.4	0.8	148	1172	69	NC

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment, the composite riffle pebble count surface fines < 6 mm was 37%, exceeding the target value of < 14%. The composite riffle pebble count surface fines < 2 mm was 20%, exceeding the target value of < 8%. Percent fines as measured by the grid-toss methodology were 22% in riffles and 5% in pool tail-outs, with the riffle grid toss exceeding the target value of <10%. The median width-to-depth ratio was 10, meeting the target value of < 16, and the entrenchment ratio of 11.4 met the target value of > 1.5 established for B stream types. The mean residual pool depth of 0.8 just met the target value of > 0.8. A pool frequency of 148/mile was observed in the reach, meeting the target of > 84/mile. Large woody debris frequency was 1,172/mile, meeting the target of > 573/mile. Along the length of the monitoring reach, 66% of the near-stream riparian vegetation was dominated by deciduous shrubs, meeting the target of > 57%. RSI data was not collected because of a lack of suitable riffles.

Other Assessments

DEQ collected data at one site in lower Lick Creek in 2004. Selected results from this assessment are presented in **Table 5-21**. Percent fines < 6 mm and < 2 mm exceeded the targets of < 14% and < 8%, respectively. The other parameters were within target ranges.

Table 5-21. Selected DEQ Data from Lower Lick Creek

% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
31	**30**	10.9	4.43

The Bitterroot National Forest conducted stream surveys at several sites on Lick Creek in 2003. Selected results are presented in **Table 5-22**. At mile 1.3 the stream was classified as a Rosgen F4 channel. Percent fines < 2 mm and < 6 mm exceeded the targets of < 8% and < 14 respectively for streams in the Idaho Batholith ecoregion. Width-to-depth ratio targets were exceeded at sites Mile 1.3 and Mile 2.4.

Table 5-22. Selected BNF Data from Lick Creek

Location	Stream Type	Year	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
Mile 1.3	F4	2003	**42**	**30**	**17.2**	1.2
Mile 2.4	B4	2003	**28**	**19**	**16.1**	2.2
Mile 3.7	A3	2003	**18**	**17**	11.1	1.2

Biological Data

Macroinvertebrate data samples were collected at two sites on Lick Creek in July 2004. At both sites, all metrics were meeting target values (**Table 5-23**).

Table 5-23. Macroinvertebrate Metrics for Lick Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
C05LICKC10	7/14/2004	71	Not applicable	0.87
C05LICKC20	7/14/2004	Not applicable	70	1.05

Summary and TMDL Development Information

The data collected by DEQ in 2007 indicate elevated levels of fine sediment in the substrate of Lick Creek, but biological data collected in 2004 indicated beneficial-use support. An assessment of riparian conditions and near-stream land uses that was conducted (concurrently with the 2007 DEQ study) found relatively few impacts. Of the 12.8 miles of streambank along Lick Creek (double its 6.4 mile length to account for both banks), only 2.5 miles (20%) had significant anthropogenic effects within 100 feet of the channel. Approximately 10 of the 12.8 miles of streambank were rated as good condition. The remaining 2.8 miles (20%) were rated as in fair or poor condition, all in areas where adjacent human activity was observed. Because the data collected by the DEQ in 2007 exhibits elevated fine sediment, a sediment TMDL will be developed for Lick Creek.

5.4.2.4 Lolo Creek (Upper, Middle, and Lower Segments)

Lolo Creek begins near the Montana/Idaho border on the west side of the Bitterroot Valley and flows for 31.5 miles through a mix of public and private lands before reaching its confluence with the Bitterroot River in Lolo, Montana. Lolo Creek (segments MT76H005_013, MT76H005_012, and MT76H005_013) was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include agriculture, silvicultural activities, streambank modification/destabilization, habitat modification other than hydromodification, and site clearance (land development or redevelopment).

Physical Condition and Sediment Sources

DEQ performed stream assessments at three locations on Lolo Creek in 2007. LOLO 26 was the uppermost reach assessed. According to the stream assessment crew, this reach was channelized on river-left along its entire length, through the use of large rock riprap, and Highway 12 runs within approximately 30 feet of the channel along most of the reach. Riparian shrubs have grown between the riprap and the river along a portion of the left bank, while the right bank was covered by shrubs and conifers. A power line crosses the channel in this reach, and the reach lacked well-formed pools and LWD. Excessive scour likely occurs along this section of river during high water, which may exacerbate streambank erosion along the right bank. According to the field crew, LOLO 34 was situated away from the road and downstream of a bridge crossing. The stream flowed through dense riparian vegetation, with alders and willows along the channel margin and conifers in the overstory. It appeared that timber was harvested along the floodplain and included a staging area that led to increased streambank erosion, locally. Stumps were observed on the floodplain. Some LWD aggregates were found in this reach, and the pools included some potential spawning gravels. Finally, assessment reach LOLO 56 was located along Fort Fizzle. The stream flowed through dense riparian vegetation, with alders and willows along the channel margin and conifers in the overstory, with some cottonwoods as well. The stream appeared to be in an essentially natural condition along this reach, though LWD inputs may have been decreased historically from extensive silviculture throughout the watershed. There was a small streambank stabilization project along the river-left bank where the trail meets the river. It used mess fabric and the upstream portion appeared to have blown out. There was one cutslope sediment source along the right bank, though whether this was natural, or influenced by upstream riprap was unclear. All three assessment reaches were classified as Rosgen C4 stream types.

2007 DEQ Data and Comparison with Water Quality Targets
The existing sediment and habitat data compared with the targets for Lolo Creek are summarized in **Table 5-24**.

Table 5-24. Lolo Creek Data Compared with Targets

Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
				% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
LOLO-26	48.1	NR	C4	**20**	5	6	**35**	28.5	**1.6**	**1.2**	**13**	**45**	65	**81**
LOLO-34	51.4	NR	C4	13	2	7	**31**	**31.1**	4.5	1.6	**11**	**161**	82	61
LOLO-56	82.5	NR	C4	**16**	**8**	6	**17**	**39.4**	3.7	1.4	**16**	**92**	86	**80**

Bold indicates target value was not met.

During the 2007 assessment, the composite riffle pebble count surface fines < 6 mm exceeded the target value of < 5% at reaches LOLO 26 and 56. The composite riffle pebble count surface fines < 2 mm exceeded the target value of < 7% at reach LOLO 56. All three reaches met the target of < 10% for percent fines in riffles as measured by the grid toss methodology, but were well above the target value of < 8% for fines in pool tail outs. The median width-to-depth ratio exceeded the target value of < 29 at reaches LOLO 34 and 56. At reach LOLO 26, an entrenchment ratio of 1.6 failed to meet the target value of ≥ 2.2, while the other two sites were meeting target criteria. The mean residual pool depth fell below the target of > 1.3 ft. at reach LOLO 26. Pool frequency failed to meet the target of > 26/mile in all three reaches. Large woody debris also failed to meet the target of > 195/mile. Along the length of all three monitoring reaches, the near-stream riparian vegetation was dominated by deciduous shrubs, meeting the target of >57%. The mean RSI did not meet the target of > 45 and <75 in LOLO 26 and LOLO 56, respectively.

Biological Data
Macroinvertebrate samples were collected at three sites on Lolo Creek in September, 2005 (**Table 5-25**). All macroinvertebrate metrics at all sites were within target ranges.

Table 5-25. Macroinvertebrate Metrics for Lolo Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
Upper Lolo	9/11/2005	77	Not applicable	1.19
Middle Lolo	9/10/2005	Not applicable	57	1.23
Lower Lolo	9/8/2005	Not applicable	63	1.23

Summary and TMDL Development Information

Macroinvertebrate results suggest full support of aquatic life beneficial uses; however, some fine sediment and habitat parameters fall outside of target ranges. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) showed that of the 63 miles of streambank along Lolo Creek (double its 31.5-mile length to account for both banks) 43.5 miles (69%) had significant anthropogenic effects within 100 feet of the channel. Approximately 21 of the 63 miles of streambank were rated as good condition, and these were located predominantly in areas where no significant near-stream human activities were observed. The remaining 42 miles (67%) were rated as in fair or poor condition. Those portions of Lolo Creek's riparian areas that were rated as food condition were dominated by forest land uses; those areas rated fair or poor were in areas dominated by roads, timber harvest/fire, rural farms, and hay/pasture lands. While not specifically addressed in DEQ's 2007 assessment, Highway 12 parallels Lolo Creek for much of its length and has been identified in previous studies as a potentially significant sediment source. Construction and maintenance of the highway have also resulted in channel straightening and bank hardening. Because Lolo Creek is currently listed for sediment impairment and significant controllable sediment sources were identified, a TMDL for sediment will be written for all three segments of Lolo Creek.

5.4.2.5 McClain Creek

McClain Creek is a small stream on the west side of the Bitterroot Valley that flows for approximately 5.4 miles through mostly private lands before joining the Bitterroot south of Lolo, Montana. McClain Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include forest roads (road construction and use).

Physical Condition and Sediment Sources

DEQ performed a stream assessment at one site along McClain Creek in 2007. The monitoring reach, MCCL 43, was located on private land in the lower watershed, a short distance upstream of the frontage road. According to the stream assessment crew, there were fields along both sides of the channel, and it appeared that the site had been historically heavily grazed with pugging and hummocking along the channel margin, indicating ongoing grazing. Areas of streambank erosion and bare ground were present, caused by cattle. Small rock riprap had been used in some sections, and dense hawthorn formed a narrow band along the channel, with grass and rose in the understory. Overall, there was a fairly well-developed riffle-pool sequence in this small stream, and pools were often associated with LWD. At the time of assessment, the reach was classified as a Rosgen E4 stream type, however upon further review of the reach data, the steep valley slope and low sinuosity of the reach indicate that the stream may be in transition from an E4b to a G4 with a potential stable channel type of B4. Therefore, the Rosgen B stream type will be applied to McClain Creek when comparing targets to existing conditions.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for McClain Creek are summarized in **Table 5-26**.

Table 5-26. McClain Creek Data Compared w Targets

Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
				% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
MCCL-15	5.6	MR	B4	**50**	**33**	**43**	**31**	5.3	7	**0.6**	211	**148**	61	NC

Bold indicates target value was not met. NC = not collected.

The reach sampled during the 2007 assessment was classified as a Rosgen E channel type, however, upon further review DEQ has reclassified it as a Rosgen G4 channel type, which is currently transitioning to a B4 channel type. The composite riffle pebble count surface fines < 6 mm was 50% and the percent surface fines < 2 mm was 33%, failing to meet the targets of ≤ 14% and ≤ 10% respectively. Percent fines as measured by the grid-toss methodology were 43% in riffles and 31% in pool tail-outs, failing to meet the target values of ≤ 10% and ≤ 6%, respectively. The median width-to-depth-ratio of 5.3 met the target value of ≤ 16, and the entrenchment ratio of 7 was meeting the target of ≥ 1.5 for B channel types. The mean residual pool depth of 0.6 feet did not meet the target of ≥ 0.8 feet. The pool frequency met the target of ≥84/mile, but the LWD frequency did not meet the target of ≥ 573/mile. Along the length of the monitoring reach, 61% of the near-stream riparian vegetation was dominated by deciduous shrubs, meeting the target of ≥57%. RSI data was not collected because of a lack of suitable riffles.

Other Assessments

In 2005, DEQ collected pebble count data at one site below Highway 93. Surface fines < 2 mm were 59% and fines < 6 mm were 71%. These values are above the targets that have been established for streams in the Middle Rockies ecoregion, suggesting excessive fine sediment in the channel of lower McClain Creek.

The Bitterroot National Forest conducted a stream assessment at mile 4.4 in 1992, 1994, and 2003, classified as a Rosgen Type B4 stream. Selected data are presented in **Table 5-27**. Percent fines < 2 mm and < 6 mm exceeded target values of ≤ 10 and ≤ 14% respectively (based on B4 stream type) at all locations and in all years for which data is available. Width/depth and entrenchment ratios were within target ranges in all cases.

Table 5-27. Selected BNF Data from McClain Creek Mile 4.4

Year	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
1992	**56**	**44**	8.7	1.9
1994	**50**	**33**	NC	NC
2003	NC	**34**	6.4	2.2

Bold indicates target value was not met. NC = not collected.

Biological Data

Macroinvertebrate data samples were collected at two sites on McClain Creek in September 2005. Both sites were classified as valley sites (**Table 5-28**). At the upper site, MCCL-1, both applicable metrics were within target ranges. At the lower site, MCCL-2, neither target was met.

Table 5-28. Macroinvertebrate Metrics for McClain Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
MCCL1	9/20/2005	Not applicable	65	0.85
MCCL2	9/20/2005	Not applicable	**39**	**0.39**

Bold indicates target value was not met.

Summary and TMDL Development Information

The available data provides compelling evidence that fine sediment levels are elevated within the channel substrate of McClain Creek. At all locations and in all years for which data is available, fine sediment levels exceeded target levels. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) supports this conclusion. Riparian health was rated as poor or fair along more than half of the stream length. Areas that were classified as good condition were located entirely where no human activities were present. As a result, a TMDL for sediment will be written for McClain Creek.

5.4.2.6 Miller Creek

Miller Creek begins near Miller Peak in the Sapphire Mountains on the east side of the Bitterroot Valley and flows for 18.3 miles through a mix of state, Plum Creek, Lolo National Forest, and private lands before joining the Bitterroot River just south of Missoula, Montana. Miller Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include crop production (crop land or dry land), grazing in riparian or shoreline zones, loss of riparian habitat, and silvicultural activities.

Physical Condition and Sediment Sources

DEQ performed stream assessments at three sites along Miller Creek in 2007. In the upper monitoring reach, MILR 11, field crews noted that the reach was located in a dense coniferous forest, with alders, red osier dogwood and mountain maple in the understory. There were numerous pools formed by alder LWD, which had potential spawning gravels. Channel form appeared generally intact, though one over-widened crossing was noted. There was no active streambank erosion. It appeared that the site was logged historically and there was an old two-track road within 150 feet of the stream along both sides. MILR 11 was classified as a Rosgen B4 channel type. At the middle reach, MILR 21, field crews noted that the reach flowed through a mountain meadow that appeared to have been logged at one time and also potentially used for agriculture/grazing. Recent logging along the river-left hillslope was observed. The channel was over-widened, though colonization of the channel margin by wetland vegetation suggests the channel is getting narrower. Primarily grass/wetland vegetation grew along the banks, and vertically eroding streambanks occurred at the outsides of meander bends. Pools were also located at meander bends. There was a small amount of “small” riprap to protect the road at one meander bend. At the lower reach, MILR 33, field crews noted it was comprised of one continuous riffle, with no pools and no LWD. The stream was partially channelized by low berms and flowed through a weed-covered floodplain area that was likely used for grazing and/or irrigated agriculture at one time. It is now primarily open space within a semi-rural subdivision. Grass and weeds line the banks, though some small cottonwoods were becoming established along the channel margin. It appeared that bankfull flows would still spill out on the floodplain in some places, particularly along river-left. Reaches MILR 21 and MILR 33 were classified as Rosgen C4 channel types.

2007 DEQ Data and Comparison with Water Quality Targets
The existing sediment and habitat compared with the targets for Miller Creek are summarized in **Table 5-29**.

Table 5-29. Miller Creek Data Compared with Targets

				Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
MILR-11	8.2	MR	B4	**27**	10	**21**	**11**	9.8	5.0	**0.6**	148	**570**	86	NC
MILR-21	23.5	MR	C4	**32**	**12**	**15**	**20**	**31.3**	3.9	**1.0**	69	**222**	**7**	NC
MILR-33	28.6	MR	C4	**24**	**14**	**24**	NC	**48.0**	5.1	**0.0**	**0**	**0**	**20**	NC

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment the composite riffle pebble count surface fines < 6 mm were not meeting the target value of < 14% in all three reaches. The composite riffle pebble count surface fines < 2 mm did not meet the target value of < 10% in MILR 21 and MILR 33. Percent fines < 6 mm in riffles, as measured by the grid-toss methodology, failed to meet the target value of < 10% in all three reaches. Percent fines < 6 mm in pool tail-outs did not meet the target value of < 6% in the two reaches where data was collected. The median width-to-depth ratio exceeded the target value of < 16 in MILR 21 and MILR 33. The entrenchment ratio was meeting the target values for B channel types in MILR 11 and for C channel types in MILR 21 and MILR 33. The mean residual pool depth did not meet its target value in all three reaches. The pool frequency target was not met in MILR 33 as there were no pools found in the reach. LWD frequency was below target values in all three reaches. Along the length of the reach MILR 11, 86% of the near-stream riparian vegetation was dominated by deciduous shrubs, meeting the target value of >57%. Shrub cover in MILR 21 and MILR 33 was considerably lower than the target value. No RSI data was collected due to a lack of suitable riffles.

Other Assessments
In 2005, DEQ collected pebble count data at two sites on Miller Creek. At the upper site, surface fines <2mm were 38% and fines <6mm were 47%. At the lower site, surface fines <2mm were 14% and fines <6mm were 23%. Values at both sites were above target ranges for streams in the Middle Rockies ecoregion.

Biological Data
Macroinvertebrate data samples were collected at one site near the mouth of Miller Creek in September 2005 (**Table 5-30**). The Valley MMI target value for macroinvertebrates was met, however the O/E metric target was not.

Table 5-30. Macroinvertebrate Metrics for Miller Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
MILR1 – near mouth	9/20/2005	Not applicable	55	**0.52**

Bold indicates target value was not met.

Summary and TMDL Development Information

Across the length of Miller Creek, a wide range of targets fell outside of reference ranges, and macroinvertebrate data indicated a potential impact to aquatic life. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) found that of the 36.6 miles of streambank along Miller Creek (double its 18.3 mile length to account for both banks) 26.5 miles (72%) had significant anthropogenic effects within 100 feet of the channel. Approximately 9.6 of the 36.6 miles of streambank were rated as good condition, and these were located almost entirely in areas where no significant near-stream human activities were observed. The remaining 27 miles (74%) were rated as in fair or poor condition, generally in areas where human activity was observed. Those portions of Miller Creek's riparian areas that were rated as good condition were dominated by forest land uses; those rated fair and poor condition were in areas dominated by rural farms and agricultural and forest lands. Most of the Miller Creek watershed is heavily impacted by silviculture, forest roads, agriculture, and suburban development, and the available data suggest that these activities may have increased sediment loading and degraded near- and in-stream habitat. For these reasons, TMDL development will be pursued in Miller Creek.

5.4.2.7 Muddy Spring Creek

Muddy Spring Creek is a 2-mile long tributary to Gold Creek on the east side of the Bitterroot Valley. Muddy Spring Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include rangeland grazing.

Physical Condition and Sediment Sources

Muddy Spring Creek was not included in DEQ's 2007 assessment. However DEQ did collect limited data on the creek in 2004 and 2006.

Existing Data and Comparison with Water Quality Targets

The existing sediment data compared with the targets for Muddy Spring Creek are summarized in **Table 5-31**.

Table 5-31. Selected DEQ Data, Muddy Springs Creek, 2004/06

Date	Stream Type	%<6mm	%<2 mm	Width/depth ratio	Entrenchment Ratio
9/20/2006	Unknown	13	9	NC	NC
7/10/2004	E4b	**50**	24	**4**	**4.4**

Bold indicates target value was not met. NC = not collected.

Surface fines <2mm and <6mm collected in 2006 were both below target levels established for streams in the Middle Rockies ecoregion. At the monitoring location in 2004, the stream was classified as an E4 channel type, and surface fines <6mm were above the E channel target value of ≤45%. Width/depth and entrenchment ratios both exceeded target values for E channel types.

Biological Data

Macroinvertebrate data samples were collected at one site near the mouth of Muddy Springs Creek in June 2004 (**Table 5-32**). Macroinvertebrate metrics met their target values.

Table 5-32. Macroinvertebrate Metrics for Muddy Spring Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	RIVPACS O/E
MS-1: near mouth	7/10/2004	Not applicable	63	0.86

Summary and TMDL Development Information

An assessment of riparian condition and near-stream land uses that was conducted by DEQ in 2007 found that 99% of the riparian areas along Muddy Spring Creek were in good condition, with few signs of significant human impact. Muddy Spring Creek was listed as partially supporting its aquatic life and coldwater fisheries beneficial uses likely caused by agriculture and range land. Recent data and field observations suggest Muddy Spring Creek is recovering from historic management practices, but because it is still recovering and surface fines data from 2004 indicate potentially elevated sediment levels, a sediment TMDL will be developed.

5.4.2.8 North Burnt Fork Creek

North Burnt Fork Creek begins in the Sapphire Mountains on the east side of the Bitterroot Valley and flows for 10.9 miles through mostly private lands before joining the Bitterroot River just north of Stevensville, Montana. North Burnt Fork Creek was listed for bottom deposits on the 2010 303(d) List. Suspected pollutant sources include grazing in riparian zones and irrigated crop production.

Physical Condition and Sediment Sources

DEQ performed stream assessments at two sites along North Burnt Fork Creek in 2007. In the upper monitoring reach, NBFC 11, field crews noted that the stream flows through a rural-residential area. The stream was over-widened along this reach and reduced floodplain access appeared to be increasing near-bank stress. An irrigation structure and cattle access were leading to over-widening and bank erosion. Riparian vegetation consisted of a mature/decadent cottonwood gallery with grass ground cover. Assessment reach NBFC 11 was classified as a Rosgen C3 channel type. In the lower monitoring reach, NBFC 15, assessment field crews noted that the stream flows through an area that was actively being used for grazing during the site visit. It appeared that the channel was slightly over-widened, though it retained a relatively coarse substrate. Extensive streambank erosion was observed, with tall exposed banks. In places, cattle crossings have laid back the banks and created areas of bare ground. There was primarily grass along the channel margin, with pugging and hummocking observed. Assessment reach NBFC 15 was classified as a Rosgen C4 channel type.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for North Burnt Fork Creek are summarized in **Table 5-33**.

Table 5-33. North Burnt Fork Creek Data Compared with Targets

Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	Riffle Pebble Count (mean) % <6mm	Riffle Pebble Count (mean) % <2mm	Grid Toss (mean) Riffle % <6mm	Grid Toss (mean) Pool % <6mm	Channel Form (median) W/D Ratio	Channel Form (median) Entrenchment Ratio	Instream Habitat Residual Pool Depth (ft)	Instream Habitat Pools / Mile	Instream Habitat LWD / Mile	Riparian Greenline % Shrub Cover	Sediment Source Riffle Stability Index
NFBC-11	32.9	MR	C3	12	10	0	**8**	**23.7**	**1.9**	1.4	**32**	444	**55**	NC
NFBC-15	24.2	MR	C3	**18**	**15**	1	1.4	**18.7**	2.7	**1.0**	**42**	**74**	**3**	73

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment, the composite riffle pebble count surface fines < 6 mm and < 2 mm was meeting the target values of < 14% and < 10 % respectively in NFBC 11, but not in NFBC 15. Percent fines as measured by the grid-toss methodology met the target value of < 10% in riffles for both reaches. The target value of < 6% for fines measured by the grid-toss in pool tail-outs was not met in reach NBFC 11. The median width-to-depth ratio did not meet the target value of < 16 in both reaches, and in NFBC 11 the entrenchment ratio was not meeting the target of > 2.5. The mean residual pool depth target value of > 1.1 was not met in NFBC 18. The pool frequency target value of > 49/mile was not met in either reach. LWD frequency did not meet the target value of > 380/mile in NFBC 15. Along the length of both monitoring reaches, the near-stream riparian vegetation made up by deciduous shrubs, failed to meet the target value of > 57%. RSI data was not collected in NFBC 11 because of a lack of suitable riffles. The RSI target value of < 75 was met in NFBC 15.

Other Assessments

In 2005, DEQ collected pebble count data at two sites on North Burnt Fork Creek. At the upper site, surface fines <2mm were 11% and fines <6mm were 19%, exceeding target values for the Middle Rockies Ecoregion. At the lower site, surface fines <2mm were 9% and fines <6mm were 9%.

Biological Data

Macroinvertebrate data samples were collected at two sites in August 2005 and at one site in September 2005 (**Table 5-34**). The Valley MMI target value for macroinvertebrates was not met in C05BRFNC01. Both Mountain MMI and O/E target values for macroinvertebrates were not met for site BURN2, near the mouth of the creek.

Table 5-34. Macroinvertebrate Metrics for North Burnt Fork Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
C05BRFNC01	8/16/2005	Not applicable	**44**	0.89
C05BRFNC02	8/17/2005	Not applicable	62	1.03
BURN2 – near mouth	9/16/2005	**50**	Not applicable	**0.39**

Bold indicates target value was not met.

Summary and TMDL Development Information

Percent fines data suggest a potential problem with sediment deposition in the substrate of North Burnt Fork Creek and much of the other available data suggest potentially significant effects to near and in-stream habitat. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) supports this conclusion, having found that of the 21.8 miles of streambank along North Burnt Fork Creek (double its 10.9 mile length to account for both banks), 21 miles (95%) had significant anthropogenic effects within 100 feet of the channel. Approximately 1.2 of the 21.8 miles of streambank were rated as good condition, and these were located almost entirely in areas where no significant near-stream human activities were observed. The remaining 20.6 miles (94%) were rated as fair or poor condition, entirely in areas where human activity was observed. Those portions of North Burnt Fork Creek's riparian areas that were rated as good condition were dominated by forest land uses; those rated fair or poor were in areas dominated by rural farms and agricultural and hay/pasture lands. Overall, the available data suggest elevated fine sediment levels which appear to be linked to land use activities within the watershed. For this reason, sediment TMDL development will be pursued.

5.4.2.9 Rye Creek

Rye Creek begins in the Sapphire Mountains on the east side of the Bitterroot Valley and flows for 17.5 miles before reaching its confluence with the Bitterroot River south of Darby, Montana. The stream's headwaters are predominately Bitterroot National Forest lands, while approximately the lower 6 miles are bordered by private lands. Rye Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include animal feeding operations (NPS), grazing in riparian or streamside zones, forest roads (road construction and use), and silvicultural activities.

Physical Condition and Sediment Sources

DEQ performed stream assessments at two sites along Rye Creek in 2007. The upper assessment reach, RYEC 28, was located a short distance downstream of the confluence with North Fork Rye Creek. The stream assessment crew noted that the channel was entrenched along this reach, with a narrow band of dense riparian shrubs, primarily comprised of willow and alder. Large eroding banks with notable stratification occurred within the reach. There is currently a horse pasture on the river-left terrace, though it is fenced away from the stream. There is evidence of skid logging on the hillslope along river-left, which burned during the 2000 fires. There were numerous car bodies in the channel at this site, covering approximately 160 feet of streambank. Grass and deciduous shrubs were growing out of the car-bodies. Assessment Reach RYEC 28 was classified as a Rosgen B4 channel type. Assessment reach RYEC 36 was located on private land in the lower watershed a short distance upstream from Highway 93. The stream assessment crew noted that the stream was converted to a ditch in this reach. There were mature/decadent cottonwoods in the overstory along the channel margin, as well as some alders. The banks were undercutting in places and exposed along much of the reach, though retreat was limited since the channel was straight. Assessment reach RYEC 36 was classified as a Rosgen C4 channel type.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for Rye Creek are summarized in **Table 5-35**.

Table 5-35. Rye Creek Data Compared with Targets

Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
				% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
RYEC-28	23.0	IB	B4	**26**	**14**	**15**	7	**16.2**	1.5	1.1	95	**238**	66	**89**
RYEC-36	22.9	IB	C4	**28**	**22**	**27**	**17**	15.3	**1.5**	1.3	**32**	523	57	NC

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment in RYEC 28, the composite riffle pebble count surface fines < 6 mm and < 2 mm did not meet the target values of ≤ 14% and ≤ 8% respectively for either reach. Percent fines, as measured by the grid-toss methodology in riffles, failed to meet the target value of ≤ 10% in either reach. Percent fines in pool tail-outs did not meet the target value of ≤10% in reach RYEC 36. The median width-to-depth ratio did not meet the target value of ≤ 16 in RYEC 28, and the entrenchment ratio target value was not met in RYEC 36. The mean residual pool depth met target values in both reaches. Reach RYEC 28 did not meet its target value of greater than 380/mile. Along the length of both monitoring reaches the near-stream riparian vegetation met the target value of greater than 57% deciduous shrubs. RSI data collected on RYEC 28 did not meet the target value of < 70.

Other Assessments

In 2005, DEQ collected pebble count data at two sites on Rye Creek. At the upper site, surface fines <2mm were 3% and fines <6mm were 12%, meeting target values for streams in the Idaho Batholith ecoregion. At the lower site, surface fines <2mm were 29% and fines <6mm were 36%, failing to meet the target values for streams in the Idaho Batholith ecoregion.

In 2003 the Bitterroot National Forest conducted stream assessments at two locations on Rye Creek in reaches classified as Rosgen B4 channel types. Selected results are presented in **Table 5-36**. All measures of surface fines exceeded target values for streams in the Idaho Batholith ecoregion, as did the width/depth ratio at the Mile 12.4 site.

Table 5-36. Selected BNF data from Rye Creek

Site	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
Mile 12.4	**38**	**38**	**21**	1.8
Mile 6.1	**41**	**37**	16	5

Bold indicates target value was not met.

Biological Data

Macroinvertebrate data samples were collected at two sites in September 2005 (**Table 5-37**). Of the macroinvertebrate metrics, only the Valley MMI at RC1 met target values.

Table 5-37. Macroinvertebrate Metrics for Rye Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
RC1: mile 6.1	9/7/2005	Not applicable	67	**0.61**
RC2: near mouth	9/7/2005	Not applicable	**44**	**0.33**

Bold indicates target value was not met.

Summary and TMDL Development Information

A comparison of existing data to target values suggest elevated levels of sediment in Rye Creek and macroinvertebrate data indicate possible effects to aquatic life. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) supports this conclusion. The study found that of the 35 miles of streambank along Rye Creek (double its 17.5-mile length to account for both banks) 22 miles (63%) had significant anthropogenic effects within 100 feet of the channel. Approximately 12 of the 35 miles of streambank were rated as good condition; while the remaining 23 miles (66%) were rated as fair or poor condition, primarily in areas with human activities. Those portions rated as good condition were dominated by forest land uses; those rated as fair or poor condition were in areas dominated by pastures, timber harvest/fire, and roads. Overall, the available data suggest possible elevated fine sediment levels as well as habitat alterations that appear to be linked to land use activities within the watershed. For this reason, sediment TMDL development will be pursued.

5.4.2.10 Sleeping Child Creek

Sleeping Child Creek begins in the Sapphire Mountains on the east side of the Bitterroot Valley and flows for 24.9 miles before reaching the Bitterroot River near Hamilton, Montana. The headwaters of the stream are dominated by Bitterroot National Forest lands, while the lower reaches are bordered by private lands. Sleeping Child Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include agriculture, highway/road/bridge runoff (non-construction related), and silvicultural activities.

Physical Condition and Sediment Sources

DEQ performed a stream assessment at one site along Sleeping Child Creek in 2007. The assessment reach, SLEE 43, was located on private land in the lower watershed and was classified as a C3 potential channel type. The field assessment crew noted that the creek was channelized along this reach and the banks were stabilized with cobble-size riprap in places. It was one long riffle with a few poorly defined pools. There was a field on river-left and grazing likely occurred historically, if not ongoing. There was a band of mature/decadent cottonwoods along the channel margin with periodic alders in the understory. There was an irrigation pipe across the stream channel upstream of the reach.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for Sleeping Child Creek are summarized in **Table 5-38**.

Table 5-38. Sleeping Child Creek Data Compared with Targets

				Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
SLEE-44	38.5	MR	C3	12	6	8	NC	24.6	**1.6**	1.5	**21**	195	**38**	**83**

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment in reach SLEE 43, the composite riffle pebble count surface fines < 6 mm was 12%, meeting the target of < 14%. The composite riffle pebble count surface fines < 2 mm was 6%, meeting the target of < 10 %. Percent fines as measured by the grid-toss methodology were 8% in riffles, meeting the target value of < 10%. The median width-to-depth ratio of 24.6 met the target value of < 29. The entrenchment ratio of 1.6 did not meet the target of > 2.5. The mean residual pool depth of 1.5 feet met the target value of > 1.3. A pool frequency of 21/mile was observed in the reach, failing to meet the target of >26/mile. LWD frequency was 195/mile, meeting the target of > 195/mile. Along the length of the monitoring reach, 38% of the near-stream riparian vegetation was made up of deciduous shrubs, failing to meet the target of > 57%. The RSI was 83, failing to meet the target value of < 75.

Other Assessments

In 2005, DEQ collected pebble count data at two sites on Sleeping Child Creek, one near the forest road and one near the mouth. Surface fines < 2 mm were 9% at the upper site and 18% at the lower; both sites failed to meet the target value of ≤ 8%. Surface fines <6mm were 10% at the upper site and 24% at the lower site, with the lower site failing to meet the target value of ≤ 14%.

The Bitterroot National Forest conducted stream assessments at two locations on Sleeping Child Creek in 2003. Selected results are presented in **Table 5-39**. Percent fines were generally above targets. Width/depth ratios were within expected ranges for the stream types at both sites.

Table 5-39. Selected BNF Data from Sleeping Child Creek

Site	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
Mile 9.3	**19**	**16**	22	2.9
Mile 20.7	**87**	**61**	7	2.3

Biological Data

Macroinvertebrate data samples were collected at two sites on Sleeping Child Creek in September 2005. O/E metrics fell below the target range for both sites (**Table 5-40**).

Table 5-40. Macroinvertebrate Metrics for Sleeping Child Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
SCC1: near end of road	9/5/2005	72	Not applicable	**0.61**
SSC2: near mouth	9/5/2005	Not applicable	61	**0.54**

Bold indicates target value was not met.

Summary and TMDL Development Information

An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) also showed mixed results. The study found that of the 49.8 miles of streambank along Sleeping Child Creek (double its 24.9 mile length to account for both banks) only 16 miles (33%) had significant anthropogenic effects within 100 feet of the channel. Overall, the available data suggest possible elevated fine sediment levels as well as habitat alterations which appear to be linked to land-use activities within the watershed, macroinvertebrate results indicate potential effects to aquatic life. For this reason, a sediment TMDL will be developed.

5.4.2.11 Sweathouse Creek

Sweathouse Creek begins in the Bitterroot Mountains on the west side of the Bitterroot Valley and flows for 11.2 miles before reaching the Bitterroot River near Victor, Montana. The headwaters of the stream are dominated by Bitterroot National Forest lands, while the lower reaches are bordered by private lands. Although the stream is not currently listed for sediment, it was listed for alterations in streamside vegetation on the 2010 303(d) List, which may be linked to sediment loading. For this reason, Sweathouse Creek was included in this analysis. Suspected sources include site clearing (land development or redevelopment) and loss of riparian habitat.

Physical Condition and Sediment Sources

DEQ performed a stream assessment at one site along Sweathouse Creek in 2007. The assessment reach, SWEA 29, was located on private land in the lower watershed, a short distance upstream from Highway 93 and was classified as a C4 stream type. The assessment field crew noted that this reach flows through grazed area. There was boulder riprap at several meander bends. It appeared that the channel was slightly over-widened and slightly entrenched in places, though wetland vegetation along portions of the channel suggests some recovery. The few willows were heavily browsed. The pools lacked cover. Eroding streambanks were associated with slumping.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for Sweathouse Creek are summarized in **Table 5-41**.

Table 5-41. Sweathouse Creek Data Compared with Targets

				Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
SWEA-29	29	IB	C4	**21**	**12**	8	10	**25**	3	1.6	**42**	**100**	**12**	**91**

Bold indicates target value was not met.

During the 2007 assessment in reach SWEA 29, the composite riffle pebble count surface fines < 6 mm and < 2 mm were 21% and 12%, exceeding their target values of < 14% and < 8%, respectively. Percent fines, as measured by the grid-toss methodology, were 8% in riffles and 10% in pool tail-outs, meeting the target values of < 10%. The median width-to-depth ratio was 25, exceeding the target value of < 16. The entrenchment ratio was 3.0, meeting the target value of > 2.5 for C stream types. The mean residual pool depth of 1.6 met the target of > 1.1. A pool frequency of 42/mile was observed in the reach, not meeting the target of > 49/mile. LWD frequency was 100/mile, not meeting the target value of > 380/mile. Along the length of the monitoring reach, 12% of the near-stream riparian vegetation was deciduous shrubs, falling short of the target value of > 57%. The RSI was 91, which failed to meet the target of < 75.

Other Assessments
In 2005, DEQ collected pebble count data at two sites on Sweathouse Creek, one near the forest boundary and one near the mouth. Surface fines < 2 mm were 8% at the upper site and 29% at the lower. Surface fines < 6 mm were 8% at the upper site and 33% at the lower. Percent fines < 2 mm and < 6 mm failed to meet the target values for the lower site.

Biological Data
Macroinvertebrate data samples were collected at two sites on Sweathouse Creek in September 2005. At the lower site, the O/E target was not met; otherwise, all metrics fell within target ranges (**Table 5-42**).

Table 5-42. Macroinvertebrate Metrics for Sweathouse Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
SHCR1: near forest boundary	9/2/2005	81	Not applicable	1.1
SHCR2: near mouth	9/2/2005	Not applicable	55	**0.34**

Bold indicates target value was not met.

Summary and TMDL Development Information
An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) also showed mixed results. The study found that of the 22.4 miles of streambank along Sweathouse Creek (double its 11.2 mile length to account for both banks), 9.3 miles (42%) had significant anthropogenic effects within 100 feet of the channel. Approximately 14 of the 22.4 miles of streambank were rated as good condition; while the remaining 8.4 miles (38%) were rated as fair or poor condition. Those portions of Sweathouse Creek's riparian areas that were rated as good condition were dominated by forest land uses; those rated as fair or poor were in areas dominated by pastures and rural farms. Overall, the available data suggest possible elevated fine sediment levels as well as habitat alterations which appear to be linked to land-use activities within the watershed. It appears that this reach would recover well with riparian plantings and grazing management. For this reason, a sediment TMDL will be developed.

5.4.2.12 Threemile Creek
Threemile Creek begins in the Sapphire Mountains on the east side of the Bitterroot Valley and flows mostly through private lands for 18 miles before reaching the Bitterroot River north of Stevensville, Montana. Threemile Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include agriculture, irrigated crop production, and rangeland grazing.

Physical Condition and Sediment Sources
DEQ performed a stream assessment at one site along Threemile Creek in 2007. The assessment reach, THRE 35, was located on private land in the lower watershed and was classified as a C4 potential stream type. The field assessment crew noted that Threemile Creek was entrenched in the survey reach, where

historic grazing and agriculture have given way to rural-residential development. Ongoing horse grazing was observed at the site and there were lawns up to the channel margin along most of the reach. There was a band of mature/decadent cottonwoods along the channel margin. Extensive streambank erosion, bare ground, and exposed banks were observed along the channel because of its entrenched character, though most of the banks are not likely retreating very rapidly. The substrate was comprised primarily of sand and fine gravel in pools and runs, while the riffles had some smaller cobbles.

2007 DEQ Data and Comparison with Water Quality Targets

The existing sediment and habitat data compared with the targets for Threemile Creek are summarized in **Table 5-43**.

Table 5-43. Threemile Creek Data Compared with Targets

				Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
Reach ID	**Mean BFW (ft)**	**Level III Ecoregion**	**Potential Stream Type**	**% <6mm**	**% <2mm**	**Riffle % <6mm**	**Pool % <6mm**	**W/D Ratio**	**Entrenchment Ratio**	**Residual Pool Depth (ft)**	**Pools / Mile**	**LWD / Mile**	**Greenline % Shrub Cover**	**Riffle Stability Index**
THRE-35	11.8	MR	C4	**61**	**29**	**49**	**94**	7.1	3.1	0.9	**74**	**137**	63	NC

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment in reach THRE 35, the composite riffle pebble count surface fines < 6 mm and < 2 mm did not meet target values of ≤ 14% and ≤ 10%, respectively. Percent fines as measured by the grid-toss methodology were 49% in riffles and 94% in pool tail-outs, failing to meet the target values of ≤ 10% and ≤ 6%, respectively. The median width-to-depth ratio met the target value of ≤ 16. The entrenchment ratio was 3.1, meeting the target value of > 2.5 for C4 stream types. The mean residual pool depth of 0.9 met its target value of greater than 0.8 feet. A pool frequency of 74/mile was observed in the reach, missing the target value of greater than 84/mile. LWD frequency was 137/mile, not meeting the target value of ≥ 573/mile. Along the length of the monitoring reach, 63% of the near-stream riparian vegetation was dominated by deciduous shrubs, meeting the target of ≥ 57%. No RSI data was collected because of a lack of suitable riffles.

Other Assessments

DEQ collected data at three sites on Threemile Creek in 2005, and the Bitterroot National Forest collected data near the forest boundary in 2004. Selected results from these studies are presented in **Table 5-44**. At the upper site percent fines < 6 mm and < 2 mm were below targets established for streams in the Middle Rockies ecoregion, as were percent fines <2mm at the middle site. Percent fines < 2 mm were exceeded at the lower and middle DEQ sites and the BNF site. Percent fines < 6 mm at the lower DEQ site and the BNF site exceeded the target values established for streams in the Middle Rockies ecoregion. The width/depth ratio at the BNF site exceeded the target value of ≥ 16 for streams with a bankfull width below 20 feet.

Table 5-44. Selected DEQ and BNF Data from Threemile Creek

Agency	Stream Type	Location	Year	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
DEQ	unknown	Upper	2005	4	0	NC	NC
DEQ	unknown	Middle	2005	**30**	9	NC	NC
DEQ	unknown	Lower	2005	**40**	**30**	NC	NC
BNF	B4	Mile 14.4	2004	**18**	**15**	**18**	NC

Bold indicates target value was not met.

Biological Data

Macroinvertebrate data samples were collected at three sites on Threemile Creek in September 2005 (**Table 5-45**). All targets were met for macroinvertebrate metrics at the upper site. For macroinvertebrate metrics at the middle and lower sites, the Valley MMI target was met but the O/E was not.

Table 5-45. Macroinvertebrate Metrics for Threemile Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
Upper Threemile	9/19/2005	78	Not applicable	0.84
Middle Threemile	9/19/2005	Not applicable	51	**0.47**
Lower Threemile	9/19/2005	Not applicable	51	**0.39**

Bold indicates target value was not met.

Summary and TMDL Development Information

Measures of fine substrate sediment levels were consistently outside of target ranges, and macroinvertebrate results suggest potentially negative effects on aquatic life. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) found that of the 36 miles of streambank along Threemile Creek (double its 18 mile length to account for both banks), 27 miles (75%) had significant anthropogenic effects within 100 feet of the channel. Only 12 of the 36 miles of streambank were rated as good condition, while the remaining 24 miles (67%) were rated as in fair or poor condition. Those portions of Threemile Creek's riparian areas that were rated as good were dominated by forest land uses; those rated as fair or poor condition were in areas dominated by agriculture and near-stream roads. Overall, the available data suggests possible elevated fine sediment levels, as well as habitat alterations, which appear to be linked to land-use activities within the watershed. For this reason, a sediment TMDL will be developed.

5.4.2.13 Willow Creek

Willow Creek begins in the Sapphire Mountains on the east side of the Bitterroot Valley and flows for 20.1 miles through mostly private lands to its confluence with the Bitterroot River near Corvallis, Montana. Willow Creek was listed for sedimentation/siltation on the 2010 303(d) List. Suspected pollutant sources include irrigated crop production, loss of riparian habitat, silvicultural activities, and natural sources.

Physical Condition and Sediment Sources

DEQ performed stream assessments at two sites along Willow Creek in 2007. The upper assessment reach, WILL 28, was located on USFS land in the upper watershed. The stream assessment crew noted that there was a field on the terrace on river-right. It appeared that historic vegetation removal may have lead to the stream cutting into the terrace along river-right at two sites within the reach. These cutslopes were contributing sediment from bank erosion process. The area was being used for horse grazing. Pools were formed by LWD and boulders. Some potential spawning gravels were observed. Assessment reach WILL 28 was classified as a Rosgen B4 channel type. The lower assessment reach, WILL 38, was located on private land in the lower watershed. The field assessment crew noted that Willow Creek had essentially been converted to a ditch in this reach and was one long riffle with a few poorly defined pools. There was an irrigation diversion, streambank erosion was limited, and some small riprap was associated with the rural-residential development. Grass and weeds lined the channel, along with a few willows. Assessment reach WILL 38 was classified as a Rosgen C4 channel type.

2007 DEQ Data and Comparison with Water Quality Targets
The existing sediment and habitat data compared with the targets for Willow Creek are summarized in **Table 5-46**.

Table 5-46. Willow Creek Data Compared with Targets

				Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Riparian	Sediment Source
Reach ID	Mean BFW (ft)	Level III Ecoregion	Potential Stream Type	% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Greenline % Shrub Cover	Riffle Stability Index
WILL-28	21.4	MR	B4	**21**	**11**	**14**	NC	14.4	4.1	1.2	69	1753	90	NC
WILL-38	17	MR	C4	**49**	**33**	**37**	**21**	**18.2**	6.3	**0.9**	**26**	**11**	**8**	NC

Bold indicates target value was not met. NC = not collected.

During the 2007 assessment both reaches failed to meet their target values for riffle pebble count surface fines < 6 mm and < 2 mm. In both reaches, percent fines as measured by the grid toss methodology exceeded the target value of < 10% in riffles and in reach WILL 38 exceeded the target value of < 6% for fines for pool-tails. The median width-to-depth ratio in reach WILL 38 did not meet the target value of ≤ 16. The entrenchment ratio of both reaches met their target values. The mean residual pool depth did not meet the target value in WILL 38. Pool frequency was low and did not meet the target value in WILL 38. Along the length of reach WILL 28, 90% of the near-stream riparian vegetation was dominated by deciduous shrubs; however, only 8% of the length of reach WILL 38 had shrub cover, failing to meet the target value of > 57%. RSI was not collected in either reach due a lack of suitable bars.

Other Assessments
DEQ collected data at three sites on Willow Creek in 2004, and the Bitterroot National Forest collected data at two sites in 2003. Selected results from these studies are presented in **Table 5-47**. Both fine sediment targets were exceeded at the upper and lower DEQ sites and the Mile 9 BNF site, and percent fines <2mm were also exceeded at the Middle DEQ site. Width-to-depth ratio met the target values at all but the Mile 9 BNF site and entrenchment ratio failed to meet targets at the Middle DEQ site and the Mile 9 BNF site.

Table 5-47. Selected DEQ and BNF Data from Willow Creek

Agency	Stream Type	Location	Year	% <6mm	% <2mm	Width / Depth Ratio	Entrenchment Ratio
DEQ	B4	Upper	2004	**45**	**39**	12.3	1.9
DEQ	E4	Middle	2004	28	**24**	10	**2.2**
DEQ	E5	Lower	2004	**72**	**66**	9.4	7
BNF	B4	Mile 11.0	2003	7	7	12.7	1.6
BNF	B3	Mile 9.0	2003	**33**	**26**	**29.8**	**1.4**

Bold indicates target value was not met.

Biological Data
Macroinvertebrate data samples were collected at three sites on Willow Creek in July 2004 (**Table 5-48**). For macroinvertebrates at the lower site the O/E target was not met; otherwise, all metrics fell within target ranges.

Table 5-48. Macroinvertebrate Metrics for Willow Creek

Station ID	Collection Date	Mountain MMI	Valley MMI	O/E
Upper Willow	7/11/2004	Not applicable	62	1.08
Middle Willow	7/11/2004	Not applicable	61	1.01
Lower Willow	7/14/2004	Not applicable	55	**0.74**

Bold indicates target value was not met.

Summary and TMDL Development Information
The available fine sediment data generally indicate potentially elevated sediment loading, with most measures of fine substrate particles in excess of established targets. An assessment of riparian condition and near-stream land uses (conducted concurrently with this study) also showed mixed results. The study found that of the 40.2 miles of streambank along Willow Creek (double its 20.1 mile length to account for both banks), 21.8 miles (54%) had significant anthropogenic effects within 100 feet of the channel. Approximately 18.4 miles of the 40.2 miles of streambank were rated as good condition; while the remaining 21.8 miles were rated as fair or poor condition. Those portions of Willow Creek's riparian areas that were rated as good condition were dominated by forest land uses and were entirely in areas with no significant human impact within 100 feet of the stream; those rated as fair or poor condition were in areas dominated by agricultural uses and roads. Overall, the available data suggests elevated fine sediment levels, as well as habitat alterations which appear to be linked to land-use activities within the watershed. For this reason, a sediment TMDL will be pursued.

5.5 TMDL Development Summary

Based on the 303(d) sediment listings and a comparison of existing conditions to water quality targets, 15 sediment TMDLs will be developed in the Bitterroot TPA. **Table 5-49** summarizes the sediment TMDL development determinations and corresponds to **Table E-1**, which contains the TMDL development status for all listed waterbody segments on the 2010 303(d) List. Three of the waterbodies in **Table 5-49** were listed for habitat/low flow alterations, but based on a comparison of existing conditions to water quality targets, will have sediment TMDLs developed.

Table 5-49. Summary of TMDL development determinations

Stream Segment	Waterbody ID	TMDL Development Determination (Y/N)
Ambrose Creek*	MT76H004_120	Y
Bass Creek*	MT76H004_010	Y
Lick Creek	MT76H004_170	Y
Lolo Creek (headwaters to Sheldon Creek)	MT76H005_013	Y
Lolo Creek (Mormon Creek to Mouth)	MT76H005_011	Y
Lolo Creek (Sheldon Creek to Mormon Creek)	MT76H005_012	Y
McClain Creek	MT76H004_150	Y
Miller Creek	MT76H004_130	Y
Muddy Spring Creek	MT76H004_180	Y
North Burnt Fork Creek	MT76H004_200	Y
Rye Creek	MT76H004_190	Y
Sleeping Child Creek	MT76H004_090	Y
Sweathouse Creek*	MT76H004_210	Y
Threemile Creek	MT76H004_140	Y
Willow Creek	MT76H004_110	Y

*Listed for habitat/low flow alterations, but based on a comparison of existing conditions to water quality targets, will have sediment TMDLs developed.

TMDL development for each waterbody segment also addresses the tributary streams in each watershed. Several of these streams were heavily affected by land management activities and the development of sediment allocations throughout the watershed helps focus loading reductions in all tributary watersheds where significant human-caused sediment loading occurs. This results in a comprehensive watershed protection approach versus sorting out individual tributaries for additional sediment TMDL development work in a piece-meal fashion, which uses resources that could be focused on implementation.

5.6 Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and rationale for load reductions from anthropogenic activities within four main source categories: streambank erosion, upland erosion, roads, and stormwater permitted point sources (which generally involve upland erosion or road construction). EPA sediment TMDL development guidance for source assessments states that an inventory of sediment sources should be compiled using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (EPA 1999). Additionally, 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)).

The source assessments evaluated loading from the primary sediment sources using standard DEQ methods, but the sediment loads presented herein represent relative loading estimates in each source category, and, as no calibration has been conducted, should not be considered as actual loading values. Rather, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. Until better information is available, and the linkage between loading and instream conditions becomes clearer, the loading estimates presented here should be considered as an evaluation of the relative contribution from sources and areas that can be further refined in the future through adaptive management.

5.6.1 Streambank Erosion

As discussed in **Section 5.3**, streambank erosion was assessed in 2007 during two monitoring timeframes, with 32 monitoring sites assessed during June/August and 23 monitoring sites assessed during October/November. Streambank erosion data collected at field monitoring sites was extrapolated to the stream reach and stream segment scales based on information in the Aerial Assessment Database, which was compiled in GIS before the data was collected in the field. Streambank erosion data was also used to estimate sediment loading at the watershed scale and to assess the potential to decrease sediment inputs due to streambank erosion. Sediment loading from eroding streambanks was assessed using Bank Erosion Hazard Index (BEHI) measurements and evaluating the Near Bank Stress (NBS) (Rosgen, 1994; Rosgen, 2004). At each assessment reach, BEHI scores were determined based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source 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
- irrigation-shifts in stream energy
- natural sources
- other

Based on the aerial assessment process (described in **Section 5.3**) in which each 303(d) listed waterbody segment is divided into different reaches, streambank erosion data from each 2007 monitoring site was used to extrapolate to the reach scale. The mean value for each unique reach category was applied to unmonitored reaches in the corresponding category to estimate loading associated with bank erosion at the listed stream segment and watershed scales. The potential for sediment load reduction was estimated as a percent reduction that could be achieved if all eroding streambanks could be reduced to a moderate BEHI score (i.e., moderate risk of erosion). For streambanks already achieving this rate, no reduction was applied. The most appropriate BMPs will vary by site, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream, and the application of riparian BMPs are anticipated to lower the BEHI scores and result in the estimated reductions. Although a moderate risk of erosion may not be achievable in all areas, greater reductions will likely be achievable in some areas; reference data (Bengeyfield, 2004) indicate a moderate BEHI score is a reasonable goal. The results are provided to determine a reasonable amount of sediment reduction to sources that influence streambank erosion. For bank erosion, some sources are the result of historical land management activities that are not easily mitigated through changes in current management. In addition, they may be costly to restore and have been irreversibly altered. Therefore, although the sediment load associated with bank erosion is presented in separate source categories (e.g., silviculture and mining), the allocation is presented as a percent reduction expected collectively from human sources.

Assessment Summary

A total sediment load of 758 tons/year was attributed to eroding streambanks within the monitoring sites. Approximately 60% of the sediment load from streambank erosion at the monitoring sites was due to anthropogenic sources, while approximately 40% was from natural sources. Monitoring site assessments suggest that riparian grazing and cropland are the greatest anthropogenic contributors of sediment loads from streambank erosion in the Bitterroot TPA, followed by the "other" category, which primarily describes the effects of residential and commercial encroachment in the watershed. For loads extrapolated to watersheds selected for TMDL development streambank erosion contributes an estimated 21,195 tons of sediment per year, 44% of which is from natural sources **(Table 5-50)**. For loads extrapolated to the entire Bitterroot TPA streambank erosion contributes an estimated 53,514 tons of sediment per year. In addition to that figure, which includes the Upper Lolo Creek TPA, a sediment load of 21,059 tons/year was estimated for the Bitterroot Headwaters TPA based on an estimated sediment load of 18.6 tons/mile/year and 1,132.23 miles of stream. Thus, a total sediment load of 74,574 tons/year is estimated for the entire Bitterroot River watershed. **Appendix E** contains additional information about the streambank erosion source assessment and associated load estimates for the 303(d) listed streams in the Bitterroot TPA.

Table 5-50. Sediment Load from Streambank Erosion and Comparison among Watersheds and Individual Sources

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources								Total Load (Tons/ Year	Total Load per Mile (Tons/ Year
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other		
Ambrose	38.1	**Tons/ Year**	79.9	211.7	341.9	0.0	0.0	0.0	237.6	87.9	959.0	25.2
		Percent	*8%*	*22%*	*36%*	*0%*	*0%*	*0%*	*25%*	*9%*		
Bass	16.1	**Tons/ Year**	5.2	18.7	0.0	0.0	0.0	1.7	205.2	9.9	240.6	14.9
		Percent	*2%*	*8%*	*0%*	*0%*	*0%*	*1%*	*85%*	*4%*		
Lick	9.8	**Tons/ Year**	15.5	47.5	0.0	0.0	0.0	0.0	113.9	3.4	180.3	18.4
		Percent	*9%*	*26%*	*0%*	*0%*	*0%*	*0%*	*63%*	*2%*		
Lolo (Including S. Fork Lolo Creek)	245.8	**Tons/ Year**	1145.7	613.2	188.8	0.0	113.4	127.4	2761.8	477.1	5427.5	22.1
		Percent	*21%*	*11%*	*3%*	*0%*	*2%*	*2%*	*51%*	*9%*		

Table 5-50. Sediment Load from Streambank Erosion and Comparison among Watersheds and Individual Sources

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources								Total Load (Tons/ Year	Total Load per Mile (Tons/ Year
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other		
McClain	7.0	**Tons/ Year**	21.2	40.5	11.1	2.7	0.0	7.1	29.8	0.0	112.4	16.1
		Percent	*19%*	*36%*	*10%*	*2%*	*0%*	*6%*	*26%*	*0%*		
Miller	56.9	**Tons/ Year**	123.7	308.0	554.0	0.0	1.1	46.0	656.5	381.8	2074.0	36.4
		Percent	*6%*	*15%*	*27%*	*0%*	*0%*	*2%*	*32%*	*18%*		
Muddy Spring Creek	2.0	**Tons/ Year**	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
		Percent	*100%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*		
North Burnt Fork	107.0	**Tons/ Year**	199.4	1667.2	383.7	0.0	0.0	70.5	659.6	245.3	2725.7	25.5
		Percent	*7%*	*43%*	*14%*	*0%*	*0%*	*3%*	*24%*	*9%*		
Rye (Including N. Fork Rye Creek)	85.8	**Tons/ Year**	113.4	245.0	155.6	0.0	39.1	62.6	1310.4	9.1	1935.2	22.6
		Percent	*6%*	*13%*	*8%*	*0%*	*2%*	*3%*	*68%*	*0%*		
Sleeping Child	117.4	**Tons/ Year**	80.1	355.9	236.9	0.0	91.2	48.5	1495.0	79.6	2387.2	20.3
		Percent	*3%*	*15%*	*10%*	*0%*	*4%*	*2%*	*63%*	*3%*		
Sweathouse	33.7	**Tons/ Year**	17.2	537.7	9.3	0.1	0.0	51.6	286.7	134.3	1036.9	30.8
		Percent	*2%*	*52%*	*1%*	*0%*	*0%*	*5%*	*28%*	*13%*		
Threemile (Including Ambrose Creek)	120.6	**Tons/ Year**	824.1	194.1	495.2	0.0	0.0	48.6	1087.0	720.6	3369.6	27.9
		Percent	*24%*	*6%*	*15%*	*0%*	*0%*	*1%*	*32%*	*21%*		
Willow	61.3	**Tons/ Year**	70.4	351.4	239.8	0.0	0.0	62.7	784.0	196.8	1705.0	27.8
		Percent	*4%*	*21%*	*14%*	*0%*	*0%*	*4%*	*46%*	*12%*		

5.6.2 Upland Erosion and Riparian Buffering Capacity

Upland sediment loading due to hillslope erosion in the Bitterroot TPA was assessed using a hydrologic simulation model known as SWAT (Soil and Water Assessment Tool). SWAT is a river basin scale model developed that quantifies the impact of land management practices in large, complex watersheds. It incorporates hydrologic, climactic, and water chemistry data with detailed land cover/land use and topography information to predict pollutant loading for seasonal and annual time frames. A SWAT model for the Bitterroot, currently underway for evaluation of sediment and nutrient loads, is being used to represent the typical land uses and associated conditions affecting sediment production. The workings of the model are detailed as part of an initial calibration report (Van Liew, unpublished); however, the tool will be complete when it is refined as part of the nutrient TMDL. Even in its initial form, the tool is useful for estimating landscape sediment yields. Because the model and associated sedimentation results are only preliminary, a simplified approach was implemented for the TMDL analysis. This consisted of the following:

- using the preliminary SWAT model for estimating existing condition baseline upland sediment sources for impaired tributaries in the Bitterroot TPA.
- and analyzing scenarios outside of the model. In this case loads from the preliminary SWAT model are multiplied by a literature-based BMP efficiency to establish the load reductions for the TMDL.

An initial existing-condition scenario was used that incorporated some basic assumptions regarding land use management practices to estimate current existing loads. Changes were then made to parameters outside of the model to represent potential improvements to land management practice improvements, and thereby estimate the sediment loads that could be expected if those practices were adopted. Improvement scenarios were applied to three land-use categories including upland range brush and grass, cultivated crops, and small acreages. It is assumed that in the Bitterroot TPA these land-use categories have real potential for improvement and are often not meeting all applicable land, soil, and water conservation practices. The sediment contributions from other land uses in the Bitterroot TPA are presumed to be either negligible or have little potential to alter the current management to reduce sediment from the existing load. Loads from unpaved roads were assessed separately and are described in **Section 5.6.3**. Because riparian vegetation can greatly influence sediment loading to streams, model results were adjusted downward to reflect the sediment removal capacity associated with existing riparian vegetation and with that reflective of improved riparian health associated with implementation of additional riparian BMPs. Riparian health was classified as poor, fair, or good per listed waterbody for both right and left banks during the aerial stratification process described in **Section 5.3.1.2**. A conservative assumption was made that poor riparian conditions can filter close to 25% of sediment, moderate riparian condition 50% of the sediment, and good riparian condition can reduce upland sediment load by 75%.

The initial model outputs represent an estimate of current conditions and practices that contribute to the upland sediment load. Allocations for upland sediment sources were derived based on a combination of reductions in sediment loads that will occur by improving range brush and grass, cultivated crop, and small acreage management by implementing upland BMPs and improving the condition (i.e., sediment-trapping efficiency) of near-channel vegetation using riparian BMPs. DEQ acknowledges, however, that this simplistic approach may not represent the true potential for that load reduction within a particular land use. Other factors that might otherwise alter the reduction potential of a given source include geography, the association of the riparian conditions to the various land uses, and the actual potential for the application of best management practices within a given land use. However, at the most basic scale, this approach does identify the relative contributions among the land-use categories and therefore serves as a starting point for focusing sediment reduction efforts and assessing those areas most likely to be affecting the stream (and most likely to have the potential for improvement). The allocation to these 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 by historic land uses.

Assessment Summary
Based on the source assessment, hillslope erosion from assessed tributaries contributes approximately 15,463 tons per year to the Bitterroot TPA. Upland erosion from the completed Upper Lolo TMDL was found negligible in the completed TMDL document; therefore, no additional load from the Upper Lolo TPA is included. Hillslope erosion from watersheds selected for TMDL development contributes an approximate 10,797 tons of sediment per year (**Table 5-51**). Based on the assessment on watersheds selected for TMDL development, 70% of the annual load is from range grass and brush, 21% from forests and wetlands, 6% from cultivated crops, 2% from small acreages, and 1% from urban areas. **Appendix H** has a more detailed description of the model setup and results and the riparian adjustment factor.

Table 5-51. Sediment Load from Upland Sources and Comparison among Watersheds*

Subbasin	Loads by SWAT HRU Category (T/year)						Delivered Sediment Load (T/year)	Subbasin Area (sq. miles)	Normalized to tons per square mile
	AGRL	BARN	FRST	RNGB	RNGE	URML			
Ambrose	101.2	18.0	75.9	182.4	210.9	2.2	**590**	**21.1**	**28.0**
Bass	20.0	0.2	6.4	130.9	211.8	0.0	**369**	**15.3**	**24.1**
Lick	0.4	0.0	1.7	0.2	0.2	0.5	**3**	**8.5**	**0.4**
Lolo (Including S. Fork Lolo Creek)	184.0	41.8	1744.5	1914.6	1044.5	15.5	**4944.9**	**203**	**24.4**
McClain	2.4	0.0	32.4	39.0	4.0	0.2	**78**	**4.1**	**19.2**
Miller	0.4	0.2	35.1	41.9	53.1	0.2	**131**	**47.3**	**2.8**
Muddy Spring Creek	0.0	0.0	2.6	8.0	6.9	0.0	**17**	**1.7**	**10.3**
North Burnt Fork	165.2	22.5	11.5	487.1	1591.6	0.9	**2279**	**85.9**	**26.5**
Rye (Including N. Fork Rye Creek)	0.8	0.3	0.0	4.0	4.7	0.0	**10**	**41.7**	**0.2**
Sleeping Child	1.3	2.7	76.9	101.5	60.8	0.1	**243**	**89.5**	**2.7**
Sweathouse	6.8	7.0	27.3	83.5	2.0	0.3	**127**	**28.3**	**4.5**
Threemile (Including Ambrose Creek)	286.7	57.6	280.0	523.1	819.2	7.5	**1974**	**70.7**	**27.9**
Willow	18.2	14.6	90.4	296.7	200.6	0.1	**621**	**48.3**	**12.8**

***SWAT HRU Categories (AGRL – Alfalfa/Grass/Hay/Cultivated Crops; BARN – Small Rural Properties/Livestock; FRST – Deciduous Forest, Evergreen Forest, Wetland; RNGB – Range Brush; RNGE – Range Grass; URML – Medium/ Low Density Urban

5.6.3 Unpaved Roads
Sediment loading from roads was assessed within the Bitterroot TPA in 2007. Roads located near stream channels can affect streams by degrading riparian vegetation, encroaching on the channel, and

increasing sediment loading. The degree of damage depends on many factors including road type, construction specifications, drainage, soil type, topography, precipitation, and the use of best management practices (BMPs). Through a combination of GIS analysis, field assessment, and application of the Water Erosion Prediction Project (WEPP) model, estimated sediment loads were developed for unpaved road crossings and parallel road segments. Road crossings and parallel segments were identified and classified relative to 6^{th} code subwatershed, land ownership, and landscape type. These classifications captured a statistically representative sample of roads in the entire watershed, based on a number of road conditions (subwatershed, road design, soil type, maintenance level, etc). Existing road conditions were modeled and future road conditions were estimated after the application of sediment reducing best management practices (BMPs). Existing culverts were also assessed for fish passage and failure. Field assessments were conducted at 136 unpaved crossings, 63 parallel segments, and 67 culverts.

Unpaved Road Crossings and Parallel Segments

Based on the field measurements, the sediment load was modeled in WEPP by road surface and usage (i.e., high vs. low) and the average for each crossing type and parallel segment was extrapolated to the remaining roads in the watershed. The model was used to approximate the sediment load associated with existing road crossings and parallel segments (and current BMP usage) and the achievable sediment loading reductions associated with implementing additional BMP implementation. Various BMP sediment reduction scenarios were evaluated based on reductions in contributing road length, reductions in road crossing density, and combinations of the two approaches. The selected scenario for estimating sediment load reductions was calculated by assuming a uniform reduction in contributing road length of 200 feet for each unpaved crossing and 500 feet for each parallel road segment. Reductions could be achieved by a variety of BMPs that reduce sediment delivery to streams such as improving ditch relief at crossings, adding water bars, adding vegetative buffers, improving maintenance, and using rolling dips and cross slopes. Additional details regarding the roads assessment are provided in **Appendix G**.

Culverts

Undersized or improperly installed culverts may be a chronic source of sediment to streams or a large acute source during failure, and they may also be passage barriers to fish. Therefore, as part of the roads assessment, the potential sediment load at risk during culvert failure was estimated and culverts were evaluated for fish passage. Culverts were analyzed for their ability to allow for fish passage, and for their ability to pass adequate flood flows. However, it is difficult to develop specific road crossing allocations for sediment delivered in the event of a culvert failure, as there are several factors that may impact the accuracy of the data, therefore specific sediment loads were not developed for each crossing. More details of the culvert analysis are provided in **Appendix G**.

Assessment Summary

Mean sediment loads from field sites were used to extrapolate existing loads throughout the entire watershed. Mean loads for unpaved crossings in mountain (0.12 tons/year), foothill (0.22 tons/year), and valley (0.07 tons/year) landscape types were applied to the total number of crossings in the TPA and further classified by 6th code HUC and land ownership. The existing total Bitterroot watershed sediment load from unpaved road crossings was estimated at 461.3 tons/year; and the total existing load from parallel road segments is estimated at 248.4 tons/year. Loads from unpaved road crossings and parallel segments from watersheds selected for TMDL development contribute an approximate 338 tons of sediment per year (**Table 5-52**).

Table 5-52. Sediment Load from Unpaved Roads and Comparison among Watersheds

Subbasin	Sediment Load From Unpaved Road Crossings	Sediment Load From Unpaved Parallel Road Segments	Total Sediment Load from Unpaved Road Crossings and Parallel Segments	Normalized to tons per square mile
Ambrose	8.1	3.2	11.3	0.54
Bass	1.8	0.4	2.3	0.15
Lick	3.3	2.1	5.4	0.64
Lolo (Including S. Fork Lolo Creek)	90.4	81.4	171.7	0.85
McClain	6.6	2.4	9.1	2.24
Miller	14	12.7	26.7	0.56
Muddy Spring Creek	0.12	0.04	0.16	0.08
North Burnt Fork	12.4	8.4	20.8	0.24
Rye (Including N. Fork Rye Creek)	33.6	30.5	64.1	1.54
Sleeping Child	17.9	12.8	30.7	0.34
Sweathouse	8	2	10	0.35
Threemile (Including Ambrose Creek)	23.8	9.1	32.8	0.46
Willow	9.7	5	14.7	0.30

The majority of sediment load from unpaved road crossings throughout the Bitterroot TPA is generated from crossings on private land (216.6 tons/year), followed by USFS land (177.5 tons/year), and Plum Creek Timber land (57.1 tons/year). The majority of sediment load from unpaved parallel road segments is generated from parallel road segments on USFS land (127.4 tons/year), followed by private land (57.1 tons/year), and Plum Creek Timber land (54.1 tons/year). Additional details regarding these results are included within **Appendix G**. The completed Upper Lolo TMDL document attributes the total sediment contribution from forest roads and sanding on U.S. Highway 12 to be between approximately 623 – 716 tons/year.

5.6.4 Point Sources

There are no municipal or individual permitted point sources of sediment that discharge to tributary streams listed for sediment impairment (**Table 5-1**). However, as of December 8, 2010, there was one stormwater permit covered under the general permit for stormwater discharges associated with mining, oil, and gas activities that discharges into Lolo Creek, and there were seven permits covered under the general permit for stormwater discharges associated with construction activity for the listed tributaries in the in the Bitterroot TPA.

Stormwater Discharge – Mining, Oil, and Gas Activities

The Billingsley Placer Mine has a MPDES stormwater permit covered under the general permit for stormwater discharges associated with mining, oil, and gas activities. This permit regulates the direct discharge of stormwater draining the facility and its grounds. Under the stipulations of that permit, the facility maintains an approved Stormwater Pollution Prevention Plan (SWPPP). The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in stormwater discharges.

According to Attachment B (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/l. The SWPPP for the Billingsley Placer Mine provides information pertaining to site conditions. Based on this information, an area of approximately 3 acres drains the facility to Lolo Creek. The annual average precipitation for this site is approximately 13 inches. Given the 3 acres of disturbed area, 13 inches of precipitation, and using the condition of the benchmark value (100 mg/l), the maximum allowable annual sediment load from this site would equate to approximately 0.4 tons/year. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements (MTR300000), which include a Stormwater Pollution Prevention Plan (SWPPP) with numerous BMPs and site stabilization before a permit can be terminated.

Stormwater Discharge – Construction Activities

Stormwater construction permits are all authorized under General Permit MTR100000. Sediment loadings from regulated construction activities are considered point sources of sediment to surface waters. These discharges occur in response to storm events and the purpose of these permits is to eliminate or minimize the discharge of pollutants from construction activities. Since construction activities at a site are relatively temporary and short term 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. Observations during field work related to TMDL development indicate that most sediment loading associated with permitted construction activities are likely related to inadequate BMP usage and improper maintenance.

Because construction activities are of a temporary nature and the number of construction sites covered by the general permit at any instant of time varies throughout the watershed, we must make a conservative estimate of potential sediment loading that could occur in each impaired watershed at any given time. To estimate the disturbed acreage associated with construction stormwater permits for each listed segment, current permit files for Bitterroot tributaries were evaluated. Each file contains the number of anticipated acres to be disturbed. Currently, only one stormwater construction permit exists that is over 50 acres, which is for ongoing construction of a ski resort in the McClain Creek watershed; however the permit covers a six and a half year time period. All other projects are <50 acres of disturbed area. Project schedules currently range from 1 to 7 years. To use a conservative approach we will estimate the maximum amount of disturbed acres from all construction projects in one year in any given watershed to be 50. Any construction project or combination of construction projects exceeding 50 acres per year in one watershed will need to follow the general permit, specific attention given to the development of the SWPPP and incorporation and installation of the appropriate BMP and BMP combinations necessary for minimizing erosion, maximizing sediment retention on site, and protecting surface waters.

Sediment erosion rates for construction sites were calculated for each specific subbasin using the small rural properties category from the SWAT model (**Appendix H**); due to similarities in land use cover type. These erosion rates were applied to the 50 acre maximum amount of disturbed area due to construction in each watershed to generate a sediment load from construction sites (**Table 5-53**).

The stormwater general permit for construction projects requires each permittee to develop a Stormwater Pollution Prevention Plan (SWPPP), and prior to permit termination, disturbed areas are required to have a vegetative density equal to or greater than 70 percent of the pre-disturbed level (or an equivalent permanent method of erosion prevention). Inspection and maintenance of BMPs is required. BMP implementation is variable throughout the watershed and frequently related to the age of the construction project (i.e. newer projects generally have better BMPs). However, assumptions must be made at a watershed scale; BMPs for disturbed soil are assumed to be the same and have the same potential for sediment reduction in both permitted and non-permitted areas. Based on studies from the U.S. EPA and the International Stormwater Best Management Practices Database, an estimated average of 65% of sediment is removed when all onsite construction BMPs are in place (Geosyntec Consultants and Wright Water Engineers, Inc., 2008; EPA, 2009b). In addition to onsite construction BMPs minimizing sediment, literature review (Wegner, 1999; Knutson and Naef, 1997) indicates that a 100 foot wide, well vegetated riparian buffer zone can be expected to filter 75-90% of incoming sediment from reaching a stream channel. Using both the efficiency percentages of 65% for onsite construction BMPs and 75% for a minimum 100 foot wide buffer between the site and the stream, we get the maximum allowable annual sediment load for each site shown in **Table 5-53**.

Table 5-53. Sediment Loading and Reductions from Permitted Construction Sites

	Loading rate based on SWAT (T/Acre/ Year)	**Load based on 50 acres of disturbance (T/ Year)**	**Load based on 50 acres of disturbance with ONLY construction site BMPs in place (T/Year)**	**Sediment load with 100 ft. vegetated buffer ONLY - BMP efficiency of 75% (T/Year)**	**Resultant sediment load with vegetated buffer applied and all construction BMPs in place (T/Year)**	**Total possible % reduction from construction sites**
Ambrose	2.62	131	46	33	11	92%
Bass	2.03	101	35	25	9	91%
Lick	0.22	11	4	3	1	91%
Lolo	1.51	75	26	19	7	91%
McClain	2.25	112	39	28	10	91%
Miller	0.05	2	1	1	0	100%
Muddy Spring Creek	2.62	131	46	33	11	92%
North Burnt Fork	4.42	221	77	55	19	91%
Rye	0.07	4	1	1	0	100%
Sleeping Child	0.64	32	11	8	3	91%
Sweathouse	0.99	49	17	12	4	92%
Threemile	2.62	131	46	33	11	92%
Willow	2.62	131	46	33	11	92%
AVERAGE OF ALL SUBBASINS	1.74	87	30	22	8	91%

Assessment Summary

Based on calculated loads from permitted sites, erosion from permitted point sources in the Bitterroot tributaries have the potential to contribute approximately 100 tons per year, with 0.4 tons per year contributed from the Billingsley Placer Mine and 97 tons per year coming from construction sites covered under General Permit MTR100000 (if each listed watershed had construction permits totaling 50 acres of disturbed area).

5.6.5 Source Assessment Summary

The estimated annual sediment load from all identified sources for the watersheds selected for TMDL development within the Bitterroot TPA is 32,330 tons per year. Each source type has different seasonal loading rates, and the relative percentage from each source category does not necessarily indicate its importance as a loading source given the variability between source assessment methods. Additionally, the different source assessment methodologies introduce differing levels of uncertainty, as discussed in **Section 5.6**. However, the modeling results for each source category, and the ability to proportionally reduce loading with the application of improved management practices (**Appendices B, D** and **E**), provide an adequate tool to evaluate the relative importance of loading sources (e.g., subwatersheds and/or source types) and to focus water quality restoration activities for this TMDL analysis. Based on field observations and associated source assessment work, all assessed source categories represent significant controllable loads.

5.7 TMDL and Allocations

The sediment TMDLs for the Bitterroot TPA will adhere to the TMDL loading function discussed in **Section 4**, but use a percent reduction in loading allocated among sources. Cover et al. (2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools; it is assumed that a decrease in sediment supply will correspond to a decrease in fine sediment and result in attainment of water quality standards. A percent-reduction approach is used because there is no numeric standard for sediment to calculate the allowable load with and because of the uncertainty associated with the loads derived from the source assessment (which are used to establish the TMDL). Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because it shifts the focus from a set number to loading reductions associated with improvements in land management practices, many of which were identified during TMDL development activities. Within this section, the existing load and allocations to the sources will be given for each waterbody segment and then the TMDL will be provided.

The TMDL is expressed as a percentage of the existing load and is composed of allocations to sources expressed as percent reductions that incorporate an implicit margin of safety. Because sediment generally has a cumulative effect on beneficial uses, and all sources in the Bitterroot TPA (including construction stormwater permits) are associated with periodic loading, an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation. Although EPA encourages TMDLs to be expressed in the most applicable timescale, TMDLs are also required to be presented as daily loads (Grumbles 2006); daily loads are provided in **Appendix I**.

Allocation Approach

The percent-reduction allocations are based on the modeled BMP scenarios for each major source type (e.g. roads, upland erosion, and streambank erosion) and reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions are expected to be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. A summary of the reduction scenarios and BMPs are discussed in **Section 5.6** per major source category, with specific details regarding reductions given in the following paragraphs.

Streambank Erosion

Bank erosion percent reductions are calculated by estimating a potential decrease in sediment loading from anthropogenic sources by improving streambank stability. For assessed stream reaches, reductions were applied by reducing BEHI values that exceeded the “moderate” category down to “moderate.” This was done for each actively eroding streambank due to anthropogenic sources, and the results were extrapolated across the stream segment. Reductions for un-assessed streams were estimated by using the percent reductions calculated for the stream segment(s) associated with that watershed. To discern a distinction between anthropogenic and natural loads for un-assessed streams, the percentage of each category within the associated assessed stream segment(s) for a watershed was applied to the un-assessed streams. This approach assumes that the same anthropogenic impacts exist throughout the watershed.

Upland Erosion

The initial model outputs represent an estimate of current conditions and practices that result in the upland sediment load. To determine the total allowable load from upland sources, land use/land cover categories where management practices may be improved are modified (through an alteration to the C-Factor, or vegetative condition) to simulate the resultant sediment loads that exist when all reasonable land, soil, and water conservation practices are employed. Upland percent-reductions are based on applying specific land use BMPs to agricultural, range, and small acreage lands in combination with riparian BMPs for all land uses. The naturally occurring load is considered equal to the load achieved with all reasonable land, soil and water conservation practices in place.

Unpaved Roads

Percent-reductions for unpaved roads are based on applying BMPs to road crossings and parallel segments to reduce the contributing road length to 200 feet for each unpaved crossing and 500 feet for each parallel road segment. No load or allocation is given to undersized, improperly installed, or inadequately maintained culverts. At a minimum, culverts should meet the 25-year event, but for fish-bearing streams, for those with a high level of road and impervious surface development upstream, or for culvert sites with large fills, meeting the 100-year event is recommended.

Point Source

The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements for stormwater under mining, oil, and gas (MTR300000) and construction (MTR100000), which include a Stormwater Pollution Prevention Plan (SWPPP) with numerous BMPs and site stabilization before a permit can be terminated.

Allocation Assumptions

Sediment load reductions are given at the watershed scale, and are based on the assumption that the same sources that affect a listed stream segment affect other streams within the watershed and that a similar percent sediment load reduction can be achieved by applying BMPs throughout the watershed. However, it is acknowledged that conditions are variable throughout a watershed, and even within a 303(d) stream segment, and this affects the actual level of BMPs needed in different areas, the practicality of changes in some areas (e.g. considering factors such as public safety and cost-effectiveness), and the potential for significant reductions in loading in some areas. Also, as discussed in **Section 4.4**, note that BMPs typically correspond to all reasonable land, soil, and water conservation practices, but additional conservation practices above and beyond BMPs may be required to achieve compliance with water quality standards and restore beneficial uses.

Sediment loading values and the resulting TMDLs and allocations are acknowledged to be coarse estimates. Progress towards TMDL achievement will be gauged by permit adherence for WLAs, BMP implementation for nonpoint sources, and improvement in or attainment of water quality targets. 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 and/or models used to develop the loads and percent reductions presented within this document.

The sediment TMDLs for all streams and stream segments presented below are expressed as a yearly load, and a percent reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in the associated tables (**Tables 5-54 through 5-56 and tables 5-59 through 5-70**).

5.7.1 Ambrose Creek (MT76H004_120)

Table 5-54. Ambrose Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		11	4	65%
Eroding Banks	Anthropogenically Influenced	721	296	44%
	Natural	238	238	
Upland Erosion	All Land Uses	590	338	43%
Point Source	Stormwater Construction	0	11*	0%
Total Sediment Load		1560	887	43%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.2 Bass Creek (MT76H004_010)

Table 5-55. Bass Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		2	0.7	68%
Eroding Banks	Anthropogenically Influenced	36	30	2%
	Natural	204	204	
Upland Erosion	All Land Uses	369	313	15%
Point Source	Stormwater Construction	0	9*	0%
Total Sediment Load		611	556.7	9%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.3 Lick Creek (MT76H004_120)

Table 5-56. Lick Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		5	2	66%
Eroding Banks	Anthropogenically Influenced	66	47	11%
	Natural	114	114	
Upland Erosion	All Land Uses	3	2	32%
Point Source	Stormwater Construction	0	1*	0%
Total Sediment Load		188	166	12%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.4 Lolo Creek

Bank erosion and unpaved road source assessments for Lolo Creek were originally estimated for the entire Lolo watershed, which includes the Upper Lolo TPA. In order to calculate loads and reductions specific to the subwatersheds for each listed segment, the area was calculated for each subwatershed and that percent area in comparison to the total Lolo Creek watershed area was used to recalculate totals for each listed segment subwatershed.

Although presented separately in the following tables, each impaired segment's TMDL consists of any upstream allocations as well, including any allocations from the Upper Lolo TMDL document (**Table 5-57**). **Table 5-58** describes the TMDL and allocation components for each listed segment of Lolo Creek.

Table 5-57. Upper Lolo TPA Sediment TMDL

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads	2201 - 2294	1940 - 2002	12 - 13%
Eroding Banks	N/A	N/A	N/A
Upland Erosion	N/A	N/A	N/A
Point Source	N/A	N/A	N/A
Total Sediment Load	2201 - 2294	1940 - 2002	12 - 13%

Table 5-58. Lolo Creek Cumulative Sediment TMDL

Subwatershed	Cumulative Sediment TMDL
Upper Lolo TPA	Upper Lolo TPA TMDL
Lolo Creek MT76H005_013	Upper Lolo TPA TMDL + Lolo Creek MT76H005_013 TMDL
Lolo Creek MT76H005_012	Upper Lolo TPA TMDL + Lolo Creek MT76H005_013 TMDL + Lolo Creek MT76H005_012 TMDL
Lolo Creek MT76H005_011	Upper Lolo TPA TMDL + Lolo Creek MT76H005_013 TMDL + Lolo Creek MT76H005_012 TMDL + Lolo Creek MT76H005_011 TMDL

5.7.4.1 Lolo Creek – Headwaters to Sheldon Creek (MT76H005_013)

Table 5-59. Lolo Creek MT76H005_013 Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		41	15	63%
Eroding Banks	Anthropogenically Influenced	863	362	28%
	Natural	897	897	
Upland Erosion	All Land Uses	1125	820	27%
Point Source	Stormwater Construction	0	7*	0%
Total Sediment Load		2926	2101	28%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.4.2 Lolo Creek – Sheldon Creek to Mormon Creek (MT76H005_012)

Table 5-60. Lolo Creek MT76H005_012 Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		84	31	63%
Eroding Banks	Anthropogenically Influenced	1762	740	28%
	Natural	1833	1833	
Upland Erosion	All Land Uses	2690	2086	22%
Point Source	Stormwater Construction	0	7*	0%
	Billingsley Placer Mine	0	0.4	0%
Total Sediment Load		6369	4697.4	26%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.4.3 Lolo Creek – Mormon Creek to Mouth (MT76H005_011)

Table 5-61. Lolo Creek MT76H005_011 Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		1.72	0.64	63%
Eroding Banks	Anthropogenically Influenced	37	16	28%
	Natural	37	37	
Upland Erosion	All Land Uses	199	122	39%
Point Source	Stormwater Construction	0	7*	0%
Total Sediment Load		275.72	182.64	34%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.5 McClain Creek (MT76H004_150)

Table 5-62. McClain Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		9	3	67%
Eroding Banks	Anthropogenically Influenced	82	71	10%
	Natural	30	30	
Upland Erosion	All Land Uses	78	57	28%
Point Source	Stormwater Construction	0	10*	0%
Total Sediment Load		199	171	14%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.6 Miller Creek (MT76H004_130)

Table 5-63. Miller Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		27	10	63%
Eroding Banks	Anthropogenically Influenced	1415	792	30%
	Natural	659	659	
Upland Erosion	All Land Uses	131	77	41%
Point Source	Stormwater Construction	0	0*	0%
Total Sediment Load		2232	1538	31%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit.

5.7.7 Muddy Spring Creek (MT76H004_180)

Table 5-64. Muddy Spring Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		0.16	0	0%
Eroding Banks	Anthropogenically Influenced	0	0	0%
	Natural	0*	0	
Upland Erosion	All Land Uses	17	15	14%
Total Sediment Load**		17	15	14%

*Bank erosion sediment loads from 1st order streams were assumed to be negligible due to their relatively low sediment contribution. As a result, for extrapolation purposes, 1st order streams were given a sediment load of 0. Muddy Spring Creek is a first order stream for its entire length. DEQ acknowledges that there may be a small natural sediment load occurring in Muddy Spring Creek; however, to be consistent with the approach, the bank erosion load is set at 0. (**See Appendix E**). **Because Muddy Spring Creek resides in USFS land, and no new construction is foreseen by the USFS, point sources due to stormwater construction were not included.

5.7.8 North Burnt Fork Creek (MT76H004_200)

Table 5-65. North Burnt Fork Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		21	8	62%
Eroding Banks	Anthropogenically Influenced	2070	952	41%
	Natural	656	656	
Upland Erosion	All Land Uses	2279	1195	48%
Point Source	Stormwater Construction	0	19*	0%
Total Sediment Load		5026	2830	44%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.9 Rye Creek (MT76H004_190)

Table 5-66. Rye Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		64	24	63%
Eroding Banks	Anthropogenically Influenced	621	379	13%
	Natural	1314	1314	
Upland Erosion	All Land Uses	10	7	33%
Point Source	Stormwater Construction	0	0*	0%
Total Sediment Load		2009	1724	14%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit.

5.7.10 Sleeping Child Creek (MT76H004_090)

Table 5-67. Sleeping Child Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		31	11	63%
Eroding Banks	Anthropogenically Influenced	885	593	12%
	Natural	1502	1502	
Upland Erosion	All Land Uses	243	197	19%
Point Source	Stormwater Construction	0	3*	0%
Total Sediment Load		2661	2306	13%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.11 Sweathouse Creek (MT76H004_210)

Table 5-68. Sweathouse Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		10	3	68%
Eroding Banks	Anthropogenically Influenced	749	315	42%
	Natural	288	288	
Upland Erosion	All Land Uses	127	95	25%
Point Source	Stormwater Construction	0	4*	0%
Total Sediment Load		1174	705	40%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.12 Threemile Creek (MT76H004_140)

Table 5-69. Threemile Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		22	7	67%
Eroding Banks	Anthropogenically Influenced	2288	1098	35%
	Natural	1082	1082	
Upland Erosion	All Land Uses	1384	836	40%
Point Source	Stormwater Construction	0	11*	0%
Total Sediment Load		4776	3034	36%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.7.13 Willow Creek (MT76H004_110)

Table 5-70. Willow Creek Sediment TMDL

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Sediment Load Allocation (Percent Reduction)
Roads		15	5	66%
Eroding Banks	Anthropogenically Influenced	922	461	27%
	Natural	783	783	
Upland Erosion	All Land Uses	621	394	37%
Point Source	Stormwater Construction	0	11*	0%
Total Sediment Load		2341	1654	29%

* This allocation represents the maximum allowable load under the constraints of the current Stormwater Construction permit. Full compliance with all conditions of the permit should achieve a load less than this amount.

5.8 Seasonality and Margin of Safety

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

5.8.1 Seasonality

The seasonality of sediment impact to aquatic life is taken into consideration in the analysis within this document. Sediment loading varies considerably with season. For example, sediment delivery increases during spring when snowmelt delivers sediment from upland sources and the resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportion of deposited fines in critical areas for fish spawning and insect growth. While fish are most susceptible to fine sediment deposition seasonally during spawning, fine sediment may affect aquatic insects throughout the year. Because both fall and spring spawning salmonids reside in the Bitterroot TPA, streambed conditions need to support spawning through all seasons. Additionally, reduction in pool habitat, by either fine or coarse sediment, alters the quantity and quality of adult fish habitat and can, therefore, affect the adult fish population throughout the year. Thus, sediment targets are not set for a particular season, and source characterization is geared toward identifying average annual loads. Annual loads are appropriate because the impacts of delivered sediment are a long-term impact once sediment enters the stream network, it may take years for sediment loads to move through a watershed. Although an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation, to meet EPA requirements daily loads are provided in **Appendix I**.

5.8.2 Margin of Safety

Incorporating a margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA 1999). All sediment TMDLs in this document incorporate an implicit MOS in a variety of ways:

- By using multiple targets, including biological indicators, to help verify beneficial use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during target development (see **Section 5.4.1**).
- By using targets and TMDLs that address both coarse and fine sediment delivery.
- Conservative assumptions were used for the source assessment process, including erosion rates, sediment delivery ratio, and BMP effectiveness (see **Appendices B**, **D**, and **E**).
- By considering seasonality (discussed above) and yearly variability in sediment loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below and in **Section 8**).

- By using naturally occurring sediment loads as described in ARM 17.30.602(17) to establish the TMDLs and allocations. This includes an allocation process that addresses all known human sediment causing activities, not just the significant sources.
- TMDLs are developed at the watershed scale so that human sources are addressed beyond just the listed waterbody segment scale, which should also improve conditions within and reduce loading to other waterbodies within the watershed.

5.8.3 Uncertainty and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes related to sediment. Because sediment has narrative water quality standards, the impairment characterization is based on a suite of water quality targets and the TMDL is based on loads derived from the source assessment; the relationship between sources and the instream condition is not straightforward and is variable among watersheds. Additionally, the assessment methods and targets used in this study to characterize impairment and measure future restoration are each associated with a degree of uncertainty.

For the purpose of this document, adaptive management 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. Adaptive management addresses important considerations, such as feasibility and uncertainty in establishing targets. For example, despite implementation of all restoration activities (**Section 8**), the attainment of targets may not be feasible due to natural disturbances, such as forest fires, flood events, or landslides.

The targets established in the document are meant to apply under median conditions of natural background and natural disturbance. The goal is to ensure that management activities achieve loading approximate to the TMDLs within a reasonable timeframe and prevent significant excess loading during recovery from significant natural events. Additionally, the natural potential of some streams could preclude achievement of some targets. For instance, natural geologic and other conditions may contribute sediment at levels that cause a deviation from numeric targets associated with sediment. Conversely, some targets may be underestimates of the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluations. In these circumstances, it is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

Some of the target parameters can be indicators of excess coarse sediment (e.g. RSI, pool frequency, and residual pool depth), but most of the direct sediment measures used as targets to assess stream condition focus on the fine sediment fraction found on the stream bottom, while the source assessments included all sediment sizes. In general, roads and upland sources produce mostly fine sediment loads, while streambank erosion can produce all sizes of sediment. Additionally, none of the source assessment techniques were calibrated, so instream measurements of suspended solids/bedload and associated loads will likely not correlate to modeled loads. Therefore, because sediment source modeling may under- or over-estimate natural inputs due to selection of sediment monitoring sections and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each watershed. Instead, source assessment model results should be considered as a tool to estimate sediment loads and make general comparisons of sediment loads from various sources.

Cumulatively, the source assessment methodologies address average sediment source conditions over long timeframes. Sediment production from both natural and human sources is driven by storm events. Pulses of sediment are produced periodically, not uniformly, through time. Separately, each source assessments methodology introduces different levels of uncertainty. For example, the road erosion method focuses on sediment production and sediment delivery locations from yearly precipitation events. The analysis included an evaluation of road culvert failures, which tend to add additional sediment loading during large flood events and increase the average yearly sediment loading if calculated over a longer time period. However, estimated loads were not incorporated into the TMDLs because the probability of culvert failure in a given year is difficult to determine and calculated peak flows for each culvert may substantially over or underestimate peak discharge, which could greatly affect the estimated culvert capacities and fill at-risk. The bank erosion method focuses on both sediment production and sediment delivery. The hillslope erosion model focuses primarily on sediment production across the landscape during typical rainfall years. Sediment delivery is a function of distance to the stream channel; however, upland loads are likely overestimated because the model does not account for upland or instream sediment routing. The significant filtering role of near-stream vegetated buffers (riparian areas) was incorporated into the hillslope analysis (**Appendix H**), resulting in proportionally reduced modeled sediment loads from hillslope erosion relative to the average health of the vegetated riparian buffer throughout the watershed. Additional discussion regarding uncertainty for each source assessment is provided in **Appendices E, G,** and **H.**

Because the sediment standards relate to a waterbody's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental, or injurious to beneficial uses, the percent-reduction allocations are based on the modeled upland and riparian BMP scenarios for each major source type. The allocations reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. However, if new information becomes available regarding the feasibility or effectiveness of BMPs, adaptive management allows for the refinement of TMDLs and allocations.

Additionally, as part of this adaptive management approach, shifts in the amount or intensity of land use activities should be tracked and incorporated into the source assessment to determine if allocations need to be revised. Cumulative impacts from multiple projects must also be considered. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Under these circumstances, additional targets and other types of water quality goals may need to be developed to address new stressors to the system, depending on the nature of the activity.

6.0 - TEMPERATURE

This section focuses on temperature as an identified cause of water quality impairment in the Bitterroot TPA. It describes: 1) the specific stream segments of concern; 2) the mechanisms by which temperature impairs beneficial uses of streams; 3) temperature targets and the available data pertaining to temperature impairments; 4) contributing sources of temperature impairment (thermal load) based on recent studies; and 5) the temperature TMDLs, allocations, and margin of safety.

6.1 STREAM SEGMENTS OF CONCERN

A number of waterbody segments in the Bitterroot TMDL Planning Area (TPA) appeared on the 2010 Montana impaired waters list with temperature limiting a beneficial use. The middle segment of the Bitterroot River (from Skalkaho Creek to Eightmile Creek) was identified as impaired by temperature conditions on Montana's 2010 impaired waters list. Mill, Miller, Sleeping Child, and Willow creeks are also identified as impaired by thermal conditions. A thermal-loading TMDL will be completed for all these waterbodies except Mill Creek. A temperature TMDL will also be completed for the lower section of the Bitterroot River because the TMDL assessment indicated this segment doesn't meet temperature standards.

6.2 ASSESSMENT METHODS

DEQ collected temperature, vegetation, channel condition, and stream flow data using both aerial photos and on-the-ground monitoring. A thermal infrared video flight (TIR) was also completed on the Bitterroot River and selected tributaries (**Attachment A**). Using the collected data for calibration, a QUAL2K hydrology, shade, and temperature model was constructed. The results of this assessment and modeling are provided in **Attachment B**. The results of the monitoring and modeling efforts form the basis for the TMDL components that follow. **Section 6.5** includes a summary of the source assessment results for each stream.

Wasteloads for wastewater treatment plants (WWTPs) were assessed using a QUAL2K model; however, the modeled wasteloads were based on average monthly flows reported to DEQ by the facilities (**Attachment B**). Additional assessments after the QUAL2K modeling estimated peak WWTP and Missoula Stormwater (MS4) discharges to compare instream conditions with wasteload allocations (WLAs) during warm, midsummer afternoons. Hourly peak WWTP and MS4 discharge rates were compared to 7Q10 instream flows using mixing equations. The QUAL2K model was also used to assess interactions between individual discharges and is provided as an addendum to the modeling report (**Attachment C**). Peak flows are used for assessing WWTP and MS4 discharges because of hourly dynamic thermal conditions found in western Montana, which are likely to affect the trout fishery, the most sensitive use related to thermal conditions (**Attachment D**).

6.3 THERMAL EFFECTS ON SENSITIVE USES

Human influences that reduce stream shade, increase stream channel width, add heated water, or decrease the ability of the stream to regulate solar heating all increase stream temperatures. Warm temperatures have negative effects on aquatic life and fish, which depend upon cool water for survival. Warmer water temperatures exert more stress on fish by effecting metabolism and reducing the amount of oxygen available in the water. This in turn may cause coldwater fish, and other aquatic species, to feed less frequently and use additional energy to survive in thermal conditions above their tolerance range. Assessing thermal effects upon a use is an important initial consideration during the TMDL process, although the TMDL components will be based on Montana's water quality temperature standards, which are reviewed in the next section.

Special temperature considerations are warranted for the westslope cutthroat trout, which are listed in Montana as a species of concern. Recently conducted research by Bear et al, (2005) found the upper incipient lethal temperature (UILT) for westslope cutthroat trout is 67°F (20°C). The UILT is the temperature considered to be survivable indefinitely by 50% of the westslope cutthroat population (Bear, et al., 2007). The lethal concentration (LD10) for westslope cutthroat is 71°F (21.8°C), which is the temperature that, on a sustained basis, will kill 10% of the population in a 24-hour period (Lines and Graham, 1988). Westslope cutthroats have maximum growth around 56.5°F (13.6°C) (Bear, et al., 2007).

Bull trout are listed as threatened under the U.S. Endangered Species Act. UILT for Bull Trout is 68.5°F (20.3°C) (Selong, et al., 2001). The LD10 for bull trout is 74°F (23.4°C) (McCullough and Spalding, 2002). Bull trout have maximum growth near 59.5°F (15.3°C) (McCullough and Spalding, 2002).

The whole length of the Bitterroot River is designated critical bull trout core habitat. Low numbers of bull trout are found in the upper reaches of the Bitterroot River above Hamilton and its two main forks. Bull trout are uncommon below Skalkaho Creek (near Hamilton) in the thermally impaired segment of the Bitterroot River. The upper segment of the Bitterroot River supports cutthroat trout, with a small portion of the population containing pure genetics. Rainbow and brown trout dominate the Bitterroot River fishery in the middle and lower segments.

Mill Creek maintains rainbow and brown trout in the lower elevations. Hybrid cutthroat trout and a small population of bull trout are found in the higher elevations of Mill Creek. Willow Creek contains brook, rainbow, and hybrid cutthroat trout. Miller Creek supports similar fish species as Willow Creek. Sleeping Child Creek contains populations of bull trout and pure cutthroat trout in higher elevations and brown and rainbow trout in the lower elevations. Sleeping Child Creek is proposed as core bull trout habitat.

6.4 Temperature Standards and Targets

6.4.1 Temperature Standards and Interpretation

Montana's water quality standard for temperature specifies a maximum allowable increase above the "naturally occurring" temperature in order to protect the existing thermal regime for fish and aquatic life. For waters classified as B-1, the maximum allowable increase over the naturally occurring temperature is 1°F, if the naturally occurring temperature is less than 66°F. Within the naturally occurring temperature range of 66 to 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 [ARM 17.30.622(e) and ARM 17.30.623(e)]. Note that under Montana water quality law, "naturally occurring" temperatures incorporate natural sources, yet may also include human sources with reasonable land and water management activities. Instream temperature monitoring and predictive modeling both indicate that naturally occurring stream temperatures in most of the Bitterroot TPA are likely at or greater than 66.5°F during part of the summer, which is the most sensitive timeframe for supporting fishery use. Based on this analysis, the maximum allowable increase from unmitigated human causes would be 0.5°F.

Water temperature, flow, channel dimension, and riparian shade data were incorporated in a QUAL2K water quality model (**Attachment B**) to assess existing water temperatures. Modeling is used to determine if human-caused disturbances in the watershed increase the water temperature above the naturally occurring level, and if so, to what degree. The potential to reduce stream temperatures through various management measures was also modeled based on varied scenarios.

Model results from an existing condition scenario and a scenario simulating reasonable land, soil, and water conservation practices were used to assess existing and potential water temperature conditions relative to Montana's water quality standards. The difference in temperatures is used to indicate if Montana's water quality temperature standard is likely being met or exceeded. The relationship between human disturbances and water temperature impairments as described in ARM 17.30.623(e) was evaluated for each stream of concern. The following decision process is applied for each stream:

> If the existing condition QUAL2K result equals or is less than 0.5°F higher than the restoration condition QUAL2K model scenario where all reasonable land, soil and water conservation practices were applied, then anthropogenic sources were concluded to not be causing or contributing to violations of the relevant B-1 water temperature standards and the stream is considered to meet the standard. In this case a TMDL is not provided.
>
> If the existing condition QUAL2K result is higher than 0.5°F compared to the restoration condition QUAL2K model scenario where all reasonable land, soil and water conservation practices were applied, then anthropogenic sources were concluded to be causing or contributing to violations of the relevant B-1 water temperature standards and the stream is considered to not meet the temperature standard. In this case a TMDL was completed.

6.4.1.1 Framework for Setting Temperature Targets

Ultimately, Montana's temperature water quality standard forms the primary basis for all temperature targets. The standard is difficult to assess without the use of a water quality model. DEQ collected data relative to the targets and used a QUAL2K model to simulate thermal conditions in each watershed; however, no model can ever fully simulate all the dynamic and complex factors that affect water quality without making some assumptions and expecting some error. Montana's temperature standard is the primary target that must be satisfied. Alternatively, compliance with standards can be satisfied by meeting all other targets: shade, channel width-to-depth (W/D) ratio, discrete sources, and streamflow that define naturally occurring conditions for each temperature influencing factor.

In this alternative approach, if all reasonable land, soil, and water conservation practices are installed or practiced, state standards are met. These alternative targets, which need to be met in combination, are referred to as "temperature-influencing targets" (**Table 6-1**). These targets are prescribed to the whole watershed.

Riparian Canopy Cover

Increased shading from riparian vegetation reduces sunlight hitting the stream, and thus reduces heat load from directly entering the stream. Riparian vegetation also creates a microclimate that is cooler than the surrounding landscape, which also reduces stream temperature. The target is a percent change in riparian canopy cover that will achieve reference potential. Human influences reducing riparian canopy cover are due to present or historic agricultural activities, suburban areas, timber harvest, and some limited areas of recreational activity in the Bitterroot watershed.

Width-to-Depth Ratio
A lower width to depth ratio equates to a deeper, narrower channel that has a smaller contact area with warm afternoon air. Also a lower width to depth ratio will increase the effectiveness of shading produced by the riparian canopy. Almost all stream channel widening in the watershed is due to present or historic agricultural activities, mostly riparian area grazing. Suburban impacts are a lesser source of channel widening. The targets provided are a reduction in bankfull width to depth ratios.

Instream Discharge Rate (stream flow conditions)
Larger volumes of water take longer to heat up during the day. The volumetric heat capacity of the stream is reduced if water is diverted from a stream and used inefficiently. Increased instream flow volume may be accomplished by voluntary actions of irrigators to improve irrigation efficiency. Reduced stream flow is entirely due to agricultural or suburban land activities where inefficient irrigation practices are used. This target is presented as an increase in irrigation efficiencies. These efficiencies should be implemented in a way that does not significantly reduce groundwater return flow to the watershed's streams during July through September.

Irrigation Return Flow
Irrigation return flows may result from agricultural irrigation systems. This source may provide increased thermal load and warm a stream. The target is a specific reduction in surface water irrigation return flows which are warmer than natural stream water temperature.

Wastewater Treatment Plant Effluents
Wastewater treatment plant (WWTP) effluents may increase a stream's water temperature. WWTP effluents shall not warm the stream individually or in combination by more than 0.25°F. This is half of the allowable increase in temperature under Montana's temperature standard which applies to the Bitterroot River.

Missoula Urban Runoff (permitted MS4 point source)
The initial flush of heated urban runoff from paved areas during summer storms may increase a stream's water temperature. The affects upon water temperature from this source are brief and very periodic. The target for this source will be to follow conditions in the Missoula MS4 permit, which should provide little to no increase in initial flush of heated urban runoff from paved areas by promoting water retention and infiltration at building sites. If runoff rates increase, infiltration of initial runoff should be considered in the collection system.

Table 6-1. Temperature Targets

Water Quality Targets	Criteria
Maximum allowable increase over naturally occurring temperature	For waters classified as B-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 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.
OR meet ALL of the temperature influencing restoration targets below	
Riparian Shade	Comparable to reference areas where riparian vegetation is managed with reasonable conservation practices.
Channel width/depth ratio	Comparable to reference conditions. See **Section 5.4.1.2**.

Table 6-1. Temperature Targets

Water Quality Targets	Criteria
Irrigation water management	15% improvement in irrigation efficiency during the summer (June through September).
Inflows to stream network	Reduce warm irrigation return flow water entering the stream network by 75%.
Wastewater Treatment Plants (if present)	No WWTP caused surface water inflow, in single or in combination, will increase temperatures more 0.25°F during the summer (June-Sept).
Missoula Urban Runoff (if present)	At minimum, follow the control measures provided in Part II, 5.a.vii. of the Missoula Area MS4 permit, or any comparable initial flush stormwater capture or interception control measures in subsequent permits renewals.

6.4.2 Framework for Temperature TMDL 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 (see **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 (**Equation 6-1**). 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.

Equation 6-1 $TMDL = \Sigma WLA + \Sigma LA + MOS$.

Where:

ΣWLA = Wasteload Allocation = Pollutants from NPDES Point Sources
ΣLA = Load Allocation = Pollutants from Nonpoint Sources + Natural Sources
MOS = Margin of Safety

For temperature TMDLs, because of the dynamic temperature conditions throughout the course of a day, the TMDL is the thermal load, at an instantaneous moment, associated with the stream temperature when in compliance with Montana's water quality standards. As stated earlier, the temperature standard for streams in the Bitterroot TPA is defined as follows: For waters classified as B-1, the maximum allowable increase over the naturally occurring temperature is 1°F, if the naturally occurring temperature is less than 66°F. Within the naturally occurring temperature range of 66 to 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 [ARM 17.30.622(e) and ARM 17.30.623(e)]. Montana's temperature standard for B1 classified waters is depicted in **Figure 6-1**.

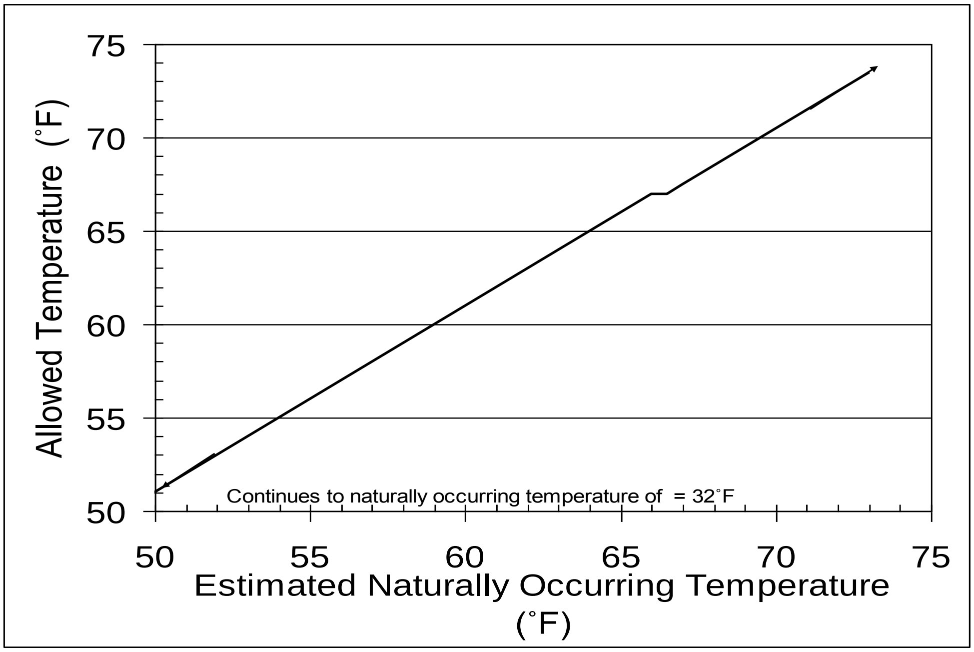

Figure 6-1. Instream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

An instantaneous load is computed by the second and applies at all times. The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure 6-1**) and using a modeled, measured, or estimated naturally occurring instantaneous temperature. The instantaneous total maximum load (per second) at any location in the waterbody is provided by **Equation 6-2**. The allowable loading over a second is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kCal increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure 6-1**.

Equation 6-2

$(\Delta-32)*(Q)*(15.6)$ = Instantaneous Thermal Maximum Load (ITML)

Where:

Δ = allowed temperatures from **Figure 6-1**
Q = instantaneous discharge in CFS
ITML = Allowed thermal load per second in kilocalories, above waters melting point
Conversion factor = 15.7

A total maximum daily heat load is easily calculated using average daily temperature calculations and applying them to **Figure 6-1** and **Equation 6-3**. The resulting average daily load is not of much use since diurnal shifts in temperature create average daily conditions, which in many circumstances do not deviate from Montana's temperature standard at a daily timeframe and do not protect the use. Fish are most distressed by temperatures during summer afternoons; this is also usually the most sensitive timeframe in regard to human-caused thermal loading. Providing thermal loads based upon an average daily temperature does not protect fish because extreme conditions are averaged throughout the day.

Nevertheless, EPA requires total maximum daily loads be provided (**Equation 6-3**). This equation pertains to all TMDLs presented in this document but is not used in any further analysis. ITML (**Equation 6-2**) is used for all further numeric heat load analysis and is protective of the affected use.

Equation 6-3

$(\Delta\text{-}32)*(Q)*(1.36*10^6)$ = Total Maximum Daily Load (TMDL)

Where:

Δ = allowed temperatures from **Figure 6-1**
Q = instantaneous discharge in CFS
TMDL = Allowed thermal load per day in kilocalories, above waters melting point
Conversion factor = $1.36*10^6$

While the above equations and translation of temperature to an instantaneous thermal load allows for a quantitative expression to compare with Montana's state standard and accurately defines a thermal load, in practical terms this is not readily translatable to on-the-ground management. Alternatively, along with numeric heat loads, the TMDL may also be expressed as surrogate indicators that would result in compliance with the temperature standard. In this case, the allocations necessary to achieve the TMDL are similar to the restoration targets by which to measure achievement of the state temperature standard. These surrogates may include an increase in riparian shade conditions, improved irrigation efficiencies, reductions in warm irrigation water return flow to the waterbody, temperature reductions in tributaries, and a heat load or surrogate based limits for each point source discharge.

6.5 Temperature TMDL Components

This section provides a review of existing conditions, targets, TMDL, and allocations for each of the stream segments identified in **Section 6.1**.

6.5.1 Middle Bitterroot River (MT76H001_020)

The middle segment of the Bitterroot River begins at the confluence of Skalkaho Creek, near the city of Hamilton, and continues to the confluence of Eightmile Creek, below Stevensville. The middle segment of the Bitterroot River was listed as impaired due to temperature on the 2010 impaired waters list. A TMDL for the middle segment of the Bitterroot River is provided in the following sections.

6.5.1.1 Existing Conditions and Targets Comparison

Data and reports reviewed in the impairment status determination describe summer maximum temperatures during low flow conditions near 71°F. The file reports that thermal conditions are influenced by reduced instream flows due to irrigation.

Although Montana Fish Wildlife and Parks (FWP) monitors water temperatures along the Bitterroot River on a yearly basis, DEQ collected the most spatially robust annual data set available for temperature of the middle segment of the Bitterroot River during the 2004 field season. The 2004 monitoring results represent a warm, low streamflow condition that approach worst-case thermal conditions. Temperature data loggers were placed at 14 sites in the middle segment of the Bitterroot River during the summer of 2004, yet only 9 were recovered after the field season. Data loggers were deployed at the latest on July 16 and retrieved at the earliest on September 1, 2004. The maximum daily temperature and the 7-day average maximum temperature data are reviewed to identify the warmest period of the season. Maximum daily temperatures were monitored between July 16 and 17, depending on the site. The weekly 7-day average of the daily maximum temperatures also occurred during the same week as maximum water temperatures were detected. Monitoring devices detected from 46 to 61 days above 59°F, depending upon location. Multiple days above 70°F occurred at all sampling locations, and no 7-day average daily maximum occurred below 62°F for any site (**Table 6-2, Map A-24** in **Appendix A)**. The warmest monitored temperature on the whole Bitterroot River, including the lower segment, was at VXING1. Temperatures in the middle segment of the Bitterroot River are above levels known to negatively affect native trout species.

Table 6-2. DEQ Middle Bitterroot River 2004 Temperature Data Summary

Site ID	Seasonal Max.		7-Day Average during warmest week of the summer				Days > 59 ˚F	Days > 70 ˚F
	Date	Value	Date	Daily Max	Daily Min	Delta T		
WTP1	07/16	72.9	07/16	71.0	62.1	8.8	46	19
BLOD1B	07/16	74.4	07/16	72.1	62.8	9.3	54	27
BLOD2	07/17	74.2	07/17	72.4	63.6	8.8	56	30
BLOD3	07/17	73.7	07/17	72.1	64.0	8.1	54	21
STEVI2	07/17	74.0	07/17	72.2	64.1	8.1	60	33
STEVI3	07/17	74.5	07/17	72.7	64.8	7.9	61	33
VXING1	07/17	75.3	07/17	73.2	64.5	8.8	56	37
VXING2	07/17	74.4	07/17	73.0	64.3	8.7	58	36

During the 2004 data logger deployment, a thermal infrared flight (TIR) was conducted along the Bitterroot River (**Attachment B**). The River heats significantly from the headwaters to near Victor. The TIR results include warm and cold water influences along with temperatures of the main channel (**Figure 6-2**). Identified warm water tributaries include Kootenai and Tin Cup creeks, while most other identified tributaries in this segment had temperatures similar to, or lower than, the Bitterroot River. Many tributaries were not identified in the TIR due to dry conditions or canopy overhang. The TIR report also provides a review of cold water springs entering the river, which cumulatively slightly reduce water temperatures near Stevensville.

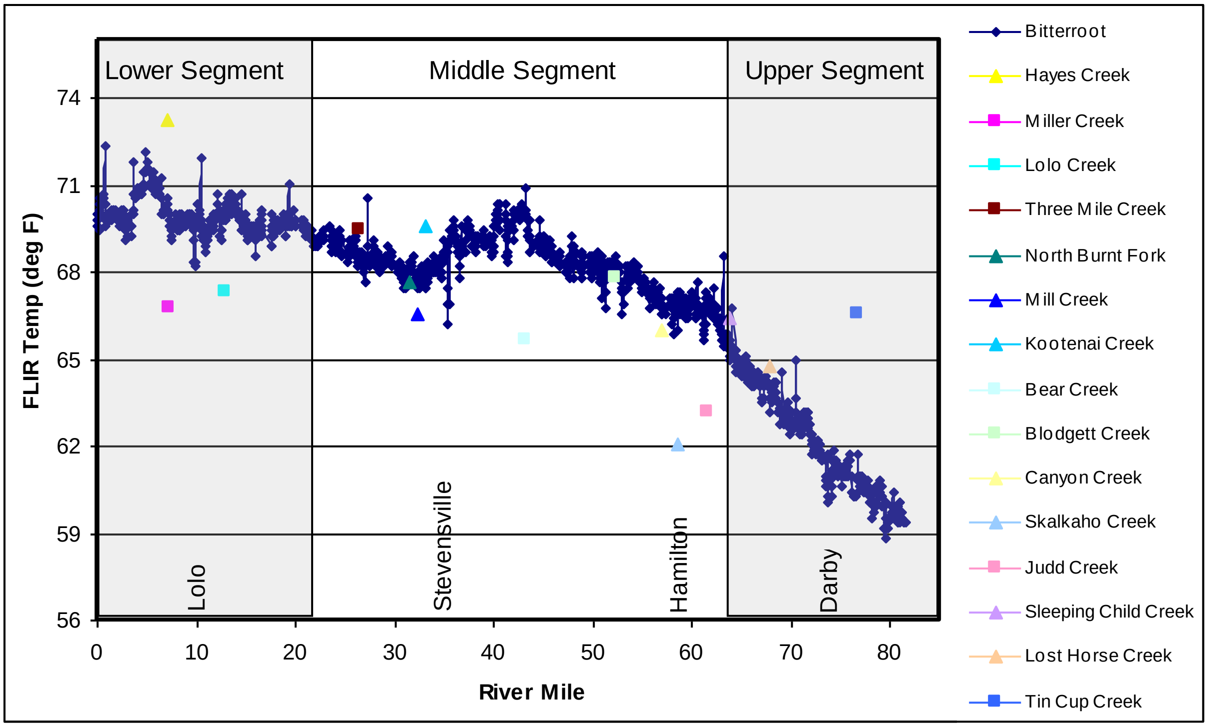

Figure 6-2. Bitterroot River Thermal Infrared Assessment Results

6.5.1.1.1 Water Quality Modeling using QUAL2K for Source Assessment and Standards Assessment

While currently available data suggests elevated stream temperatures in the middle segment of the Bitterroot River, a QUAL2K water quality model was used to determine if the temperatures are a result of natural conditions or human activities. The model results will help determine if human-caused disturbances in the watershed have increased the water temperature above the naturally occurring level, and if so, to what degree. The model incorporated temperature, flow, stream channel, and shade information and calibrated to thermal infrared data, which was used to calibrate the model to best represent existing average summer conditions. Additionally, various scenarios that represent thermal restoration approaches in the watershed were applied in the model to determine targeted temperatures. A full description of the model and results can be found in **Attachment B**. The following is a summary of the modeling considerations:

1. Although the river channel is wide, spring runoff has the greatest influence in forming the river's channel. Summer flows are low and usually form a wide channel margin between water's edge and streambanks. Overall, the segment does not have an apparently over-wide channel from human influences. Although slight human influences are present that may over-widen the channel in limited areas, restoration is not warranted when considering the liabilities associated with restoring a river channel formed in large part by natural spring runoff conditions. A narrowing of the channel was not modeled as a restoration scenario.
2. Thermal conditions in the East and West Fork Bitterroot rivers were assessed independently from this effort yet are the driving factor of temperature to the upper Bitterroot River. Reductions in temperature from these two main tributaries, along with all other smaller tributaries that enter the Bitterroot River, were assessed in a restoration scenario.
3. Shade conditions along the Bitterroot River were incorporated into the model. Reference riparian vegetation shade conditions were modeled in a restoration scenario.

4. Wastewater Treatment Plant (WWTP) loads were incorporated into the model. Scenarios were completed to determine the WWTPs' effects on stream temperatures.
5. The Bitterroot watershed has a complex irrigation network. Irrigation water withdrawals were incorporated into the model. Estimated irrigation water efficiencies were modeled in restoration scenarios. Warm irrigation water returns are poorly understood and were not explicitly incorporated into the model but are likely present.

The following sections review existing conditions and restored conditions about each of the human-influenced thermal factors. Temperature monitoring and modeling results relative to each source are reviewed briefly.

6.5.1.1.2 Targets and Linkage to Stream Temperature

Riparian and Stream Channel Conditions

During 2007 DEQ conducted an assessment of riparian vegetation class, height, density, and offset using a stereoscope and aerial photos (**Attachment A**). Riparian effective shade was estimated along each 500-meter reach (**Figure 6-3**). Field verification was also conducted. The riparian canopy information was used to calibrate the shade components of the QUAL2K water quality temperature model.

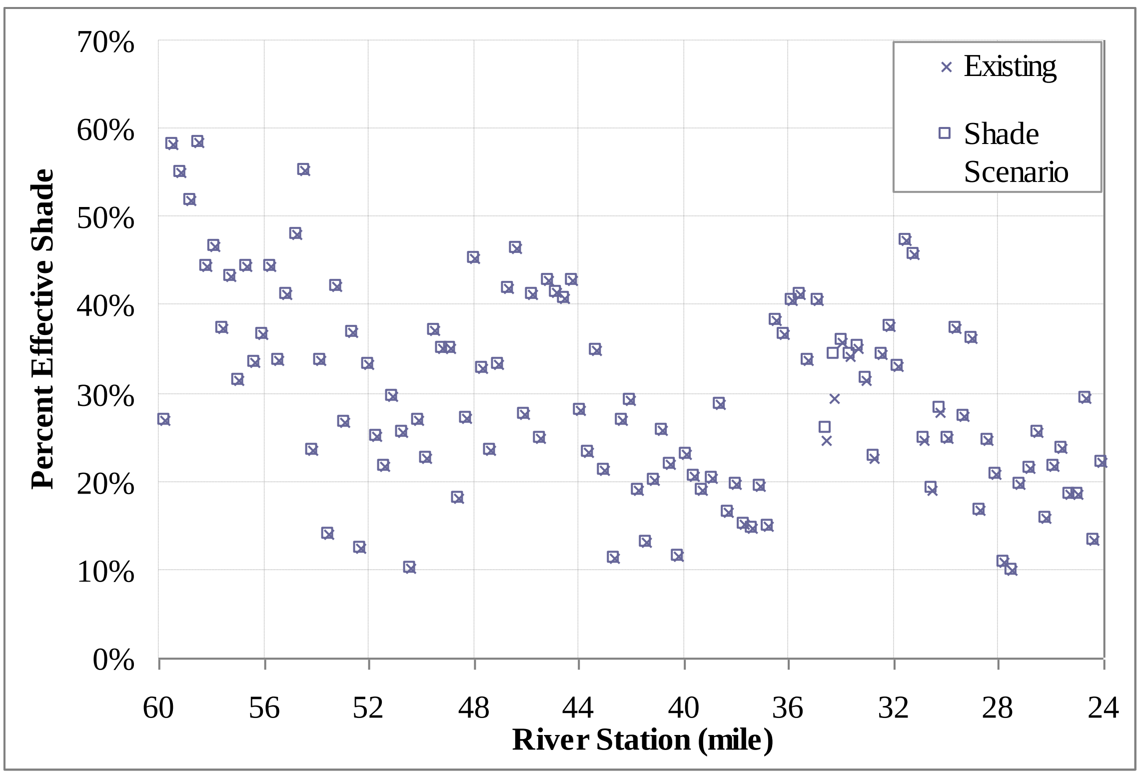

Figure 6-3. Middle Bitterroot River Effective Shade Assessment Results

Average daily effective shade ranged from 10% to 58% along the middle segment of the Bitterroot River (**Figure 6-3**). This segment is a relatively large stream with average active channel widths of approximately 220 feet. The channel size is mostly influenced by a large spring runoff from the surrounding mountains, which in turn forms the channel. Channel widths are not considered significantly influenced by human activities.

Riparian habitat along this segment consists of intermittent plant communities, including forbs/grasses, mixed deciduous trees, coniferous trees, and shrubs. A major portion of the segment contains in-tact riparian areas, but agricultural fields, residential areas, a golf course, roads, and other human influences slightly reduce shade along the stream. These influences did not reduce effective stream shade to a large extent because of the wide channel and the generally north/south aspect of the river. Current shade is estimated at 30.2%, and restored riparian vegetation would increase effective shade to 30.8%. This is only a 0.4% increase in shade, which equates to a 0.03°F reduction in maximum daily temperature in this segment of the Bitterroot River during average summer afternoons. Even though shade restoration will likely result in small temperature decreases, shade targets are provided because they are part of a straightforward riparian restoration approach that supports reduction of other pollutants and also because healthy riparian areas benefit fish and wildlife.

Headwater and Tributary Thermal Influence

Temperature TMDLs were completed during 2005 for both the East and West forks of the Bitterroot River during a TMDL project for the Bitterroot Headwaters TMDL planning area. Shade and stream channel assessment results from the Bitterroot Headwaters TMDLs were used to generally populate a Stream Segment Temperature (SSTEMP) model for estimation of temperature reduction from the headwaters area. The results indicated that shade improvement in the Bitterroot Headwaters TMDL planning area could likely decrease water temperatures by about 1°F at the upper boundary of the river's upper segment. Along with the two major forks of the Bitterroot River, all other immediate tributary temperatures along the river were reduced by 1°F. The tributary cooling effect was shown to dissipate as the water flowed downstream and is estimated at 0.6°F decrease in maximum daily temperature at the upper boundary of the middle segment of the river (**Attachment B**).

Wastewater Influences

Darby, Hamilton, and Stevensville WWTPs discharge to the upper or middle segments of the Bitterroot River. Darby's system consists of lagoons, while the Hamilton and Stevensville facilities are secondary treatment systems. Stevensville uses a polishing pond on the end of its treatment process, which acts thermally like a lagoon. Darby and Hamilton WWTP discharges increase instream temperatures during the heat of the summer afternoons, while Stevensville appears to have a minimal affect (**Attachment C**). Temperature modeling indicates that effluents can be assessed by mixing calculations because initial heat loads are dissipated or offset by volumetric heat capacity between the effluents. If each of these WWTPs were discharging at current daily peak rates to a 7Q10 flow condition, they would heat the river approximately 0.09°F during the heat of summer afternoons in the most sensitive location (**Attachment C**). This maximum heat increase spatially occurs just below Hamilton WWTP's mixing zone.

If each WWTP were to discharge at double their existing hourly peak flow rate, or at their design capacity hourly peak flow, whichever is greater, in combination they would heat the river by about 0.25°F, once again the most affected location being directly below Hamilton's mixing zone (**Attachment C**). The target for wastewater influences is to not heat any part of the middle segment of the Bitterroot River outside of mixing zones higher than 0.25°F during June-September. To ensure the WWTPs are meeting this target, any municipality shall not increase their effluent temperature and shall discharge at rates below double their existing hourly peak flow rate, or at their design capacity hourly peak flow, whichever is greater. All of the flow rates provided are based upon doubling existing hourly peak flow rates except Hamilton, which is based upon the design capacity hourly peak flow rate. The WWTP flow rates associated with the target conditions are provided in **Table 6-3**. If these conditions are not met, the facility must initiate action to prove they do not heat the Bitterroot River more than 0.25°F.

If changes to a waste treatment process occur that are likely to increase the temperature of any effluent in the watershed, or if flow rates will increase above the thresholds given for the surrogate WLA approach, an effluent temperature assessment must be initiated to determine if the plant will meet the target requirement of $\leq$ 0.25°F temperature increase at the end of the mixing zone due to the future WWTP plant modification (**Table 6-4**). Monitoring and reporting requirements for this process are provided in **Section 8.0**. The WWTP target conditions will also be interpreted into a WLA process and expressed as a discrete heat load in the heat-based numeric TMDL.

Table 6-3. Data and mixing calculation results for existing WWTP discharge at hourly peak flow conditions

	Darby	Hamilton	Stevensville
Upstream Discharge at 7Q10 (cfs)	120	152	159
Upstream Temperature (˚F)	63.4	66.7	69.5
Effluent Discharge hourly Peak Flow (cfs)	1.18	3.54	2.26
Effluent Temperature (˚F)	69	70.5	70.5
Mixed Instream Temperature (˚F)	63.4	66.8	69.5
Mixed Instream Δ T due to Effluent (˚F)	0.06	0.09	0.01

Table 6-4. Data and mixing calculation results for WWTP discharge rates at build out scenario using existing discharge temperature and hourly discharge peak flow condition

	Darby	Hamilton	Stevensville
Upstream Discharge at 7Q10 (cfs)	120	152	159
Upstream Temperature (˚F)	63.4	66.7	69.5
Effluent Discharge hourly Peak Flow* (cfs)	2.36	10.30	4.52
Effluent Temperature (˚F)	69	70.5	70.5
Mixed Instream Temperature (˚F)	63.5	66.9	69.5
Mixed Instream Δ T due to Effluent (˚F)	0.108	0.241	0.028

*Hourly peaks calculated using double the existing peak flow rate, or the design capacity peak flow rate from the permit statement of basis, whichever is greater, multiplied by hourly peaking factor from DEQ Circular 4.

Irrigation - Depletion of Instream Volumetric Heat Capacity

Irrigation depletes the volume of water in the stream and reduces instream volumetric heat capacity. The reduced stream water volume heats up more quickly, and to a higher temperature, given the same amount of thermal input. Therefore, the higher temperatures are manifested well downstream of irrigation withdrawals. Also, there are a number of irrigation reservoirs in the watershed, most notable are East Fork Reservoir and Como Lake. The reservoirs may possibly be used in conjunction with increased irrigation efficiency to provide instream flow during the heat of the summer. Implementation of irrigation efficiencies could result in a 15% reduction in irrigation water use. The irrigation savings should be applied to instream flow during the heat of the summer, while not significantly affecting groundwater return flow rates to the stream network. Maximum daily temperatures in the middle segment could be reduced by about 0.9°F during an average summer day if a 15% irrigation water use savings were applied to instream flow during the summer months (**Attachment B**).

Irrigation - Warm Irrigation Return Flow

Irrigation-return flows may increase stream temperatures by putting heated water back into the stream network. These return flows are difficult to assess because of their intermittent nature and therefore not all have been measured. Three irrigation-return flows warmer than the Bitterroot River were found via the Thermal Infrared (TIR) flight, and on average they were 2°F higher than the Bitterroot River

(**Attachment A**). Other warm irrigation-return flows likely enter the Bitterroot River but are difficult to assess because of their small size and intermittent nature. Also, irrigation-returns are present on tributaries. All mainstem and tributary irrigation-returns should be more fully assessed (see **Section 8.0**). Within the watershed, irrigation-return flows that are warmer than the stream they enter should be reduced by 75% on a volume basis.

6.5.1.1.3 Summary of Targets and Existing Conditions for the Middle Segment of the Bitterroot River
Table 6-5 reviews temperature targets for the middle segment of the Bitterroot River. The targets will incorporate an "or" statement where Montana's temperature standards should be met, or all the temperature-influencing targets should be met. The temperature-influencing targets include target conditions for tributary watershed areas, shade along the segment, channel conditions, irrigation water use and waste, and wastewater effluents. If all these targets are met in combination, Montana's water temperature standards will be achieved in the middle segment of the Bitterroot River.

Table 6-5. Temperature Targets and Existing Conditions for the Middle Segment of the Bitterroot River

Water Quality Targets	Criteria	Existing Condition
Maximum allowable increase over naturally occurring temperature	For waters classified as B-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 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.	Calibrated QUAL2K model results are compared to restoration scenario results. Modeling conclusions indicate Montana's temperature standard is not being met during average summer afternoon conditions. If conditions provided below for sources are met, daily maximum summertime temperatures would likely be reduced the most near river mile 46.5, by about 1.5°F (**Attachment B**).
OR meet ALL of the temperature influencing restoration targets below		
Tributary temperatures	Reduce all tributary temperatures by an average of 1°F from current conditions via increased shade, irrigation efficiencies and channel restoration.	The EF and WF Bitterroot River temperature TMDLs developed during 2005 and subsequent SSTEMP modeling indicate a 1°F reduction is likely in these tributaries. Specific warm tributaries found during TIR include Hayes, Threemile, Kootenai, McClain, and Tin Cup Creeks. Other moderate temperature tributaries may also easily be cooled via restoration practices.
Effective Shade	30.8% Effective Shade	30.2% Effective Shade
Channel Condition	No change.	Cumulative Widths ≈ 220 ft
Irrigation water management (Higher efficiency)	15% improvement in irrigation efficiency during the warmest months (mid-June through August), while not affecting groundwater recharge or base flow volume of the Bitterroot River.	The irrigation system should be assessed for inefficiencies to determine if this estimated efficiency based upon regional irrigation management studies is achievable and to identify specific strategies to reduce irrigation use, maintain groundwater conditions, and keep water in the River. Effects to groundwater returning to the river should be considered during implementation of

Table 6-5. Temperature Targets and Existing Conditions for the Middle Segment of the Bitterroot River

Water Quality Targets	Criteria	Existing Condition
		this target condition.
Irrigation return flow	Reduce volume of warm irrigation water entering any of the watersheds stream network by 75%.	There are three known warm irrigation return flow locations to the main channel of the Bitterroot River. Others are likely present, yet are likely smaller or intermittent. The irrigation system should be assessed thoroughly to reduce warm irrigation water waste into the state’s surface waters and to further quantify heat loads from this source.
Wastewater Treatment Plants	No WWTP caused surface water inflow, in single or in combination, may increase temperatures more than 0.25°F. Do not increase loads associated with current temperature of effluent at double the facilities current peak hourly discharge or peak hourly design capacity whichever is greater. If modifications to waste treatment process are likely to heat a discharge or discharge rates are above the thresholds, a thermal study must be conducted prior to modification.	All three WWTPs in combination currently increase daily max temp by 0.09°F, while Hamilton is the most significant contributor of heat loads. Wastewater increases volumetric heat capacity and thus also cools portions of the River. Modeling results indicate that simple mixing calculations can be used to assess each source in the future.

A naturally occurring model scenario defines water temperature conditions resulting from the implementation of all reasonable land, soil, and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the naturally occurring temperature in waterbodies of interest and establishes the temperatures to which a 0.5°F temperature increase is allowable in this segment. This, in turn, can be used to identify if standards are exceeded and a TMDL is needed. The naturally occurring scenario for the middle segment of the Bitterroot River (miles 24–60) is a full collection of the restoration scenarios described in the previous sections of this report. In a significant portion of the segment, more than a 0.5°F increase in summertime daily maximum temperature is apparent when compared with a restored scenario, where reasonable land, soil, and water conservation practices are in place (**Figure 6-4)**. At river mile 46, the most sensitive location on this segment, maximum daily temperatures can likely be reduced by 1.5°F on an average summer afternoon with reasonable conservation practices.

None of the shade, irrigation water use, irrigation water return flow, or tributary targets are fully met. Both the temperature modeling and target assessments indicate Montana’s water temperature standards are not being met. Therefore, the segment is in need of a temperature TMDL.

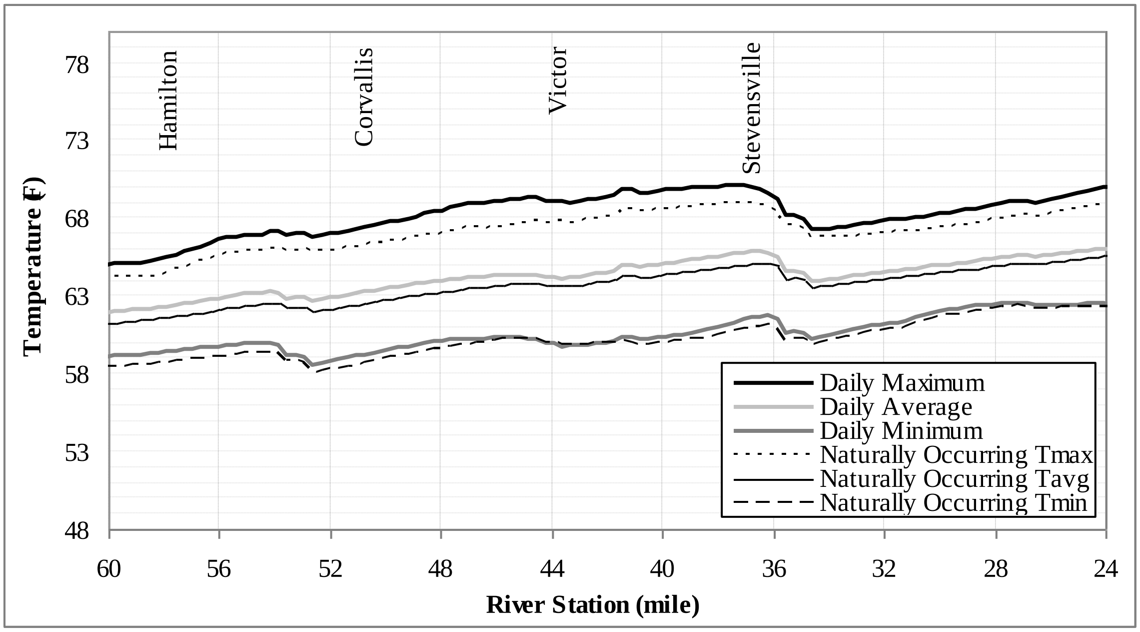

Figure 6-4. Middle segment of the Bitterroot River simulated water temperatures for existing conditions and naturally occurring scenario

6.5.1.2 TMDL, Allocations and Margin of Safety

Thermal conditions in the middle segment of the Bitterroot River are largely the result of complex interactions among the factors reviewed in **Table 6-5**, which prevents an easy interpretation of the influence of each one independent of the others. Modeling results indicate that irrigation use and an array of human sources in the tributaries have the largest human-caused heating effect upon this segment of river. Irrigation return-flows in the watershed may have a moderate heating effect on temperatures of this segment. Reduced riparian canopy conditions along the upper and middle segments of the Bitterroot River are only a small source of heating. Also, point sources have a small affect upon thermal conditions, yet were provided wasteload allocations to ensure they do not increase above a significant level. If all allocations provided in this section are met, Montana's temperature standards will be achieved in the middle segment of the Bitterroot River.

6.5.1.2.1 Surrogate TMDL for Promoting Nonpoint Source Load Reductions

Monitoring and modeling results provided much of the technical framework for developing a surrogate temperature TMDL and allocation approach. Applying a surrogate TMDL is more useful for guidance of nonpoint source restoration approaches than a heat-based numeric TMDL. The surrogate TMDL approach also affords point sources with a straightforward operating approach to meet the difficult to monitor, heat wasteload allocations. Influences to stream temperatures are not always intuitive at a watershed scale, and a modeling effort helped estimate the relative thermal effects from stream shading, tributary influences, WWTP discharges, and instream flow to stream temperatures during the warmest time of year. Significant sources and surrogate allocation approaches for each source are provided in **Table 6-6**. If each surrogate allocation is followed, the temperature standard will be met.

Table 6-6. Temperature TMDL for the middle segment of the Bitterroot River

The TMDL equals the resultant thermal load associated with stream temperature when all conditions below are met:	
Source Type	**Load Allocation (surrogate)**
Agricultural, urban and other land uses that could reduce riparian health and resultant **shade** provided by the near stream vegetation along the Bitterroot River.	The thermal load that can reach the stream segment when there is an average daily shade along the segment of 30.8%.
Forestry, agricultural, suburban, other land uses and inefficient use of water that could negatively affect shade, channel width/depth ratio or flow on **tributaries**.	No measurable or modeled increase in thermal loading from preventable human caused increases in any tributaries contributing flow to the Bitterroot River. No reduction in thermal buffering capacity due to inefficient irrigation or urban water use practices.
WWTPs (WLA)	No individual or cumulative increase above 0.25°F due to WWTP effluents in the watershed. This may be achieved by each WWTP if they do not discharge more than double the facilities current peak hourly discharge or peak hourly design capacity whichever is greater. If modifications to waste treatment process are likely to heat a discharge or discharge rates increase above thresholds provided, a thermal study must be conducted prior to modification. Monitor effluent temperatures during June-September in first year of first permit renewal cycle according to requirements in **Section 8.3.1**.
Inefficient agricultural or urban **water use**.	No reduction in thermal buffering capacity due to inefficient irrigation or urban water use practices along the segment.
Warm **irrigation return water**	A load associated with a condition where 75% reduction in irrigation water entering the Bitterroot River or tributaries in which the irrigation water is warmer than instream conditions.

6.5.1.2.2 Numeric TMDL, Allocations and Margin of Safety

The TMDL is also expressed as a numeric heat load to compare with heat-based wasteload allocations. The numeric TMDL applied to the middle segment of the Bitterroot River is **Equation 6-2**. An example heat load is developed using **Equation 6-2**, **Figure 6-1**, and modeling results from **Appendices B** and **C**. An applied example of how the temperature TMDL for the middle segment of the Bitterroot River equates to stream temperature and heat loading during an average midsummer afternoon is provided in **Table 6-7**. Temperature and heat results provided in this table are based on conditions approximating 7Q10 flow near Victor, Montana, during the heat of an average warm midsummer afternoon (159 cfs). This area is the most heated location of the segment. The TMDL along with associated load and wasteload allocations are provided in kilocalories per second above water's melting point.

Table 6-7. Middle segment of the Bitterroot River numeric TMDL, allocation and MOS example at 7Q10 during a typical hot sunny summer afternoon near Victor, MT

TMDL Component	**Collective Load Allocation**		**Waste Load Allocation**	**Margin of Safety**		
Source Description	Estimated Natural Sources	Human sources with all reasonable land, soil and water conservation practices in place. This includes: • Well managed agricultural and suburban land use activities along the Bitterroot River and tributaries that provide similar shading as reference areas • Irrigation occurring with 15% efficiency savings applied to summer stream flow • 75% reduction of warm irrigation return flow water entering the Bitterroot River and tributaries. • Tributary temperature reductions	WWTP WLAs	Reserved for safety factor and uncertainty in analysis	=	**TMDL**
Estimated Contribution to Temperature TMDL	66 °F	1.3°F	0.25°F	0.25°F		67.8°F
Heat Load in Kcal/Sec	84,334	2,480	620	620		88,054

Surface water dischargers currently are a small source of heating to the Bitterroot River but could become a significant source and are therefore given wasteload allocations. The wasteload allocations (WLAs) are premised upon an approach that any WWTP may not discharge more than their current design capacity estimated hourly peak discharge, or double their existing peak hourly discharge rate, whichever is higher. This would assure all WWTPs in combination will accumulatively contribute to no more than a 0.25°F increase in temperature. This equates to half of the allowable increase allowed under the standard for B-1 waters over a naturally occurring temperature of 66.5°F.

The WLAs may be expressed alternatively by permitting each facility to discharge up to double their existing peak discharge rate or up to their design capacity, whichever is higher as long as existing thermal conditions of the effluent are not increased. Yet, if updates to water treatment process increase the temperature conditions of an effluent, or a facility discharges at a higher rate than provided by the WLA at any time, the facility must measure and report temperature for one year, following monitoring requirements in **Section 8.3.1**.

Modeling indicated that loads associated with each WWTP are attenuated and offset by additional volumetric heat capacity between discharges (**Attachment C**). Therefore, each facility can use mixing equations as a tool to determine compliance and not have to worry about cumulative effects of all WWTPs. A facility must provide verification via monitoring and assessment that it will not increase thermal conditions in the river below their mixing zone by more than 0.25°F prior to updates to their system or if they exceed discharge rates provided in this document. These analyses shall use effluent peak flow estimates and 7Q10 instream flow.

All other stormwater, CAFO and groundwater discharge permitted activities in the watershed have negligible effects on water temperature of the middle segment of the Bitterroot River during critical conditions and, therefore, do not need wasteload allocations due to their insignificance and timing of runoff conditions compared to impacts to the fishery.

The thermal WLAs do not represent all pollutant WLAs that will be developed in the Bitterroot River watershed. Other pollutant category TMDLs (e.g., nutrients) developed during future TMDL projects may contain WLAs, which may or may not be more restrictive to a facilities management than the thermal WLAs.

6.5.2 Lower Bitterroot River (MT76H001_030)

The lower segment of the Bitterroot River begins at the confluence of Eightmile Creek, below Stevensville, and flows to the confluence with the Clark Fork River near Missoula. The lower segment of the Bitterroot River is not currently listed as impaired due to temperature on the 2010 impaired waters list. TMDL project monitoring and modeling of the Bitterroot River included this segment along with the upper and middle segments of the Bitterroot River. Results from this effort indicate the segments temperature standard is not being met. This segment will be listed as impaired by temperature during the next accessible listing cycle to incorporate data from this assessment. A TMDL for the lower segment of the Bitterroot River is provided in the following sections.

6.5.2.1 Existing Conditions and Targets Comparison

Data and reports reviewed in the impairment status determination describe summer maximum temperatures during low flow conditions near 72°F during the early 1990s. The file mentions that temperatures become quite elevated in this segment and bull trout are not present. Yet temperature is not indicated as a cause of impairment. Therefore this segment was included in TMDL temperature project field monitoring and temperature modeling.

Although Montana Fish Wildlife and Parks (FWP) monitors water temperatures along the Bitterroot River on a yearly basis, DEQ collected the most spatially robust annual data set available for temperature of the lower segment of the Bitterroot River during the 2004 field season. The 2004 monitoring results represent a warm, low stream flow condition which approach worst case thermal conditions. Temperature data loggers were placed at 7 sites in the lower segment of the Bitterroot River during the summer of 2004, yet only 6 were recovered after the field season. Data loggers were deployed at the latest on July 16 and retrieved at the earliest on September 1, 2004. The maximum daily temperature and the 7-day average maximum temperature data are reviewed to identify the warmest period of the season. Maximum daily temperatures were monitored between July 16 and 17, depending on the site. The weekly 7-day average of the daily maximum temperatures also occurred during the same week as maximum water temperatures were detected. Monitoring devices detected from 44 to 61 days above 59°F, depending upon location. Many days above 70°F occurred at all sampling locations and no 7-day average maximum occurred below 62°F for any site (**Table 6-8, Map A-24** of **Appendix A)**. Temperatures in the lower segment of the Bitterroot River are above levels known to negatively affect native trout species which are managed for in this watershed.

Table 6-8. DEQ Lower Bitterroot River 2004 Temperature Data Summary

Site ID	Seasonal Max.		7-Day Average during warmest week of the summer				Days >	Days >
	Date	Value	Date	Daily Max	Daily Min	Delta T	59 °F	70 °F
KEL1	07/16	74.4	07/19	72.0	66.4	5.6	48	28
STEVI5	07/17	74.3	07/18	73.0	65.3	7.6	61	33
CLG3	07/16	74.7	07/18	73.1	66.2	6.9	50	33
CLG2	07/17	74.6	07/18	73.1	65.9	7.2	50	33
CLG6	07/16	74.7	08/14	73.5	63.9	9.7	51	36

During the 2004 data logger deployment, a thermal infrared flight (TIR) was conducted along the Bitterroot River (**Attachment A**). The River heats significantly from the headwaters to near Victor, then levels off from victor to the mouth. The warmest temperatures detected in the Thermal Infrared (TIR) flight were found just downstream of Hayes Creek in the lower segment of the Bitterroot River. Temperatures remain relatively consistent, and warm, throughout this segment. The TIR results include warm and cold water influences along with temperatures of the main channel (**Figure 6-2**). Identified warm water tributaries include Hayes, McClain, and Three Mile Creeks, while most other identified tributaries in this segment were similar to or had lower temperatures than the Bitterroot River. Many tributaries were not identified in the TIR effort due to dry conditions or canopy overhang. The TIR report also provides a review of cold water springs entering the River, which cumulatively slightly reduce water temperatures near Stevensville.

6.5.2.1.1 Water Quality Modeling using QUAL2K for Source Assessment and Standards Assessment

While currently available data suggests elevated stream temperatures in this segment of the Bitterroot River, a QUAL2K water quality model was used to determine if the temperatures are a result of natural conditions or human activities. The model results will help determine if human-caused disturbances in the watershed have increased the water temperature above the naturally occurring level, and if so, to what degree. The model incorporated temperature, flow, stream channel, and shade information and calibrated to thermal infrared data, which was used to calibrate the model to best represent existing average summer conditions. Additionally, various scenarios that represent thermal restoration approaches in the watershed were applied in the model to determine targeted temperatures. A full description of the model and results can be found in **Attachment B**. A summary of the modeling considerations is presented in **Section 6.5.1.1.1**.

The following sections review existing conditions and restored conditions about each of the human-influenced thermal factors. Temperature monitoring and modeling results relative to each source are reviewed briefly.

6.5.2.1.2 Targets and Linkage to Stream Temperature

Riparian and Stream Channel Conditions

During 2007 DEQ conducted an assessment of riparian vegetation class, height, density, and offset using a stereoscope and aerial photos (**Attachment A**). Riparian effective shade was estimated along each 500-meter reach (**Figure 6-5**). Field verification was also conducted. The riparian canopy information was used to calibrate the shade components of the QUAL2K water quality temperature model.

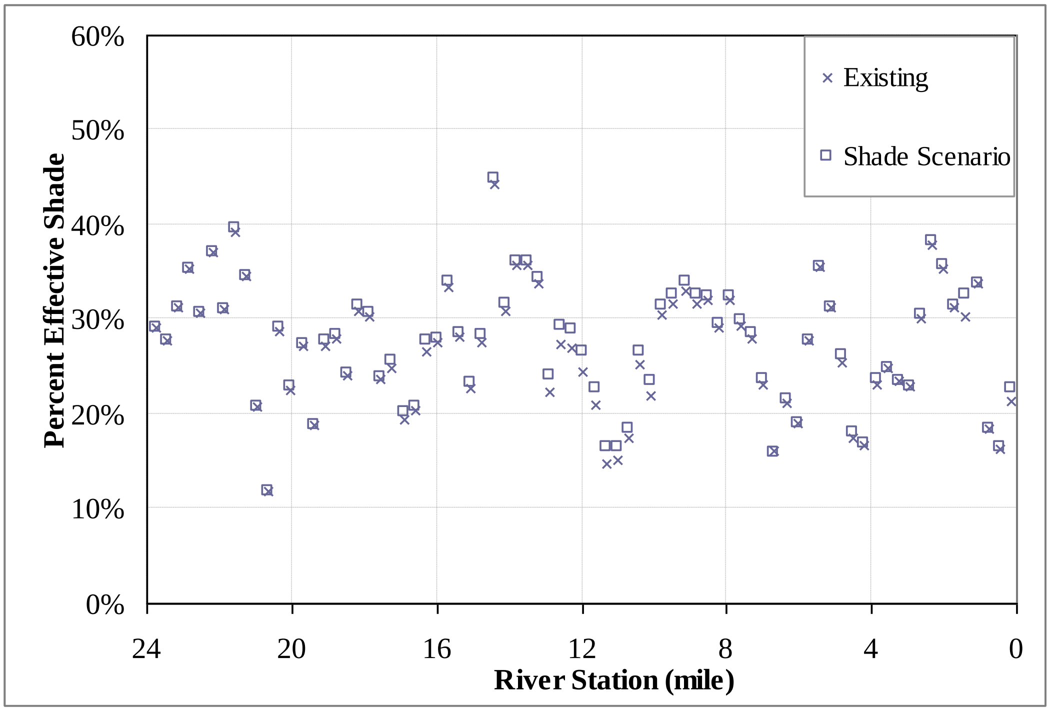

Figure 6-5. Lower Bitterroot River Effective Shade Assessment Results

Average daily effective shade ranged from 12% to 45% along the lower segment of the Bitterroot River (**Figure 6-5**). This segment of river is a relatively large stream with average active channel widths of approximately 240 feet. The stream width is mostly driven by natural hydrological process of spring snow melt from the surrounding mountains. Therefore, riparian vegetation is less likely to affect stream temperature than on smaller streams.

Riparian habitat along this segment consists of intermittent plant communities, including forbs/grasses, mixed deciduous trees, pine trees, and shrubs. A major portion of the segment has intact riparian areas, but agricultural fields, residential areas, and other human influences reduce shade along the river. These influences did not reduce effective stream shade to a large extent because of the wide channel and the generally north/south aspect of the river. Current shade is estimated at 26.8%, and restored riparian vegetation would increase effective shade to 27.3%. This is only a 0.5% increase in shade, which equates to a 0.07°F reduction in maximum daily temperature during average summer afternoons. Even though shade restoration will likely result in small temperature decreases, shade targets are provided because they fit into a straightforward riparian restoration approach that supports reduction of other pollutants and also because healthy riparian areas benefit fish and wildlife

Headwater and Tributary Thermal Influence

Temperature TMDLs were completed during 2005 for both the East and West forks of the Bitterroot River during a TMDL project for the Bitterroot Headwaters TMDL planning area. Shade and stream channel assessment results from the Bitterroot Headwaters TMDLs were used to generally populate a Stream Segment Temperature SSTEMP model for estimation of temperature reduction from the headwaters area. The results indicated that shade improvement in the Bitterroot Headwaters TMDL planning area could likely decrease water temperatures by about 1°F at the upper boundary of the river's upper segment. Along with the two major forks of the Bitterroot River, all other immediate tributary temperatures along the river were reduced by 1°F. The tributary cooling effect was shown to dissipate as the water flowed downstream and is estimated at 0.4°F decrease in maximum daily temperature at the upper boundary of the lower segment of the river (**Attachment B**).

6.5.2.1.4 Wastewater Influences

Darby, Hamilton, Stevensville and Lolo WWTPs discharge to the Bitterroot River. Darby, Hamilton and Stevensville discharge upstream of this segment. Modeling indicates the upstream dischargers do not contribute to heating of this segment due to heat dissipation and increased volumetric heat capacity of the river (**Attachment D**). Because these heat loads are completely offset and do not affect this segment, they are not provided heat WLAs. Lolo discharges to the Lower Bitterroot River. Lolo currently does not significantly increase instream temperatures (**Attachment D**). Yet, a WLA is provided for Lolo because of the potential for future growth.

The target for the Lolo WWTP will be to not heat any part of the lower segment of the Bitterroot River outside of mixing zone higher than 0.25°F during June-September. To determine if a facility is meeting this target, any municipality shall not shift their effluent temperature and shall discharge at rates below double their existing hourly peak flow rate, or at their design capacity hourly peak flow, whichever is greater. The flow rates associated with the target conditions are provided in **Table 6-9**. If these conditions are not met, the facility must initiate action to prove they do not heat the Bitterroot River more than 0.25°F.

If changes to a waste treatment process occur that are likely to increase the temperature of any effluent in the watershed, or if flow rates will increase above the thresholds given for the surrogate WLA approach, an effluent temperature assessment must be initiated to determine if the plant will meet the target requirement of $\leq$ 0.25°F temperature increase at the end of the mixing zone due to the future WWTP plant modification (**Table 6-10**). Monitoring and reporting requirements for this process are provided in **Section 8.3.1**. The WWTP target conditions will also be interpreted into a WLA process and expressed as a discrete heat load in the heat-based numeric TMDL.

Table 6-9. Data and mixing calculation results for existing WWTP discharge at hourly peak flow conditions

	Lolo
Upstream Discharge at 7Q10 (cfs)	392
Upstream Temperature (˚F)	70.2
Effluent Discharge hourly Peak Flow (cfs)	1.23
Effluent Temperature (˚F)	70.5
Mixed Instream Temperature (˚F)	70.2
Mixed Instream Δ T due to Effluent (˚F)	0.001

Table 6-10. Data and mixing calculation results for WWTP discharge rates at build out scenario using existing discharge temperature and hourly discharge peak flow condition

	Lolo
Upstream Discharge at 7Q10 (cfs)	392
Upstream Temperature (˚F)	70.2
Effluent Discharge hourly Peak Flow* (cfs)	2.47
Effluent Temperature (˚F)	70.5
Mixed Instream Temperature (˚F)	70.2
Mixed Instream Δ T due to Effluent (˚F)	0.002

*Hourly peaks calculated using double the existing peak flow rate, or the design capacity peak flow rate from the permit statement of basis, whichever is greater, multiplied by hourly peaking factor from DEQ Circular 4.

Irrigation - Depletion of Instream Volumetric Heat Capacity
Irrigation depletes the volume of water in the stream and reduces instream volumetric heat capacity. The reduced stream water volume heats up more quickly, and to a higher temperature, given the same amount of thermal input. Therefore, the higher temperatures are manifested well downstream of irrigation withdrawals. Also, there are a number of irrigation reservoirs in the watershed, most notable are East Fork Reservoir and Como Lake. The reservoirs may possibly be used in conjunction with increased irrigation efficiency to provide instream flow during the heat of the summer. Implementation of irrigation efficiencies could result in a 15% reduction in irrigation water use. The irrigation savings should be applied to instream flow during the heat of the summer, while not significantly affecting groundwater return flow rates to the stream network. Maximum daily temperatures in the lower segment could be reduced by about 0.9°F during an average summer day if a 15% irrigation water use savings were applied to instream flow during the summer months (**Attachment B**).

Irrigation - Warm Irrigation Return Flow
Irrigation-return flows may increase stream temperatures by putting heated water back into the stream network. These return flows are difficult to assess because of their intermittent nature and therefore not all have been measured. Three irrigation-return flows warmer than the Bitterroot River were found via the Thermal Infrared (TIR) flight, and on average they were 2°F higher than the Bitterroot River (**Attachment A**). Other warm irrigation-return flows likely enter the Bitterroot River but are difficult to assess because of their small size and intermittent nature. Also, irrigation-returns are present on tributaries. Alternatively, without irrigation returns, some streams would not have enough water to sustain fish. A notable irrigation water return empties into lower Threemile Creek, where it increases daily maximum stream temperature of this tributary up to 4°F during warm summer afternoons (McDowell and Rokosch, 2005). All mainstem and tributary irrigation-returns should be investigated to determine approaches for reducing heat loads. Within the watershed, irrigation-return flows that are warmer than the stream they flow into should be reduced by 75% on a water volume or heat load basis.

6.5.2.1.3 Summary of Targets and Existing Conditions for the Lower Segment of the Bitterroot River
Table 6-11 reviews temperature targets for the lower segment of the Bitterroot River. The targets will incorporate an "or" statement where Montana's temperature standards should be met, or all the temperature influencing targets should be met. The temperature-influencing targets include target conditions for tributary watershed areas, shade along the segment, channel conditions, irrigation water use and waste, stormwater and wastewater effluents. If all these targets are achieved in combination, a condition that attains Montana's water temperature standards will be met in the lower segment of the Bitterroot River.

Table 6-11. Temperature Targets and Existing Conditions for the Lower Segment of the Bitterroot River

Water Quality Targets	Criteria	Existing Condition
Maximum allowable increase over naturally occurring temperature	For waters classified as B-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 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.	Calibrated QUAL2K model results are compared to restoration scenario results. Modeling conclusions indicate Montana's temperature standard is not being met during average summer afternoon conditions. If conditions provided below for sources are met, daily maximum summertime temperatures would likely be reduced the most near river mile 11, by about 0.8°F (**Attachment B**).
OR meet ALL of the temperature influencing restoration targets below		
Tributary temperatures	Reduce all tributary temperatures by an average of 1°F from current conditions via increased shade, irrigation efficiencies and channel restoration.	The EF and WF Bitterroot River temperature TMDLs developed during 2005 and subsequent SSTEMP modeling indicate a 1°F reduction is likely in these tributaries. Specific warm tributaries found during TIR include Hayes, Three Mile, Kootenai, McClain, and Tin Cup Creeks. Other moderate temperature tributaries may also easily be cooled via restoration practices.
Effective Shade	26.8% Effective Shade	27.3% Effective Shade
Channel width/depth ratio	No change.	Cumulative Widths ≈ 240 ft
Irrigation water management (Higher efficiency)	15% improvement in irrigation efficiency during the warmest months (mid-June through August), while not affecting base flow volume of the Bitterroot River.	The irrigation system should be assessed for inefficiencies to determine if this estimated efficiency based upon regional irrigation management studies is achievable and to identify specific strategies to reduce irrigation use, maintain groundwater conditions, and keep water in the stream. Effects to groundwater returning to the river should be considered during implementation of this target condition.
Irrigation return flow	Reduce warm irrigation water entering any of the watersheds stream network by 75%.	There are three known warm irrigation return flow locations. Others are likely present, yet are likely smaller or intermittent. The irrigation system should be assessed thoroughly to reduce overland waste to the state's surface waters and to further quantify heat loads from this source.

Table 6-11. Temperature Targets and Existing Conditions for the Lower Segment of the Bitterroot River

Water Quality Targets	Criteria	Existing Condition
Wastewater Treatment Plants	No WWTP caused surface water inflow, in single or in combination, may increase temperatures more than 0.25°F. Do not increase loads associated with current temperature of effluent at double the facilities current peak hourly discharge or peak hourly design capacity whichever is greater. If modifications to waste treatment process are likely to heat a discharge, a thermal study must be conducted prior to modification.	Modeling and mixing calculations indicate WWTPs in combination currently increase daily max temp very slightly in the lower segment of the Bitterroot River (See **Table 6-9**).
Missoula Urban Runoff (MS4)	Follow the minimum control measure provided in Part II. 5.a.vii. of the MPDES Missoula small MS4 permit authorization (MTR040007), or any updated runoff reduction or initial flush stormwater capture control measures in subsequent permits renewals. Renewed permits must contain initial flush mitigation measures.	Modeling and mixing calculations indicate potential for increased stream temperature up to 0.25°F due to storm runoff. This happens very infrequently and for very short duration (**Attachment D**).

A naturally occurring model scenario defines water temperature conditions resulting from the implementation of all reasonable land, soil, and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the naturally occurring temperature in waterbodies of interest and establishes the temperatures to which a 0.5°F temperature increase is allowable in this segment. This, in turn, can be used to identify if standards are exceeded and a TMDL is needed. The naturally occurring scenario for the lower segment of the Bitterroot River (miles 0–24) is a full collection of the restoration scenarios described in the previous sections of this report. In a significant portion of the segment, more than a 0.5°F increase in summertime daily maximum temperature is apparent when compared with a restored scenario, where reasonable land, soil, and water conservation practices are in place (**Figure 6-6)**. At river mile 11, the most sensitive location on this segment, maximum daily temperatures can likely be reduced by at least 0.8°F with reasonable conservation practices.

None of the shade, irrigation water use, irrigation water return flow, or tributary targets are fully met. Both the temperature modeling and target assessments indicate Montana's water temperature standards are not being met. Therefore, the segment is in need of a temperature TMDL.

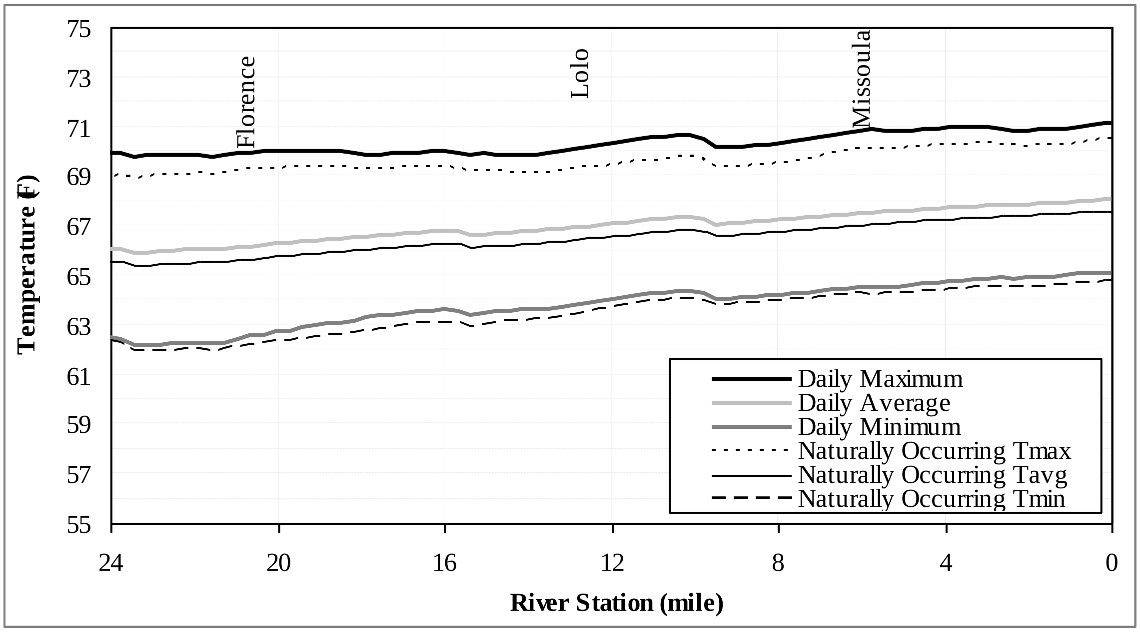

Figure 6-6. Lower segment of Bitterroot River simulated water temperatures for existing conditions and naturally occurring scenario

6.5.2.2 TMDL, Allocations and Margin of Safety

Thermal conditions in the middle segment of the Bitterroot River are largely the result of complex interactions among the factors reviewed in **Table 6-5**, which prevents an easy interpretation of the influence of each one independent of the others. Modeling results indicate that irrigation use and an array of human sources in the tributaries have the largest human-caused heating effect upon this segment of river. Irrigation return-flows in the watershed may have a moderate heating effect on temperatures of this segment. Reduced riparian canopy conditions along the Bitterroot River are only a small source of heating. Also, point sources have a small affect upon thermal conditions, yet were provided wasteload allocations to ensure they do not increase above a significant level. Missoula's stormwater runoff poses a moderate heating effect, yet it is a very brief and periodic source. If all allocations provided in this section are met, Montana's temperature standards will be achieved in the middle segment of the Bitterroot River.

6.5.2.2.1 Surrogate TMDL for Promoting Nonpoint Source Load Reductions

Monitoring and modeling results provided much of the technical framework for developing a surrogate temperature TMDL and allocation approach. Applying a surrogate TMDL is more useful for guidance of nonpoint source restoration approaches than a heat-based numeric TMDL. Influences to stream temperatures are not always intuitive at a watershed scale, and the modeling effort helped estimate the relative effects that stream shading, tributary influences, WWTP discharges, and stream flow have on stream temperature during the warmest time of year. Significant sources and surrogate allocation approaches for each are provided in **Table 6-12**. If each surrogate allocation is followed, the temperature standard will be met.

Table 6-12. Temperature TMDL for the lower segment of the Bitterroot River

The TMDL equals the resultant thermal load associated with stream temperature when all conditions below are met:	
Source Type	**Load Allocation (surrogate)**
Agricultural, urban and other land uses that could impact riparian health and resultant **shade** provided by the riparian or near stream vegetation along the Bitterroot River.	The thermal load that can reach the stream segment when there is an average daily shade of 27.3% using a Solar Pathfinder along the segment.
Inefficient agricultural or urban **water use**.	No reduction in thermal buffering capacity due to inefficient irrigation or urban water use practices along the segment.
Forestry, agricultural, suburban, other land uses and inefficient use of water that could impact shade, channel width/depth ratio or flow on **tributaries**.	No measurable increase in thermal loading from preventable human caused increases in any tributaries contributing flow to the Bitterroot River. No reduction in thermal buffering capacity due to inefficient irrigation or urban water use practices.
Warm **irrigation return water**	A load associated with a condition where 75% reduction in irrigation water or associated heat loads entering the Bitterroot River or tributaries in which the irrigation water is warmer than instream conditions.
WWTPs (WLA)	No individual or cumulative increase above 0.25˚F due to WWTP effluents in the watershed. This may be achieved by each WWTP if they do not discharge more than double the facilities current peak hourly discharge or peak hourly design capacity whichever is greater. If modifications to waste treatment process are likely to heat a discharge or discharge rates increase above thresholds provided, a thermal study must be conducted prior to modification. Monitor effluent temperatures during June-September in first year of first permit renewal cycle according to requirements in **Section 8.3.1**.
Missoula Stormwater (WLA)	No measurable or modeled increase in total first flush stormwater volumes. This should be achieved by following the minimum control measure provided in Part II. 5.a.vii. of the MPDES Missoula small MS4 permit authorization (MTR040007), or any updated runoff reduction or initial flush stormwater capture control measures in subsequent permits renewals. Renewed permits must contain initial flush mitigation measures.

6.5.2.2.2 Numeric TMDL, Allocations and Margin of Safety

The TMDL is also expressed as a numeric heat load to compare with heat-based waste load allocations. The numeric TMDL applied to the lower segment of the Bitterroot River is **Equation 6-2**. An example heat load is developed using **Equation 6-2**, **Figure 6-2,** and modeling results from **Appendices B** and **C**. An applied example of how the temperature TMDL for the lower segment of the Bitterroot River equates to stream temperature, heat load and Montana's temperature standard and heat loading during an average summer afternoon is provided in **Table 6-13**. Temperature and heat results provided in this table are based on conditions approximating 7Q10 flow near Missoula, Montana during the heat of an average warm summer afternoon (392 cfs). The TMDL along with associated load and wasteload allocations are provided in kilocalories per second above water's melting point. A composite load allocation to all nonpoint sources is given in this example with natural temperatures provided in a separate load allocation.

Table 6-13. Lower segment of the Bitterroot River numeric TMDL, allocation and MOS example at 7Q10 during a typical hot sunny summer afternoon near Missoula, MT

TMDL Component	Load Allocation		Waste Load Allocation*	Margin of Safety		
Source Description	Estimated Natural Sources	Human sources with all reasonable land, soil and water conservation practices in place. This includes: • Well managed agricultural and suburban land use activities along the Bitterroot River and tributaries that provide similar shading as reference areas • Irrigation occurring with 15% efficiency savings applied to summer stream flow • 75% reduction of heat load from warm irrigation return flow entering the Bitterroot River and tributaries. • Tributary temperature reductions	WWTP WLAs	Reserved for safety factor and uncertainty in analysis	=	**TMDL**
Estimated Contribution to Temperature TMDL	68.2°F	1.7°F	0.25°F	0.25°F		70.4°F
Heat Load in Kcal/Sec	221,370	10,396	1,529	1,529		234,824

*Missoula MS4 WLA is not represented in the numeric TMDL table due to the infrequent and short lived nature of the source. See **Table 6-12** for a surrogate wasteload allocation approach for the Missoula MS4 permit area.

Wasteload Allocations

Surface water dischargers currently are a small source of heating to the Bitterroot River but could become a significant contribution of heat and are therefore given wasteload allocations. The waste load allocations (WLAs) are premised upon an approach that any WWTP may not discharge more than their current design capacity estimated hourly peak discharge or double their existing peak hourly discharge rate, whichever is higher. This would assure all WWTPs in combination will accumulatively contribute to no more than a 0.25˚F increase in temperature. This equates to half of the allowable increase allowed under the standard for B-1 waters over a naturally occurring temperature of 66.5˚F.

The WLAs may be expressed alternatively by permitting each facility to discharge up to double their existing peak discharge rate or up to their design capacity, whichever is higher as long as existing thermal conditions of the effluent are not increased. Yet, if updates to water treatment process increase the temperature conditions of an effluent or a facility discharges at a higher rate than provided by the WLA at any time, the facility must measure temperature and calculate loads for one year, following monitoring requirements in **Section 8.3.1**.

Modeling indicated that loads associated with each WWTP are attenuated and offset by additional volumetric heat capacity between discharges (**Attachment C**). Therefore, each facility can use mixing equations as a tool to determine compliance and not have to worry about cumulative effects of all WWTPs. A facility must provide verification via monitoring and assessment that it will not increase thermal conditions in the river below their mixing zone by more than 0.25°F prior to updates to their system or if they exceed discharge rates provided in this document. These analyses shall use effluent peak flow estimates and 7Q10 instream flow.

The Missoula MS4 urban area has the only NPDES permitted stormwater system with direct connectivity to the Bitterroot River. Much of Missoula's permitted area (>80%) does not reach the Bitterroot River via surface runoff. A major portion is not in the Bitterroot watershed, and a significant fraction of the area within the watershed is mitigated via dry wells, retrofitted with other infiltration techniques, or used for irrigation. The remainder of runoff from Missoula that may reach the Bitterroot River drains during timeframes where storms have cooled the landscape via cloud cover, cool precipitation and evaporation. Yet this source contributes a warm first flush of runoff during very limited storm events after the landscape is initially heated on days with air temperatures above 75°F. Estimated temperature increases from the runoff indicate this source heats the lower Bitterroot River by less than 0.25°F (**Attachment D**). The frequency of this source is estimated at 1-2 times per year and the duration is estimated at about 1-2 hours during critical thermal timeframes for supporting the fishery. Because of moderate magnitude, but very low duration and frequency, a surrogate allocation is provided. The surrogate WLA is that the Missoula MS4 permit area shall not significantly increase runoff volume. This surrogate allocation shall be met by following minimum runoff control measures provided in Part II, 5.a.vii. of the Missoula Area MS4 permit, or any updated initial flush stormwater capture or interception control measures in subsequent permits renewals. Renewed permits must contain similar or greater Low Impact Development (LID) water retention and infiltration requirements as the current permit in order to meet the intent of this WLA.

A special consideration for meeting the WLA and capturing initial stormwater runoff in Missoula will be infiltration of the stormwater into the ground via LID designs, instead of surface detention. Surface detention may provide increased heat load to the Bitterroot River via flushing of warmed water from ponds or wetlands, especially if these are located near the river. Groundwater will cool the river, whereas pond water may increase temperatures. Infiltration ponds, dry wells, grassy swales, and other LID designs to infiltrate water are preferred approaches to reducing runoff for mitigation of thermal conditions in the Bitterroot River. Already, many areas of the city have these types of water infiltration approaches in place. New development and redevelopment must continue and enhance this trend.

All other stormwater, CAFO and groundwater discharge permitted activities in the watershed have negligible effects on water temperature of the middle segment of the Bitterroot River during critical conditions and, therefore, do not need wasteload allocations due to their insignificance and timing of runoff conditions compared to impacts to the fishery.

The thermal WLAs do not represent all pollutant WLAs that will be developed in the Bitterroot River watershed. Other pollutant category TMDLs (e.g., nutrients) developed during future TMDL projects may contain WLAs, which may or may not be more restrictive to a facilities management than the thermal WLAs.

6.5.3 Mill Creek (MT76H004_040)

Source assessment data collected on Mill Creek was not robust enough in relation to sources present in the watershed for completing a temperature TMDL at this time. Mill Creek's temperature TMDL will be addressed during future TMDL development efforts using a rotating watershed approach for schedule completion.

6.5.4 Miller Creek (MT76H004_130)

Miller Creek originates in the Sapphire Mountains and flows west to its confluence with the Bitterroot River between Lolo and Missoula. Miller Creek is currently listed as impaired due to temperature on the 2010 impaired waters list.

6.5.4.1 Existing Conditions and Targets Comparison

Data and reports reviewed in the impairment status determination describe temperatures that are likely negatively affecting bull and cutthroat trout. Temperatures increased between monitoring sites during the summer of 2004. The file mentions that temperatures become quite elevated in this segment and bull trout are not present.

Timber harvest near stream corridors has occurred intermittently in the mountainous headwater areas within the watershed. Livestock grazing practices and irrigated hay production have the potential to reduce riparian vegetation shrub and tree growth and reduce stream flows throughout the watershed. Suburban development from Missoula occurs in the middle and lower portions of this watershed. Suburban activities such as lawn care (watering and encroachment to the stream) and small acreage livestock tending impact riparian shade in the suburban landscape.

Temperature data was collected during the 2004 and 2007 summer field seasons at three sites (**Map A-25** of **Appendix A**). Monitoring in the headwaters indicates cool water conditions that support native fish species. Water temperatures rise in a downstream direction until the warm stream water is used for irrigation. Below Trails End Road, stream water is almost fully diverted for irrigation use during the summer and springs provide water cool groundwater to the stream channel in the lowest mile of Miller Creek (**Map A-25** of **Appendix A**). In the warmest section of the stream, monitoring devices detected 69 days above 59°F and 47 days above 70°F. Temperatures in the middle and lower reaches of Miller Creek are above levels known to negatively affect native trout species (**Table 6-14**).

Table 6-14. Miller Creek Temperature Data Summary

Site ID	Seasonal Max.		7-Day Average during warmest week of the summer				Days >	Days >
	Date	Value	Date	Daily Max	Daily Min	Delta T	59 °F	70 °F
Mil1	08/17/04	86.6	08/14/04	81.9	54.6	27.3	44	38
Mil2	07/17/04	57.3	08/14/04	55.9	48.4	7.6	0	0
Mil3	07/17/04	74.6	07/26/04	71.6	49.9	21.7	43	24
MILLR-1	07/28/07	57.4	07/28/07	56.7	50.0	6.7	0	0
MILLR-2	07/18/07	71.0	07/17/07	69.5	54.4	15.1	53	3
MILLR-3	07/28/07	78.7	07/28/07	76.5	58.5	18.0	69	47

During the 2004 data logger deployment, a thermal infrared flight (TIR) was conducted along Miller Creek (**Attachment A**). The Creek heats significantly from the headwaters to below Trails End Road, then most of the water is diverted from the stream for irrigation and springs provide cold water to the lowest section of the stream. Temperatures in the middle reaches of Miller Creek were estimated at 80°F.

6.5.4.1.1 Water Quality Modeling using QUAL2K for Source Assessment and Standards Assessment

While currently available data strongly suggests elevated stream temperatures in the middle and lower reaches of Miller Creek, a QUAL2K water quality model was used to determine if the temperature increases are the result of anthropogenic activities. The model results assist in determining if human caused disturbances within the watershed have increased the water temperature above the "naturally occurring" level and, if so, to what degree. The model incorporated actual temperature, flow, and shade information collected during the warmest part of the summer, which was used to calibrate the model to best represent existing condition. Additionally, various scenarios that represent thermal restoration approaches in the watershed were applied within the model to determine targeted temperature conditions. The full description of the model and results can be found in **Attachment B**.

The following sections review existing conditions and estimated restored conditions about each of the human caused thermal influencing factors affecting Miller Creek. Temperature monitoring and modeling results relative to each source are reviewed briefly in the following sections.

6.5.4.1.2 Riparian and Stream Channel Conditions

During 2007 DEQ conducted a riparian vegetation class, height, vegetation density and offset assessment using a stereo scope and aerial photos. From this effort, riparian effective shade was estimated along each 500 m reach and a desired condition was also estimated (**Figure 6-7**). A field verification effort was also conducted. This riparian canopy information was used to calibrate the riparian shade components of the QUAL2K water quality temperature model.

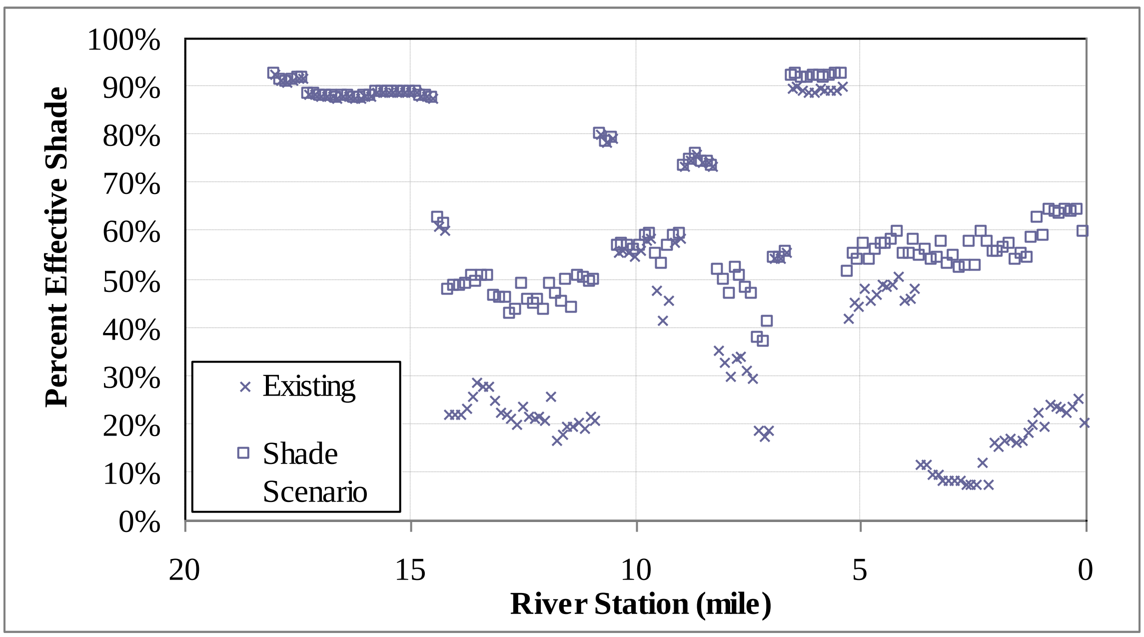

Figure 6-7. Miller Creek Effective Shade Assessment Results

Daily effective shade ranged from 92% in the headwaters to 7% near the Bitterroot River (**Figure 6-7**). Miller Creek is a small stream with a very narrow active channel and thus shading from riparian vegetation is likely to affect stream temperatures to a high degree. Riparian vegetation along Miller Creek consists of conifer forest in the headwaters and intermixed shrubs, deciduous trees, forbs and grass in the remainder of the watershed. Predominant human impacts currently influencing streamside vegetation include livestock grazing and hay production between miles 0-4 and11-15 along with grazing and suburban development along river miles 4-11 (**Figure 6-7, Map A-26**). Also, timber harvest likely impacts shade on tributaries. Average current shade along Miller Creek is estimated at 48% and a restored riparian vegetation condition would increase effective shade to 65% along Miller Creek. This represents a significant potential increase in shade which equates to a 7.5°F reduction in maximum daily temperature during average summer afternoons in the middle section of the stream. Impacts to stream side vegetation are a significant source of heat to Miller Creek.

Miller Creek's channel is overly wide in some areas. This condition contributes to higher solar radiation entering the stream and higher stream temperatures. The width-to-depth targets provided in **Section 5.4.1.2** also apply to Miller Creek temperature TMDL.

6.5.4.1.3 Irrigation Water Use

Use of stream water for irrigation depletes the volume of water in the stream. The reduced water volume heats up more quickly and to a higher temperature given the same amount of thermal input. Therefore, the higher temperatures due to reduced capacity for buffering heat are manifested downstream of irrigation withdrawals. Alternatively, irrigation and subsequent groundwater return flow may cool the stream in cases were severe dewatering occurs and subsequent stream flow is mostly groundwater.

Irrigation occurs along Miller Creek, but was not assessed within the model framework. The thermal infrared results indicate that the lowest mile of Miller Creek is not connected via surface water to upstream conditions during low flow: likely this is due to irrigation water use along with water loss to alluvial groundwater as the stream enters the Bitterroot Valley. In the lowest reach of Miller Creek, warmed stream water is used for irrigation and lost to groundwater, then returns via cool groundwater about a mile downstream. The stream is severely dewatered in this lower section of Miller Creek and thus downstream conditions are dominated by small springs.

Yet upstream, from miles 4-14, irrigation uses are likely to have a significant warming influence upon the stream where water is used for irrigation but do not likely return much cool groundwater when compared to the reduced stream flow which heats up quickly. Stream temperatures in this reach were approaching 80°F during the summer with irrigation a likely influence along with stream shade reduction (**Table 6-14**). Targets relevant to irrigation efficiency and warm irrigation water return flow to the stream are provided in **Table 6-15**.

6.5.4.1.4 Summary of Targets and Existing Conditions for Miller Creek

Table 6-15 provides a review of temperature targets for Miller Creek. The targets will incorporate an "or" statement where Montana's temperature standards should be met or all the temperature influencing targets should be met. The temperature influencing targets include target conditions for timber harvest in headwaters tributaries, vegetation produced shade along the segment, channel conditions, irrigation water use and waste, and wastewater effluents. If all these targets are met, Montana's water temperature standards will be met in Miller Creek.

Table 6-15. Temperature Targets and Existing Conditions for Miller Creek

Water Quality Targets	Criteria	Existing Condition
Maximum allowable increase over naturally occurring temperature	For waters classified as B-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 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.	Calibrated QUAL2K model results are compared to restoration scenario results. Modeling conclusions indicate Montana's temperature standard is not being met during average summer afternoon conditions. If conditions provided below for sources are met, daily maximum summertime temperatures would likely be reduced by at least 8°F (**Attachment B**).
OR meet ALL of the temperature influencing restoration targets below		
Effective Shade (timber harvest, hay production, livestock grazing, and suburban land use)	48% Effective Shade	65% Effective Shade
Channel width/depth ratio	See **Table 5-4**	See **Table 5-29**
Irrigation water management (Higher efficiency)	15% improvement in irrigation efficiency during the warmest months with water saving applied to in-stream flow (mid-June through August).	The irrigation system should be assessed for inefficiencies to determine if this estimated efficiency based upon regional irrigation management studies is achievable and to identify specific strategies to reduce irrigation use and keep water in the River.
Irrigation return flow	Reduce warm irrigation water entering any of the watersheds stream network by 75%.	Unknown

A naturally occurring model scenario for Miller Creek defines water temperature conditions resulting from the implementation of all reasonable land, soil and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the restored temperature condition in waterbodies of interest and establishes the temperatures to which a 0.5°F (0.23°C) temperature increase is allowable. This, in turn, can be used to identify if standards are exceeded and determine if a TMDL is needed. The naturally occurring scenario for Miller Creek assesses sources that impact shade along the segment. In a significant portion of the segment, more than a 0.5°F increase in daily maximum temperature is apparent when compared to a restored scenario where land and water conservation practices are in place (**Figure 6-8)**. Maximum daily temperatures can likely be reduced by at least 7.5 to 8°F with reasonable conservation practices that restore shade along the stream.

None of the targets have been attained. Both the modeling and temperature influencing target assessment approaches indicate Montana's water temperature standards are not being met. Therefore, Miller Creek is in need of a temperature TMDL.

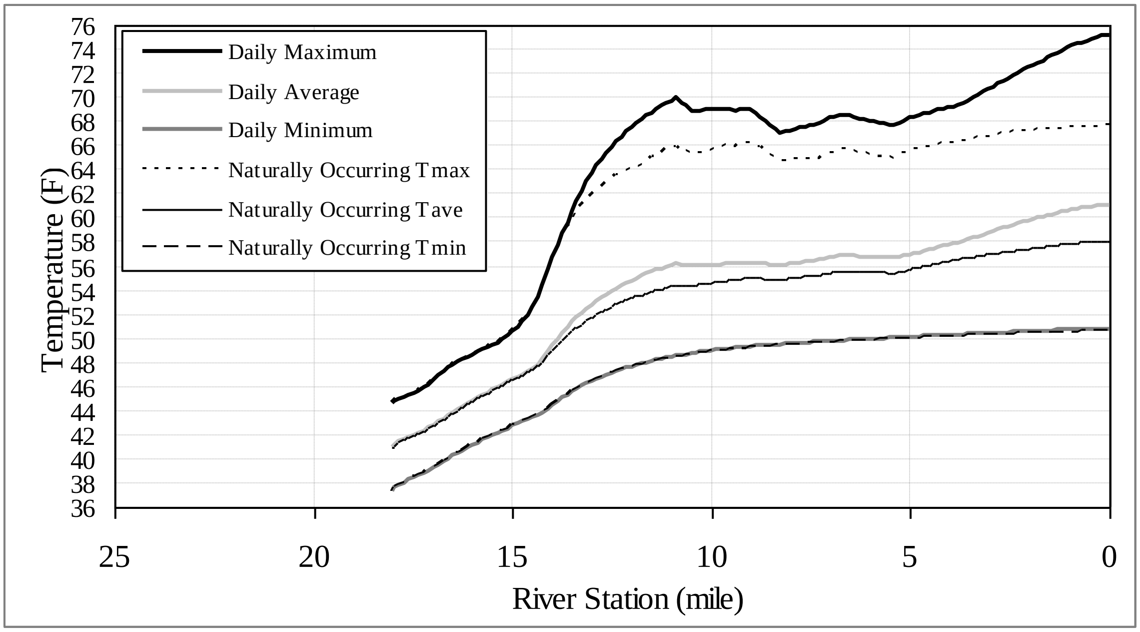

Figure 6-8. Miller Creek simulated water temperatures for existing conditions and naturally occurring scenario.

6.5.4.2 TMDL, Allocations and Margin of Safety

Thermal conditions within Miller Creek are largely the result of complex interactions among the factors reviewed in **Table 6-15**, which prevents an easy interpretation of the influence of each one separate from the others. Modeling results indicate that vegetation impacts from grazing, hay production and suburban development along Miller Creek provide the largest heating effect upon this segment of stream. Inefficient irrigation practices and timber harvest within the watershed may have moderate impacts to temperatures within this segment of stream. No point sources are present. If all allocations provided in this section are met, Montana's temperature standards will be achieved in Miller Creek.

6.5.4.2.1 Surrogate TMDL for Promoting Nonpoint Source Load Reductions

Monitoring and modeling results provided much of the technical framework for developing a surrogate temperature TMDL and allocation approach. Applying a surrogate TMDL is more useful for guidance of nonpoint source restoration approaches than a heat based numeric TMDL. Influences to stream temperatures are not always intuitive at a watershed scale and the modeling effort helped estimate the relative effects that stream shading, tributary influences, and stream flow have on stream temperature during the warmest time of year. Significant sources and surrogate allocation approaches for each are provided in **Table 6-16**. If each surrogate allocation is followed, the temperature standard will be met. It is likely that the allocations will reduce afternoon summer temperatures by at least 8°F and potentially even higher if irrigation efficiencies and headwater tributary timber harvest allocations are assessed and met. The most influential nonpoint source restoration strategy for Miller Creek will be restoring shade producing vegetation along the whole segment.

Table 6-16. Miller Creek temperature TMDL

The TMDL equals the resultant thermal load associated with stream temperature when all conditions below are met:	
Source Type	**Load Allocation (surrogate)**
Agricultural, urban and other land uses that could impact riparian health and resultant **shade** provided by the riparian or near stream vegetation along Miller Creek.	The thermal load that can reach the stream segment when there is an average daily shade of 65% along Miller Creek using a Solar Pathfinder.
Forestry land use in headwater **tributaries**.	No measurable or modeled increase in thermal loading from timber harvest in tributaries contributing flow to Miller Creek.
Inefficient agricultural or urban **water use**.	No reduction in thermal buffering capacity due to inefficient irrigation or urban water use practices along the segment.
Warm **irrigation return water**	A load associated with a condition where 75% reduction in irrigation water entering Miller Creek or tributaries in which the irrigation water is warmer than instream conditions.

6.5.4.2.2 Numeric TMDL

The TMDL may also be expressed as a numeric heat load to compare with heat based waste load allocations. **Equation 6-2** is the numeric TMDL applied to Miller Creek. An example heat load calculation for heat of the summer afternoon weather and stream flow conditions near Trails End Road crossing is developed using **Equation 6-2**, **Figure 6-1** and modeling results from **Attachment B**. An applied example of how the temperature TMDL for Miller Creek equates to stream temperature and heat loads during an average summer afternoon is provided in **Table 6-17**. This example is provided for the average summer flow of about 4cfs. The TMDL along with associated load and wasteload allocations are provided in kilocalories per second above water's melting point.

Table 6-17. Miller Creek numeric TMDL, allocation and MOS example during a typical summer afternoon

TMDL Component	**Load Allocation**		**Margin of Safety**		
Source Description	Natural Sources	Human sources with all reasonable land, soil and water conservation practices in place. This includes: • Well managed agricultural and suburban land use activities along the Miller Creek and tributaries that provide similar shading as reference areas • Irrigation occurring with 15% efficiency savings applied to summer stream flow • 75% reduction of warm irrigation return flow water entering the Miller Creek and tributaries.	Reserved for safety factor and uncertainty in analysis	=	**TMDL**
Estimated Contribution to Temperature TMDL	66.5°F	1.0°F	0.5°F		68.0°F
Heat Load in Kcal/Sec	2,153	62	31		2,246

6.5.5 Sleeping Child Creek (MT76H004_090)

Sleeping Child Creek originates in the Sapphire Mountains and flows to its confluence with the Bitterroot River south of Grantsdale. Sleeping Child Creek is currently listed as impaired due to temperature on the 2010 impaired waters list.

6.5.5.1 Existing Conditions and Targets Comparison

Sleeping Child Creek originates in the Sapphire Mountains and flows west to its confluence with the Bitterroot River. Much of Sleeping Child Creek's watershed is composed of mountainous terrain and includes timbered and grassland slopes. Timber harvest within the stream corridor has occurred in the headwaters. A forest road travels along the valley bottom, but is almost exclusively on the north side of the stream and therefore has an inconsequential impact on effective shade. Also, during 2000, fire burned about 10-12 miles of the stream corridor. The fire occurred in the middle reaches of the stream segment, between river miles 9 to 19. Livestock grazing practices and irrigated hay production have the potential to reduce riparian vegetation shrub and tree growth along the lowest seven miles of the stream corridor. Also in the lower reaches, water is diverted for hay production.

Temperature data was collected during 2007 summer field season at two sites. Monitoring site SCHI-1 is located near river mile 12, above hay and irrigation influences, and SCHI-2 is located near Sleeping Child Creek's confluence with the Bitterroot River. Water temperatures rise in a downstream direction. At site SCHI-2 monitoring equipment detected 60 days above 59°F and 17 days above 70°F. Temperatures in the middle reach of Sleeping Child Creek are slightly lower than near the mouth. Stream temperatures are above levels known to negatively affect native trout species and human caused sources are present (**Table 6-18**).

Table 6-18. Sleeping Child Creek Temperature Data Summary

Site ID	Seasonal Max		7-Day Average during warmest week of the summer				Days >	Days >
	Date	Value	Date	Daily Max	Daily Min	Delta T	59 °F	70 °F
SCHI-1	07/18/07	68.4	08/14/04	67.3	59.4	7.9	46	0
SCHI-2	07/14/07	73.8	08/14/04	72.3	61.6	10.7	60	17

6.5.5.1.1 Water Quality Modeling using QUAL2K for Source Assessment and Standards Assessment

While currently available data suggests elevated stream temperatures in Sleeping Child Creek, a QUAL2K water quality model was used to determine if the temperature conditions are the result of natural conditions or anthropogenic activities. The model results assist in determining if human caused disturbances within the watershed have increased the water temperature above the "naturally occurring" level and, if so, to what degree. The model incorporated actual temperature, flow and shade information collected during the warmest part of the summer, which was used to calibrate the model to best represent existing conditions. Additionally, various scenarios that represent thermal restoration approaches in the watershed were applied within the model to determine targeted temperature conditions. The full description of the model and results can be found in **Attachment B**.

The following sections review existing conditions and estimated restored conditions about each of the human caused thermally influencing factors. Temperature monitoring and modeling results relative to each source are reviewed briefly in the following sections.

6.5.5.1.2 Riparian and Stream Channel Conditions

During 2007 DEQ conducted a riparian vegetation class, height, vegetation density and offset assessment using a stereo scope and aerial photos. From this effort, riparian effective shade was estimated along each 500 m reach and a desired condition was also estimated (**Figure 6-9**). A field verification effort was also conducted. This riparian canopy information was used to calibrate the riparian shade components of the QUAL2K water quality temperature model.

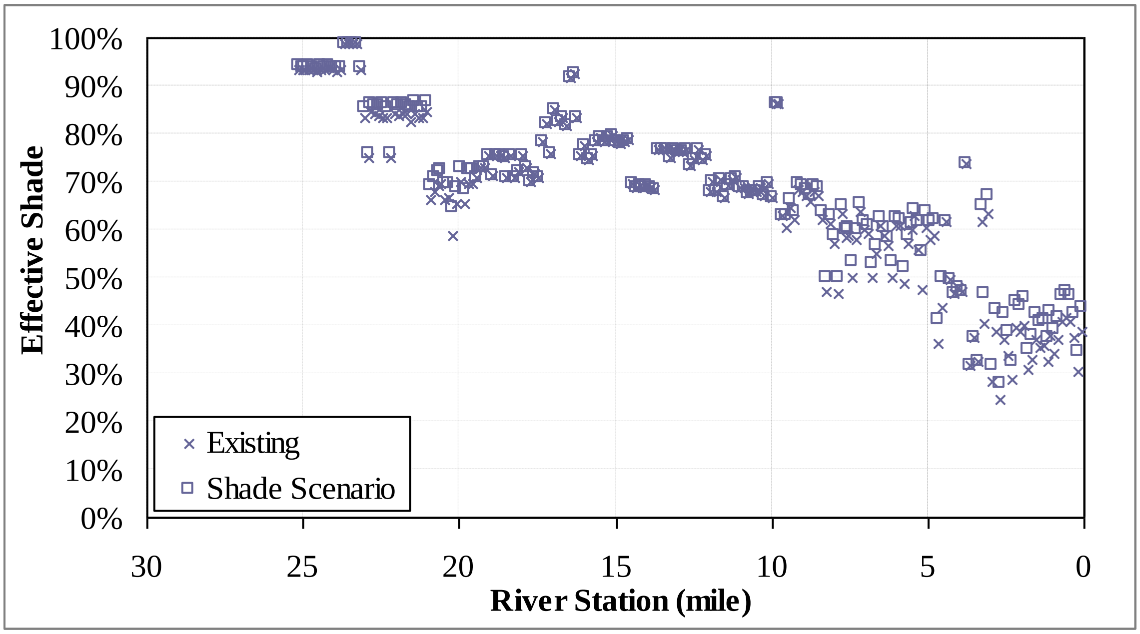

Figure 6-9. Sleeping Child Creek Effective Shade Assessment Results.

Daily effective shade ranged from 98% in the headwaters to 25% near the Bitterroot River (**Figure 6-9**). Sleeping Child Creek is a small stream with a narrow active channel and thus streamside shading from vegetation is likely to affect stream temperatures significantly. Riparian vegetation along Sleeping Child Creek consists of conifer forest in the headwaters and intermixed shrubs, deciduous trees, forbs and grass in the remainder of the watershed. Predominant human impacts currently impacting streamside vegetation include livestock grazing and hay production, particularly between miles 0 to 7 (**Figure 6-9**). Also, timber harvest likely impacts shade in the headwaters. Sleeping Child Creek flows through a clearcut section near mile 20. A wildfire burned portions of the riparian area between miles 9 to 19. Riparian vegetation condition aerial photo assessment results are provided in **Map A-27**.

Average current shade along Sleeping Child Creek is estimated at 67% and a restored riparian vegetation condition excluding fire impacted area regeneration, would increase effective shade to 68.5% along Sleeping Child Creek. If fire regeneration were to be included in the analysis restored conditions would be approximately 69% effective shade. The restoration scenario that does not include fire regeneration represents an increase in shade which equates to a 1.03°F reduction in maximum daily temperature during average summer afternoons near mile 20, and a similar increase near the confluence with the Bitterroot River. Impacts to stream side vegetation are a source of heat to Sleeping Child Creek.

Sleeping Child Creek's channel is overly wide in some areas. This condition contributes to higher solar radiation entering the stream and higher stream temperatures. The width-to-depth targets provided in **Section 5.4.1.2** also apply to Sleeping Child Creek temperature TMDL.

6.5.5.1.3 Irrigation Water Use

Use of stream water for irrigation depletes the volume of water in the stream. The reduced water volume heats up more quickly and to a higher temperature given the same amount of thermal input. Therefore, the higher temperatures due to reduced capacity for buffering heat are manifested downstream of irrigation withdrawals. Alternatively, irrigation and subsequent groundwater return flow may cool the stream in cases were severe dewatering occurs and subsequent stream flow is mostly groundwater.

Irrigation occurs along Sleeping Child Creek, but was not assessed within the model framework. The aerial photo review indicates irrigation occurs in the lower seven miles of stream. The extent of water use is not fully understood at this time but likely contributes to warmer stream water in the lowest few miles of Sleeping Child Creek. Because of this, irrigation efficiency that reduce stream water use should occur and associated water savings should be left in the stream. Targets relevant to irrigation efficiency and warm irrigation water return flow to the stream are provided in **Table 6-19**.

6.5.5.1.4 Summary of Targets and Existing Conditions for Sleeping Child Creek

Table 6-19 provides a review of temperature targets for Sleeping Child Creek. The targets will incorporate an "or" statement where Montana's temperature standards should be met or all the temperature influencing targets should be met. The temperature influencing targets include target conditions for timber harvest in headwaters tributaries, vegetation produced shade along the segment, channel conditions and irrigation water use and waste. If all these targets are met, Montana's water temperature standards will be met in Sleeping Child Creek.

Table 6-19. Temperature Targets and Existing Conditions for Sleeping Child Creek

Water Quality Targets	Criteria	Existing Condition
Maximum allowable increase over naturally occurring temperature	For waters classified as B-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 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.	Calibrated QUAL2K model results are compared to restoration scenario results. Modeling conclusions indicate Montana's temperature standard is not being met during average summer afternoon conditions. If conditions provided below for sources are met, daily maximum summertime temperatures would likely be reduced by over 1°F (**Attachment B**).
OR meet ALL of the temperature influencing restoration targets below		
Effective Shade (timber harvest, hay production, and livestock grazing)	69% Effective Shade	67% Effective Shade
Channel width/depth ratio	See **Table 5-4**	Some reaches are likely exceeding targets. See **Table 5-38.**

Table 6-19. Temperature Targets and Existing Conditions for Sleeping Child Creek

Water Quality Targets	Criteria	Existing Condition
Irrigation water management (Higher efficiency)	15% improvement in irrigation efficiency during the warmest months with water saving applied to in-stream flow (mid-June through August).	The irrigation system should be assessed for inefficiencies to determine if this estimated efficiency based upon regional irrigation management studies is achievable and to identify specific strategies to reduce irrigation use and keep water in the River.
Irrigation return flow	Reduce warm irrigation water entering any of the watersheds stream network by 75%.	Unknown

A naturally occurring model scenario of Sleeping Child Creek defines water temperature conditions resulting from the implementation of all reasonable land, soil and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the "naturally occurring" temperature in waterbodies of interest and establishes the temperatures to which a 0.5°F (0.23°C) temperature increase is allowable. This, in turn, can be used to identify if standards are exceeded and determine if a TMDL is needed. The naturally occurring scenario for Sleeping Child Creek assesses sources that impact shade along the segment. In a small portion of the segment below a clear cut, more than a 1°F increase in daily maximum temperature is apparent when compared to a restored scenario where land conservation practices are in place (**Figure 6-10)**. Also, in the lower portion of the stream, water is heated slightly above the 0.5°F threshold from irrigated hay production and riparian grazing that reduce shade from riparian vegetation. The modeling results indicate that temperature standards are slightly exceeded in Sleeping Child Creek.

None of the targets have been attained. Both the modeling and temperature influencing target assessment approaches indicate Montana's water temperature standards are not being met. Therefore, Sleeping Child Creek is in need of a temperature TMDL.

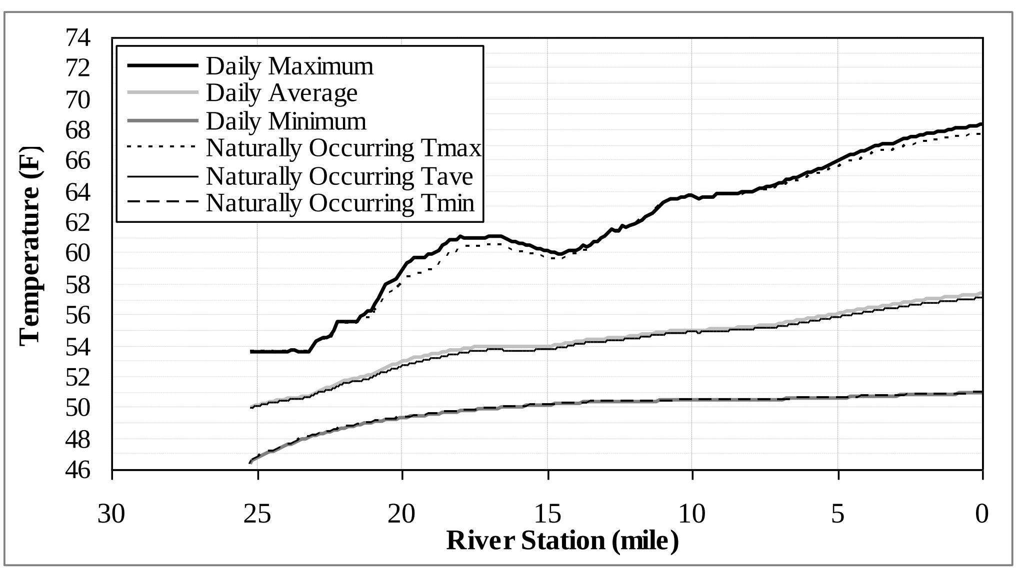

Figure 6-10. Sleeping Child Creek simulated water temperatures for existing conditions and naturally occurring scenario.

6.5.5.2 TMDL, Allocations and Margin of Safety

Thermal conditions within Sleeping Child Creek are largely the result of complex interactions among the factors reviewed in **Table 6-19**, which prevents an easy interpretation of the influence of each one separate from the others. Modeling results indicate that vegetation impacts from timber harvest, grazing and irrigated hay production along Sleeping Child Creek provide the a heating effect upon this segment of stream, yet irrigation water use and return flows are similarly large influence upon stream temperatures. No point sources are present. If all allocations provided in this section are met, Montana's temperature standards will be achieved in Sleeping Child Creek. Additionally, the temperature reductions due to natural revegetation in the area affected by the fire were not considered in the TMDL document, but this area should be managed to recover as quickly as possible.

6.5.5.2.1 Surrogate TMDL for Promoting Nonpoint Source Load Reductions

Monitoring and modeling results provided much of the technical framework for developing a surrogate temperature TMDL and allocation approach. Applying a surrogate TMDL is more useful for guidance of nonpoint source restoration approaches than a heat based numeric TMDL. Influences to stream temperatures are not always intuitive at a watershed scale and the modeling effort helped estimate the relative effects that stream shading, tributary influences, and stream flow have on stream temperature during the warmest time of year. Significant sources and surrogate allocation approaches for each are provided in **Table 6-20**. If each surrogate allocation is followed, the temperature standard will be met. It is likely that the allocations will reduce afternoon summer temperatures by at least 1°F and potentially even higher if irrigation efficiencies and headwater tributary timber harvest allocations are assessed and met. The most influential nonpoint source restoration strategy for Sleeping Child Creek will be restoring shade producing vegetation along the whole segment.

Table 6-20. Sleeping Child Creek temperature TMDL

The TMDL equals the resultant thermal load associated with stream temperature when all conditions below are met:	
Source Type	**Load Allocation (surrogate)**
Agricultural, urban and other land uses that could impact riparian health and resultant **shade** provided by the riparian or near stream vegetation along the Bitterroot River.	The thermal load that can reach the stream segment when there is an average daily shade of 68.5% along Sleeping Child Creek using a Solar Pathfinder.
Forestry land use in headwater **tributaries**.	No measurable or modeled increase in thermal loading from timber harvest in tributaries contributing flow to Sleeping Child Creek.
Inefficient agricultural or urban **water use.**	No reduction in thermal buffering capacity due to inefficient irrigation or urban water use practices along the segment.
Warm **irrigation return water**	A load associated with a condition where 75% reduction in irrigation water entering Sleeping Child Creek or tributaries in which the irrigation water is warmer than instream conditions.

6.5.5.2.2 Numeric TMDL

The TMDL may also be expressed as a numeric heat load to compare with heat based waste load allocations. **Equation 6-2** is the numeric TMDL applied to Sleeping Child Creek. An example heat load calculation for heat of the summer afternoon weather and stream flow conditions near Trails End Road crossing is developed using **Equation 6-2**, **Figure 6-1** and modeling results from **Attachment B**. Two examples of how the temperature TMDL for Sleeping Child Creek equates to stream temperature and heat loads during an average summer afternoon is provided in **Table 6-21, 6-22**. These examples are provided for the average summer flow of about 5 cfs and provide information about each of the areas where standards are not met due to differing sources. The TMDL along with associated load and wasteload allocations are provided in kilocalories per second above water's melting point. Two examples are provided for differing source areas, **Table 6-21** represents a location downstream of a timber harvest area and **Table 6-22** represents a culmination of watershed influences near the watershed outlet.

Table 6-21. Sleeping Child Creek numeric TMDL, allocation and MOS example during a typical summer afternoon below a clear cut section near mile 19

TMDL Component	Load Allocation		Margin of Safety		
Source Description	Natural Sources	Human sources with all reasonable land, soil and water conservation practices in place. This includes: • Well managed agricultural and suburban land use activities along the Sleeping Child Creek and tributaries that provide similar shading as reference areas • Irrigation occurring with 15% efficiency savings applied to summer stream flow • 75% reduction of warm irrigation return flow water entering the Sleeping Child Creek and tributaries.	Reserved for safety factor and uncertainty in analysis	=	TMDL
Estimated Contribution to Temperature TMDL	59.0°F	1.0°F	0.5°F		60.5°F
Heat Load in Kcal/Sec	2,106	79	38		2,223

Table 6-22. Sleeping Child Creek numeric TMDL, allocation and MOS example during a typical summer afternoon near confluence with Bitterroot River

TMDL Component	Load Allocation		Margin of Safety		
Source Description	Natural Sources	Human sources with all reasonable land, soil and water conservation practices in place. This includes: • Well managed agricultural and suburban land use activities along the Sleeping Child Creek and tributaries that provide similar shading as reference areas • Irrigation occurring with 15% efficiency savings applied to summer stream flow • 75% reduction of warm irrigation return flow water entering the Sleeping Child Creek and tributaries.	Reserved for safety factor and uncertainty in analysis	=	TMDL
Estimated Contribution to Temperature TMDL	67.5°F	1.0°F	0.5°F		69.0°F
Heat Load in Kcal/Sec	2,769	78	39		2,886

6.5.6 Willow Creek (MT76H004_110)

Willow Creek originates in the Sapphire Mountains and flows to its confluence with the Bitterroot River near the Town of Corvallis. Willow Creek is currently listed as impaired due to temperature on the 2010 impaired waters list.

6.5.6.1 Existing Conditions and Targets Comparison

The east half of Willow Creek's watershed consists of mountainous terrain and includes timbered and rangeland slopes. Timber harvest has occurred in the watershed, but not within the stream corridor. A forest road travels along the valley bottom, but is usually on the north side of the stream and therefore has an inconsequential impact on effective shade. Livestock grazing practices and irrigated hay production have the potential to reduce riparian vegetation shrub and tree growth along the lowest seven miles of the stream corridor. Also in the lower half of the watershed, water is diverted for hay and crop production and the stream mixes with irrigation ditches that originate from the Bitterroot River.

Three major ditches cross Willow Creek. The upper most canal crossing near river mile eight, usually referred to as the Big Canal is managed by the Bitterroot Irrigation District. At this crossing a flume moves irrigation canal water over the stream without mixing. About 0.15 cfs may be provided to Willow Creek via a gate at the flume during very low stream flow for irrigation use on about 10 acres of land downstream. Most of the water from irrigated land in the Willow Creek watershed managed by the Bitterroot Irrigation District derives from Lake Como. The Daily Ditch Company manages both the Republican and Hedge Ditches which both cross Willow Creek, each of these ditches mix with Willow Creek Water and are managed with a head gate on the downstream side of the ditch. Both of these ditches move water from the Bitterroot River into, and through, the Willow Creek watershed. Streamflows in the lower section of Willow Creek are highly managed by the irrigation system.

Temperature data was collected during 2007 summer field season at eight sites. Monitoring site Will-2 is located about a mile downstream of where irrigation crops begin. Sites Will-3 and Will-4 are above and below the Bitterroot Irrigation District Canal crossing. Sites Will-5 and Will-6 lie above and below the Hedge Ditch crossing. Sites Will-7 and Will-8 fall above and below the Republican Ditch crossing. Site Will-9 is downstream of Corvallis, and the Corvallis Ditch diversion.

Water temperatures rise in a downstream direction until Willow Creek mixes with the Hedge and Republican Ditches. At both of these locations ditch water derived from the Bitterroot River is mixed with Willow Creek stream water and summer daily maximum temperatures are lower below the ditch crossings but daily average temperatures are higher. At site SCHI-2 monitoring equipment detected 60 days above 59°F and 17 days above 70°F. (**Table 6-23**).

Table 6-23. Willow Creek Temperature Data Summary

	Seasonal Max.		7-Day Average during warmest week of the summer				Days >	Days >
Site ID	**Date**	**Value**	**Date**	**Daily Max**	**Daily Min**	**Delta T**	**59 °F**	**70 °F**
WILL-2	08/03/07	66.3	07/31/07	65.1	55.3	9.8	52	0
WILL-3	07/28/07	76.7	07/22/07	74.0	60.5	13.5	67	22
WILL-4	07/14/07	76.5	07/17/07	74.5	66.7	7.9	67	22
WILL-5	07/20/07	79.5	07/17/07	78.1	64.1	14.0	67	21
WILL-6	07/14/07	78.9	07/16/07	77.0	64.2	12.8	67	23
WILL-7	07/14/07	77.8	07/16/07	75.7	64.3	11.4	65	22

Table 6-23. Willow Creek Temperature Data Summary

Site ID	Seasonal Max.		7-Day Average during warmest week of the summer				Days >	Days >
	Date	Value	Date	Daily Max	Daily Min	Delta T	59 °F	70 °F
WILL-8	07/14/07	76.1	07/16/07	74.7	66.1	8.6	67	21
WILL-9	07/14/07	75.9	07/16/07	74.5	66.6	7.9	68	21
WILL-10	07/14/07	76.4	07/16/07	74.5	67.2	7.3	67	21

6.5.6.1.1 Water Quality Modeling using QUAL2K for Source Assessment and Standards Assessment

While currently available data suggests elevated stream temperatures in Sleeping Child Creek, a QUAL2K water quality model was used to determine if the temperature conditions are the result of natural conditions or anthropogenic activities. The model results assist in determining if human caused disturbances within the watershed have increased the water temperature above the “naturally occurring” level and, if so, to what degree. The model incorporated actual temperature, flow and shade information collected during the warmest part of the summer, which was used to calibrate the model to best represent existing conditions. Additionally, various scenarios that represent thermal restoration approaches in the watershed were applied within the model to determine targeted temperature conditions. The description of the model and results can be found in **Attachment B**.

The following sections review existing conditions and estimated restored conditions about each of the human caused thermally influencing factors. Temperature monitoring and modeling results relative to each source are reviewed briefly in the following sections.

6.5.6.1.2 Riparian and Stream Channel Conditions

Riparian effective shade was estimated using conditions from aerial photo assessment throughout the Bitterroot watershed tributaries and coarsely applied to Willow Creek (See **Map A-28** in **Appendix A**). This riparian canopy information was used to calibrate the riparian shade components of the QUAL2K water quality temperature model.

Daily effective shade is estimated at 62% in the headwaters and 37% in the Bitterroot River Valley. Willow Creek is a small stream with a narrow active channel and thus streamside shading from vegetation is likely to affect stream temperatures significantly. Riparian vegetation along Willow Creek consists of conifer forest in the headwaters and intermixed shrubs, deciduous trees, forbs and grass in the remainder of the watershed. Predominant human impacts currently impacting streamside vegetation include livestock grazing and hay/crop production. Average current shade along all of Willow Creek is estimated at 57% and a restored riparian vegetation condition would likely increase effective shade to 65%.

Willow Creek’s channel is also overly wide in some areas. This condition contributes to higher solar radiation entering the stream and higher stream temperatures. The width-to-depth targets provided in **Section 5.4.1.2** also apply to Willow Creek temperature TMDL.

6.5.6.1.3 Irrigation Water Use

Use of stream water for irrigation depletes the volume of water in the stream. The reduced water volume heats up more quickly and to a higher temperature given the same amount of thermal input. Therefore, the higher temperatures due to reduced capacity for buffering heat are manifested downstream of irrigation withdrawals. Alternatively, irrigation and subsequent groundwater return flow may cool the stream in cases were severe dewatering occurs and subsequent stream flow is mostly groundwater.

There are about 50 decreed water rights in the watershed originating in Willow Creek or its tributaries that cumulatively account for about 90 cfs. About 85 water appropriations could account for over 500 cfs of water use, yet are not verified (Buck, 1958). It is unlikely that this much water is available in the summer. Currently the eastern tributaries of the Bitterroot River are proceeding with the adjudication process but no results are available at this time. Water use from the streams in the watershed is extensive and the lower reaches of Willow Creek are fed by reemerging groundwater or irrigation canal water. During the summer timeframe in drought years, a section of Willow Creek carries little to no water from near Gottard-Hull Ditch to Republican Ditch.

Three major ditches cross Willow Creek. The upper most canal crossing near river mile eight, usually referred to as the Big Canal, is managed by the Bitterroot Irrigation District. At this crossing a flume moves irrigation canal water over the stream without mixing. About 0.15 cfs may be provided to Willow Creek via a gate at the flume during very low stream flow for irrigation use on about 10 acres of land downstream. Most of the water from irrigated land in the Willow Creek watershed managed by the Bitterroot Irrigation District derives from Lake Como. The Daily Ditch Company manages both the Republican and Hedge Ditches which both cross Willow Creek, each of these ditches mix with Willow Creek Water and are managed with a head gate on the downstream side of the ditch. Both of these ditches move water from the Bitterroot River into, and through, the Willow Creek watershed. Streamflows in the lower section of Willow Creek are highly managed by the irrigation system.

Stream temperatures likely increase due to irrigation diversions in the middle reaches of the stream but maximum daily temperatures are cooled by irrigation water canals that mix with the stream. Average daily temperatures are slightly increased by the mixing effect, yet maximum daily temperatures of the stream are decreased due to the thermal inertia of the ditches and the Bitterroot River. When the mixing of stream and irrigation water was removed from the model, the model would not run due to streambeds being dry. Therefore, this scenario could not be included in **Attachment B** and is not considered in a restoration approach at this time.

Because of the complex and extensive irrigation system found in this watershed and its varied effects upon water temperature and stream flow, the irrigation system return flow influences are not considered in the allocation approach or naturally occurring modeling scenarios (**Table 6-17**). Nevertheless, irrigation efficiencies and irrigation water management within this watershed are addressed in the TMDL, the adaptive management approaches, and follow-up monitoring components of the TMDL document and are included in the targets.

6.5.6.1.4 Summary of Targets and Existing Conditions for Willow Creek

Table 6-24 provides a review of temperature targets for Willow Creek. The targets will incorporate an "or" statement where Montana's temperature standards should be met or all the temperature influencing targets should be met. The temperature influencing targets include target conditions for vegetation produced shade along the segment, channel conditions, irrigation water use and waste. If all these targets are met, Montana's water temperature standards will be met in Willow Creek.

Table 6-24. Temperature Targets and Existing Conditions for Willow Creek

Water Quality Targets	Criteria	Existing Condition
Maximum allowable increase over naturally occurring temperature	For waters classified as B-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 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.	Calibrated QUAL2K model results are compared to restoration scenario results. Modeling conclusions indicate Montana's temperature standard is not being met during average summer afternoon conditions. If conditions provided below for sources are met, daily maximum summertime temperatures would likely be reduced by at least 2.5°F (**Attachment B**).
OR meet ALL of the temperature influencing restoration targets below		
Effective Shade (timber harvest, hay production, and livestock grazing)	65% Effective Shade	57% Effective Shade
Channel width/depth ratio	See **Table 5-4**	See **Table 5-46**
Irrigation water management (Higher efficiency)	15% improvement in irrigation efficiency during the warmest months with water saving applied to in-stream flow (mid-June through August).	The irrigation system should be assessed for inefficiencies to determine if this estimated efficiency based upon regional irrigation management studies is achievable and to identify specific strategies to reduce irrigation use and keep water in the River.
Irrigation return flow	Complete study to determine best management practice which will benefit the fishery.	See text.

A naturally occurring model scenario of Willow Creek defines water temperature conditions resulting from the implementation of all reasonable land, soil and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the "naturally occurring" temperature in waterbodies of interest and establishes the temperatures to which a 0.5°F (0.23°C) temperature increase is allowable. This, in turn, can be used to identify if standards are exceeded and determine if a TMDL is needed. The naturally occurring scenario for Willow Creek assesses sources that impact shade along the segment. In the lowest portion of the stream, water is heated at least 2.5°F from irrigated crop production and riparian grazing that reduce shade by impacting riparian vegetation. The modeling results indicate that temperature standards are exceeded in Willow Creek.

The streamside vegetation shade targets and W/D ratio targets are not met. It's also likely that the irrigation targets are not met. Both the modeling and temperature influencing target assessment approaches indicate Montana's water temperature standards are not being met. Therefore, Willow Creek is in need of a temperature TMDL.

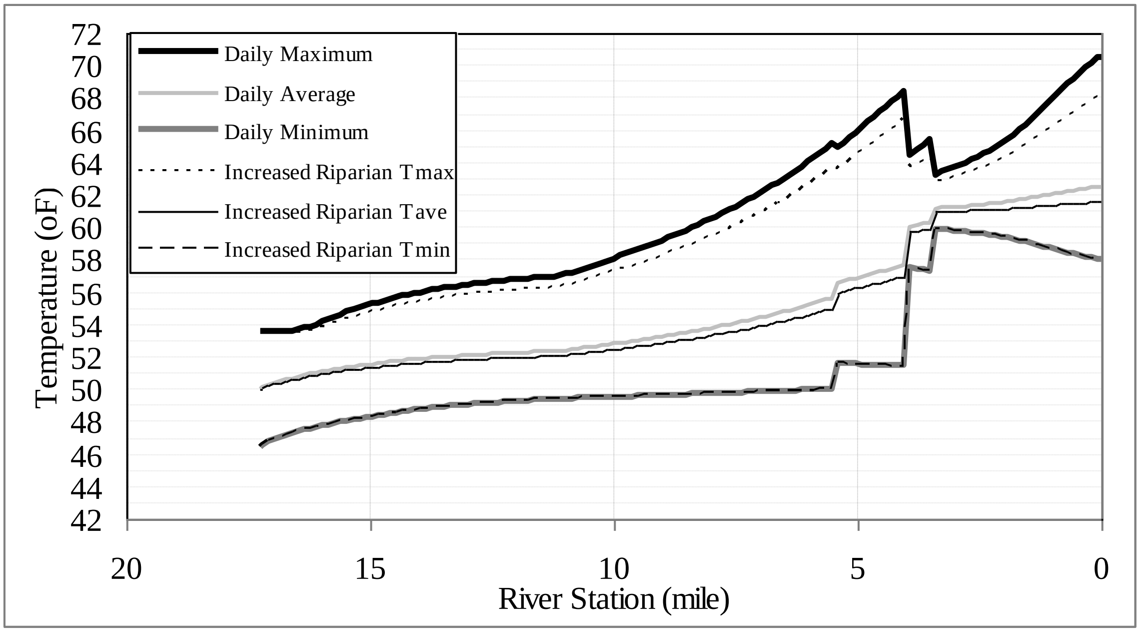

Figure 6-11. Willow Creek simulated water temperatures for existing conditions and an increased shade scenario.

6.5.6.2 TMDL, Allocations and Margin of Safety

Thermal conditions within Willow Creek are largely the result of complex interactions among the factors reviewed in **Table 6-21**, which prevents an easy interpretation of the influence of each one separate from the others. Modeling results indicate that vegetation impacts from timber harvest, grazing and irrigated hay production along Willow Creek provide the largest heating effect upon this segment of stream. No point sources are present. If all allocations provided in this section are met, Montana's temperature standards will be achieved in Willow Creek.

6.5.5.2.1 Surrogate TMDL for Promoting Nonpoint Source Load Reductions

Monitoring and modeling results provided much of the technical framework for developing a surrogate temperature TMDL and allocation approach. Applying a surrogate TMDL is more useful for guidance of nonpoint source restoration approaches than a heat based numeric TMDL. Influences to stream temperatures are not always intuitive at a watershed scale and the modeling effort helped estimate the relative effects that stream shading, tributary influences, and stream flow have on stream temperature during the warmest time of year. Significant sources and surrogate allocation approaches for each are provided in **Table 6-25**. If each surrogate allocation is followed, the temperature standard will be met. It is likely that the allocations will reduce afternoon summer temperatures by at least 1°F and potentially even higher if irrigation efficiencies and headwater tributary timber harvest allocations are assessed and met. The most influential nonpoint source restoration strategy for Willow Creek will be restoring shade producing vegetation along the whole segment.

Table 6-25. Willow Creek temperature TMDL

The TMDL equals the resultant thermal load associated with stream temperature when all conditions below are met:	
Source Type	**Load Allocation (surrogate)**
Agricultural, urban and other land uses that could impact riparian health and resultant shade provided by the riparian or near stream vegetation along the Bitterroot River.	The thermal load that can reach the stream segment when there is an average daily shade of 68.5% along Willow Creek using a Solar Pathfinder.
Forestry land use in headwater tributaries.	No measurable or modeled increase in thermal loading from timber harvest in tributaries contributing flow to Willow Creek.
Inefficient agricultural or urban water use.	No reduction in thermal buffering capacity due to inefficient irrigation or suburban water use practices along the segment.
Warm irrigation return water	Complete investigation to determine best management practice which will benefit the fishery.

6.5.6.2.2 Numeric TMDL and Allocations

The TMDL may also be expressed as a numeric heat load to compare with heat based waste load allocations. **Equation 6-2** is the numeric TMDL applied to Willow Creek. An example heat load calculation for heat of the summer afternoon weather and stream flow conditions near Trails End Road crossing is developed using **Equation 6-2**, **Figure 6-1** and modeling results from **Attachment B**. Two examples of how the temperature TMDL for Willow Creek equates to stream temperature and heat loads during an average summer afternoon is provided in **Table 6-26**. These examples are provided for the average summer flow of about 5cfs and provide information about each of the areas where standards are not met due to differing sources. The TMDL along with associated load and wasteload allocations are provided in kilocalories per second above water's melting point.

Table 6-26. Willow Creek numeric TMDL, allocation and MOS example during a typical summer afternoon at river mile 4.5

TMDL Component	**Load Allocation**		**Margin of Safety**		
Source Description	Natural Sources	Human sources with all reasonable land, soil and water conservation practices in place. This includes: • Well managed agricultural and suburban land use activities along the Willow Creek and tributaries that provide similar shading as reference areas • Irrigation occurring with 15% efficiency savings applied to summer stream flow • Study irrigation system for reducing irrigation water impact while keeping water in the stream.	Reserved for safety factor and uncertainty in analysis	=	TMDL
Estimated Contribution to Temperature TMDL	61.0°F	1.0°F	0.5°F		62.5°F
Heat Load in Kcal/Sec	2,262	78	38		2,379

6.6 Margin of Safety and Seasonal Considerations

All TMDL/Water Quality Restoration Planning documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream, and load allocations. TMDL development must also incorporate a margin of safety into the allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes, in detail, considerations of seasonality and a margin of safety in the temperature TMDL development process.

The margin of safety is addressed in several ways as part of this document:

- Explicit MOSs are provided in each of the thermal TMDLs.
- Montana's water quality standards are applicable to any timeframe and any season. The temperature modeling analysis investigated temperature conditions during the heat of the summer when the temperature standards are most likely exceeded and when the most significant human caused sources are likely to heat the stream the most.
- The assessment and subsequent allocation scenarios addressed stream flow influences that affect the streams dissipative and volumetric heat capacity.
- Compliance with targets and refinement of load and wasteload allocations are all based on an adaptive management approach (**Section 6.7**) that relies on future monitoring and assessment for updating planning and implementation efforts.

Seasonal considerations are significant for temperature. Obviously, with high temperatures being a primary limiting factor for westslope cutthroat and bull trout, summer temperatures are a paramount concern. Therefore, focusing on summer thermal regime is an appropriate approach. Seasonality addresses the need to ensure year round beneficial use support. Seasonality is addressed in this TMDL document as follows:

- Temperature monitoring occurred during the summer season, which is the warmest time of the year. Modeling simulated heat of the summer conditions when instream temperatures are most stressful to the fishery. The fishery is the most sensitive use in regard to thermal conditions.
- Temperature targets, TMDL, load and wasteload allocations apply year round, but it is likely that exceedances occur mostly during summer conditions.
- Restoration approaches will help to stabilize stream temperatures year round, including reducing the formation of anchor ice which may limit fish health.
- Thermal WLAs are based upon yearly 7Q10s, which are lower than summer time 7Q10s. The summer timeframe is stressful to the fishery, the most sensitive use. An inherent MOS for the WLAs is provided by the use of yearly 7Q10s.

6.7 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 or living with the uncertainty when more effort is likely unnecessary to restore uses by easily identified sources.

The processes 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 an 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 thermal conditions meet state standards.

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

Any influencing factors that increase water temperatures, including global warming, could impact thermally sensitive fish species in Montana. The assessments and technical analysis for the temperature TMDLs considered a worst case scenario reflective of current weather conditions, which inherently accounts for any global warming 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.

Uncertainties in environmental assessments should not paralyze, but should point to the need for flexibility in our understanding of complex systems and to adjust our current thinking and future analysis. Implementation and monitoring recommendations presented in **Section 8.2** and **8.3** provide a basic framework for reducing uncertainty and further understanding of the complex issues TMDLs undertake.

7.0 - Other Identified Issues or Concerns

7.1 Habitat Related Non-Pollutant Listings

Water quality issues are not limited to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the DEQ assessment process and do not appear on the 303(d) list (such as Fred Burr Creek or Eightmile Creek). In other cases, streams may appear in the water quality integrated report with a non-pollutant listing such as “alteration in stream-side or littoral vegetative covers” that could be linked to a pollutant, but may not require TMDL development. These habitat related non-pollutant causes are often associated with sediment and temperature issues, or potential sediment and temperature issues. They may also be having a harmful effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when attempting to improve water quality conditions in individual streams, and the Bitterroot watershed as a whole. In some cases, pollutant and non-pollutant causes are listed for a waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the habitat related non-pollutant listings. **Table 7-1** presents the habitat related pollution listings in the Bitterroot TPA, and highlights those streams that have an associated pollutant listing.

Table 7-1. Waterbody segments in the Bitterroot TPA with habitat related non-pollutant listings

Stream Segment	Waterbody Segment ID	2010 Probable Causes of Impairment
Ambrose Creek	MT76H004_120	Physical substrate habitat alterations
Bass Creek	MT76H004_010	Low flow alterations
Bear Creek	MT76H004_030	Low flow alterations
Bitterroot River (East and West Forks to Skalkaho)	MT76H001_010	Alteration in stream-side or littoral vegetative covers
Bitterroot River (Skalkaho to Eightmile)*	MT76H001_020	Low flow alterations
Bitterroot River (Eightmile to mouth/ Clark Fork River)*	MT76H001_030	Alteration in stream-side or littoral vegetative covers
Blodgett Creek	MT76H004_050	Low flow alterations
Kootenai Creek	MT76H004_020	Alteration in stream-side or littoral vegetative covers and Low flow alterations
Lick Creek*	MT76H004_170	Alteration in stream-side or littoral vegetative covers
Lolo Creek (Mormon Creek to mouth/ Bitterroot River)*	MT76H005_011	Physical substrate habitat alterations and Low flow alterations
Lolo Creek (Sheldon Creek to Mormon Creek)*	MT76H005_012	Physical substrate habitat alterations
Lolo Creek (headwaters to Sheldon Creek)*	MT76H005_013	Physical substrate habitat alterations
Lost Horse Creek	MT76H004_070	Low flow alterations
Mill Creek*	MT76H004_040	Alteration in stream-side or littoral vegetative covers and Low flow alterations
Miller Creek*	MT76H004_130	Alteration in stream-side or littoral vegetative covers
North Channel Bear Creek	MT76H004_032	Low flow alterations

Table 7-1. Waterbody segments in the Bitterroot TPA with habitat related non-pollutant listings

Stream Segment	Waterbody Segment ID	2010 Probable Causes of Impairment
North Fork Rye Creek	MT76H004_160	Alteration in stream-side or littoral vegetative covers
Rye Creek*	MT76H004_190	Alteration in stream-side or littoral vegetative covers
Skalkaho Creek	MT76H004_100	Low flow alterations
South Fork Lolo Creek	MT76H005_020	Physical substrate habitat alterations and Low flow alterations
Sweathouse Creek	MT76H004_210	Alteration in stream-side or littoral vegetative covers and Low flow alterations
Threemile Creek*	MT76H004_140	Low flow alterations
Tin Cup Creek	MT76H004_080	Alteration in stream-side or littoral vegetative covers
Willow Creek*	MT76H004_110	Alteration in stream-side or littoral vegetative covers
* Streams listed for habitat related non-pollutants, and having associated sediment or temperature pollutant listings.		

7.2 Descriptions of Non-Pollutant Causes of Impairment

Non-pollutant listings are often used as a probable cause of impairment when available data at the time of assessment does not necessarily provide a direct quantifiable linkage to a specific pollutant; yet non-pollutant sources or indicators do indicate impairment. In some cases the pollutant and non-pollutant categories are linked and appear together in the cause listings; however a non-pollutant category may appear independent of a pollutant listing. The following discussion provides some rationale for the application of a non-pollutant cause to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation or remediation.

Alteration in Stream-side or Littoral Vegetation Covers

Alteration in stream-side 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 stream-side vegetation, destabilized banks from loss of vegetative root mass could lead to over-widened stream channel conditions, 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 anthropogenically influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

Low Flow Alterations

Streams are typically listed for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that stream. This could result in dry channels or extreme low flow conditions that do not support fish and aquatic life. Additionally, low flow conditions have the potential to limit sediment-transport capacity which may lead to an accumulation of fine sediments that could affect fish and aquatic life. It could also result in lower flow conditions which absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish. It should be noted that while Montana law states that TMDLs cannot impact Montana water rights and thereby affect the allowable flows at various times of the year, the identification of low flow alterations as a probable source of impairment does not violate state or federal regulations or guidance related to stream assessment and water quality impairment determination. Subsequent to the identification of low flow alterations as a probable cause of impairment, it is up to local users, agencies, and entities to improve flows through water and land management.

7.3 Monitoring and BMPs for Pollution Affected Streams

Streams listed for habitat related pollution as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment and temperature information where data is minimal and the linkage between probable cause, habitat related pollution listing, and affects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Section 8.0** are presented to address pollutant issues for the Bitterroot TPA streams, but are equally applicable to streams listed for the above pollution categories.

8.0 - Framework Water Quality Restoration and Monitoring Strategy

8.1 TMDL Implementation and Monitoring Framework

While certain land uses and human activities are identified as sources and causes of water quality impairment during TMDL development, the management of these activities is of more concern than the activities themselves. This document does not advocate for the removal of land and water uses to achieve water quality restoration objectives, but instead for making changes to current and future land management practices that will help improve and maintain water quality. This section discusses the framework for TMDL implementation and a monitoring strategy to help ensure successful TMDL implementation and attainment of water quality standards.

8.1.1 Agency and Stakeholder Coordination

DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. DEQ will work with participants to use these TMDLs as a basis for developing locally-driven watershed restoration plans, administer funding specifically for water quality improvement and pollution prevention projects, and can help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers continue to work collaboratively with local and state agencies to achieve water quality restoration goals which will progress toward meeting TMDL targets and load reductions. Specific stakeholders and agencies that have been and will likely continue to be vital to restoration and water quality maintenance efforts include the Bitter Root Water Forum (BRWF), Lolo Watershed Group (LWG), USFS, DNRC, FWP and DEQ. Additionally, local land managers, stakeholder groups, and other state and federal agencies may be helpful in providing technical, financial or coordination assistance.

8.1.2 Water Quality Restoration Plan Development

A watershed restoration plan (WRP) provides a framework strategy for water quality restoration and monitoring in the Bitterroot TPA, 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. Watershed restoration plans 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 following are key elements suggested for the WRP:

- Implement best management practices (BMPs) to protect water conditions so that all streams in the watershed maintain good quality, with an emphasis on waters with completed TMDLs.
- Develop more detailed cost-benefit and spatial considerations for water quality improvement projects.

- Develop an approach for future BMP installments and efficiency results tracking.
- Provide information and education to reach out to stakeholders about approaches to restoration, its benefits, and funding assistance.

The Lolo Watershed Group is working on a Water Quality Restoration Plan for Lolo Creek, and is receiving financial and technical support from the DEQ under a '319 grant' to initiate WRP development. DEQ encourages collaboration among local stakeholders, interested parties, state and federal agencies in the development of the Lolo WRP and any future efforts to develop a Bitterroot TPA WRP.

8.1.3 Adaptive Management and Uncertainty

An adaptive management approach is recommended to manage costs as well as achieve success in meeting the water quality standards and supporting all beneficial uses. This approach works in cooperation with the monitoring strategy and allows for adjustments to the restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary. These adjustments would take into account new information as it arises.

The adaptive management approach is outlined below:

- TMDLs and Allocations: The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and further assumes that meeting target conditions will ensure full support of all beneficial uses. Much of the monitoring proposed in this section of the document is intended to validate this assumption. If it looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed based on achievable reductions via application of reasonable land, soil, and water conservations practices.
- Water Quality Status: As new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified. Additionally, as restoration activities are conducted in the Bitterroot TPA and target variables move towards target conditions, the impairment status of the 303(d) listed waterbodies is expected to change. An assessment of the impairment status will occur after significant restoration occurs in the watershed.

8.1.4 Funding and Prioritization

Funding and prioritization of restoration or water quality improvement project is integral to maintaining restoration activity and monitoring successes and failures. Several government agencies fund watershed or water quality improvement projects. Below is a brief summary of potential funding sources to assist with TMDL implementation.

Section 319 funding

Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 40 percent match requirement. 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county. The LWG recently received 319 funding to assist with the development of the WRP. The Bitter Root Water Forum has received 319 funding to assist with nonpoint-source-pollution education and outreach.

Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for on-the-ground 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 Bitterroot TPA include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats.

Watershed Planning and Assistance Grants

The MT 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.

Other Funding Sources

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (DEQ, 2007) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

8.2 Implementation Strategies and Recommendations

For each major source of human-caused pollutant loads in the Bitterroot TPA, general management recommendations are outlined below. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Bitterroot TPA should focus on all major sources for each pollutant category. Yet, restoration should begin with addressing either the sources with the biggest cost to load reduction benefit or the largest source categories found during TMDL development.

For each major source, BMPs will be most effective as part of a management strategy that focuses on critical areas within the watershed, which are those areas contributing the largest pollutant loads or are especially susceptible to disturbance. Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by ensuring that new activities within the watershed incorporate all appropriate BMPs, and ensuring continued implementation and maintenance of those BMPs currently in place or in practice. Restoration might also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key sediment or thermal sources. In these cases, BMPs are usually identified as a first effort followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 8.3**.

8.2.1 Riparian and Floodplain Management

Riparian areas and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. Therefore, enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Bitterroot TPA.

Initiatives to protect riparian areas and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants. However, in areas with a much smaller buffer or where historical vegetation removal and development have shifted the riparian vegetation community and limited its functionality, a tiered approach for restoring stream channels and adjacent riparian vegetation should be considered that prioritizes areas for restoration based on the existing condition and potential for improvement. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover on streambanks to riparian vegetation target levels associated with the sediment and temperature TMDLs. Passive riparian restoration is preferable, but in areas where stream channels are unnaturally stable or streambanks are eroding excessively, active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be needed. Factors influencing appropriate riparian restoration would include the severity of degradation, site-potential for various species, and the availability of local sources as transplant materials. In general, riparian plantings would promote the establishment of functioning stands of native species (grasses and willows). Wee management should also be a dynamic component of managing riparian areas.

The following recommended restoration measures would help stabilize the soil, decrease sediment reaching the streams, provide increased shade from riparian vegetation and in some cases reduce channel widths.

- Harvest and transplant locally available sod mats with dense root mass to immediately promote bank stability and capture sediments.
- Transplant mature shrubs, particularly willows (Salix sp.), to rapidly restore instream habitat and water quality by providing overhead cover and stream shading
- Seed with native graminoids (grasses and sedges) and forbs, a low cost activity where lower bank shear stresses would be unlikely to cause erosion.
- Plant willows by “sprigging” to expedite vegetative recovery; sprigging involves clipping willow shoots from nearby sources and transplanting them in the vicinity where needed.

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, “hard” approaches generally redirect channel energy and exacerbate erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat.

8.2.2 Grazing Management

Development of riparian grazing management plans should be a goal for landowners in the watershed who are not currently using a plan. 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 these areas. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure. Grazing should be managed to provide filtering capacity via adequate groundcover, stream bank stability via mature riparian vegetation communities, and shading from mature riparian climax communities.

Grazing management includes the timing and duration of grazing, the development of multipasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the stream bank and channel. The primary recommended BMPs for the Bitterroot TPA are providing off-site watering sources, limiting livestock access to streams, providing "water gaps" where livestock access to a stream is necessary, planting woody vegetation along stream banks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank revegetation are a preferred BMPs, in some instances bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution can be obtained in Appendix A of Montana's NPS Management Plan (DEQ, 2007).

8.2.3 Small Acreages

Small acreages are growing rapidly, and many small acreage owners own horses, cattle, or sheep. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further information may be obtained from the Montana Nonpoint Source Management Plan (DEQ, 2007) or the MSU extension website at: http://www.msuextension.org/ruralliving/Index.html.

8.2.4 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality. To minimize water quality effects from AFOs, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). This plan is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and other options for manure disposal. An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO), and in addition may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary, as well as, regulatory components. If voluntary efforts can eliminate discharges to state waters, in some cases no direct regulation is necessary through a permit. Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters, which additionally increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce waste loads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90 percent (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water.

Opportunities for financial and technical assistance (including comprehensive nutrient management plan development) in achieving voluntary AFO and CAFO compliance are available from conservation districts and NRCS field offices. Voluntary participation may aide in preventing a more rigid regulatory program from being implemented for Montana livestock operators in the future.

Further information may be obtained from the DEQ website at: http://www.deq.mt.gov/wqinfo/mpdes/cafo.asp. Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and other resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education & outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ internal (Permitting Division), as well as external entities (DNRC, local watershed groups, conservation districts, MSU Extension, etc.).

8.2.5 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment and nutrient 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 Bitterroot TPA are vegetated filter strips (VFS) 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 percent for filter strips and 50 percent for buffers (DEQ, 2007). 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 which will also supply shade to reduce instream temperatures. Filter strips widths along streams should be at least double the average mature canopy height to assist in providing stream shade. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (DEQ, 2007).

8.2.6 Irrigation

Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to stream flow can have a profound effect on the ability of a stream to attenuate pollutants, especially 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 recommend flow-related recommendations and enhancements as a means to achieve full support of beneficial uses. However, local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

Irrigation management is a critical component of attaining both coldwater fishery conservation and TMDL goals. Irrigation efficiency management practices in the Bitterroot TPA involve investigating how to reduce the amount of stream water diverted during July and August, while still growing crops on traditional cropland. It may be desirable to investigate irrigation practices earlier in the year that promote groundwater return during July and August. Understanding irrigation water, groundwater and surface water interactions is an important part of understanding how irrigation practices will affect stream flow during specific seasons.

Many of the irrigation practices in the Bitterroot TPA are based in flood irrigation methods. In some cases, head gates and ditches leak, which can decrease the amount of water flowing in streams. The following recommended activities would result in notable water savings:

- Install upgraded head gates for more exact control of water diversions and to minimize leakage when not in operation.
- Develop more efficient means to supply water to livestock.
- Determine necessary amounts of water to divert that would reduce over watering and improve forage quality and production.
- Redesign irrigation systems.
- Upgrade ditches (including possible lining) to increase ditch conveyance efficiency.
- Investigate field application efficiency and reduce irrigation runoff from fields.

Future studies could investigate irrigation groundwater return flow timeframes from specific areas along the Bitterroot TPA tributaries. A portion of spring and early summer flood irrigation on near-stream locations 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 were year round irrigation efficiencies could be more beneficial to preserving flow in the stream during hot summer timeframes. Preserving winter and spring base flow should also be considered during irrigation management and associated groundwater investigations.

8.2.7 Forestry and Timber Harvest

Timber harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, road building including culvert design, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a waterbody), the riparian protection principles behind the law should be applied to numerous land management activities (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. 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. Following the SMZ Law is a step toward meeting temperature TMDLs in this watershed, but does not provide a regulatory mechanism to fully meet the temperature TMDL shade related load allocations along forested streams. When Montana's SMZ Law was developed, meeting Montana's temperature standards through the process was not a primary consideration.

United States Forest Service (USFS) Inland Fish (INFISH) Riparian Habitat Conservation Area (RHCA) guidelines likely protect shade to a level in which the TMDL allocation would be met if they were followed throughout most of the forested portions of the watershed. This guidance 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).

8.2.8 Unpaved Road BMPs

The road sediment reductions in this document represent a gross estimation of the sediment load that would remain once appropriate road BMPs were applied at all locations, which include a reduction in contributing road length to 200-feet for each unpaved crossing and 500-feet for each parallel road segment. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's Nonpoint Source Management Plan (DEQ, 2007). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.
- Insloping roads along steep banks with the use of cross slopes and cross culverts.
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope.
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grading materials to the center of the road and avoiding removing the toe of the cutslope.
- Preventing disturbance to vulnerable slopes.
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.
- No new roads with long parallel sections within 150 feet of streams. Limit new road stream crossings to the extent practicable.

8.2.9 Culverts and Fish Passage

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 found that approximately 64% of the culverts were designed to accommodate 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 67 culverts in the watershed 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. A coarse assessment of fish passage indicated that 84 percent of the assessed culverts pose a fish passage risk at all flows. 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.

8.2.10 Stormwater Construction Permitting and BMPs

Construction activities disturb the soil, and if not managed properly, they can be substantial sources of sediment. Construction activity disturbing one acre or greater is required to obtain permit coverage through DEQ under the Storm Water General Permit for Construction Activities. A Stormwater Pollution Prevention Plan (SWPPP) must be developed and submitted to obtain a permit. A SWPPP identifies pollutants of concern, which is most commonly sediment, construction related sources of those pollutants, any nearby waterbodies that could be affected by construction activities, and BMPs that will be implemented to minimize erosion and discharge of pollutants to waterbodies. The SWPPP must be implemented for the duration of the project, including final stabilization of disturbed areas, which is a vegetative cover of at least 70% of the pre-disturbance level or an equivalent permanent stabilization measure. Development and implementation of a thorough SWPPP should ensure WLAs within this document are met. Additionally, because of the risk of sediment loading from construction activities disturbing 10 or more acres, EPA recently added effluent limitation guidelines, sampling requirements, and new source performance standards to control the discharge from construction sites; the changes will be incorporated into the next construction Storm Water General Permit authorization in Montana in January 2012 and the requirements will be phased in based on the area of land disturbance.

Land disturbance activities that are smaller than an acre (and exempt from permitting requirements) also have the potential to be substantial pollutant sources, and BMPs should be used to prevent and control erosion consistent with the upland erosion allocations. Potential BMPs for all construction activities include construction sequencing, permanent seeding with the aid of mulches or geotextiles, check dams, retaining walls, drain inlet protection, rock outlet protection, drainage swales, sediment basin/traps, earth dikes, erosion control structures, grassed waterways, infiltration basins, terraced slopes, tree/shrub planting, and vegetative buffer strips. The EPA support document for the construction permit requirements has extensive information about construction related BMPs, including limitations, costs, and effectiveness (EPA 2009a).

8.2.11 Urban Area Stormwater BMPs

Any BMPs which promote onsite or after collection infiltration, evaporation, transpiration or reuse of the initial flush stormwater should be implemented as practicable on all new or redevelopment projects. These BMPs include, but are not limited to:

- Bioretention
- Permeable pavements
- Green roofs
- Cisterns & rain barrels
- Trees & expanded tree boxes
- Reforestation & restoration
- Parking & street designs
- Water Conservation
- Drywells
- Routing water via grassy swales instead of lined systems
- Permeable underground pipe in gravel systems for areas above groundwater

- Infiltration basins
- Water reuse

EPA provides more comprehensive information about stormwater best management practices on their website at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.

8.2.12 WWTPs

To ensure the WWTPs are meeting each thermal WLA, any municipality shall not increase their effluent temperature and shall discharge at rates below double their existing hourly peak flow rate, or at their design capacity hourly peak flow, whichever is greater. The WWTP flow rates associated with the target conditions are provided in **Table 6-3**. If these conditions are not met, the facility must initiate action to prove they do not heat the Bitterroot River more than 0.25°F.

If changes to a waste treatment process occur that are likely to increase the temperature of any effluent in the watershed, or if flow rates will increase above the thresholds given for the surrogate WLA approach, an effluent temperature assessment must be initiated to determine if the plant will meet the target requirement of ≤ 0.25°F temperature increase at the end of the mixing zone due to the future WWTP plant modification (**Table 6-4**). Monitoring and reporting requirements for this process are provided in **Section 8.3.1**.

8.2.13 Nonpoint Source Pollution Education

Because most nonpoint source pollution (NPS) is generated by individuals, a key factor in reducing NPS is increasing public awareness through education. The Bitter Root Water Forum and the Lolo Watershed Group provide educational opportunities to both students and adults through local water quality workshops and informational meetings. Continued education is key to ongoing understanding of water quality issues in the Bitterroot TPA, and to the support for implementation and restorative activities.

8.3 Monitoring Recommendations

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The margin of safety is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate. Where applicable, analytical detection limits must be below the numeric standard.

The monitoring framework presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

The objectives for future monitoring in the Bitterroot TPA include: 1) baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality, 2) tracking and monitoring restoration activities and evaluating the effectiveness of individual and cumulative restoration activities, and 4) refining the source assessments. Each of these objectives is discussed below for both sediment and temperature.

8.3.1 Baseline and Impairment Status Monitoring

Monitoring should continue to be conducted to expand knowledge of existing conditions and also collect data that can be evaluated relative to the water quality targets. Although DEQ is the lead agency for developing and conducting impairment status monitoring, other agencies or entities may collect and provide compatible data. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent with DEQ methodology so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals. The information in this section provides general guidance for future impairment status monitoring.

Sediment

For sediment investigation in the Bitterroot TPA, each of the streams of interest was stratified into unique reaches based on physical characteristics and anthropogenic influence. The 32 sites assessed equates to only a small percentage of the total number of stratified reaches, and even less on a stream by stream basis. Sampling additional monitoring locations to represent some of the various reach categories that occur would provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole, by which to assess reach by reach comparisons and the potential influencing factors and resultant outcomes that exist throughout the watershed.

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 it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle Pebble Count; using Wolman Pebble Count methodology and/or 49-point grid tosses in riffles and pool tails
- Residual Pool Depth Measurements
- Greenline Assessment; NRCS methodology

Additional information will undoubtedly be useful and assist impairment status evaluations in the future and may include total suspended solids, identifying percentage of eroding banks, human sediment sources, areas with a high background sediment load, macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts.

Temperature Ambient Stream Monitoring and Assessment

Currently USGS monitors temperature on a continuous basis at the USGS gage near Missoula. Montana Fish Wildlife and Parks monitors continuous summer season temperatures at five sites on the Bitterroot River: near Darby, Hamilton, Bell Crossing, Florence, and Missoula. This monitoring can be used to track long term trends in stream temperatures in the Bitterroot River. Temperature monitoring on the tributaries where TMDLs are provided occurs less consistently and will likely be initiated via future TMDL review by DEQ.

The Tri-State Water Quality Council and Montana Department of Natural Resources and Conservation collected temperature and discharge data above and below an irrigation return in Threemile Creek. DEQ will incorporate this data into DEQ's assessment records.

Temperature Wasteload Monitoring
Three distinct conditions shall prompt temperature assessment or monitoring in effluents. First, if a WWTP initiates upgrades to their system which will likely alter effluent temperature, an engineering assessment of likely thermal alteration of the effluent must be completed and approved by DEQ prior to the upgrade. The assessment must consider if the facility upgrade would continue to achieve the 0.25°F thermal increase at the point where the effluent fully mixes with the Bitterroot River at 7Q10 during sensitive timeframes for the fishery. If the engineering assessment indicates temperature conditions at the end of the mixing zone are not met, an approach to meet the thermal conditions must be supplied to DEQ prior to any plant upgrades. DEQ shall require monitoring during the season following the upgrade.

Alternatively, if no upgrades are completed, a discharger will initiate temperature monitoring the season immediately following the permit renewal. Also, if a WWTP discharges more than double existing hourly peak flow rate or their design capacity hourly peak flow, whichever is greater, the discharger will be required to complete temperature monitoring during one season immediately following the flow exceedance or submit a report to DEQ confirming that the facility is below the 0.25°F thermal increase level at 7Q10 flows at the point where their effluent fully mixes with the Bitterroot River.

The temperature WLA monitoring and reporting will include the following procedures. Effluent temperature monitoring will be conducted using digital recording thermometers with accuracy to 0.4 ºF. Temperatures will be reported to DEQ in an excel spreadsheet by the following December for data recorded on half hour increments of time during May 1st through September15th and will include a brief summary of methods by which the data was collected. Upstream and effluent monitoring data will be used to determine if a 7-day average of the daily maximum temperatures of the effluent during the warmest week of the summer, populate a mixing equation for facility to determine the heating rate of the Bitterroot River at 7Q10 while applying the prior mentioned temperature statistic for calculations, and compare these results to those estimated in **Tables 6-3** and **6-9**. If effluent temperatures or flow rates are above those stated in **Tables 6-3** and **6-9**, the facility must demonstrate how they are (or will) conform to the heat load associated with a less than a 0.25 ºF change in the Bitterroot River at the point where each effluent is fully mixed with river water at a 7Q10 flow.

During permit renewals, monitoring and reporting requirements must be updated to include monthly maximum discharge along with monthly average discharge rates and the monitoring requirements stated in the paragraphs above. Monthly maximum discharge will be computed from at least daily discharge volume sampling, if not continuous discharge sampling.

8.3.2 Tracking and Monitoring Restoration Activities and Effectiveness
Restoration activities which address nonpoint sources should be tracked watershed-wide as they are implemented. Information about specific locations, spatial extent, designs, contact information, and any effectiveness evaluation should be compiled about each project as they occur.

Monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. At a minimum, effectiveness monitoring should address the pollutants that are targeted for each project.

Particularly for sediment, which has no numeric standard, effectiveness and reductions in loading should be evaluated using load estimate approaches applied within this document for each source category. Evaluating in-stream parameters used for sediment targets will not be practical for most projects since the sediment impacts within a stream represent cumulative impacts from many watershed scale activities.

Information about all restoration projects, along with tracking overall extent of BMP implementation, should be compiled into one location. If sufficient implementation progress is made within a watershed, DEQ will create a monitoring plan to assess target conditions and implement the monitoring. Results would be compared to targets to determine if the TMDL is achieved.

8.3.3 Source Assessment Refinement

In many cases, the level of detail provided by the source assessments only provides broad source categories or areas that need to reduce pollutant loads, and additional source inventory and load estimate work may be desirable. Strategies for strengthening source assessments for each of the pollutants may include:

Sediment

More thorough sampling or field surveys of source categories such as bank erosion or road crossings to help prioritize implementation strategies based on an assessment of a larger population of eroding banks or road crossings of concern. Culverts should be assessed for fish passage and their capacity to pass storm event flows, as culvert failure is often a source f discrete sediment loads.

Efforts to improve upon load estimates, either within a given source category or via a calibrated approach to allow improved comparison between source categories is also a possibility, but not a requirement for TMDL implementation. Improvements might include:

- a refined bank erosion retreat rate for Bitterroot River watershed streams,
- a better understanding of bank erosion effects from historical land management activities,
- improved modeling for upland erosion delivery in forested watersheds where riparian zones have recovered from SMZ law implementation,
- road erosion modeling calibration and improved consideration of load impacts from road rills and gullies, and
- evaluation of "hot spots" that simple watershed scale models may not adequately address, such as a confined animal operation adjacent to a stream.

Temperature

Three specific conditions could benefit from further source characterization to better optimize thermal restoration approaches. The first is further characterization of tributaries to the stream segments where TMDLs are provided within this document. Thermal monitoring of tributaries may better characterize where restoration activities should be focused within a watershed.

The second source characterization which would benefit restoration priorities entails an irrigation system assessment. This assessment should include a water use assessment (with which the adjudication process may assist) and irrigation delivery and use efficiency evaluation. Points of surface waste or ditch/stream mixing locations would be an important component of this effort. The results of an irrigation system assessment would be beneficial for guiding restoration funds to address this largest human influence upon stream temperatures.

The third source characterization which could benefit restoration priorities is monitoring of urban runoff with an approach similar to the waste load allocation (WLA) monitoring reviewed above (**Section 8.3.1**) at any locations where urban runoff from Hamilton or Missoula enters the Bitterroot River. Currently no temperature data is available for urban runoff entering the Bitterroot River.

9.0 – Public Participation and Response to Comments

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 Bitterroot TMDL Planning Area (TPA).

9.1 Participants and Roles

TMDL development for sediment impairments on tributaries of the Bitterroot River and temperature impairments on tributaries and the mainstem of the Bitterroot River occurred over a span of many years. Over the course of this project, local interest in the Bitterroot TMDLs grew, continually increasing the number of participants in the TMDL development process in the Bitterroot TPA. DEQ worked with many stakeholders to keep them apprised of project status and solicited input from TMDL advisory groups. Because TMDL development continued for a long period of time, DEQ also worked with the Bitter Root Water Forum (BRWF) to keep contact information for participants up to date throughout this project. This effort will continue through current and future TMDL development projects in the Bitterroot TPA.

Due to the large number of participants in this process, all individual participants are not named, and instead, a description of the groups of participants in the development of the sediment tributary and temperature TMDLs in the Bitterroot TPA 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 the Bitterroot sediment tributary and temperature 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 TMDL program.

Bitter Root Water Forum
The Bitter Root Water Forum is a non-profit organization located in Hamilton, MT. This watershed group focuses on protecting and restoring water quality and quantity in the Bitterroot River watershed. Their mission is to help people restore, preserve, and enhance healthy waters for all users in the Bitterroot valley.

The BRWF administered a contract with DEQ to conduct tasks related to TMDL development, including data collection through third party contracting, and coordination of local stakeholder outreach activities.

The BRWF provided invaluable assistance to DEQ in identifying stakeholders and members of both the watershed and technical advisory groups for these TMDLs, and also participated on the Bitterroot TMDL Technical Advisory Group.

Conservation Districts

DEQ provided the Bitterroot Conservation District and the Missoula Conservation District with consultation opportunity during development of the sediment TMDLs for tributaries of the Bitterroot River and temperature TMDLs for tributaries and mainstem of the Bitterroot River. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the technical advisory group defined below.

Bitterroot TMDL Watershed Advisory Group

Representatives of applicable interest groups were requested to participate in the Bitterroot TMDL Watershed Advisory Group (WAG) to work with DEQ and the Bitterroot and Missoula conservation districts in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested WAG participation from the interest groups defined in MCA 75-5-704 and included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The WAG also included additional stakeholders, landowners, and resource professionals with an interest in maintaining and improving water quality and riparian resources, including representatives of local irrigation districts.

WAG involvement was voluntary and the level of involvement was at the discretion of the individual members. The WAG acted strictly in an advisory capacity during TMDL development and did not retain decision-making authority regarding TMDL activities. Communications with WAG members was typically conducted through email. Opportunities for review and comment were provided for WAG participants at varying stages of TMDL development, including opportunities for review of the draft TMDL document prior to the public comment period.

Bitterroot TMDL Technical Advisory Group

The Bitterroot TMDL Technical Advisory Group (TAG) consisted of selected resource professionals and technical advisors who possess a familiarity with water quality issues and processes in the Bitterroot TPA. Individuals included representatives from state and federal agencies, local resource professionals, and members of local government. The TAG also included members with technical knowledge of water quality modeling to provide feedback on the modeling effort for these TMDLs.

TAG members participated at their discretion and in an advisory role in the TMDL process. TAG 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 TAG feedback on project planning. Typically, draft documents were released to the TAG for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Interested Parties and General Public

Interested parties are those persons or groups of persons with an interest in the Bitterroot TMDLs, and have chosen to be informed and/or involved in the TMDL process. DEQ maintained contact with interested parties typically through email, the DEQ wiki for TMDL development projects, and with the assistance of the Bitter Root Water Forum. The BRWF maintains a contact and distribution list of watershed stakeholders and provided avenues for information dissemination and feedback through public outreach events, watershed meetings, and emails.

DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com) acts much like a website and contains TMDL project-specific pages that are maintained with current information. These pages allowed DEQ to provide the Bitterroot WAG, TAG, stakeholders, interested parties, and general public with up-to-date information about the Bitterroot TMDLs, and to post information about project schedule changes and public meetings. The wiki also provided a place for the general public to request information about the Bitterroot TMDLs and to be added to DEQ's contact list of Bitterroot TMDL interested parties.

The following information about the Bitterroot sediment tributary and temperature TMDLs was made available on the DEQ wiki:

- Maps of the Bitterroot TMDL Planning Area boundaries and impaired streams
- Information on the streams included in this project
- A detailed project schedule
- Periodic postings of project status updates
- Project contact information
- Information on the roles of the Bitterroot WAG and TAG and a list of WAG and TAG members
- Dates, times, and locations of public meetings
- Electronic copies of presentations from prior Bitterroot TMDL meetings

This information will continue to be available on DEQ's wiki during nutrient TMDL development in the Bitterroot TPA.

Though not directly involved in TMDL development, the general public plays a vital role with regard to implementation of water quality improvement actions. It is important that the general public is aware of the process and given opportunities to participate, and as such were kept informed via public meetings, the DEQ wiki, and information dissemination by the BRWF. In addition, the general public has the opportunity for review and comment of the TMDL document during the formal public comment period.

9.2 Response to Public Comments

Upon completion of the draft TMDL document, and prior to submittal to EPA, 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, and DEQ addresses and responds to all formal public comments. This section includes DEQ's responses to all official public comments received during the public comment period.

The formal public comment period for the "Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan" was initiated on April 22, 2011 and closed on May 24, 2011. A public informational meeting and open house was held in Hamilton, MT on May 5, 2011. DEQ provided an overview of the document, answered questions, and solicited public input and comment on the TMDLs. The announcement for the meeting was distributed to the conservation districts, WAG, TAG, stakeholders and interested parties via email. Notice of the meeting was posted on the DEQ webpage and DEQ wiki, and also advertised in the following newspapers: Bitterroot Star, Missoulian, and Ravalli Republic.

One comment letter was received during the public comment period. The letter is divided into three separate questions below, and responses prepared by DEQ follow each of the questions. The original comment letter is held on file at DEQ and may be viewed upon request.

Comment #1: Having just seen the public notification in the Ravalli Republic this morning, I have yet to complete a review of the entire document. However, based on the executive summary and the review of the tributary TMDL it seems pretty clear to me that there are two obvious regulatory issues that would resolve most of these problems. Those are stream setbacks and proper monitoring of stream diversions for irrigation.

I appreciate that neither of these are popular political topics. But without the regulatory control of both of these problems, it is difficult to see how any alternate plan will have any significant impact.

DEQ Response to Comment #1: Your interpretation of approaches to restore sediment and temperature conditions in the Bitterroot River and tributaries are correct in that they should focus on managing areas near stream corridors and irrigation systems.

Streamside areas should be provided an opportunity to grow native vegetation. Native vegetation acts to hold streambank soils in place through deep rooting and it also filters pollutants when runoff from surrounding land occurs. Shrubs and trees along a stream intercept solar radiation and thus reduce stream temperature. Streamside vegetation plays an important role in reducing sediment and thermal loads to streams.

Interactions between the Bitterroot watershed's irrigation system, groundwater and stream discharge are complex. The TMDL document identifies that an irrigation system assessment should be completed to determine where irrigation efficiencies and conservation practices should be focused. Generally, the further irrigation occurs from an active stream, the more efficient it should be to help keep water in the streams. Yet, inefficient irrigation systems in strategic areas of a watershed, generally close to a stream with porous aquifers, can cool a stream via groundwater return in mid-summer, that is, if enough water volume is available to support a fishery in the stream. Warmed irrigation surface water reentering streams should always be minimized. Therefore, irrigation system monitoring would be quite useful in future irrigation related conservation efforts, if completed in a systematic and well planned fashion.

Comment #2: I have only lived in the Bitterroot for ten years now so it is impossible for me to know how things were. But it is easy to see where things are going. It is heartbreaking to hear from the long time locals that they would never eat a fish caught in the Bitterroot due to the pollution. It isn't going to fix itself and it is only getting worse.

DEQ Response to Comment #2: Generally, the more human activity in a watershed, the more likely pollutants may enter streams and lakes. Yet, Montana Fish, Wildlife and Parks (FWP) does not currently provide any fish consumption advisories in the Bitterroot watershed. Montana has further information about sport fish consumption provided at: http://meic.org/files/air-quality/mercury/MT_fish_guide.

Comment #3: Please make an effort to bring this issue to the public eye by whatever means you have available. Without better public awareness it will be impossible to put the proper people in office to make the needed changes.

DEQ Response to Comment #3: The Montana Department of Environmental Quality's (DEQ) Nonpoint Source Program encourages local governments to use and incorporate riparian buffers and setbacks into their land use planning strategies. *Montana's 2007 Nonpoint Source Management Plan* (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2007) outlines what is appropriate when considering riparian buffers into land use planning. DEQ's Nonpoint Source Program supports projects that maintain or improve instream flows and riparian restoration efforts, environmental education, as well as other water quality improvement projects through 319 Grants. However, the Nonpoint Source Program is voluntary in Montana (i.e., DEQ does not have authority to enforce action). County governments do have the authority and ability to protect water quality through regulated setbacks; however previous county efforts in the Bitterroot have failed. People who get involved and strive to make a difference by working with state agencies and local governments are a crucial piece of the land use planning process, and will have the most effective influence upon future government action.

In Ravalli County, the Bitter Root Water Forum is a lead non-governmental organization for promoting environmental restoration projects along with watershed education and outreach. The Clark Fork Coalition also works in Bitterroot on many water quality improvement projects including stream flow restoration which "concentrates on protecting and restoring streamflows in tributaries that are important for the reproduction of native fish, such as bull trout and westslope cutthroat trout, as well as for the overall health of our aquatic and terrestrial ecosystems." Visit http://brwaterforum.org and www.clarkfork.org for more information. You may want to contact these organizations if you are interested in personal involvement in education, local zoning efforts, or water quality restoration efforts.

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