MIDDLE BLACKFOOT-NEVADA CREEK TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY IMPROVEMENT PLAN

Sediment, Nutrient, Trace Metal and Temperature TMDLs

September 22, 2008

ERRATA SHEET FOR THE "MIDDLE BLACKFOOT-NEVADA CREEK TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY IMPROVEMENT PLAN"

The Middle Blackfoot-Nevada Creek TMDL was approved by EPA on September 22, 2008. Several copies were printed and bound for distribution or sent electronically on compact disks. The original version had minor changes that are explained and corrected in this errata sheet. If you have a bound copy, please note the corrections below or simply print out this 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.

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

TABLE EDITS

Changes are noted in the shaded cells.

Document Location:

Page 262, Section 9.1.7, Table 9-8

Original Table:

Table 9-8. Nevada Creek and Middle Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Crossings	Rural Residential
Middle Blackfoot Planning Area							
Yourname Creek	181	130	1	1	1	48	0
Wales Creek	87	52	29	29	0	6	0
Frazier Creek	17	7	0	0	0	10	0
Ward Creek	48	22	0	8	0	18	0
Kleinschmidt Creek	12	1	0	0	0	11	0
Rock Creek	754	503	0	219	0	32	0
Warren Creek	128	13	1	4	0	110	0
Monture Creek	342	36	0	146	0	160	0
Blackfoot River (Nevada Cr. to Monture Cr.)	2560	1127	876	504	0	54	0
Cottonwood Creek (Blackfoot)	583	286	7	241	0	213	0
Richmond Creek	13	0	0	1	0	12	0
West Fork Clearwater River	175	0	0	90	0	85	0
Deer Creek	271	0	0	148	0	124	0
Blanchard Creek	146	21	0	7	0	119	0
Blackfoot River (Monture Cr. To Clearwater River)	948	477	64	0	0	280	127
Totals	**6,265**	**2,675**	**978**	**1,431**	**1**	**1,052**	**127**

Corrected Table:

Table 9-8. Nevada Creek and Middle Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Crossings	Rural Residential
Middle Blackfoot Planning Area							
Yourname Creek	181	130	1	1	1	48	0
Wales Creek	87	52	29	0	0	6	0
Frazier Creek	17	7	0	0	0	10	0
Ward Creek	48	22	0	8	0	18	0
Kleinschmidt Creek	12	1	0	0	0	11	0
Rock Creek	754	503	0	219	0	32	0
Warren Creek	128	13	1	4	0	110	0
Monture Creek	342	36	0	146	0	160	0
Blackfoot River (Nevada Cr. to Monture Cr.)	2560	1127	876	504	0	54	0
Cottonwood Creek (Blackfoot)	583	286	7	77	0	213	0
Richmond Creek	13	0	0	1	0	12	0
West Fork Clearwater River	175	0	0	90	0	85	0
Deer Creek	271	0	0	148	0	124	0
Blanchard Creek	146	21	0	7	0	119	0
Blackfoot River (Monture Cr. To Clearwater River)	948	477	64	0	0	280	127
Totals	**6,265**	**2,675**	**978**	**1,205**	**1**	**1,282**	**127**

TEXT EDITS

Shaded text shows the text in error and the corrected text.

Location in the TMDL	Original Text	Corrected Text
Page 319, Section 10.2.1.5, paragraph under the "Suspected Sources and Causes" title.	The suspected causes of degradation on Cottonwood Creek include excess sediment production and delivery, removal of bankline vegetation, and low flow alterations (**Table 10-4**). In terms of sediment supply, results of the sediment source assessment indicate that upland areas are the largest contributors of sediment to the stream. Sediment from hill slope erosion accounts for 994 tons of controllable sediment. Timber harvesting in the uppermost reaches is believed to be the cause of most hill slope generated sediment. Sediment produced from livestock grazing practices and hay production in the valley reaches accounts for 35% of the hill slope sediment load.	The suspected causes of degradation on Cottonwood Creek include excess sediment production and delivery, removal of bankline vegetation, and low flow alterations (**Table 10-4**). In terms of sediment supply, results of the sediment source assessment indicate that upland areas are the largest contributors of sediment to the stream. Sediment from hill slope erosion accounts for 994 tons of controllable sediment. Grazing accounts for the majority of the controllable hillslope load; therefore, it receives the highest percentage of the allocated load at 90%. The remaining 10% is allocated to the smaller forestry hillslope load (Table J-9).

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EXECUTIVE SUMMARY

The Middle Blackfoot-Nevada Creek planning area is located in Powell and Missoula counties and encompasses 1,430 square miles of mixed federal, state, and private land ownership. It includes the entire Nevada Creek watershed and the portion of the Blackfoot River watershed from the mouth of Nevada Creek to the mouth of the Clearwater River (**Appendix A, Figure A-2**). Elevations range from approximately 3,770 to 9,370 feet above sea level with a mean of 5,460 feet. The streams drain from conifer forested mountain slopes into broad, alluvial grassland and shrubland valleys. The main stems of the Blackfoot River and Nevada Creek flow through agricultural valleys where most land uses are related to livestock production.

The Clean Water Act requires the development of TMDLs that specify water quality conditions to support all beneficial uses associated with the classification category. The planning area waters are classified as B-1, supporting uses for drinking, culinary, and food processing 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.

This document combines a framework approach to TMDL development and a generalized watershed restoration strategy. The framework approach to TMDL development in the Middle Blackfoot-Nevada Creek planning area is in response to the requirement to specifying maximum daily pollutant loading from a typically limited amount of data describing existing flow and water quality conditions. Data for the Middle Blackfoot – Nevada Creek TPA are limited, and some impairment decisions are based on a preliminary translation of Montana's water quality standards. The level of certainty associated with targets, TMDLs, and allocations is low in many cases, and future adjustments may be needed. The targets, TMDLs, and allocations are presented as starting points from which watershed stakeholders can voluntarily begin to investigate and address water quality problems in the Middle Blackfoot – Nevada Creek TPA. Compliance with the targets, TMDLs, and allocations is voluntary. Adaptive management approaches to facilitate revision of the targets, TMDLs, and allocations are presented. Adaptive management in the context of TMDLs is a process of making initial land and water management adjustments based on initial loading estimates, monitoring the resulting water and land condition responses, and modifying management options and water condition goals toward meeting water quality standards and supporting beneficial uses.

The major pollutant categories in the planning area waters are excess sediment, nutrients, trace metals, and elevated stream temperatures. The extent of the impaired water bodies in the planning area is displayed in figures in **Appendix A** against several natural resource, land cover, and land use themes. Sediment impairments were identified as a degree of departure from fine sediment content and channel habitat condition targets deemed protective of the most sensitive uses of aquatic life and cold water fisheries. Gross sediment loading estimates from general landscape processes and sources are divided into daily loads from predominant land uses with the combined aid of a coarse resolution loading model and limited field assessments. Assessment results were coarsely extrapolated to similar channel reaches.

Nutrient impairments were identified as the degree of departure from nutrient standards for the Clark Fork River and interim target values developed from data stratified by ecoregional setting and climatic season. Recommended annual reductions are based on departures from standards and targets. In the absence of numeric nutrient standards, the preliminary target values for total phosphorus and total nitrogen were applied in a daily loading equation to satisfy the TMDL requirement.

Temperature impairment was assessed through a review of data collected during separate, generally unrelated assessment projects conducted over a period of five to six years. The data were screened to include those representing characteristic flow, water temperature, and climatic conditions during middle to late summer. Stream channel shading conditions were determined from a combination of field stream assessments and interpretation of aerial photography. The selected data were used in conjunction with a daily time step temperature loading model to determine whether water temperature increases were within those allowed by the temperature standards for B-1 streams. The model results are based on inputs of flow, shade, water temperature, and climate condition measurements from past restoration project monitoring, field evaluations, flow monitoring, and weather station data.

A limited amount of water quality sampling and seasonal flow measurements were used to characterize trace metals loading during high and low flow conditions. Similar to those for nutrients, metals TMDLs are presented in the form of a daily loading equation using established numeric concentration standards.

Pollutant source assessments identified transportation and land use related sources of loading. Restoration strategies focus on implementing best management practices for livestock grazing, irrigated livestock forage production, timber harvest, unpaved road erosion control, and controls applied to residential development.

The restoration process identified in this document is voluntary, cannot divest water rights or private property rights, and does not financially obligate identified stakeholders unless such measures are already a requirement under existing Federal, State, or Local regulations. Restoration strategies are intended to balance the varying uses of water while adhering to Montana's water quality and water use laws. This document is intended to describe the current knowledge of water quality conditions and suggest a path for water quality restoration. As more knowledge is gained through the restoration process and monitoring, this plan will need adjustment to accommodate evolving scientific information and incorporate lessons learned in observing environmental responses to land and water management. Montana's water quality programs provide for future TMDL reviews and offers technical and financial assistance toward restoring water quality.

The document structure provides specific sections that address TMDL components and watershed restoration. They are described in **Section 1.0**. **Table Ex-1** that follows contains a summary of the TMDL components addressed in this document.

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

Pollutants of Concern By Waterbody	Stream Name – Pollutant/s	Water Body ID
	Upper Washington Creek - Sediment	MT76F003_071
	Lower Washington Creek – Sediment, Fe	MT76F003_072
	Upper Jefferson Creek - Sediment	MT76F003_021
	Lower Jefferson Creek – Sediment, Al, Fe, TP, TN	MT76F003_022
	Gallagher Creek – Sediment, TP, TKN	MT76F003_030
	Buffalo Gulch - Sediment	MT76F003_130
	Upper Nevada Creek – Sediment, Temp., Cd, Pb, Hg, TKN	MT76F003_011
	Nevada Lake – Sediment, DO, TP, TKN	MT76F007_020
	Braziel Creek – Sediment, TP, TN	MT76F003_040
	Black Bear Creek – Sediment, TP, TKN	MT76F003_060
	Murray Creek – Sediment, As, Chl-*a*, TP, NO_{3+2}, TKN, Temp.	MT76F003_120
	Upper Douglas Creek – Sediment, As, Chl-*a*, TP, TKN, NO_{3+2}Temp.	MT76F003_081
	Cottonwood Creek – TP, TKN, Salinity/TDS/Chlorides	MT76F003_090
	Lower Douglas Creek – Sediment, As, TKN, TP, Temp.	MT76F003_082
	Nevada Spring Creek - Sediment	MT76F003_100
	McElwain Creek – Sediment, TP, NO_{3+2}	MT76F003_050
	Lower Nevada Creek – Sediment, TP, TKN,	MT76F003_012
	Blackfoot River (Nevada to Monture) – Sediment, Temp., TP, TN	MT76F001_31
	Yourname Creek – Sediment, TP	MT76F004_080
	Wales Creek – Sediment, Chl-*a*, TP, NO_{3+2}	MT76F004_050
	Frazier Creek – Sediment, TP, TKN	MT76F004_010
	Ward Creek - Sediment	MT76F004_060
	Kleinschmidt Creek – As, Cu, Sediment, Temp.	MT76F004_110
	Rock Creek - Sediment	MT76F004_090
	Warren Creek – Non-pollutant Causes	MT76F004_070
	Monture Creek - Sediment	MT76F004_100
	Cottonwood Creek (Blackfoot R.) - Sediment	MT76F004_040
	Chamberlain Creek - Fully Supporting	
	Richmond Creek - Sediment	MT76F005_020
	West Fork Clearwater River – Chl-*a*, Sediment	MT76F005_040
	Deer Creek - Sediment	MT76F005_030
	Buck Creek, Sediment	MT76F005_050
	Blanchard Creek - Sediment	MT76F005_060
	Blackfoot River (Monture to Clearwater) – Sediment, TP, TN, Temp.	MT76F001_32
	Al = Aluminum, As = Arsenic, Cd = Cadmium, Cu = Copper, Fe = Iron, Hg = Mercury, DO = Dissolved Oxygen, Chl-a = Chlorophyll-a, TP = Total Phosphorus, TKN = Total Kjeldahl Nitrogen, TN = Total Nitrogen, NO_{3+2} = Nitrate + Nitrite Nitrogen,	
Pollutant Sources	Livestock Grazing Irrigated Hay Production Silviculture Activities Road Erosion Placer Mining Residential Development Unknown Sources	

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

Targets	**Sediment**
	B Channels
	Riffle substrate: <6mm (%) - ≤20
	Riffle substrate: <2mm (%) - ≤10
	McNeil Cores <6.35 mm (%) - ≤27
	Pool Frequency (pools/mile) - ≥20
	Residual Pool Depth (ft) - ≥0.6
	Median W:D Ratio - 12-16
	Median pool tailout surface fines <6 mm (%) -Median pool tailout surface fines <6 mm (%) - ≤17
	McNeil Cores <2mm (%) - ≤12
	McNeil Cores <.85 mm (%) - ≤6
	Woody Vegetation Extent (%) - ≥88
	Marcoinvertebrate Multi-Metric Index - ≥48
	RIVPACS Observed/Expected - ≥0.8
	Pool Extent (%) - ≥10
	Woody Debris Aggregate Extent (%) - ≥3
	C Channels
	Riffle substrate: <6mm (%) - ≤22
	Riffle substrate: <2mm (%) - ≤7
	McNeil Cores <6.35 mm (%) - ≤27
	Pool Frequency (pools/mile) - ≥46
	Residual Pool Depth (ft) - ≥2
	Median W:D Ratio - 12-20
	Median pool tailout surface fines <6 mm - ≤23
	McNeil Cores <2mm (%) - ≤15
	McNeil Cores <.85 mm (%) - ≤6
	Woody Vegetation Extent (%) - ≥61
	Entrenchment Ratio - >2.2
	Pool Extent (%) - ≥35
	Woody Debris Aggregate Extent (%) - ≥7
	E Channels
	Riffle substrate: <6mm (%) - ≤36
	Riffle substrate: <2mm (%) - ≤20
	Pool Frequency (pools/mile) - ≥40
	Residual Pool Depth (ft) - ≥1.5
	Median W:D Ratio - 6-11
	Woody Vegetation Extent (%) - ≥74
	Marcoinvertebrate Multi-Metric Index - ≥48
	Pool Extent (%) - ≥29
	Woody Debris Aggregate Extent (%) - ≥12
	Nutrients
	Upper Nevada Creek and Tributaries
	Total Phosphorus 0.01 mg/L
	Total Nitrogen 0.33 mg/L
	Mean Benthic Chl-a 100.00 mg/m^2
	Max. Benthic Chl-a 150.00 mg/m^2
	Nevada Creek Reservoir
	Trophic Status Index Value 50

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

	Total Phosphorus 0.02 mg/L Chl-a 7.2 µg/L Dissolved Oxygen 5.0 µg.L Lower Nevada Creek and Blackfoot River Total Phosphorus 0.02 mg/L Total Nitrogen 0.30 mg/L Mean Benthic Chl-a 100.00 mg/m2 Max. Benthic Chl-a 150.00 mg/m2 **Metals** Chronic aquatic life standards **Temperature (B-1 waters)** Woody vegetation shade replacement allowing maximum 1°F allowable increase over naturally occurring temperature when naturally occurring <67ºF or; maximum 0.5°F increase over naturally occurring temperature when naturally occurring is >67ºF; Channel width:depth per sediment targets by channel type; Nevada Creek Lower Douglas Creek ≥15% flow augmentation July 15th -August 15th Douglas Creek Murray Creek Cottonwood Creek Lower Nevada Creek 20% Reservoir heating reduction Upper Douglas Creek

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

Required TMDLs	**Sediment** Upper Washington Creek Lower Washington Creek Upper Jefferson Creek Lower Jefferson Creek Gallagher Creek Buffalo Gulch Upper Nevada Creek Braziel Creek Black Bear Creek Murray Creek Upper Douglas Creek Cottonwood Creek Lower Douglas Creek Nevada Spring Creek McElwain Creek Lower Nevada Creek Blackfoot River (Nevada to Monture) Yourname Creek Wales Creek Frazier Creek Ward Creek Kleinschmidt Creek Rock Creek Warren Creek Monture Creek Cottonwood Creek (Blackfoot R.) Richmond Creek West Fork Clearwater River Deer Creek Blanchard Creek Blackfoot River (Monture to Clearwater) **Nutrients** **Total Phosphorus** Lower Jefferson Creek Gallagher Creek Upper Nevada Creek Nevada Lake Braziel Creek Black Bear Creek Murray Creek Upper Douglas Creek Lower Douglas Creek McElwain Creek Lower Nevada Creek Blackfoot River (Nevada to Monture) Blackfoot River (Monture to Clearwater) West Fork Clearwater River Yourmane Creek Wales Creek Frazier Creek

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

	Total Nitrogen Lower Jerson Creek Gallagher Creek Upper Nevada Creek Nevada Lake Braziel Creek Black Bear Creek Murray Creek Upper Douglas Creek Lower Douglas Creek McElwain Creek Lower Nevada Creek Blackfoot River (Nevada to Monture) Blackfoot river (Monture to Clearwater) West Fork Clearwater River Yourname Creek Wales Creek Frazier Creek **Metals** **Aluminum** Lower Jefferson Creek **Copper** Upper Nevada Creek **Iron** Lower Washington Creek Lower Jefferson Creek Upper Nevada Creek **Lead** Upper Nevada Creek **Temperature** Upper Nevada Creek Lower Nevada Creek Murray Creek Cottonwood Creek (Douglas Creek) Upper Douglas Creek Lower Douglas Creek Kleinschmidt Creek
Allocations	**Sediment** Allowable loading and reductions allocated to principal land uses by impaired segment. **Metals** Lower Washington Creek <u>Iron</u> High flow 60% and low flow 28% reduction from the composite sources of: • Natural background sources of metals that are either particulate bound or dissolved; • Controllable Human caused sources of metals that are either particulate bound or dissolved. Lower Jefferson Creek <u>Iron and Aluminum</u> Annual 34% reduction from the composite sources as stated above for iron in Lower

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

	Washington Creek. Upper Nevada Creek <u>Iron, Copper, Lead</u> Annual 26% reduction from the composite sources as stated above for iron in lower Washington Creek. **Nutrients** Composite allocation to anthropogenic sources of nutrients including: • Dissolved loads of TP and TN from subsurface irrigation return flows; • Naturally occurring particulate and dissolved loads of TP and TN in both streams and groundwater; • TP and TN loading from agricultural sources, principally livestock grazing, irrigated hay production, irrigation return flows, and livestock feeding; • Particulate bound TP and TN from road erosion; • Particulate bound TP and TN from timber harvest; • Particulate bound TP and TN from placer mining. **Temperature** Allocations to temperature surrogate parameters by segment: • Needed percent increases in woody riparian vegetation as bankline extent of woody vegetation by listed segment; • Channel width:depth ratio per sediment targets by channel type in upper and lower Nevada Creek; • ≥15 percent increase in stream flow during July 15th to August 15th -;- lower Nevada Creek, Douglas Creek, Murray Creek and Cottonwood Creek; • 20 percent reduction in reservoir heating in upper Douglas Creek.
Margin of Safety	**Sediment** • Liberal assumption in size of hillslope contributing area; • Inclusion of "forest roads" HRU in hillslope sediment source assessment; • Assumed minimum achievable reduction of 25 percent in human caused stream bank erosion on the best condition streams; • Adaptive management goals for sediment. **Metals** • Chronic aquatic life standard as a basis for the maximum daily loads; • Monitoring and adaptive management adjustments to particulate and dissolved metals loading estimates; **Nutrients** • Conservative assumptions regarding impairment based on small data sets; • Seasonal targets applied year around; • Implicit MOS provided through the adaptive management strategy. **Temperature** • Conservative estimate of shade potential; • Focused future assessment and adaptive management.

Table Ex-1. Summary of Required TMDL Elements for the Middle Blackfoot River-Nevada Creek TMDL Planning Area

Seasonality	**Sediment** Daily distribution of loading based on hydrologic seasons. **Metals** Loading based on flow and target metal concentration (adjusted for hardness for copper and lead). High and low flow conditions presented. **Nutrients** Growing season TP and TN concentration targets applied year around, thus loading based on seasonal flow. **Temperature** Daily loads based on flow and current temperature that both vary seasonally.

SECTION 1.0
DOCUMENT ORGANIZATION AND CONTENT

The Middle Blackfoot and Nevada Creek TMDL document is comprised of ten chapters (sections) and seven appendices. This introductory chapter provides readers with a description of how the document is organized with a brief synopsis of each of the document chapters and associated appendices. It is intended to serve as a quick reference to readers and assist with the location of information in this large document.

Section 2.0 is titled “TMDL Regulatory Framework” and describes the origins, purpose, and intent of TMDL planning. The current beneficial use support status, probable causes and probable sources of water quality impairment, and listing history and justification for each 303(d) Listed water body in the Middle Blackfoot and Nevada Creek TPAs are provided in this Section. This chapter also provides definitions of and approaches for the application of water quality standards to major pollutant categories including sediment, metals, temperature, and nutrients.

General physical characteristics of the Middle Blackfoot and Nevada Creek TPAs are described in **Section 3.0** (Watershed Characterizations). The location and size, geology, soils, climate, hydrology, stream geomorphology, vegetation, landownership, land uses, and fisheries and aquatic life of each planning area are described. **Appendix A** contains a series of maps and figures which correspond to this chapter and help illustrate the physical characteristics described in **Section 3.0**.

TMDL development involves extensive research of multiple data sources, the application of numerous methodologies, and the development of assessment approaches to identify the sources, causes, and solutions to water quality impairments. **Section 4.0** provides a brief summary of assessments, methodologies, data, and data sources utilized in identifying sources and causes of water quality impairments as well the development of water quality restoration targets, TMDLs, loads, and allocations.

Major water quality pollutants are addressed in the Middle Blackfoot and Nevada Creek TMDL document beginning with sediment in **Section 5.0**. While TMDLs are not developed for “habitat” or “low flows,” these common causes of water quality impairment are discussed in the section. The section begins with a description of sediment and habitat target parameters and justification for their use in impairment determinations. A comparison of current conditions and target conditions is provided for each stream from the Middle Blackfoot and Nevada Creek TPAs with a past or current sediment, habitat, or low flow impairment listing. This comparison leads to the water quality impairment status or impairment determination. The discussion of individual streams and their water quality impairment status is followed by a summary of the sediment source assessment. Sources of sediment (hillslope erosion, road disturbances, and streambank erosion) and their relative contribution to the total sediment load are contained in **Section 5.5**. **Appendix C** contains the details of the stream bank erosion assessment. **Appendix D** contains a description of the sediment and habitat target development process and results. An example of daily sediment loading calculations is included in **Appendix E**. The example is that for upper Nevada Creek.

Section 6.0 is a description of trace metals impairments. Metals standards, the metals monitoring record for impaired waters, and departures from standards are described in the section for each impaired stream. **Section 6.0** also contains a listing of metals standards exceedences for streams that were not determined to be impaired by metals due to small or single figure datasets. The section discusses the widespread incidence of arsenic detections in the planning area and suggests potential naturally occurring sources. Metals concentrations in stream sediments are described. **Section 6.0** concludes the metals water quality impairment status by stream, briefly describes the metals source assessment processes, and describes the relationship between metals and sediment loading. The water column and sediment metals monitoring results and monitoring location map are in **Appendix F**.

Section 7 addresses nutrient impairments and begins with a description of how ecoregional and seasonal nutrient parameter targets were developed. When available, nutrient impairment determinations are made with the aid of supplemental data on chlorophyll-*a* concentration. Chlorophyll-*a* targets are listed for aquatic life and recreational use support.

Nutrient impairment of lakes and reservoirs required development of targets different from the nutrient parameter targets developed for streams. The lake and reservoir targets and their development are described in **Section 7.0**, and the impairments for Seeley Lake, Salmon Lake, and Nevada Reservoir are described.

Section 7.0 describes the nutrient monitoring record of each impaired water body in the form of graphs of measured values compared to seasonal targets and draws a water quality impairment status conclusion in each case. The nutrient source assessment methods that include field assessment monitoring and loading estimates from the Soil Water Assessment Tool (SWAT) are described. The differences between the two assessment method conclusions are displayed and discussed for tributary streams, the main stem of Nevada Creek and the main stem Blackfoot River.

The final pollutant category, temperature, is addressed in **Section 8.0**. Developing stream temperature targets for the Middle Blackfoot and Nevada Creek TPAs required interpretation of Montana's standards for water temperature. The process of developing temperature targets which included existing data review and analysis, identifying sources of temperature increases, determining naturally occurring conditions, and modeling are described in the beginning of **Section 8.0**. The water quality impairment status for each temperature listed streams is then determined by comparing modeled current conditions with modeled target conditions. Maps of temperature impaired streams, monitoring locations, and temperature modeling networks and inputs can be found in **Appendix A**.

Section 9.0 presents the TMDLs and allocations for each major pollutant category in the order of sediment, metals, nutrients, and temperature. Assessment data are tabulated for each of three sediment generating processes: hillslope erosion, road erosion, and stream bank erosion. Methods for distinguishing naturally occurring from controllable sediment loads are described. The necessary sediment load reductions are allocated to specific land uses. Calculations for determining metals TMDLs are also presented in **Section 9.0**. Metals TMDLs are presented through the daily loading equation for high and low flow conditions using numeric standards. Metals allocations are to a composite of source categories. Controllable load reductions are closely tied to those for sediment. Temperature TMDLs are expressed as needed changes to surrogate target conditions including shade replacement, channel width to depth ratio requirements, and flow augmentation potential. Temperature allocations are assigned to influencing land uses.

Section 10.0 of the document is the Restoration and Monitoring Plan. **Section 10.0** provides a detailed discussion of the sources and causes of water quality impairments for each 303(d) Listed stream leading to recommendations for improving water quality. The recommendations consist primarily of implementing general or specific BMPs listed in **Appendix H**. **Appendix A** and **Appendix B** can also be referenced while reading this section for additional information. Water quality issues are then summarized and prioritized. **Section 10.0** also presents a strategy for implementation which identifies partnership opportunities and funding available for implementation. A monitoring strategy for evaluating success of implementation is described, as are recommendations for additional monitoring that will increase the understanding of water quality issues and solutions in the watershed. The chapter concludes with a discussion of milestones for measuring progress and a section devoted to adaptive management.

SECTION 2.0
REGULATORY FRAMEWORK

2.1 TMDL Development Requirements

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify water bodies within its boundaries that do not meet water quality standards. The document entitled "Water Quality Integrated Report for Montana," prepared by the Water Quality Planning Bureau of the Montana Department of Environmental Quality (DEQ, 2006)1 identifies threatened and impaired waters and describes the methodology for determining impairment status. The biannual development of this document, formerly referred to as the 303(d) List, is intended to fulfill the CWA requirement to identify waters not meeting standards.

An "impaired water body" is a water body or stream segment for which sufficient credible data show that the water body or stream segment is failing to achieve compliance with applicable water quality standards (Montana Water Quality Act; Section 75-5-103(11)). A "threatened water body" is defined as a water body or stream segment for which sufficient credible data and calculated increases in loads show that the water body or stream segment is fully supporting its designated uses, but is threatened for a particular designated use because of (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices; or (b) documented adverse pollution trends (Montana Water Quality Act; Section 75-5-103(31)). State Law and Section 303 of the CWA require states to develop TMDLs for impaired and threatened water bodies.

A TMDL is a pollutant budget identifying the maximum amount of a pollutant that a water body can assimilate without exceeding applicable standards. TMDLs are the mass of a pollutant entering a water body per unit of time and are most often expressed in pounds per day. TMDLs include pollutant loads from point sources, nonpoint sources, and naturally occurring sources. Due to inherent uncertainty in pollutant loading estimates, TMDLs must incorporate a margin of safety. TMDLs must also consider the seasonality of pollutant loading. In Montana, TMDLs are commonly developed in the context of a watershed-wide water quality restoration plan. Along with pollutant-specific TMDLs, this plan also includes recommendations for restoring beneficial uses affected by more general, reach-scale impairment causes, such as aquatic or riparian habitat degradation or flow modification, that are not addressed by reductions in pollutant loading.

TMDLs are developed for each water body-pollutant combination identified on the list of impaired or threatened waters. Montana State Law regarding TMDL development (75-5-703(8)) directs DEQ to "support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL…" This directive is reflected in the TMDL development and implementation strategy within this plan. Water quality protection practices are not considered voluntary where they exist as requirements under Federal, State, or Local regulations.

1 DEQ refers to the Montana Department of Environmental Quality unless otherwise noted.

2.2 Water Bodies and Pollutants of Concern

A recent court ruling and subsequent settlements have obligated the U.S. EPA and the State of Montana to address pollutant-water body combinations from the Montana's 1996 list of impaired waters. State and federal TMDL guidance also indicates that the most recent list be used for determining the need for TMDLs. Therefore, both 1996 and 2006 impairment listings are addressed in this document. A total of 72 pollutant-water body combinations are accounted for in the Middle Blackfoot River-Nevada Creek TPA when 1996 and 2006 listings are combined. All pollutants that appeared on either the 1996 or 2006 lists have been addressed in the impairment status review, TMDLs, or watershed restoration plans presented in this document. TMDLs were not prepared for impairments where additional information suggested that the initial listings were inaccurate or where conditions since listing have improved such that the pollutant no longer impairs a beneficial use. Where a pollutant is recommended for removal from the list, justification is provided. **Tables 2-1 and 2-2** provide a summary of beneficial use support for water body listings for the 1996 and 2006 303(d) Lists for the Nevada Creek and Middle Blackfoot River TMDL planning areas. The water bodies in the tables are listed in order from upstream to downstream.

Table 2-1. Use Support Status of Listed Water Bodies in the Nevada Creek TMDL Planning Area

Water Body Name and Location Description	Water Body ID	Year	Aquatic Life	Cold Water Fishery	Drinking Water	Primary Contact Recreation	Agriculture	Industry
Washington Creek (upper) from Cow Gulch to the mouth (Nevada Creek)	MT76F003_071	1996	N	N	N	N	X	X
		2006	X	X	X	P	F	F
Washington Creek (lower) from Cow Gulch to the mouth (Nevada Creek)	MT76F003_072	1996	N	N	N	N	X	X
		2006	P	P	X	P	F	F
Jefferson Creek (upper) from headwaters to one mile above Madison Gulch	MT76F003_021	1996	N	N	P	N	X	P
		2006	P	P	F	F	F	F
Jefferson Creek (lower) Headwaters to 1 mile above Madison Gulch	MT76F003_022	1996	N	N	P	N	X	P
		2006	P	P	F	P	F	F
Gallagher Creek from the BLM property line to the mouth (Nevada Creek)	MT76F003_030	1996	P	P	X	X	F	F
		2006	P	P	F	P	F	F
Buffalo Gulch from headwaters to mouth (Nevada Creek)	MT76F003_130	1996	X	X	X	X	X	X
		2006	P	P	X	X	X	X
Nevada Creek (upper) from headwaters to Nevada Lake	MT76F003_011	1996	P	P	X	X	X	X
		2006	P	P	N	P	F	F
Nevada Lake	MT76F007_020	1996	P	P	X	P	X	X
		2006	P	P	F	P	F	F

Table 2-1. Use Support Status of Listed Water Bodies in the Nevada Creek TMDL Planning Area

Water Body Name and Location Description	Water Body ID	Year	Aquatic Life	Cold Water Fishery	Drinking Water	Primary Contact Recreation	Agriculture	Industry
Braziel Creek 2.8 miles upstream from mouth (Nevada Cr) T12N R10W Sec 22	MT76F003_040	1996	P	P	X	X	X	X
		2006	P	P	F	F	F	F
Black Bear Creek 2.8 miles upstream from mouth (Sturgeon Creek) T12N R10W Sec 22	MT76F003_060	1996	P	P	X	X	X	X
		2006	N	N	F	N	F	F
Murray Creek from headwaters to mouth (Douglas Creek)	MT76F003_120	1996	P	P	X	T	X	X
		2006	P	P	N	N	F	F
Douglas Creek (upper) from headwaters to Murray Creek	MT76F003_081	1996	P	P	X	X	X	X
		2006	P	P	N	N	F	F
Cottonwood Creek from South Fork Cottonwood Creek to mouth (Douglas Creek)	MT76F003_090	1996	P	P	X	X	X	X
		2006	X	X	X	N	F	F
Douglas Creek (lower) from Murray Creek to mouth (Nevada Creek)	MT76F003_082	1996	P	P	X	X	X	X
		2006	N	N	N	N	F	F
Nevada Spring Creek from headwaters to mouth (Nevada Creek)	MT76F003_100	1996	P	P	X	X	X	X
		2006	N	N	X	P	F	F
McElwain Creek 2 miles upstream from mouth (Nevada Creek) T13N R12W Sec 27-28	MT76F003_050	1996	P	P	X	P	X	X
		2006	P	P	F	P	F	F
Nevada Creek (lower) from Nevada Lake to mouth (Blackfoot River)	MT76F003_012	1996	P	P	X	X	X	X
		2006	N	N	F	P	F	F

Legend:
F= Full Support; **P**= Partial Support; **N**= Not Supported; **T**= Threatened; **X**= Not Assessed (Insufficient Credible Data)

Table 2-2. Use Support Status of Listed Water Bodies in the Middle Blackfoot TMDL Planning Area

Water Body Name and Location Description	Water Body ID	Year	Aquatic Life	Cold Water Fishery	Drinking Water	Primary Contact Recreation	Agriculture	Industry
Yourname Creek from headwaters to the mouth (Blackfoot River)	MT76F004_080	1996	P	P	X	T	X	X
		2006	P	P	F	P	F	F
Wales Creek from reservoir outlet to the mouth (Blackfoot River)	MT76F004_050	1996	P	P	X	T	X	X
		2006	P	P	F	P	F	F

Table 2-2. Use Support Status of Listed Water Bodies in the Middle Blackfoot TMDL Planning Area

Water Body Name and Location Description	Water Body ID	Year	Aquatic Life	Cold Water Fishery	Drinking Water	Primary Contact Recreation	Agriculture	Industry
Frazier Creek from headwaters to mouth (Blackfoot River)	MT76F004_010	1996	P	P	X	T	X	X
		2006	N	N	F	P	F	F
Ward Creek from the headwaters to Browns Lake	MT76F004_060	1996	P	P	X	X	X	X
		2006	P	P	F	F	F	F
Kleinschmidt Creek from mouth 1.5 miles upstream	MT76F004_110	1996	X	X	X	X	X	X
		2006	P	P	N	F	F	F
Rock Creek from headwaters to the mouth (North Fork Blackfoot River)	MT76F004_090	1996	P	P	X	F	F	F
		2006	P	P	X	F	F	F
North Fork Blackfoot River from headwaters to mouth (Blackfoot River)	MT76F004_030	1996	X	P	X	X	X	X
		2006	F	F	F	F	F	F
Warren Creek from headwaters to the mouth (Blackfoot River)	MT76F004_070	1996	P	P	X	T	X	X
		2006	P	P	F	P	F	F
Monture Creek from headwaters to the mouth (Blackfoot River)	MT76F004_100	1996	P	P	F	F	F	F
		2006	P	P	F	F	F	F
Blackfoot River (Nevada Creek to Monture Creek)	MT76F001_31	1996	P	P	F	F	F	F
		2006	P	P	F	F	F	F
Cottonwood Creek 10 miles upstream from the mouth (Blackfoot River)	MT76F004_040	1996	P	P	X	X	X	X
		2006	F	F	F	F	F	F
Chamberlain Creek from East Fork to mouth (Blackfoot River)	MT76F004_020	1996	P	P	X	T	X	X
		2006	F	F	F	F	F	F
Richmond Creek from headwaters to mouth (Lake Alva)	MT76F005_020	1996	X	T	X	X	X	X
		2006	P	P	F	F	F	F
West Fork Clearwater River from headwaters to mouth (Clearwater River)	MT76F005_040	1996	X	T	X	X	X	X
		2006	F	F	F	P	F	F
Deer Creek from headwaters to mouth (Seeley Lake)	MT76F005_030	1996	X	T	X	X	X	X
		2006	F	P	F	F	F	F
Seeley Lake	MT76F007_010	1996	P	P	X	P	X	X
		2006	F	F	F	F	F	F
Buck Creek from headwaters to the mouth (Placid Creek)	MT76F005_050	1996	X	T	X	X	X	X
		2006	X	X	X	X	X	X
Salmon Lake	MT76F007_030	1996	P	P	X	P	X	X
		2006	F	F	F	F	F	F

Table 2-2. Use Support Status of Listed Water Bodies in the Middle Blackfoot TMDL Planning Area

Water Body Name and Location Description	Water Body ID	Year	Aquatic Life	Cold Water Fishery	Drinking Water	Primary Contact Recreation	Agriculture	Industry
Blanchard Creek from the North Fork to the mouth (Clearwater River)	MT76F005_060	1996	P	P	F	F	F	F
		2006	P	P	F	N	F	F
Blackfoot River (Monture Creek to Clearwater River)	MT76F001_32	1996	P	P	F	F	F	F
		2006	P	P	F	F	F	F

Legend:
F= Full Support; **P**= Partial Support; **N**= Not Supported; **T**= Threatened; **X**= Not Assessed (Insufficient Credible Data)

Table 2-3 lists the probable causes and sources of impairment for water bodies on the 1996 and 2006 303(d) Lists of impaired waters. Probable causes of impairment, as identified on the 1996 and 2006 lists, include sediment related listings (sedimentation/siltation, suspended solids), metals (aluminum, iron, arsenic), thermal modification, nutrients, streamside vegetation cover alteration, and flow alteration (dewatering). Metals, temperature, nutrients, and sediment TMDLs are needed for specific water bodies in this TPA. Habitat and flow related listings are not pollutant-specific causes of impairment. In this document, such impairment causes will be addressed more generally as sources of pollution in the Water Quality Restoration Plan (WQRP) that is **Section 10** of this document.

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Nevada Creek TMDL Planning Area				
Washington Creek (upper) Headwaters to Cow Gulch	Flow Alteration Habitat Alterations Siltation	Placer Mining Resource Extraction	Low flow alterations Physical substrate habitat alterations	Dredge Mining Impacts from Abandoned Mine Lands (Inactive)ing
Washington Creek (lower) from Cow Gulch to the mouth (Nevada Creek)	Flow Alteration Habitat Alterations Siltation	Placer Mining Resource Extraction	Low Flow Alteration Sedimentation/Siltation	Agriculture Highway/Road/Bridge Runoff (Non-construction Related) Impacts from Abandoned Mine Lands (Inactive) Streambank Modifications. destabilization
Jefferson Creek (upper) from headwaters to one mile above Madison Gulch	Flow Alteration Habitat Alterations Siltation	Irrigated Crop Production Placer Mining Range Land	Alteration in stream-side or littoral vegetative covers Sedimentation/Siltation	Channelization Placer Mining Rangeland Grazing Streambank Modification/ destabilization

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Jefferson Creek (lower) Headwaters to 1 mile above Madison Gulch	Flow Alteration Habitat Alterations Siltation	Irrigated Crop Production Placer Mining Range Land	Alteration in stream-side or littoral vegetative covers Aluminum Iron Low flow Alterations TP Sedimentation/Siltation Solids (Suspended/Bedload)	Channelization Dredge Mining Grazing in Riparian or Shoreline Zones Irrigated Crop Production Stream bank Modifications/ Destabilization Unknown Sources (Iron, Aluminum)
Gallagher Creek from the BLM property line to the mouth (Nevada Creek)	Flow Alteration	Agriculture Irrigated Crop Production	Alteration in stream-side or littoral vegetative covers Low flow Alterations TP Sedimentation/Siltation TKN	Agriculture Rangeland Grazing
Buffalo Gulch from headwaters to mouth (Nevada Creek)	Not Listed	Not Listed	Physical substrate habitat alterations Sedimentation/Siltation	Forest Roads (Road Construction and Use) Livestock (Grazing or Feeding Operations) Silviculture Activities Forest Roads (Road Construction and Use)
Nevada Creek (upper) from headwaters to Nevada Lake	Flow Alteration Nutrients Habitat Alterations Siltation Thermal Modifications	Agriculture Dam Construction Irrigated crop Production Logging Road Construction/ Maintenance Natural Sources Pasture Land Resource Extraction Stream Bank Modification/ Destabilization	Alteration in stream-side or littoral vegetative covers Cadmium Lead Mercury Physical substrate habitat alterations Solids (Suspended/ Bedload TKN	Agriculture Grazing in Riparian or Shoreline Zones Placer Mining
Nevada Lake	Nutrients Organic Enrichment/DO Siltation	Agriculture Land Development Silviculture	Oxygen, Dissolved TP Sedimentation/Siltation TKN	Unknown Sources Upstream/ Downstream Source

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Braziel Creek 2.8 miles upstream from mouth (Nevada Creek) T12N R10W Sec 22	Habitat Alterations Siltation	Harvesting, Restoration, Residue Management Logging Road Construction/ Maintenance Pasture Land Stream Bank Modification/ Destabilization	Alteration in stream-side or littoral vegetative covers Sedimentation/Siltation TP	Rangeland Grazing Silviculture Activities Highway/Road/ Bridge Runoff (Non-construction Related)
Black Bear Creek 2.8 miles upstream from mouth (Sturgeon Creek) T12N R10W Sec 22	Habitat Alterations Siltation	Agriculture Harvesting, Restoration, Residue Management Logging Road Construction/ Maintenance Range Land Silviculture	Alteration in stream-side or littoral vegetative covers Sedimentation/Siltation Solids (Suspended/Bedload) TP TKN	Grazing in Riparian or Shoreline Zones Managed Pasture Grazing Silviculture Harvesting Forest Roads (Road Construction and Use)
Murray Creek from headwaters to mouth (Douglas Creek)	Flow Alteration Habitat Alterations Siltation Thermal Modifications	Agriculture Pasture Land Removal of Riparian Vegetation	Alteration in stream-side or littoral vegetative covers Arsenic Chl-a Low flow Alterations $NO_3 + NO_2$ as N TP Sedimentation/Siltation Temperature, water TKN	Grazing in Riparian or Shoreline Zones Irrigated Crop Production Rangeland Grazing Silviculture Activities Streambank Modification/ destabilization Unknown Sources (As) Flow Alterations from Water Diversions
Douglas Creek (upper) from headwaters to Murray Creek	Flow Alteration Habitat Alterations Siltation Nutrients Salinity/TDS/ Chlorides Thermal Modifications	Agriculture Irrigated Crop Production Pasture Land Placer Mining Resource Extraction Stream bank Modification/ Destabilization	Alteration in stream-side or littoral vegetative covers Arsenic Chl-*a* Low flow Alterations $NO_3 + NO_2$ as N TP Sedimentation/Siltation Temperature, water TKN	Grazing in Riparian or Shoreline Zones Rangeland Grazing Irrigated Crop Production Flow Alterations from Water Diversions Unknown Sources (As)
Cottonwood Creek from South Fork Cottonwood Creek to mouth (Douglas Creek)	Flow Alteration Nutrients Salinity/TDS/ Chlorides	Agriculture	Low flow Alterations	Agriculture

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Douglas Creek (lower) from Murray Creek to mouth (Nevada Creek)	Flow Alteration Habitat Alterations Siltation Nutrients Salinity/TDS/ Chlorides Thermal Modifications	Agriculture Irrigated Crop Production Pasture Land Placer Mining Resource Extraction Stream bank Modification/ Destabilization	Alteration in stream-side or littoral vegetative covers Arsenic Low flow Alterations TP Sedimentation/Siltation Temperature, water TKN	Grazing in Riparian or Shoreline Zones Rangeland Grazing Loss of Riparian Habitat Irrigated Crop Production Flow Alterations from Water Diversions Unknown Sources (As)
Nevada Spring Creek from headwaters to mouth (Nevada Creek)	Habitat Alterations Siltation	Agriculture Dam Construction Range Land	Alteration in stream-side or littoral vegetative covers Sedimentation/Siltation	Grazing in Riparian or Shoreline Zones Impacts from Hydrostructure Flow Regulation/ modification
McElwain Creek 2 miles upstream from mouth (Nevada Creek) T13N R12W Sec 27-28	Flow Alterations Pathogens Siltation	Agriculture Irrigated Crop Production Range Land Silviculture	Alteration in stream-side or littoral vegetative covers Low flow Alterations $NO_3 + NO_2$ as N TP Sedimentation/Siltation	Grazing in Riparian or Shoreline Zones Irrigated Crop Production Flow Alterations from Water Diversions
Nevada Creek (lower) from Nevada Lake to mouth (Blackfoot River)	Flow Alteration Nutrients Habitat Alterations Siltation Thermal Modifications	Agriculture Dam Construction Irrigated crop Production Logging Road Construction/Mainten ance Natural Sources Pasture Land Resource Extraction Stream Bank Modification/Destabi lization	Low flow Alteration TP Physical substrate habitat alterations Sedimentation/Siltation TKN	Agriculture Streambank Modification/ destabilization
Middle Blackfoot River TMDL Planning Area				
Yourname Creek from headwaters to the mouth (Blackfoot River)	Flow Alteration	Agriculture Irrigated Crop Production	Low Flow Alteration Alteration in stream-side or littoral vegetative covers Sedimentation/Siltation TP	Riparian Grazing Irrigated Crop Production Rangeland Grazing

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Wales Creek from reservoir outlet to the mouth (Blackfoot River)	Flow Alteration Siltation	Agriculture Irrigated Crop Production	Low flow Alteration Alteration in stream-side or littoral vegetative covers Nitrate/Nitrite (NO_3 + NO_2 –N) TP Sedimentation Chlorophyll-a (Chl-a)	Agriculture Rangeland Grazing Irrigated Crop Production Upstream Impoundment (e.g., Pl-566 NRCS Structures)
Frazier Creek from headwaters to mouth (Blackfoot River)	Flow Alteration	Agriculture Irrigated Crop Production	Alteration in stream-side or littoral vegetative covers Low flow Alterations Sedimentation/siltation TKN TP	Grazing in Riparian or Shoreline Zones Flow Alterations from Water Diversions Irrigated Crop Production Hydrostructure Impacts to Fish Passage
Ward Creek from the headwaters to Browns Lake	Flow Alterations	Agriculture Irrigated Crop Production	Physical substrate habitat alterations Sedimentation/Siltation	Agriculture Silviculture Activities Unspecified Unpaved Road or Trail
Kleinschmidt Creek from mouth 1.5 miles upstream	Not Listed	Not Listed	Alteration in stream-side or littoral vegetative covers Thermal Modifications Sedimentation/Siltation Arsenic Copper	Grazing in Riparian or Shoreline Zones Managed Pasture Grazing Impacts from Hydrostructure Flow Regulation/ modification Unknown Sources
Rock Creek from headwaters to the mouth (North Fork Blackfoot River)	Flow Alteration Habitat Alterations Siltation	Agriculture Aquaculture Flow Regulation/Modification Highway Road/Bridge Construction Irrigated Crop Production Range Land Riparian Vegetation Removal	Alteration in stream-side or littoral vegetative covers Low flow Alterations Sedimentation/Siltation	Grazing in Riparian or Shoreline Zones Range Land Grazing Irrigated Crop Production Silviculture Harvesting
North Fork Blackfoot River from headwaters to mouth (Blackfoot River)	Habitat Alterations Siltation	Harvesting, Restoration, Residue Management Natural Sources Silviculture	None (Fully-Supporting)	None

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Warren Creek from headwaters to the mouth (Blackfoot River)	Flow Alteration	Agriculture Irrigated Crop Production	Fish Passage Barrier Low flow Alterations	Channelization Agriculture Irrigated Crop Production
Monture Creek from headwaters to the mouth (Blackfoot River)	Habitat Alterations Siltation	Agriculture Natural Sources Range Land Steam bank Modification /Destabilization	Alteration in stream-side or littoral vegetative covers	Grazing in Riparian or Shoreline Zones
Blackfoot River (Nevada Creek to Monture Creek)	Nutrients Siltation	Agriculture Natural Sources Silviculture	Total Nitrogen (TN) Total Phosphorus (TP) Thermal Modifications	Irrigated Crop Production
Cottonwood Creek 10 miles upstream from the mouth (Blackfoot River)	Flow Alteration Habitat Alterations Siltation	Agriculture Irrigated Crop Production Natural Sources Range Land	None (Fully Supporting)	None
Chamberlain Creek from East Fork to mouth (Blackfoot River)	Flow Alteration Habitat Alterations Suspended Solids	Agriculture Harvesting, Restoration, Residue Management Logging Road Construction/Maintenance Range Land Silviculture	None (Fully Supporting)	None
Richmond Creek from headwaters to mouth (Lake Alva)	Non priority Organics Siltation	Harvesting, Restoration, Residue Management Silviculture	Sedimentation/Siltation	Forest Roads (Road Construction and Use)
West Fork Clearwater River from headwaters to mouth (Clearwater River)	Non priority Organics Siltation	Harvesting, Restoration, Residue Management Silviculture	Chl-*a*	Natural Sources Unknown Sources
Deer Creek from headwaters to mouth (Seeley Lake)	Non priority Organics Siltation	Harvesting, Restoration, Residue Management Silviculture	Sedimentation/Siltation	Forest Roads (Road Construction and Use) Silviculture Harvesting
Seeley Lake	Organic Enrichment/DO	Land Development Silviculture	None (Fully-Supporting)	None
Buck Creek from headwaters to the mouth (Placid Creek)	Siltation	Silviculture,	Not Assessed	None Identified
Salmon Lake	Nutrients Organic Enrichment/DO Siltation	Agriculture Land Development Silviculture	None (Fully-Supporting)	None

Table 2-3. Probable Cause(s) and Source(s) for 1996 and 2006 Impaired Waters Lists

Water Body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Blanchard Creek from the North Fork to the mouth (Clearwater River)	Habitat Alterations Siltation	Agriculture Pasture Land	Alteration in stream-side or littoral vegetative covers Low Flow Alteration Sedimentation/Siltation	Agriculture Grazing in Riparian or Shoreline Zones Flow Alterations from Water Diversions Highway/Road/ Bridge Runoff (Non-construction Related)
Blackfoot River (Monture Creek to Clearwater River)	Nutrients Siltation	Agriculture Natural Sources Silviculture	TN TP Thermal Modifications	Flow Alterations from Water Diversions Streambank Modifications/ destabilization

2.3 Listing History and Impairment Justifications (Middle Blackfoot TPA)

The following sections contain brief synopses of the listing history of impaired water bodies in the Middle Blackfoot River and Nevada Creek TPAs between 1996 and 2006. Listing and delisting justifications contained in the DEQ SCD/BUD files are summarized when available and principal references given for each water body. A map of the listed water bodies is located in **Appendix A**. Impairment status and impairment listing reviews will also be provided for each water body in **Section 5.0** of this document in text form.

Yourname Creek

Seven miles of Yourname Creek from its headwaters to its mouth were listed in 1996 as partially supporting of aquatic life and cold water fishery uses and threatened for recreational use due to flow alteration. These listings persisted through 2004.

A 1991 stream assessment by Montana Department of Health and Environmental Sciences (DHES)2 reported significant dewatering and fish passage barriers due to irrigation diversion upstream of the Wales Creek Road crossing. Limited placer mining was observed in the headwaters reach above the Deer Gulch confluence. From the Wales Creek Road crossing toward the headwaters bank erosion or bank failure was observed along 20% to 40% of the channel due to cattle grazing. Unstable banks and significant amounts of stream bank manure accumulation were observed. Both riffles and runs contained 25% to 50% fine sediment ≤0.25 inch in diameter; pools contained 75% to 100% fine sediment of this size. Pool filling was observed. Stream bank vegetation condition improved with distance above the Wales Creek Road crossing. Common aquatic plant growth was observed in the headwaters reach that was absent below Deer Gulch. A 1992 fisheries report by Montana Fish, Wildlife, and Parks (FWP)3 described west slope cutthroat trout (WSCT) occurrence in Yourname Creek as uncommon. However, an August, 1992, a fish population study 1.8 miles above the mouth showed high

2 DHES refers to the Montana Department of Health and Environmental Sciences unless otherwise noted. DHES became Montana Department of Environmental Quality (DEQ) on July 1, 1995.
3 FWP refers to the Montana Fish, Wildlife, and Parks unless otherwise noted.

densities of YOY cutthroat trout. The lowest mile of Yourname Creek was on the FWP list of chronically dewatered streams in 2003.

Stream assessment work by DEQ in September of 2003 at a site 300 yards below the Wales Creek Road crossing observed turbid conditions with particle sizes ≤6 mm comprising 51% of the substrate. Water column sampling at the assessment site detected elevated concentrations of TKN (0.47 mg/L), TN (0.49 mg/L), and TP (0.14 mg/L).

A macroinvertebrate sample collected at the DEQ assessment site contained fewer than expected mayfly and stonefly taxa indicating a more pollution tolerant assemblage and reach scale habitat limitations. The Chlorophyll-*a* (Chl-*a*) result for the site was 127 mg/m^2. The 2006 listings for Yourname Creek include full support for agricultural, industrial, and drinking water uses and partial use support for aquatic life, cold water fishery, and contract recreation due to flow alteration, stream-side vegetation alterations, sedimentation/siltation, and TP. The listed impairment sources are riparian, range land grazing, and irrigated crop production.

Wales Creek

A two-mile reach of Wales Creek above its mouth on the Blackfoot River was listed as impaired due to flow alteration and siltation in 1996. A lack of sufficient and credible data prevented listing of the stream in 2000 and 2002. Elevated fine surface sediment concentrations (67% ≤6 mm), TKN, TP, and NO3 + NO2 –N were detected in samples collected in 2003 during a DEQ growing season assessment. The nutrient concentrations accompanied a Chl-*a* level of 105 mg/m2 that exceeded the guidance level (100 mg/m2) for contact recreation. A macroinvertebrate sample assessed by Bollman (2004) contained evidence of large accumulations of organic debris of riparian origin on the channel substrate. The lowest 2 miles of Wales Creek were listed as chronically dewatered on FWP dewatered streams lists for 1991, 1997, and 2003. Flows within the impaired reach are regulated by an irrigation reservoir located 3 miles above the mouth and several direct diversions from the channel below the reservoir. The reservoir is an effective fish passage barrier to an upper watershed having few impacts from timber harvest or grazing. Grazing management below the reservoir is given as the main source of bank erosion noted along 41% of the channel. Active riparian vegetation removal was also noted during the 2003 assessment. Wales Creek is listed in 2006 for low flow alterations, stream-side vegetation alternations, sedimentation/siltation, NO3 + NO2 –N, TP, and Chl-*a* concentration resulting in partial support for aquatic life, cold water fishery, and primary contact recreation uses. Drinking water and agricultural and industrial uses are fully supported.

Frazier Creek

The 1996 303(d) List concluded partial support for aquatic life and cold water fishery uses and threatened recreational use on Frazier Creek due to flow alteration for irrigated crop production. This assessment record was carried forward on the 1998 listing. In 2000, sufficient and credible data (SCD) was deemed lacking for all use support determinations except contact recreation, which was partially supported due to habitat alterations. The change in impairment cause probably reflects observations made during a 1991 DHES habitat assessment that reported heavy sedimentation in the reach above the upper reservoir due to logging and grazing in the riparian zone, logging road ford crossings, and frequent livestock trampling of spring pools and stream margins. The 2000 listing persisted through 2004.

DEQ conducted an assessment of Frazier Creek during the summer of 2003 that included water chemistry, periphyton, and macroinvertebrate sampling. While there was little evidence of the earlier reported bank erosion in the upper reach of the stream, the section below the reservoirs was dominated by herbaceous cover with no woody vegetation present. The channel was heavily silted below the lower reservoir. Both reservoirs and several road crossings were assessed as fish passage barriers. The steam has been diverted out of the original channel below the lower reservoir, and this more recent channel is incised into a degraded Rosgen F channel type. Approximately 75% to 95% of the flow is diverted for irrigation, and evidence of past overgrazing is common. The riparian assessment worksheet used in the 2003 assessment scored 66% of potential indicating moderate impairment. Bollman (2004) interpreted the macroinvertebrate assemblage as indicating optimal riffle development, which may be reflected in the favorable Low Valley multi-metric score of 58 for the stream. The same sample, however, indicated siltation and accelerated channel bar formation problems, reach scale riparian habitat damage, and marginal riparian zone width. A second macroinvertebrate assessment index called the River Invertebrate Prediction and Classification System (RIVPACS) scored the Frazier Creek sample as representing 54% of the expected invertebrate community, indicating use impairment.

The periphyton sample collected just below the lower reservoir was assessed by Bahls (2004) as indicating moderate impairment due to sedimentation. The periphyton siltation index was near the threshold for severe impairment. The periphyton pollution index is just below the threshold of minor impairment from organic loading, and the overall periphyton interpretation indicated partial support of aquatic life. The water chemistry data from 2003 indicated nutrient impairment due to TKN (0.54 mg/L) and TP (0.105 mg/L) concentrations significantly higher than the corresponding ecoregional reference values for the growing season. Impairment determinations stemming from interpretation of the 2003 data conclude non-support for aquatic life and cold water fishery uses, partial support for contact recreation, and full support for agricultural, industrial, and drinking water uses. The 2006 impairment cause listings expanded from only flow alteration to include alterations in stream-side vegetation cover, sedimentation/siltation, TKN, and TP.

Ward Creek

A three-mile reach of Ward Creek upstream from its mouth on Browns Lake was listed in 1996 for flow alterations. A Ward Creek assessment by DHES in 1991 noted fine sediment accumulation in riffles ranging from 25% to 50% and from 50% to 75% in pools. These observations were interpreted as a lack of sediment transport capacity affected by flow diversions from the channel. Flow alteration was dropped for the listed impairment causes in 2000 through 2004 and was replaced by habitat alterations and siltation. Water column sampling and biological assessments by DEQ in 2001 noted that fine sediment accumulations within two valley bottom reaches appeared higher than similar streams in the area. Fine sediment ≤6 mm comprised 41% of the channel substrate; the fraction ≤2 mm was 36% of surface fines. A view bucket fine sediment value in the reach immediately above Browns Lake was 77% ≤6 mm.

A periphyton sample from the reach about 4 miles from the top of the drainage contained a high percentage (55%) of pollution tolerant taxa and an excess of filtering taxa indicating a lack of coarse-textured substrate. The sample collected near the mouth at Browns Lake indicated that similar conditions prevailed there. It contained high counts of tolerant taxa and compositional indicators of carbon, nutrient, and sediment loading. The macroinvertebrate assessment of Ward Creek by Bollman (2001) concluded moderate impairment of aquatic life due to sedimentation and associated nutrient and organic loading as indicated by few pollution sensitive taxa, low stonefly counts, and excess numbers of filter feeding organisms.

Ward Creek in 2006 is listed as partially supporting aquatic life and cold water fishery uses due to physical substrate habitat alteration and sedimentation/siltation. All other uses are fully supported.

Kleinschmidt Creek
Due to a lack of sufficient and credible data, Kleinschmidt Creek was not listed in 1996. Stream temperature monitoring by FWP during the late 1990s documented mean and maximum daily stream temperatures in Kleinschmidt Creek that were 2-3°C higher than those in nearby Rock Creek and nearing the threshold temperatures fostering the release of the microbial parasite that causes whirling disease in trout. A United States Fish and Wildlife Service (USFWS) assessment of Kleinschmidt Creek by Marler (1998) described degraded riparian conditions on Kleinschmidt Creek brought about by grazing practices, channel straightening, and channel diversion structures. Grazing pressure replaced the original willow/sedge community with a more homogenous sedge/rush dominated type and caused exotic weed infestations. The straightened and obstructed channel lowered sediment transport capacity and damaged fish habitat by causing fine sediment deposition.

A restoration project in the late 1990s treated about 2500 feet of channel, and a second project that began in 2000 treated another 6250 feet. Native fish populations remained low, and the 2000 through 2004 303(d) Listings for Kleinschmidt Creek included impairments to aquatic life and cold water fishery uses caused by thermal modifications, fish habitat degradation, riparian degradation, other habitat alterations, and water column copper concentrations. The copper exceedence stems from a 1969 analysis result.

DEQ conducted an assessment of Kleinschmidt Creek in September of 2003 and recorded high surface fine sediment levels, an elevated (75 mg/L) total suspended sediment concentration and a water column arsenic concentration of 22 µg/L. At the time, the human health standard for arsenic in drinking water was 18 µg/L. The 2006 impairment listings for Kleinschmidt Creek add arsenic as a metals impairment cause and replaced the riparian degradation cause with ones for sedimentation/siltation and alterations in steam-side vegetation. The temperature monitoring added an impairment temperature.

Rock Creek
Rock Creek, an 8.2-mile tributary to the North Fork Blackfoot River in the Kleinschmidt Flats area, was listed as partially supporting aquatic life and cold water fishery uses due to flow alteration, habitat alteration, and siltation in 1996. Flow diversions and removal of riparian vegetation by grazing livestock were among the main impairing sources leading to low native fish densities and replacement of natives with brook trout. Restoration activities beginning in 1990 include approximately 3000 feet of channel restoration, off-stream water developments, and removal of confined livestock from riparian areas. Fish surveys have documented density

increases since 2000 for brown and brook trout (Pierce et al., 2002b), but numbers of native species are still considered low. A riparian habitat assessment by DEQ in 2003 concluded a poorly functioning riparian zone. Macroinvertebrate assessments (Bollman, 2004) had mixed results with a finding of full support for a site six miles above the mouth and partial support for a site 150 yards upstream from the mouth due to possible nutrient enrichment, warmer than expected water temperatures, and sediment deposition. These findings have caused the continued listing of the stream in 2006 due to flow alteration, stream-side vegetation alteration, and sedimentation/siltation.

North Fork Blackfoot River

Twenty-five miles of the North Fork Blackfoot River from its headwaters to mouth was listed as impaired due to habitat alteration and siltation in 1996. The stream, the primary Blackfoot River spawning tributary for fluvial bull trout (Pierce and Schmettering, 1999), was listed by FWP (1991) as chronically dewatered in 1991 within a reach 6 to 12 miles upstream of the mouth. Restoration efforts in the late 1990s focused on improvement of riparian grazing management, reduction of fish entrainment in irrigation canals, instream flow leasing within the dewatered reach, and channel restorations on North Fork tributaries.

Fish population surveys have documented upward trends in bull trout and WSCT numbers during the late 1990s with corresponding decreased in brown and rainbow trout numbers. DEQ's finding of full support on the North Fork in 1999 has been carried forward in the 2006 listing.

Warren Creek

In 1996, 11 miles of Warren Creek from its headwaters to its mouth on the Blackfoot River were listed as partially supporting aquatic life and cold water fishery uses and threatened for recreational use due to flow alteration. A stream assessment by DHES in 1991 observed significant flow diversions, riparian vegetation removal, and channel straightening with associated bank stability problems and sedimentation adjacent to irrigated lands downstream of the Highway 200 crossing. The assessment record contains note of a fish kill reported on lower Warren Creek in 1992 caused by dewatering.

Restoration efforts in this area in 1996 focused on livestock impacts and included removal of confined livestock, riparian fencing, off-stream water development, and limited riparian shrub planting (Pierce and Schmetterling, 1999). Impairment listing from 2000 through 2004 added habitat alterations as an impairment cause. Further restoration work on the stream occurred in 2001 that included channel reconstruction, additional fencing, and off-stream water development. Pierce and others (Pierce et al., 2004) reported brown trout density decreases in 2003 and continued problems with fine sediment accumulation, dewatering, and elevated temperatures. The impairment causes of 2004 were carried through in 2006 with continued partial support for aquatic life and cold water fishery. The previous threatened status for primary contact recreation has been changed to partial support for this use. Agricultural, industrial, and drinking water uses, unassessed in 1996, are fully supported in 2006.

Monture Creek

The entire length of Monture Creek was listed as partially supporting for aquatic life and cold water fishery uses in 1996 due to habitat alteration and siltation. All other uses were fully supported. The siltation cause was removed in 2000, and habitat alteration remained the sole impairment cause through 2004. FWP fisheries data recorded low trout numbers in the late 1970s that persisted through the 1980s. FWP data in 1989 reported low numbers of juvenile and few adult trout. Brook trout dominated the fishery. Numbers of WSCT and bull trout were judged as low (390/mi.) for the available habitat. Monture Creek was recognized as a "core" bull trout area by Thomas (1992) in a status report on bull trout in Montana.

In 2001 and 2002, FWP reported upward trends in bull trout redd counts from 74 in 1999 to 80 in 2000 and 93 in 2001 after restoration projects to place large woody debris and install riparian fencing. The fish count within the project reach was 96 fish/1000 ft up from 74 fish/1000 ft in 1999. Counts increased for all species except WSCT. Counts in the restored section were up from 60/1000 ft in 1999 to 119 in 2001; counts declined from 107 to 80 in an unrestored reach during the same period. Increases were also noted for juvenile bull trout and WSCT between 1998 and 2000; brown and rainbow trout numbers declined during the same period. Whirling disease was detected in Monture Creek in 2001. A macroinvertebrate assessment by Bollman (2004) concluded cold, clean water with some sediment deposition. An assessment score of 83% indicated full support.

The 2006 listing for Monture Creek includes partial support for aquatic life and cold water fishery uses due to alteration of stream-side plant cover related to riparian grazing in the reaches downstream of the Highway 200 crossing. All other uses are fully supported.

Blackfoot River
The Middle Blackfoot River TMDL TPA includes the main stem Blackfoot River and its tributaries from just above the mouth of Nevada Creek to just below the mouth of the Clearwater River. The entire 65-mile extent of the Blackfoot River from the mouth of Nevada Creek to the mouth of the Blackfoot on the Clark Fork of the Columbia River near Bonner, Montana, was listed in 1996 through 2000 as being impaired for nutrients and siltation. In the 2000 303(d) List, this reach was divided into three segments: (1) Nevada Creek to Monture Creek, (2) Monture Creek to Belmont Creek, and (3) Belmont Creek to the mouth of the Blackfoot at Bonner. Listings after 2000 discuss the main stem of the Blackfoot in the context of these three segments. The Middle Blackfoot TPA includes the entire first segment and the upper 11 miles of the 23.9-mile segment between Monture and Belmont creeks.

The main stem of the Blackfoot River from Nevada Creek to Monture Creek was listed for nutrients and siltation in 1996 as a result of assessment work reported by Ingman and others (1990) from data collected during 1980s and early 1990s as part of broader investigations into water quality in the Clark Fork River Basin. The listings were based on water chemistry data indicating elevated levels of total nitrogen (343 µg/L) and total phosphorus (1110 µg/L). Assessments of macroinvertebrate communities completed by DHES concluded suboptimal conditions for aquatic insects due to cobble substrates embedded by fine sediment. Fisheries assessment by FWP (Pierce & Peters, 1990) observed that some of the lowest fish counts on the Blackfoot River occurred within the reach below Nevada Creek.

Impairment for temperature (Thermal Modifications) replaced the siltation listing on the main stem Blackfoot between Nevada Creek and Belmont Creek in 2000. A 5°C increase in temperature across the mouth of Nevada Creek that brought instream temperatures to about 77° F in the reach below Nevada Creek was referenced as the basis for the listing. The justification for removal of the siltation listing is unclear since fine sediment embeddedness was mentioned in the 2000 assessment record. Both the nutrient and temperature listings have persisted through 2006 with the nutrient listing being specified in 2006 as being due to total nitrogen (TN) and total phosphorus (TP).

Cottonwood Creek (Middle Blackfoot River)
The 10 miles of Cottonwood Creek upstream from its mouth on the Blackfoot River were listed in 1996 as partially supporting aquatic life and cold water fishery uses due to flow and habitat alterations and siltation. The listing resulted from a DHES habitat assessment in 1991 that reported bank trampling by grazing livestock near the mouth with a decreasing severity upstream. A macroinvertebrate assessment (Bollman, 1997) reported moderate impairment near the mouth due to somewhat low species richness values for Ephemeroptera (mayfly), Plecoptera (stonefly), and Tricoptera (caddisfly) (EPT). Fishery surveys by FWP during the early 1990s reported abundant brown and brook trout numbers, but rare instances of WSCT or bull trout.

Pierce & Schmetterling (1999) reported on extensive best management practices (BMP), restoration and flow enhancements during 1997 and 1998 that included improved riparian livestock management practices, providing fish ladders at diversion structures, fish screens at canals, the lining of 8000 feet of irrigation canal, leasing of 8663 acre-feet per year of salvage water, and developing conservation easements.

The most recent DEQ assessment in 1999 concluded that due to improved instream flows, improved riparian grazing practices, and fish passage improvements, the aquatic life conditions had improved significantly. Although moderate habitat impairment persisted, the chemical and biological evidence indicated minor impairment and full use support. Cottonwood Creek has been listed as fully supporting from 2000 through 2006.

Chamberlain Creek
Aquatic life and cold water fishery uses were listed as partially impaired and recreation use listed as threatened for Chamberlain Creek in 1996 due to flow and habitat alterations and excess suspended sediment. These listings resulted from a DHES assessment in 1991 that reported sediment contributions from an unpaved adjacent roadway and locally heavy bank trampling by grazing livestock. Peters (1990) reported extensive channel disturbance and flow diversion into a constructed off-channel pond during 1989. Pierce (1991) reported fish passage problems, a lack of channel woody debris, and grazing damage to banks.

Pierce and others (Pierce et al., 1997) reported on extensive restoration efforts on Chamberlain Creek during the 1990s. These included relocation of the constructed pond, channel reconstruction, donation of over 3000 acre-feet of water for instream flows, removal fish passage barriers, consolidation of irrigation conveyance structures, woody debris replacement, and implementation of grazing BMP. Pearson Creek, a Chamberlain Creek tributary that had been completely diverted, was reconnected to the Chamberlain Creek channel, adding an additional 1 cubic foot per second (cfs) to base flow and about 8 cfs to peak flows.

Fish surveys conducted after the restoration effort documented a doubling in the catch of WSCT, use of the stream by bull trout that had not been seen in Chamberlain Creek since the early 1980s, and sharp increases in young-of-year WSCT and brown trout. These improvements resulted in the removal of all impairments and a finding of full support for all beneficial uses in the 2000 listing that has persisted through 2006.

Richmond Creek

Richmond Creek was listed in 1996 as impaired for non-priority organics and siltation with runoff from logging operations cited as the principal impairment source. The stream has not been listed in subsequent years due to lack of SCD. DEQ conducted assessment and sampling in 2003. A riparian habitat assessment by DEQ and macroinvertebrate samples (Bollman, 2004) all supported a finding of full support. However, riffle pebble count data indicated excess fine sediment and the 2006 listing concluded partial support for aquatic life and cold water fishery uses due to sedimentation/siltation. All other uses are listed as fully supporting.

West Fork Clearwater River

The cold water fishery use on 10 miles of the West Fork was listed as threatened due to non-priority organics and siltation in 1996 with silvicultural activities listed as the impairment source. Beneficial uses other than cold water fishery were not assessed in 1996, and the stream was not listed from 2000 to 2004 due to lack of SCD.

Streebin and others (Streebin et al., 1973) reported severe logging related damage to streambanks, and FWP (1977) reported a deteriorating fishery trend and reduced beaver complex extent resulting from road sources and natural sources. Bull trout in the West Fork were rare according to data downloaded from the Montana Fisheries Information System (MFISH) database in 1992 and 1994. The Montana Bull Trout Scientific Group (1995) designated the West Fork as a “core” area for fluvial bull trout. Thomas (1992) reported bull trout occurrence as rare with competition form contaminating brook trout.

Reassessment of the West Fork by DEQ occurred in September of 2003 at two assessment and sampling sites located above and below the Marshall Creek confluence. Water column samples, field parameters, and substrate particle size measurements, as well as macroinvertebrate, periphyton, and Chl-*a* samples, were collected. The results described a cold stream with low levels of fine sediment and low to non-detectable concentrations of nutrients and metals. The macroinvertebrate and periphyton assessment indicated full support for aquatic life (Bollman, 2004, Bahls, 2004). The West Fork Clearwater River is listed as fully supporting of all beneficial uses except primary contact recreation in 2006 due to elevated Chl-*a*.

Deer Creek

The cold water fishery use along entire length of Deer Creek from its headwater to its mouth on Seeley Lake was listed as threatened in 1996 due to non-priority organics and siltation. Silviculture was given as the impairment source. The stream was removed from subsequent lists due to a lack of SCD. Early water chemistry data from the late 1960s, the 1970s, and the early 1980s documented extremely elevated nitrate nitrogen and TP concentrations in the heavily logged watershed.

DEQ conducted assessments at two sampling locations in 2003. Chl-*a* concentrations were elevated at both assessment sites. The site upstream of the Sheep Creek confluence had a Chl-*a* result of 94.8 mg/m2; the site between Sheep Creek and the mouth had a Chl-*a* value of 65.2 mg/m2. Nutrient concentrations, however, were less than the method detection limits or well below levels associated with undesirable aquatic plant growth. Field notes from the assessment speculate that the low nutrient concentrations may reflect thorough nutrient uptake by algae and aquatic vascular plants. Macroinvertebrate samples collected in 2003 reflected healthy and diverse aquatic life conditions, functioning reach scale habitat, and good water quality at both assessment sites. However, the 2003 assessment concluded elevated fine sediment in channel substrate pebble counts, and the stream was listed due to sedimentation/siltation in 2006.

Seeley Lake

Seeley Lake was listed as partially supporting aquatic life, cold water fishery, and contact recreation uses in 1996 due to organic enrichment. Seeley was classified as mesotrophic in the early 1970s (Cladouhos, 1971), and this classification was confirmed in the 1990s (Rezanka and Butler, 1998). Data for nutrients, oxygen, and Secchi depth have been constant to lower over this period. However, nitrogen from an increasing number of shoreline septic systems has been a source of water quality concern.

Similar to Salmon Lake, a recent introduction of northern pike has caused compositional changes that, as yet, have unknown fisheries consequences. Poly-chlorinated biphenyl (PCB) compounds were detected in sediment during a study by Phillips and Bahls (1994). A fish consumption advisory of one meal/week was issued for rainbow trout due to PCB bioaccumulation, but no PCBs were ever detected in fish tissue. Sediment mercury levels measured during the same study (0.08-0.1µg/g) were lower than typical background concentrations. There have been no indications of nuisance algae blooms. A single case of an elevated fecal coliform count occurred at a swimming beach in 1973, but the data is judged to be too old to represent current conditions. Seeley Lake is currently listed as fully supporting.

Buck Creek

In 1996, the support for cold water fishery was listed as threatened due to siltation for a 2.4-mile segment of Buck Creek upstream from its mouth on Placid Lake. An assessment by DEQ in August of 2004 could not include biological or water chemistry sampling due to dry channel conditions. Aside from the substrate and channel morphology reassessment effort on Buck Creek in 2004, no additional assessment has occurred. Therefore, neither aquatic biology nor water chemistry data are available for Buck Creek, resulting in a lack of SCD for determining use support. Due to the lack of SCD, the stream was listed as being “Not Assessed” in 2006.

Salmon Lake

Salmon Lake was listed as impaired in 1996 due to nutrients, organic enrichment, and siltation. These listings stemmed from fish surveys from the 1950s through the 1970s that indicated higher than normal numbers of non-game fish (Whitney and Averett, 1958, Marcoux, 1973). A DHES assessment by Phillips and Bahls (1994) concluded an impacted fishery due to temperature and lack of shoal area physical factors possibly due to turbidity from an east shoreline roadway. Nutrient concentrations measured since the mid-1980s appear to be within the normal range. No excess algal growth has been documented. Interpretation of Chl-*a* as a trophic status indicator concluded that the lake is currently less nutrient-rich than at the start of the record during the late 1970s. Temperature and depth profiles demonstrate anoxic hypolimnium conditions in July with recovery during August. A maximum temperature of about 23°C occurs during July and August. Temperature plots indicate that lake stratification has shifted little since the early 1980s.

The lake fishery has historically been diverse with small numbers of trout, whitefish, and kokanee and abundant non-salmonid species. Bull trout and WSCT are present in very small numbers. Lack of salmonids is likely due to rapid warming in early June followed by more rapid cooling in the fall. The temperature regimen is believed to be naturally occurring. An illegal introduction of northern pike occurred in the drainage in the late 1980s or early 1990s and now comprises an increasing proportion of the fishery. Pike introduction is the largest factor limiting the fish populations, having reduced pre-introduction fish densities by 70% to 90%. Currently fish populations fluctuate with abundance of northern pike. Water quality and habitat are not currently limiting uses. Salmon Lake water quality is listed in 2006 as fully supporting.

Blanchard Creek

A 3-mile reach of Blanchard Creek from its North Fork confluence to its mouth on the Clearwater River was listed as impaired due to habitat alterations and siltation in 1996. The habitat alteration cause is more specifically referred to as "alteration in stream-side or littoral vegetative covers," and the siltation cause is referred to as "sedimentation/siltation" in the 2006 listing. A flow alteration listing was added in 2004. These listings stem from a DHES stream habitat assessment contracted in 1991 that reported severe grazing impacts to stream banks and riparian vegetation concentrated on state-owned lands and severe dewatering segment-wide. A water leasing project in 1994 improved flow conditions and young-of-year trout densities (Pierce et al., 1994), but abandonment of leasing in subsequent dry years was followed by reductions in fish numbers (Pierce et al., 2002b). Personal communication with a local landowner documented continued riparian overgrazing and weed infestation on state lands in 1999.

More recently, a macroinvertebrate and habitat assessment by Bollman (2004) concluded partial support for aquatic life due to shortened riffle segments, channel over-widening, fine gravel build up in the channel substrate, sub-optimal flow status, and little woody vegetation establishment on stream banks with evidence of grazing related bank damage.

2.4 Listing History and Impairment Justifications (Nevada Creek TPA)

Upper Washington Creek

Washington Creek was listed in 1996 as non-supporting of aquatic life, cold water fishery, drinking water, and contact recreation uses due to flow and habitat alterations and siltation. The stream was divided into two segments for the 2000 listing. Upper Washington Creek, extending 5.8 miles from the headwaters to the Cow Gulch confluence, was listed in 2000 as non-supporting of aquatic life and cold water fishery uses and partially supporting of contact recreation use due to flow and habitat alterations. The drinking water use was not assessed, and the stream was fully supporting of agricultural and industrial uses. These listings were carried forward through 2004.

A habitat assessment by DHES in 1989 found that nearly the entire headwaters segment was disturbed by past placer mining. Dredge piles adjacent to the channel were potential sediment sources. Active mining that completely altered the channel was occurring along a 2-mile reach above the Cow Gulch confluence. By 1992, the recently mined channel had been replaced by a stepped series of retention ponds connected by a straightened, armored ditch that was devoid of vegetation. Despite reclamation of the site by DEQ in 2002, similar conditions were described by a DEQ assessment in 2003. One active mining permit remains in upper Washington Creek and is located on the boundary between sections 5 and 8, Township 12 North, Range 8 West. The operation, located in the stream channel, has disturbed approximately 1 acre.

A macroinvertebrate sample collected about 1 mile downstream of the mining disturbance indicated good water quality and habitat conditions (Bollman, 2004).

Upper Washington Creek in 2006 is listed as non-supporting of aquatic life and cold water fishery uses and partially supporting of primary contact recreation due to low flow alteration and sedimentation/siltation. Agricultural and industrial uses are fully supported. Support for the drinking water use remains unassessed.

Lower Washington Creek
After being divided into two segments, the lower Washington Creek segment from Cow Gulch to the mouth was listed in 2000 as partially supporting of aquatic life, cold water fishery, and contact recreation uses due to flow alteration and siltation. The drinking water use was unassessed, and agricultural and industrial uses were fully supported. These listings were carried forward through 2004.

A DHES habitat assessment in 1989 described Washington Creek between Nevada Creek Road and Highway 141. Livestock grazing was the dominant land use. Several pastures separated by fencing had variable degrees of vegetation utilization. Stream bank vegetation was dominated by grass species in all pastures with little woody species regeneration. Steam banks were heavily trampled in higher use pastures. The channel contained enlarging gravel bars, showed evidence of pool filling, and contained notable macrophyte growth. A second DHES assessment was completed in 1992 farther upstream that described channel effects of dredge mining, heavy grazing impacts on banks, and aggrading channel conditions. The lack of woody vegetation and amount of standing dead woody species suggested past herbicide use. The channel substrate was dominated by fine sediment, and water appeared turbid. The stream was completely dewatered below diversions. Lower Washington Creek was on the FWP dewatered streams list in 1991 and was described as chronically dewatered during summer months.

A macroinvertebrate habitat assessment by McGuire (1995) documented fine sediment deposition and a restricted riparian zone. Observations by DEQ in 1996 concluded moderate impairment to instream habitat and moderate watershed erosion despite some BMP implementation in 1994. The channel surface substrate contained 30% sand and fine organic detritus. Riparian shrubs were hedged by livestock, and the water was slightly turbid.

A DEQ assessment in 2003 documented extensive historic placer mining which left a cobble-dominated surface within the riparian zone that lacked topsoil. Grazing evidence was common with few younger age class woody plants. Some old age class cottonwoods were present, but with little evidence of regeneration. The channel substrate was dominated by silt, sand, and small gravel with moderate deposition of fine in pools and point bars. Several large wood logs were in conspicuous numbers in lowest 2 miles of the stream. Four diversions were observed that depleted flow by 75%. Water column sampling results indicated elevated arsenic (13 µg/L), Mn (83 µg/L), and Fe (1380 µg/L) concentrations. Sediment sampling detected elevated quantities of As and Mn.

A macroinvertebrate assessment by Bollman (2004) observed a non-insect dominated assemblage with few cold water species and concluded likely nutrient enrichment, elevated temperatures, high sediment deposition, marginal flow status, and an embedded and monotonous substrate.

Lower Washington Creek is listed in 2006 as partially supporting aquatic life, cold water fishery, and contact recreation due to low flow alteration and sedimentation. Drinking water and agricultural and industrial uses are fully supported.

Upper Jefferson Creek

Jefferson Creek was listed in 1996 as non-supporting of aquatic life, cold water fishery, and contact recreation uses and partially supporting of drinking water and industrial uses. Agricultural use support was not assessed. Listed causes were flow alteration, habitat alteration, and siltation. The stream was split into upper and lower segments for the 2000 listings, but lack of sufficient and credible data prevented listing of the upper segment.

Upper Jefferson Creek was extensively placer mined beginning in the 1940s (Phillips and Humprey, 1987) with subsequent periodic activity by those operating under the small miner exclusion. One small mining permit remains active in Jefferson Creek for a property approximately 2 miles upstream of the Madison Gulch confluence. A second property located about 4 miles upstream of Madison Gulch was covered under a small miner permit in the late 1980s. The property was abandoned by the permit holder and regraded by DEQ in 1991 into a series of ponds connected by a constructed channel. Coarse substrate materials along a portion of the constructed channel cause the stream to flow beneath the constructed channel surface within this reach.

Turbidity measurements were made in November of 1980 and June of 1981 to measure the effects of placer mining operations on water quality. Large increases from 33 Jackson Candle Units (JCU) above to 1500 JCU below mining operations were measured in 1980; lower values were measured in 1981, but clear negative mining effects of were evident (0.9 JCU upstream and 72 JCU downstream). The headwaters segment of Jefferson Creek was assessed as functioning at unacceptable risk (USFS, 2000) due to a measured mean of 47% for fine sediment in spawning gravels. The measure range was 36% to 57%. Periodic stream assessments during the 1980s and 1990s by DHES and DEQ concluded impairment of cold water fisheries use from placer mining, timber harvest, road erosion, and livestock grazing sources. Extensive placer mining channelized the stream. Reclamation of mining disturbances resulted in sparse grass stands and several generally stable stream channel ponds. Active mining operations rerouted several channel reaches causing major bank stability and erosion problems.

A 2003 assessment by DEQ documented accelerated channel down-cutting at placer mined reaches with moderate lateral bank erosion and sediment-clogged gravels in riffles and pools. From 65% to 85% of the riparian zone had insufficient soil to retain moisture and provide a rooting medium. Stream banks were dominated by closely cropped grasses and sage brush. Channel features were homogenized and insufficient to dissipate energy. Fish habitat was severely damaged with very little cover, poor spawning gravels, passage barriers, and likely entrainment in irrigation diversions and isolated ponds. The mining diversion removed approximately 50% of the flow into retention ponds with numerous brook trout stranded without an available outlet. Earthmoving associated with the mining was extensive enough to prevent location of the original channel. Wolman pebble count data from upper Jefferson Creek contained bimodal peaks for silt and sand sized particles. The percentage of counts ≤2 mm was 52% indicating excessive fine sediment accumulation. This result is similar to a U.S. Forest Service finding (Watershed Baseline Condition for the Blackfoot River Section 7 Watershed, 2000) of the stream functioning at unacceptable risk.

Macroinvertebrate samples were collected at two locations in upper Jefferson Creek. The upstream most sample site was about 1 mile downstream of the nearest, recent placer mining disturbance. The sample contained a lower than expected number of mayfly taxa, which generally are more pollutant-sensitive. The numbers of taxa requiring a clean channel substrate was adequate. A low (4) number of stonefly taxa, however, indicated likely disturbance of riparian vegetation or stream bank conditions. The second sample collected at the downstream end of the segment supported a more pollution tolerant assemblage. As with the upstream site, mayfly and stonefly taxa numbers were low indicating potential water quality problems and habitat disturbance.

Upper Jefferson Creek is listed in 2006 as partially supporting of aquatic life and cold water fishery uses due to stream-side vegetation cover alterations and sedimentation/siltation. All other uses are fully supported.

Lower Jefferson Creek

Because Jefferson Creek was not split into two assessment segments in 1996, the upper and lower Jefferson Creek segments had the same 1996 impairments. Where upper Jefferson lacked sufficient and credible data between 2000 and 2004, lower Jefferson was listed as partially supporting aquatic life, cold water fishery, and contact recreation uses due to flow and habitat alterations. Agricultural and industrial uses were listed as fully supported during this period, and the drinking water use was unassessed.

Periodic habitat assessments of lower Jefferson Creek were conducted by DHES and DEQ from the late 1980s through the middle 1990s. These assessments have concluded either moderate or severe habitat impairment due to dewatering, damage from grazing livestock, or damage from placer mining. An assessment by the North Powell County Conservation District (Cochran et al., 1993) also concluded moderate-to-severe impairment in most reaches due to overgrazing and placer mining. Although the mining disturbances were quite old, active erosion of dredge spoils and over-steepened banks were causing channel aggradation and braiding. Jefferson Creek from the Dalton Mountain Road crossing to the mouth is listed as chronically dewatered. No bull trout were found in either Jefferson Creek or Madison Gulch (Watershed Baseline Condition for the Blackfoot River Section 7 Watershed, 2000).

A fishery survey by FWP near the Jefferson Creek mouth observed WSCT and rainbow trout, but no young of the year for either species were seen until sampling about 2 miles above the mouth.

Macroinvertebrate assessments by McGuire (1994) averaged the metrics scores from two sites above the Madison Gulch confluence; the averaged score was 36% of reference indicating moderate impairment of aquatic life. Bollman (1997) also assessed a site just above Madison Gulch that scored 53% of reference that was felt to reflect improvements resulting from BMP implemented in 1994. Returning to the site, Bollman (2004) interpreted a sample as likely indicating nutrient enrichment with probable warm water conditions and reach scale habitat disturbance. Substrate conditions were not limiting. A second site located 100 yards farther upstream scored similarly. The aquatic life support trend that emerged from macroinvertebrate assessments between 1994 and 2003 indicated that the community shifted from nutrient and temperature tolerant species to mainly temperature tolerant species.

Nutrient sampling by Anderson and Walker (2004) found no nitrogen parameters exceeding threshold values for the runoff season. Both TP and SRP exceeded the seasonal thresholds during both June and October sampling in 2003. Metals sampling by Anderson and Walker (2004) detected a dissolved aluminum (Al) exceedence (270 µg/L) during high flows in June of 2003; dissolved Al in a sample collected at low flow the following October was less than the method detection limit. Iron (Fe) and manganese (Mn) in October of 2003 low flow samples exceeded the secondary aesthetics criteria for drinking water (300 and 50 µg/L respectively). All other water column metals levels were below applicable standards. A TSS value of 25 mg/L in lower Jefferson Creek compared to a TSS result of 4.3 mg/L measured in upper Jefferson Creek.

Lower Jefferson Creek is listed in 2006 as partially supporting of aquatic life, cold water fishery, and primary contact uses due to low flow alterations, stream-side vegetation cover alterations and sedimentation/siltation, suspended/bedload solids, Al, Fe, and TP. All other uses are fully supported.

Gallagher Creek

Gallagher Creek was listed in 1996 as partially supporting aquatic life and cold water fishery uses due to flow alteration. Agricultural and industrial uses were fully supported. Contact recreation and drinking water uses were unassessed. Flow alteration was replaced in 2000 by habitat alteration. This listing persisted through 2004.

A 1991 stream assessment by DHES observed that little of the flow diverted for irrigation was returned to the channel in its lower reaches. Significant channel damage from livestock grazing, excess substrate fine sediment, fish passage barriers, and turbid conditions were also observed. A 2003 stream assessment by DEQ documented common livestock-caused bank erosion, riffle embeddedness, and riffle habitat restriction due to fine sediment accumulation, grazing damage to willow cover, and little evidence of seasonal high flow conditions. A stream assessment by DEQ in 2003 included pebble count results of 53% fines ≤2 mm and 66% fines ≤6 mm. Nutrient parameter results indicated that TKN (0.55 mg/L) and TP (0.154 mg/L) were above seasonal threshold values. The Chl-*a* value (56.3 mg/m^2) was slightly elevated. No elevated metals levels were measured. A 2003 macroinvertebrate survey of a site 150 yards above the mouth (Bollman, 2004) observed low mayfly richness and low caddis fly and clinger taxa numbers possibly due to fine sediment deposition. The assemblage indicated persistent flow, but questioned the adequacy of flow for sediment transport near the mouth.

The 2006 listings for Gallagher Creek are partial support for aquatic life, cold water fishery, and contact recreation use due to low flow alteration, stream-side vegetation cover alteration, sedimentation/siltation, TKN, and TP. Drinking water, agricultural, and industrial uses are fully supported.

Buffalo Gulch

Use support was not assessed on Buffalo Gulch in 1996. The stream was listed from headwaters to mouth in 2000 as partially supporting aquatic life and cold water fishery uses due to habitat alterations and siltation. These impairments persisted, and other uses remained unassessed through 2004.

A draft environmental impact statement prepared by the Lincoln Ranger District of the Helena National Forest (USFS, 1999) reported a modeled sediment production rate in Buffalo Gulch that was four time greater that the modeled "natural" rate. The DEQ conducted stream assessments and sampling in 2003 at a site 0.5 mile above the mouth and another site 3 miles above the mouth. The macroinvertebrate assessment (Bollman, 2004) for the upper site indicated good water quality and full support; the lower site contained slightly fewer sensitive taxa and low stonefly taxa indicting some disturbance to reach scale habitats, but impairment was judged as slight, implying full support for aquatic life. Analysis of periphyton samples from the two sites indicated moderate impairment from sediment and evidence of organic loading (Bahls, 2004). Water quality analysis indicted high levels of soluble reactive phosphorus (SRP) at both sites (0.118 and 0.122 mg/L) and elevated arsenic (13 µg/L) for the lower site. In 2006 the stream is listed as partially supporting for aquatic life and cold water fishery uses due to stream-side vegetation alterations and sedimentation/siltation. Other uses remain unassessed.

Upper Nevada Creek

Thirty-three miles of Nevada Creek were listed in 1996 as partially supporting aquatic life and cold water fishery uses due to flow and habitat alterations, nutrients, siltation, and thermal modifications. By the 2000, the stream was split into two assessment segments separated by the Nevada Lake reservoir. In 2000, along 18.3 miles of upper Nevada Creek from the headwaters to Nevada Lake, the listings for flow alteration and thermal modifications were dropped, the siltation cause was replaced by one for suspended sediment, the nutrient cause was specified as relating to nitrogen, and metals was added as an impairment cause. These listing causes persisted through 2004.

A FWP fisheries inventor during the late 1970s described upper Nevada Creek as having a total trout density of 252 fish per mile. By 1995, trout densities were described as low, and counts included non-salmonids such as longnose sucker and northern squawfish. Macroinvertebrate assessments in 1994 and 1996 drew conclusions of slight impairment with EPT taxa numbers increasing from 11 to 20 over the period. Habitat assessments by McGuire (1995) and Bollman (1997) for a site at the mountain-valley margin and another just above Nevada Lake documented deteriorating conditions at the downstream site characterized by eroding banks, limited riparian vegetation, and increased sedimentation. Conditions at the downstream site had not changed significantly.

The range in TSS values measured on upper Nevada Creek broadened form 3 to 106 mg/L in the late 1980s to a range of 2 to 274 mg/L by the mid-1990s. The metal listings stem from 1980s and early 1990s samples exceeding secondary human health aesthetic standards for Fe and Mn and the chronic aquatic life standards for Fe. Two exceedences of copper standards occurred in 1980 and 2005 during high flow conditions. Two high flow mercury exceedences occurred during the 1980s. A sample collected at U.S. Geological Survey (USGS) station number 12335500 located on Nevada Creek upstream of Nevada Lake during May of 2005 was split for low detection limit mercury analysis at two separate laboratories. Both results were less than the human health mercury standard of 0.05 µg/L. Elevated concentrations of both copper (10 µg/L) and Fe (7.27 mg/L) were detected in high flow sample collected in May of 2005.

Elevated water column nutrient concentrations in upper Nevada Creek include two TKN readings in June and July of 1980 of 0.091 and 0.82 mg/L. Two total nitrogen (TN) results exceeded seasonal threshold values during the spring and summer of 2004. Seasonal SRP and TP threshold values have been consistently exceeded in samples collected at USGS station 12335500. Nine of ten SRP results and six of ten TP results measured from May of 2003 through August of 2004 exceeded threshold values.

Upper Nevada Creek is listed in 2006 as partially supporting aquatic life, cold water fishery, and contact recreation uses and non-supporting of drinking water use due to stream-side vegetation cover alterations, physical substrate habitat alterations, suspended/bedload solids, TKN, Cd, Pb, and Hg.

Nevada Lake

Nevada Lake was listed as partially supporting for aquatic life, cold water fishery, and contact recreation uses in 1996 due to nutrients, organic enrichment, and siltation. Support for other uses was not assessed.

The FWP fishery surveys and stocking records list rainbow trout as a common year round resident in Nevada Lake. Gill net catches at four locations in 1983 caught 17 salmonids making up 16% of total fish caught. Most of catch consisted of coarse-scaled suckers. Rainbow trout ranging from 3 to 5 inches were stocked annually with about 2100 fish per release from 1990-2001. Two thousand WSCT about 4.5 inches long were stocked in May of 2002 and April of 2003.

The lake assessment project conducted by DEQ during 2003 and 2004 rated 10 shoreline stations and noted some human disturbance at all locations. Woody cover was observed at two of ten stations with no or sparse cover noted at the remaining eight stations. Fish cover rated as sparse at four of the five stations having fish cover. Using stress indicators identified by Whittier and others (2002), the Nevada Lake shoreline was rated as moderately disturbed.

Data from the lakes assessment had distributions for both TKN and TP in Nevada Lake that registered higher than the median values from comparable reservoirs with mountainous catchment basins. Median Nevada Lake Seechi depth measurements were also lower. The range in discharge from Nevada Lake is from 2.6 to 429 cfs (Pierce et al., 1990). High TSS concentrations have been observed in Nevada Creek below the dam and are believed to be due to the combined effects of shoreline sediment entrained by wave action and bottom sediment release with reservoir draw-down.

In 2006 Nevada Lake is listed as partially supporting aquatic life, cold water fishery, and contact recreation uses due to oxygen depletion, sedimentation/siltation, TKN, and TP. Drinking water and agricultural and industrial uses are fully supported.

Braziel Creek

Upstream form its mouth on Nevada Creek, a 3-mile segment of Braziel Creek was listed in 1996 as partially supporting of aquatic life and cold water fishery uses due to habitat alterations and siltation. Other uses were unassessed. The stream was not listed from 2000 through 2004 due to a lack of SCD.

A 1989 stream assessment by DHES documented unstable banks and a narrow extent of riparian vegetation consisting of alders with a closely cropped grass understory. Several land slides were contributing sediment to the channel. Other observations included undersized road culverts, pools, and spawning gravels partially filled with fine sediment, channel debris jams, and manure accumulations on banks. Roads were noted as a potentially large sediment source at high flows. The U.S. Department of Interior Bureau of Land Management (BLM) conducted properly functioning condition and lotic checklist assessments in 1990 and 1997. The stream rated as functioning at risk due to accelerated lateral bank erosion and sub-optimal riparian vegetation conditions.

DEQ conducted an assessment of Braziel Creek in September of 2003 that include water column, periphyton and macroinvertebrate sampling, and substrate particle size evaluation. Water column concentrations of TN and $NO_3 + NO_2$ –N were less than threshold values for aquatic life support (Suplee, 2005), but TP (155 µg/L) was nearly an order of magnitude beyond the suggested use support threshold. Wolman pebble count results were 32% of surface fines ≤2 mm and 36% at ≤6 mm, indicating excess fine sediment. The macroinvertebrate assessment (Bollman, 2004) for a sample collected 50 yards upstream of the Nevada Creek Road indicated excellent water quality and full use support. The periphyton assessment by Bahls (2004) noted that the non-diatom algae in the sample were dominated by a known nuisance genera indicating minor sediment impairment, but concluded an overall slight impairment with no evidence of habitat disturbance.

Overall, the assessment record indicated an excess sediment supply to the channel from unrestricted livestock access, logging disturbances, and road erosion. Braziel Creek is listed in 2006 as partially supporting aquatic life and cold water fishery uses due to stream-side vegetation cover alterations, sedimentation/siltation, and TP. Since the Chl-*a* was not elevated, contact recreation use, as well as agricultural, industrial, and drinking water uses, are fully supported.

Black Bear Creek
The lowest 3 miles of Black Bear Creek, from its mouth on Sturgeon Creek, were listed as partially supporting aquatic life and cold water fishery uses in 1996 due to habitat alterations and siltation. The siltation cause was dropped in 2000, and the stream was listed through 2004 due to habitat alterations alone.

A DHES assessment of Black Bear Creek in 1991 recorded extensive bank damage from grazing livestock and elevated (64°F)water temperatures in the valley bottom reach. Logging related debris and slash accumulations in the channel were noted in the upstream forested reaches. A lotic checklist assessment in 1993 observed low vigor and diversity of stream bank vegetation and resulting bank erosion. Both assessed reaches were scored as "non-functioning." The assessment noted that the bottom of the drainage had been used as a logging skid trail.

A 2003 stream assessment by DEQ noted severe grazing effects resulting in fine sediment accumulation, low pool numbers, an over-widened channel, and removal of woody riparian vegetation. Some willow restoration had been attempted. A macroinvertebrate sample collected during the assessment contained too few organisms for a proper count. The sample was dominated by pollution tolerant worm and midge species (Bollman, 2004). A periphyton sample contained 20% pollution tolerant diatom species and indicated organic and nutrient enrichment and fine sediment accumulation (Bahls, 2004). Water column samples collected during the assessment contained elevated levels of NO3 + NO2 –N, TKN, TP, and total suspended solids (TSS).

In 2006, 7.5 miles of Black Bear Creek from its headwaters to its mouth, is listed as non-supporting of aquatic life, cold water fishery, and contact recreation uses due to stream-side vegetation cover alterations, sedimentation/siltation, suspended/bedload solids, TKN, and TP. Agricultural, industrial, and drinking water uses are fully supported.

Murray Creek
In 1996 Murray Creek, from the mouth to a point one mile upstream, was listed as partially supporting of aquatic life and coldwater fishery uses. The contact recreation use was listed as threatened due to flow and habitat alteration, siltation, and thermal modification. Support for other uses was not assessed. Murray Creek was not listed for any use from 2000 through 2004 due to lack of SCD.

Habitat assessments of Murray Creek dating from the 1980s and early 1990s refer to grazing damage. Pierce and others (Pierce et al., 2001) reported severe bank erosion from grazing livestock in the "middle" reach with conditions improving downstream, as well as toward the headwaters. Woody riparian vegetation in the middle reach was not regenerating. Several fish barriers were observed. Headwaters conditions showed good woody debris recruitment in a healthy riparian zone. Similar headwaters conditions were described in a 2003 DEQ assessment. Fine sediment accumulation increased from headwaters to mouth as evidenced by pool filling and low flows due to irrigation diversions with little flow actually entering Douglas Creek.

Pebble count results showed that 30% of the substrate particles were <2 mm and 41% were <6 mm within the middle reach. These values doubled near the mouth. Culvert related fish barriers persisted. Water column samples form the middle and lower reaches exceeded seasonal thresholds for $NO_3 + NO_2$ –N, TKN, and TP. The result for Chl-*a* was 77.9 mg/m^2. A water column arsenic concentration of 16 µg/L was detected near the mouth. The lowest three miles of Murray Creek are listed by FWP as chronically dewatered.

A FWP fishery survey in 2000 found no salmonids in the reach near the mouth and trout numbers increased with distance upstream. Macroinvertebrate assemblages (Bollman, 2004) showed good water quality, flow, and habitat conditions in the middle reach that deteriorated markedly toward the mouth due to dewatering and reach scale habitat disturbances. Analysis of periphyton samples showed a similar trend, but indicated better conditions than those concluded from the macroinvertebrate assessment.

In 2006 Murray Creek is listed as partially supporting aquatic life, cold water fishery uses, and non-supporting for contact recreation and drinking water uses due to low flow alteration, stream-side vegetation cover alterations, sedimentation/siltation, water temperature, $NO_3 + NO_2$ –N, TKN, TP, Chl-*a*, and arsenic. Agricultural and industrial uses are fully supported.

Upper Douglas Creek

Fifteen miles of Douglas Creek, from its headwaters to its mouth on Nevada Creek were listed in 1996 as impairing aquatic life and cold water fishery uses due to flow alteration, nutrients, habitat alterations, salinity/TDS/chlorides, siltation, and thermal modifications. Other uses were unassessed. By 2000, Douglas Creek had been divided into two segments, a 12.6-mile segment extending from the headwaters to the confluence with Murray Creek and a 9.3-mile segment extending from Murray Creek to the Douglas Creek mouth on Nevada Creek. The upper segment was listed in 2000 as impairing aquatic life and cold water fishery uses due to thermal modifications and habitat alterations. Support for the drinking water use was not assessed in 2000. The salinity related impairment was removed in 2000 because salinity levels were not sufficiently high to affect uses. Upper Douglas Creek was listed as fully supporting agricultural and industrial uses in 2000. The 2000 listings persisted through 2004.

Habitat along upper Douglas Creek was assessed by DHES in 1989. Despite observations of unlimited livestock access, the stream was considered to be in “fairly good” condition. Fish surveys by FWP in the early and middle 1980s and late 1990s recorded common occurrences of genetically pure WSCT. Further fishery surveys coupled with stream temperature monitoring by FWP in 1998 (Pierce and Schmetterling, 1999) observed a deteriorating fishery and measured temperature increases of from 8°C to 13°C across a series of irrigation reservoirs on upper Douglas Creek. Stream assessments, substrate measurements, and water sampling in the area of the reservoirs by DEQ in September of 2003 observed elevated surface fines, TKN, and TP levels. At a second site near the downstream end of the segment, fine sediment dramatically increased from 30% to more than 60% at ≤2 mm. The concentration of $NO_3 + NO_2$ –N climbed from 10 to 200 µg/L, and levels of TKN and TP remained high. An arsenic concentration of 25 µg/L was detected at the lower site.

Interpretation of macroinvertebrate samples collected at the same two locations concluded degraded water quality conditions and reach scale damage to stream bank and riparian vegetation. Corresponding periphyton samples indicated minor stress due to organic loading, sedimentation, and nutrient enrichment. Results for Chl-*a* were 97 mg/m^2 at the upper and 106 mg/m^2 at the lower site; these levels were deemed sufficiently close to the 100 mg/m^2 use support threshold for contact recreation and aquatic life uses to impair these uses.

The impairment status of upper Douglas Creek in 2006 is partial support for aquatic life and cold water fishery uses, non-support for drinking water and contact recreation, and full support for agricultural and industrial uses. The lengthy list of habitat and pollutant-related causes is given in **Table 2-3**.

Cottonwood Creek (Douglas Creek)
Six miles of Cottonwood Creek from its South Fork confluence to its mouth on Douglas Creek were listed in 1996 as partially supporting aquatic life and cold water fishery uses due to flow alteration, nutrients, salinity/total dissolved solids (TDS)/chlorides, siltation, and thermal modifications. By 2000, the only cause listed as impairing aquatic life and cold water fishery was habitat alteration. Other uses were unassessed.

There are no numeric standards for salinity, TDS, or chlorides that apply to the Douglas Creek watershed. An assessment of the effects of these parameters on beneficial uses has been evaluated (Welch, 2004). While TDS values measured in the Douglas Creek drainage are elevated, none approach levels believed to suppress aquatic life, the most sensitive use. All impairments due to salinity, TDS, and chlorides were subsequently removed.

Fishery surveys by FWP in 1987 observed WSCT as 96% of the catch. A 1992 survey recorded brown trout occurrence as abundant, brook trout as common, and native species as uncommon to rare. The stream habitat conditions were assessed in 1989 by DHES. Significant bank damage from grazing livestock was observed along a reach extending two mile above the mouth. Grazing related damage, substrate embeddedness, stream bank manure accumulations, and evidence of dewatering showed in 20% to 40% of upstream reaches. Water chemistry data from the 1970s nd 1980s contained elevated results for TP (230 µg/L) and SRP (150 µg/L). Although a fecal coliform bacteria count was high (1450 organisms/ml), the NO_3 + NO_2 –N value was low (20 µg/L). A water column sample collected in the spring of 1989 contained a high (500 µg/L) TKN value, but TP and SRP levels were less than recommended seasonal use support thresholds.

The justification for removal of the nutrient and thermal impairment causes after 1996 appears to be a lack of recent data. Therefore, the 2006 listing status for Cottonwood Creek reflects the 2000 use support assessment that concluded data were insufficient to determine use support for aquatic life, cold water fishery, or drinking water uses. Full support determinations for agricultural and industrial uses, as well as the non-support determination for contact recreation due to dewatering, are carried forward in 2006.

Lower Douglas Creek
Similar to the upper segment, lower Douglas Creek was listed in 2000 as partially supporting aquatic life and cold water fishery uses due to habitat alternations and thermal modifications.

The 2003 DEQ assessment observed approximately six feet of channel incisement, poor riparian vegetation condition, little woody riparian plant regeneration, common bank failure, substrate embeddedness, and near complete dewatering.

Fisheries surveys in the 1970s characterize lower Douglas as dominated by non-salmonid species such as longnose dace, suckers, shiners, and mountain whitefish. Bollman (2004) reported a high (4.67) biotic index indicating impairment, low EPT taxa richness, and lack of cold water or long–lived species. Lower Douglas Creek assessment by DEQ noted 70% benthic cover by macrophytes. Bahls (2004) concluded severe impairment due to siltation and organic loading after examining periphyton samples.

Lower Douglas Creek flows have ranged from 23 cfs in April to less than 1 cfs during the summer months with gradual increases to a 13 to 16 cfs range during fall months. In October of 2003 an elevated arsenic concentration of 21 µg/L was measured. Total recoverable iron measured at 1410 µg/L in May of 2005 exceeded the chronic aquatic life standard of 1000 µg/L. Nutrient concentrations of TKN, TP, and SRP exceeded seasonal thresholds during spring and fall sampling in 2003.

Lower Douglas Creek listings for 2006 are non-support for all uses except agricultural and industrial uses which are fully supported. Impairment causes are low flow alterations, stream-side vegetation alterations, water temperature, TP, TKN, sedimentation/siltation, and arsenic.

Nevada Spring Creek

Nevada Spring Creek was listed in 1996 as partially supporting aquatic life and cold water fishery uses due to habitat alterations and siltation. Other uses were not assessed.

Habitat assessments of Nevada Spring Creek by Peters (1990) and Pierce (1991) observed severely degraded bank and substrate conditions due to livestock grazing and in-channel diversion structures. A PFC assessment by Fitzgerald (1996) concluded the riparian vegetation to be non-functioning. Elevated TKN and TP values were measured by Pierce et al (1990).

A habitat restoration project conducted on the upper 1.6 miles of the stream completely reconstructed the channel in 2001 and 2002. A second project in the fall of 2003 reconstructed the channel throughout the lower half of the stream. These projects lengthened the stream by 2350 feet and reduced the width-to-depth ratio from 22 to 3.2 (Pierce et al, 2004). The channel reconstruction and accompanying riparian grazing management changes resulted in a 9.6°F decrease in maximum June through September water temperatures. Brown trout density increased fourfold, and evidence of use by young of year WSCT was found one year after project completion. The temperature effects of the project were sufficient to improve temperature conditions in lower Nevada Creek (Peters, 2004).

In the 2006 listing Nevada Spring Creek is non-supporting of aquatic life and cold water fishery uses and partially supporting of primary contact recreation due to stream-side vegetation cover alteration and sedimentation/siltation. Agricultural and industrial uses are fully supported. Support for the drinking water use remains unassessed.

McElwain Creek
In 1996 McElwain Creek, from the mouth to a point 2 miles upstream, was listed as partially supporting of aquatic life, coldwater fishery, and contact recreation uses due to flow alteration, pathogens, and siltation. Support for other uses was not assessed. McElwain Creek was not listed for any use from 2000 through 2004 due to lack of SCD.

An assessment by DHES in 1991 noted excess pool filling with fine sediment from logging, road erosion, and grazing sources. A 1993 BLM assessment recorded similar conditions. The entire stream was assessed by DEQ in August of 2004. The stream channel was completely dewatered within the listed reach, contained fine sediment accumulations, and a degraded riparian vegetation condition with little woody regeneration. Road encroachment was a noted sediment source in the upper drainage.

Fisheries surveys by FWP (1992) reported a genetically pure population of WSCT with marked fish density decrease between upper and lower reaches. A 2004 macroinvertebrate assessment of a sample collected about 3 miles above the listed reach concluded intact aquatic habitats. A water column sample collected at the same site in August of 2004 contained elevated $NO_3 + NO_2$ –N (40 µg/L) and TP (85 µg/L). The result for Chl-*a* was 37 mg/m^2. A water temperature range of from 14°C to 16°C was measured during the 1991 assessment. A range of maximum temperatures between 19°C and 22°C was measured during June, July, and August of 2001 by FWP.

Documentation for the 1996 pathogen listing is not available. McElwain Creek is listed in 2006 as partially supporting aquatic life, cold water fishery, and contact recreation uses due to low flow and stream-side vegetation cover alterations, sedimentation/siltation, $NO_3 + NO_2$ –N, and TP. Other uses are fully supported.

Lower Nevada Creek
The 1996 impairment status for lower Nevada Creek was the same as that for the upper segment. From below the dam impounding Nevada Lake to its mouth on the Blackfoot River, 24.9 miles of Nevada Creek were listed in 2000 as non-supporting of aquatic life and cold water fishery uses and partially supporting primary contact recreation due to flow and habitat alterations, nutrients, and siltation. Agricultural, industrial, and drinking water uses were fully supported. These listings were carried forward for the 2004 listing.

Fisheries surveys during the late 1970s on Nevada Creek by FWP counted low trout densities (252 fish/mile). By 1990, trout densities had dropped to about half of 1970s levels except for the area immediately upstream of the mouth (Peters and Pierce, 1990). The Unites State Forest Service (Watershed Baseline Condition for the Blackfoot River Section 7 Watershed, 2000), reporting on the general condition of bull trout in the Nevada Creek, found a single fish in Nevada Creek during 1993. The assessment concluded that conditions in the Nevada Creek drainage held little potential for salmonid habitat due to irrigation practices, livestock grazing, mining, and road erosion.

Macroinvertebrate samples assessed by McGuire (1995) and Bollman (1997) contained high densities of pollution tolerant species and indicated both habitat and water quality impacts.

Numerous riparian habitat assessments by DHES and later by DEQ during the 1990s observed near complete seasonal dewatering, severely eroding banks, intermittent channel entrenchment, and channel straightening. Stream flow and sediment and nutrient monitoring by the USGS below the dam and near the mouth recorded highly variable flow and suspended sediment concentrations associated with dam releases for irrigation. Nutrient monitoring at USGS station number 12338700 near the mouth of Nevada Creek has consistently indicated elevated TKN, TN, SRP, and TP values.

Lower Nevada Creek is listed as non-supporting for aquatic life and cold water fishery, partially supporting for contact recreation, and fully supporting for drinking water and agricultural and industrial uses. The listed impairment causes in 2006 are low flow alteration, physical substrate habitat alteration, stream-side vegetation habitat alteration, sedimentation/siltation, TKN, and TP.

2.5 Applicable Water Quality Standards

Water quality standards include the uses designated for a water body, the legally enforceable standards that ensure that the uses are supported, and a non-degradation policy that protects the high quality of a water body. The ultimate goal of this water quality restoration plan, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Pollutants addressed in this Water Quality Restoration Plan include nutrients, sediment, metals, and thermal modification. This section provides a summary of the applicable water quality standards for each of these pollutants.

2.5.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a water body based on the potential of the water body to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life, drinking water, agriculture, industrial supply, and recreation and wildlife. The Montana Water Quality Act (WQA) directs the Board of Environmental Review (BER, i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (Administrative Rules of Montana (ARM) 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana uses a watershed based classification system with some specific exceptions. As a result, all waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that water body must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3) or removal of a designated use because of natural conditions can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet U.S. EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

All water bodies within the Middle Blackfoot River and Nevada Creek TPAs are classified as B-1. The descriptions of the B-1 surface water classification are presented in **Table 2-4**.

Table 2-4. Montana Surface Water Classification and Designated Beneficial Uses Applicable to the Middle Blackfoot River and Nevada Creek Watersheds

Classification	Designated Uses
B-1 CLASSIFICATION	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

2.5.2 Standards

In addition to the Use Classification described above, Montana's water quality standards include numeric and narrative criteria as well as a nondegradation policy.

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (DEQ, 2006). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective in instances of long-term (i.e., life long) exposures as well as through direct, short-term contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages, and durations of exposure. Chronic aquatic life standards are protective in cases of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival, and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective in cases of short-term exposures to a parameter and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant" or an authorization to degrade must be granted by the Department. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that water body.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface water quality standards. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a water body. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Middle Blackfoot-Nevada Creek TPA are summarized below.

Sediment

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table 2.5.** The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a reference condition that reflects a water body'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.

Table 2-5. Applicable Rules for Sediment Related Pollutants

Rule(s)	Standard
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is: 5 NTU for waters classified as B-1.
17.30.602(17)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(21)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

Metals

Numeric standards for water column metals in Montana include specific standards for the protection of both aquatic life and human health. Acute and chronic criteria have been established for the protection of aquatic life. The numeric criteria for cadmium, copper, chromium, lead, nickel, silver, and zinc vary according to the hardness of the water. Among these, copper is the only metal of concern in the Middle Blackfoot-Nevada Creek TPA. **Table 2-6** lists the numeric aquatic life and human health criteria from Circular DEQ-7 for the metals that are impairment causes in the Middle Blackfoot-Nevada Creek TPA. These values are used to determine standards exceedences in this document. The metals data record indicates that other metals are below water quality standards.

It should be noted that recent studies have indicated some metals concentrations vary through out the day because of diel pH and alkalinity changes. In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

Table 2-6. Montana Numeric Surface Water Quality Standards Guide for Metals

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Aluminum (Dissolved)	750	87	-
Arsenic (TR)	340	150	Pre- 01/23/06 – 18 Post- 01/23/06 - 10
Cadmium	0.52 @25 mg/L hardness	0.097 @25 mg/L hardness	5
Copper	3.79 @ 25 mg/L hardness	2.85 @ 25 mg/L hardness	1300
Iron (TR)	-	1000	300
Lead (Pb)			
Mercury (TR)	1.7	0.91	0.05

[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
Note: TR – total recoverable.

The human health standard for arsenic reflects Montana's recent adoption of the national maximum contaminant level (MCL) of 10 µg/L, effective as of January 23, 2006. For analyses prior to this date, the former health advisory level of 18 µg/L is used to determine compliance with standards. The human health standards for iron and manganese are secondary maximum contaminant levels which are based on aesthetic water properties such as taste, odor, and the tendency of these metals to cause staining. Neither iron nor manganese is classified as a toxin or a carcinogen. Therefore, narrative standards adopted for these metals state that concentrations "must not reach values that interfere with the uses specified in the surface and ground water standards" (Circular DEQ-7 DEQ 2006). The secondary MCLs for iron and manganese in **Table 3-3** serve as use support "guidance" together with consideration of the number, degree, and timing of exceedences and the concentrations of these metals likely to occur after conventional treatment. If the data indicate that the human health guidance values for iron and manganese would be consistently exceeded after conventional treatment, use of the water body for drinking water is considered impaired for these constituents. Iron also has a chronic aquatic life standard of 1000 µg/L used to determine impairment for aquatic life and cold water fishery uses.

Montana also has a narrative standard that pertains to metals in sediment. No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife (ARM 17.30.623(2)(f)). This narrative standard applies to metals laden sediment.

Temperature
Montana's temperature standards address a maximum allowable increase above "naturally occurring" temperatures to protect the temperature regime required for fish and aquatic life. Additionally, Montana's temperature standards address the maximum allowable rate at which temperature changes (i.e., above or below naturally occurring) can occur to avoid fish and aquatic life temperature shock.

For waters classified as B-1, the maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 67ºF) is 1°F, and the rate of change cannot exceed 2°F per hour. If the natural occurring temperature is greater than 67ºF, the maximum allowable increase is 0.5ºF (ARM 17.30.622(e), ARM 17.30.623(e)).

The term "naturally occurring" is defined in Montana's water quality standards as "conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural" (ARM 17.30.602 (19). Regarding dam operations, guidance for interpretation of the term "reasonable operation" is given by the General Operation Standards (ARM 17.30.636 (1) that state that "Owners and operators of water impoundments that cause conditions harmful to prescribed beneficial uses shall demonstrate to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects."

Nutrients
There are no statewide numeric aquatic life standards for nutrients. Numeric human health standards exist for nitrates. Human health standards for nitrogen are listed in **Table 2-7.**

Table 2-7. Human Health Standards for Nitrogen for the State of Montana

Parameter	Human Health Standard (µL)[1]
Nitrate as Nitrogen (NO3-N)	10,000
Nitrite as Nitrogen (NO2-N)	1,000
Nitrate plus Nitrite as N	10,000

[1]Maximum Allowable Concentration.

Waters of Montana are protected from excessive nutrient concentrations by narrative standards. The exception is the Clark Fork River above the confluence with the Flathead River, where numeric water quality standards for total nitrogen (300 µg/L) and total phosphorus (20 µg/L upstream of the confluence with the Blackfoot River and 39 µg/L downstream of the confluence), as well as algal biomass measured as Chl-*a* (summer mean and maximum of 100 and 150 mg/m^2 respectively) have been established.

The narrative standards applicable to nutrients that protect all uses elsewhere in Montana are contained in the General Prohibitions of the surface water quality standards (ARM 17.30.637 et. Seq.). The prohibition against the creation of "*conditions which produce undesirable aquatic life*" is generally the most relevant to nutrients. Numeric targets for determining nutrient impairment have been developed from a stratified dataset of nutrient analysis results from a variety of streams have been determined by DEQ to be supporting aquatic life and other beneficial uses.

2.5.3 Reference Condition Approach for Narrative Standards

DEQ uses the reference condition approach in determining if narrative water quality standards are being achieved. The term "reference condition" is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. Montana's water quality standards define "reasonable land, soil, and water conservation practices" as those that protect beneficial uses (ARM 17.30.602(24)). Reasonable land, soil, and water conservation practices include, but are not limited to, the best management practices applicable to the pollution producing activities within a watershed (DEQ, 2006a).

The standards further define developed land where all reasonable land, soil, and water conservation practices have been applied as a "naturally occurring" condition (ARM 17.30.602(19)). Therefore, reference condition is a useful standard of comparison because it reflects a naturally occurring condition on developed lands where, in the context of historic land uses, all beneficial uses are supported. The intention is to differentiate between naturally occurring conditions and widespread or significant alterations of biology, chemistry, or stream morphology due to human activity. The narrative water quality standards applicable to sediment, temperature, nutrients, turbidity, and pH are based on the departure from naturally occurring conditions, making the use of reference conditions important for judging compliance with these particular standards.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the suspended sediment concentration of a stream during the summer base flow should not be compared to that of a reference stream during a spring runoff event. In addition, a comparison should not be made to the lowest or highest values of a reference site, which represent the outer boundaries of reference conditions.

The following approaches may be used to determine reference conditions:

<u>Primary Approaches</u>

- Regional Approach:
  Comparing conditions in a waterbody to baseline data from minimally impaired waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat

- Historical Approach:
  Evaluating historical data relating to condition of the waterbody in the past
- Unimpaired Segment Approach:
  Comparing conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream

Secondary Approaches

- Literature Approach:
  Reviewing literature (e.g. a review of studies of fish populations, etc.) that were conducted on similar waterbodies that are least impaired
- Professional Opinion Approach:
  Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or capability)
- Modeling Approach:
  Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.)

DEQ uses the primary approach for determining reference condition if adequate regional reference or other primary reference data are available and uses the secondary approach to estimate reference condition when there are no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

2.5.4 Developing Parameter Values or Ranges for Reference Condition

Use of Mean and Standard Deviation versus the Use of Median and Percentiles
Assessing the degree of water quality impairment through a comparison with reference conditions requires developing representative reference values to use in the comparison. Statistical means or averages are commonly used because they integrate both natural variability and measurement variability into a single summarizing number. The comparison is made between means or average values from a reference data set with means derived from data collected from the water body being assessed to determine whether the latter compares favorably with or falls within the range of one standard deviation around the reference mean. This comparison assumes a "normal" or symmetrical distribution of the data around each of the means. Normal data distributions are rare among water resources data sets that more commonly tend to have a non-normal distribution (Hensel and Hirsch, 1995). In addition, the small data sets commonly encountered for water quality parameters can often yield unreliable mean values due to extreme values or skewed distributions. For these reasons it is more appropriate to use non-normal or non-parametric statistical measures when setting reference values for most water quality parameters.

Normally distributed data are evaluated according to their degree of variance from a central mean, non-normally distributed data are most often evaluated based upon how they are ranked from lowest to highest. Ranked data are summarized according to their position among four quartiles of the data set. Quartiles are used to split the data distribution into four groups, each containing 25% of the measurements. A "box and whisker" diagram with labeled quartiles of a hypothetical reference data distribution is illustrated on the right in **Figure 2-1** with two comparison data points on the left.

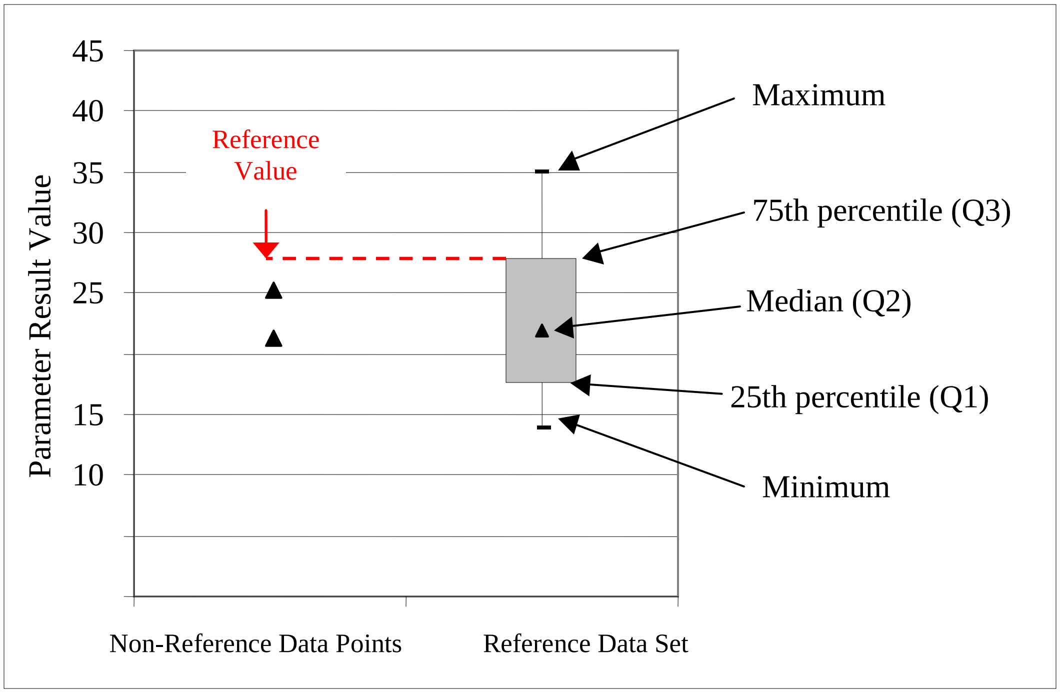


Figure 2-1. Box and Whisker Diagram of Ranked Data Distributed in Quartiles

The convention for naming quartiles is "Q1" for the first (lowest) quartile, below which 25% of the measurements fall; "Q2" for the second quartile (the median), below which 50% of the samples fall; and "Q3" for the third quartile, below which 75% of the samples fall. The non-parametric quartile range is a more realistic approach than using the parametric mean and standard deviation because water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on parametric statistical summaries if the data are not normally distributed or if the data set is small. The box and whisker diagram is a relatively straightforward visual representation of the dispersion of observations in a data set.

Selection of the appropriate reference data quartile as a water quality goal or target depends upon whether larger or smaller values represent the preferred water quality condition. If smaller values are preferred, as with percent fine sediment in spawning gravels for example, Q3 of the reference distribution is used as a potential target value. Values greater than Q3 are interpreted as being beyond the expected range of this parameter for a stream representing reference conditions for fine sediment. Alternately, should larger values equate to an improved water quality condition, as in the case with a parameter such as pool frequency, Q1 of the reference data set would be the selected target since a lower number is below the range of pool frequency expected for a reference condition stream. Depending upon the preference for either a higher or lower value, Q3 or Q1 reference values can be applied as TMDL targets for comparison with limited data points from a non-reference waterbody of interest. As in **Figure 2-1**, if all comparison values are lower than the appropriate reference value, the target or reference condition is satisfied for that parameter, and this comparison can be used as evidence toward a potential non-impairment conclusion.

When the data set from the non-reference water body of interest is small, the individual data points are compared to the appropriate quartile from a reference data set. When the data set from an unassessed water body is larger, its quartile values are calculated and compared to those of the reference data set for determining impairment status. This approach is illustrated in **Figure 2-2**.

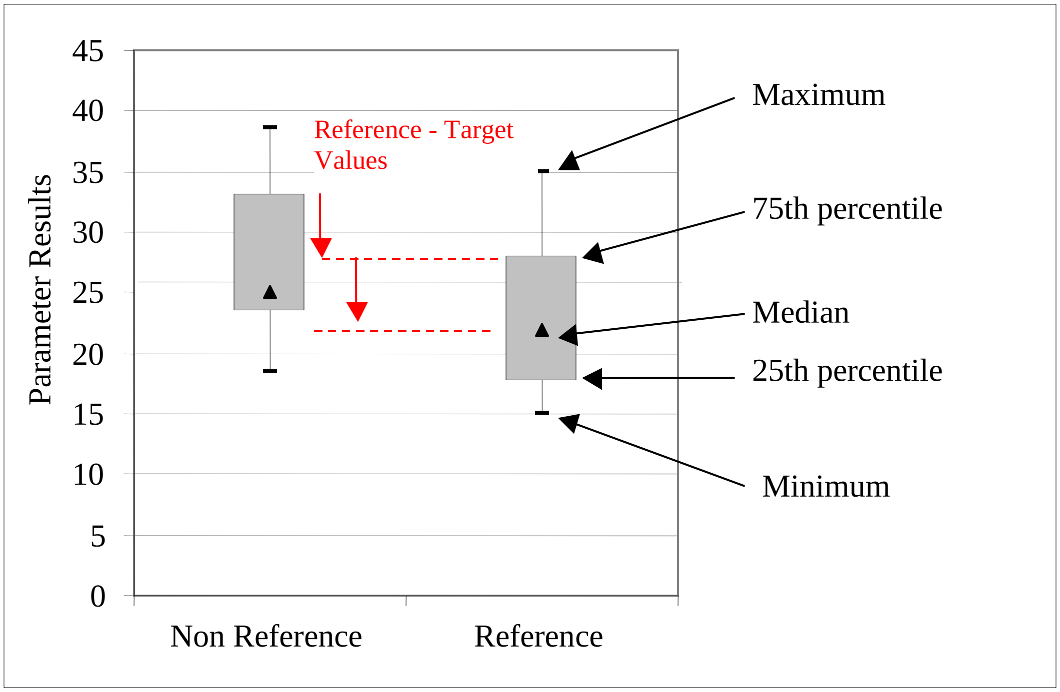


Figure 2-2. Comparison of Non-Reference to Reference Distributions Using a Target 75th Percentile (Lower Values More Desirable)

When comparing reference to non-reference distributions, both the median (Q2) and Q3 (or Q1 if lower values are preferred) are used in the comparison. In the **Figure 2-2** example, both of these quartiles are higher in the non-reference data set, suggesting potential impairment. In order to apply this approach to support an impairment determination, human-caused pollutant sources or stressors linked to the water quality parameter in question must be present, implying potential for conditions to be improved to where non-reference and reference data distributions compare more favorably. The use of this approach requires a sufficient amount of non-reference data to establish quartile values and develop boxplot diagrams.

Comparing non-parametric, distributional statistics for interpreting narrative water quality standards and developing numeric targets is consistent with EPA guidance for nutrient criteria (EPA, 2000). Furthermore, the selection of the appropriate Q1 or Q3 values as use support criteria from a reference data set is consistent with ongoing DEQ guidance for interpreting narrative water quality standards where there is adequate confidence in the quality of the reference data set (Suplee, 2004). As this confidence diminishes or improves, adjustments will be needed in selecting the appropriate quartile. For parameters where lower values reflect higher water quality conditions, the reference Q2 value may be more appropriate with only “fair” confidence in the quality of a reference data set. The 90th percentile of the reference distribution may be the most appropriate target with “very high” confidence in a reference data set.

When comparing data from reference water bodies to that collected on non-reference water bodies, it is often desirable to stratify or divide the data set for each into subsets that functionally contribute to the variability of the measurements or observations. The stratification of data according to stream channel type, stream size, geologic setting, or prevailing climate is a common means to manage variability and reduce the likelihood of mistakenly attributing differences due to natural setting or system size to those caused by human influences. Meaningful stratification will limit comparisons to those between functionally equivalent systems.

SECTION 3.0
WATERSHED CHARACTERIZATION

This section describes the physical and ecological settings of the Middle Blackfoot (MBPA) and Nevada Creek (NCPA) TMDL planning areas.

3.1 Location and Description of the Watershed

The Blackfoot River watershed lies in west central Montana, extending from approximately 30 miles northwest of Helena to 7 miles east of Missoula (**Appendix A, Figure A-1**). For TMDL planning purposes, the Blackfoot Watershed was divided into four planning areas (from upstream to downstream); the Blackfoot Headwaters, Nevada Creek, the Middle Blackfoot, and the Lower Blackfoot (**Appendix A, Figure A-2**).

The Middle Blackfoot TPA is the largest of the four planning areas covering approximately 1,076 square miles (688,800 acres). This planning area includes the contributing area from the confluence of the Blackfoot River with Nevada Creek to the confluence of the Blackfoot River and the Clearwater River. Elevations in the MBPA range from approximately 3,770 to 9,370 feet above sea level with a mean of 5,460 feet.

The Nevada Creek TPA is the smallest of the four planning areas and is located in the southeast portion of the Blackfoot River watershed. NCPA is approximately 227,059 acres (354.8 square miles) and encompasses the mainstem of Nevada Creek and its contributing tributaries. The area ranges in elevation from 4,240 to 8,280 feet above sea level with an average elevation of 5,490 feet.

3.2 Geology

The Blackfoot River watershed has a long and complicated geologic history. Exposed rocks range from Precambrian-age (1.5 billion year old), shale, siltstone, sandstone, and carbonate, to Quaternary-age (15,000-year-old) glacial deposits (Alt and Hyndman, 1986). The Precambrian formations belong to a grouping of rocks called "Belt" rocks. Belt rocks formed as a result of almost 500 million years of deposition of sediments into a large inland sea referred to as the Belt Basin. These sedimentary deposits are remarkably consistent over large distances and have been measured to be over 40,000 feet thick locally. During the formation of the Rocky Mountains from 75 to 60 million years ago, Belt rocks in the area of the Blackfoot watershed were uplifted, folded and thrust eastward over younger Paleozoic and Cretaceous sedimentary rocks. Granitic intrusions were emplaced within the Belt rocks both before and after thrusting and resulted in the formation of several mineral deposits. Large portions of the watershed were subsequently covered with volcanic rocks during the middle Tertiary period (approximately 40 million years ago). Remnants of these rocks are found primarily in the southern portion of the watershed as are sedimentary deposits derived from these volcanic rocks. In more recent times, the Blackfoot River watershed area was subjected to two major periods of glaciation, the Bull Lake glaciation about 70,000 years ago and the Pinedale glaciation of 15,000 years ago. Glaciation strongly influences the current landscape as evidenced by numerous moraines and associated hummocky topography, kettle lakes, and broad expanses of flat glacial outwash.

The geology of the Middle Blackfoot TPA consists mostly of Precambrian Belt sedimentary rocks comprising 51% of the planning area (Mudge et al., 1982 and Lewis, 1998). Quaternary alluvium and glacial deposits are the next most prevalent and comprise nearly 44% of the Middle Blackfoot TPA. Five other rock types including volcanic, sedimentary, and intrusive formations cover the remaining 4% of the area (**Appendix A, Figure A-4**). Locally, resistant outcroppings of Belt formations influence channel morphology and substrate composition. Glacial deposits in the northern portion of the planning area controls exchange of flow between surface water and groundwater.

The geology of the Nevada Creek TPA (**Appendix A, Figure A-3**) consists mostly of Cretaceous and Tertiary volcanic rocks, which comprise nearly 33% of the planning area (Mudge et al., 1982 and Lewis, 1998). Tertiary volcanic rocks in the area typically weather easily and form fine-grained valley fill deposits that are prone to erosion in the event of channel destabilization. Tertiary sedimentary rocks and Precambrian sedimentary rocks are the next most prevalent rock types covering 28% and 25% of the basin, respectively. Tertiary Bozeman Formation sedimentary rocks typically form soils with high infiltration rates, low available water capacity, and low productivity. In contrast to the Middle Blackfoot TPA, Quaternary alluvium and glacial deposits cover less than 10% of the Nevada Creek TPA and are most abundant in the valley bottom portion of the watershed, notably near the confluence with the Blackfoot River. High infiltration rates in these glacial deposits can influence the location of gaining and losing reaches. Paleozoic sedimentary rock and Cretaceous and Tertiary intrusive rocks (granite) cover the remaining 5.5% of the area.

3.3 Soils

The STATSGO (State Soil Geographic Database) soils database provides a consistent means of assessing generalized soil characteristics on a watershed scale.

Thirty soil units are present in the Middle Blackfoot TPA, of which seven cover 75% of the planning area (**Appendix A, Figure A-5**). The majority of the top seven soil units are gravelly loams and silty loams that correlate with the location of Quaternary alluvium and glacial deposits. The exception is the Worock-Garlet-Danaher Association which appears to correlate with the location of coarser grained Proterozoic (Belt) sedimentary rocks. The 23 minor soil units as a group correlate well with exposures of intrusive and extrusive igneous rocks, as well as various Belt lithologies. The majority of soil types present have similar surface textures, are moderately well to well drained, and have a depth to water table between 3 and 6 feet.

Table 3-1. Major Soil Units in the Middle Blackfoot Planning Area

Map Unit Name	Percent Area	Surface Texture
WALDBILLIG-HOLLOWAY-BATA (MT610)	19.6%	Gravelly silty loam
WOROCK-GARLET-DANAHER (MT662)	11.6%	Gravelly loam
PERMA-QUIGLEY-WILDGEN (MT445)	9.0%	Gravelly loam
ROCK OUTCROP-COEROCK-PHILLCHER (MT483)	8.5%	Unweathered bedrock
STEMPLE-GARLET-COWOOD (MT139)	8.3%	Very channery loam
WILDGEN-WINFALL-RUMBLECREEK (MT634)	7.5%	Gravelly loam
TOTELAKE-WINFALL-YOURAME (MT579)	6.8%	Gravelly loam

Eight soil units are present in the Nevada Creek TPA of which four collectively comprise 83% of the planning area (**Appendix A, Figure A-6**. Textures of the soil units closely reflect the geology of the area. Gravelly soils are typically found in areas covered by a veneer of glacial deposits. The textural term “channery” used in **Tables 3-1 and 3-2** refer to flat rock fragments, most likely derived from Proterozoic (Belt) sedimentary rocks. The majority of soil types present have similar surface textures, are moderately well to well drained, and have a depth to water table between 3 and 6 feet.

Table 3-2. Major Soil Units in the Nevada Creek Planning Area

Soil Map Unit Name	Percent Area	Surface Texture
STEMPLE-MOCMONT-HELMVILLE (MT546)	30.4%	Very channery loam
BIGNELL-YOURAME-ROY (MT045)	22.0%	Gravelly clay loam
FERGUS-ROY-TETONVIEW (MT199)	18.7%	Loam
REPP-WHITORE-WINKLER (MT473)	12.1%	Very gravelly loam
WOROCK-GARLET-DANAHER (MT662)	9.2%	Gravelly loam
WINKLER-PERMA-BIGNELL (MT650)	3.0%	Gravelly loam
WARSING-VASTINE FAMILY-FLUVAQUENTIC HAPLAQUOLLS (MT665)	2.0%	Loam
LOBERG-DANAHER-WOROCK (MT342)	1.6%	Clay loam
OVANDO-ELKNER-SHADOW (MT436)	0.9%	Gravelly silty loam

3.4 Climate

Two National Oceanographic and Atmospheric Administration (NOAA) stations have recorded climatic data for the MBPA and NCPA (http://www.wrcc.dri.edu/summary/climsmmt.html). These two sites include the Ovando 9 SSE station (#246304) and the Ovando Station (#246302). The Ovando station #246302, is located near the town of Ovando, at an elevation of 4,100 feet. This station recorded continuous precipitation data from 1899 to 1976 (**Appendix A, Figure A-7**). Further to the south, the Ovando 9 SSE station #246304 is located just north of the confluence of Nevada Creek and the Blackfoot River at an elevation of 4260 feet. This station covers a period of record between 1977 and 2005 (**Appendix A, Figure A-8**).

From 1899 to 1976, the average annual total precipitation measured at the Ovando station (#246302) was 16.94 inches with 78.6 inches total snowfall (**Appendix A, Figure A-7**). At the

Ovando 9 SSE station #246304, which has recorded climate data since 1977, the measured average annual total precipitation is 12.46 inches with 36.7 inches total snowfall (**Appendix A, Figure A-8**). Lower total precipitation at Ovando 9 SSE station suggests drier conditions in the past 26 years of record. Basin-wide hydrologic gage data collected from 1983 to 2002 also suggest a drier trend in climate (**Section 3.5**).

In addition to measured trends of reduced total precipitation in the last 25 years, the Ovando climate data suggest a shift in seasonal patterns of precipitation as well. In general, precipitation over the past 25 years has consisted of a substantial reduction in winter precipitation and more moderate increase in summer precipitation. If the Ovando precipitation data from the two stations are joined into a composite dataset and grouped into 1939-1982 and 1982-2005 time frames, it is apparent that mean monthly precipitation during the months of December through February have decreased by over 0.5 inches since 1982, which translates to reduced precipitation of over 40% during those winter months (**Appendix A, Figure A-9 and Figure A-10**). In contrast, the data depict a more moderate increase in summer precipitation during the months of July and August. These trends indicate that over the past 22 years, precipitation patterns have shifted relative to the 43 years prior to less winter snowfall and more summer rains. This trend is supported by observed trends in stream flows (**Section 3.5**). Although the Ovando climate stations are both located within the valley bottom and within 10 miles of one another, the temporal changes generated from the composite record for the two stations may reflect geographic variations in precipitation. However, this trend is very closely supported by continuous records kept at the Lincoln Ranger Station (#245040) in the Blackfoot Headwaters TPA (**Appendix A, Figure A-1**).

The NOAA climate station data reflect specific station parameters of location and elevation. Local elevations in each planning area can be several thousand feet higher than the NOAA climate stations. Consequently, NOAA station information does not accurately depict climatic conditions at higher portions of the watershed, which tend to receive more precipitation than lower elevations. To address this limitation in climate station data, regional climate information has been developed using the PRISM model (Parameter-Elevation Regressions on Independent Slopes Model). PRISM grid data indicate a minimum precipitation of 17 inches, maximum precipitation of 75 inches, and a mean precipitation of 32.5 inches in the middle Blackfoot River drainage (**Appendix A, Figure A-12**). The PRISM model indicates a mean precipitation of 23.1 inches (range = 17.0 to 30.0 inches) in the Nevada Creek drainage (**Appendix A, Figure A-11**).

3.5 Hydrology

The surface water hydrology of the Middle Blackfoot TPA reflects relationships between regional precipitation, surface water runoff, and water use. Gage stations monitored by the United States Geological Survey (USGS) and United States Forest Service (USFS) at several locations (**Appendix A, Figure A-12**) on the Blackfoot River and some of its major tributaries provide the basis for describing the Middle Blackfoot TPA hydrology (**Table 3-3**). Gage data document a reduction in total basin water yield over the last 20 years. The data also documents stream flow variability throughout the basin that correlates with the physiographic setting of individual sub-watersheds.

Table 3-3. Stream Gage Data for the Middle Blackfoot Planning Area

Site Number	Site Name	Years Represented	Drainage Area (sq mi)
USGS 12340000	Blackfoot River near Bonner	1898-1905, 1939-2002	2290
USGS 12339450	Clearwater River near Clearwater	1974-1992	345
USGS 12338500	Blackfoot River near Ovando	1940-1963	1274
USGS 12335000	Blackfoot River near Helmville	1940-1953	481
USGS 12335100	Blackfoot River above Nevada Creek near Helmville	1999-2001	494
USGS 12338300	North Fork Blackfoot River above Dry Gulch near Ovando	1997-2002	316
USFS 160605	North Fork Blackfoot River near USFS boundary	1991-2002	281
USGS 12338690	Monture Cr near Ovando	1973-1983	140
USGS 12337780	Nevada Creek at mouth near Helmville	2001-2003	308

Available gage station data allow for limited determination of the relative contributions of flow of the major tributaries in the Middle Blackfoot TPA to the mainstem Blackfoot River (**Appendix A, Figure A-13**). Within the Middle Blackfoot TPA, primary tributaries include the North Fork Blackfoot River, Monture Creek, Nevada Creek, and the Clearwater River. Available data suggest that the North Fork Blackfoot River contributes a major proportion of Blackfoot River stream flow. Moreover, these limited data indicate that the North Fork Blackfoot River's contribution of flow is disproportionate to its contributing area. Although the North Fork Blackfoot River drainage is approximately 15% of the Blackfoot River watershed area, it contributes 25% to 35% of the total Blackfoot River annual discharge (DNRC, 2001). Flow from the North Fork Blackfoot River commonly exceeds that of the headwaters of the Blackfoot River above Nevada Creek. In 2000, for example, the measured mean monthly discharges on the North Fork Blackfoot River exceeded those on the mainstem Blackfoot River near Helmville (**Appendix A, Figure A-14**). From 2000-2002, the average annual yield measured on the Blackfoot River near Helmville was 341,000 acre-ft, and measured surface water yield on the North Fork Blackfoot during that same time frame was 416,000 acre-ft.

The headwaters of the North Fork Blackfoot River and Monture Creek originate in the Scapegoat Wilderness of the Lolo National Forest, and relatively large proportions of these contributing basins are high elevation mountain environments. These streams tend to have a typical snowmelt-dominated hydrograph that peaks in the months of May and June (**Appendix A, Figure A-15**). In contrast, the Nevada Creek and Clearwater River basins encompass extensive, relatively low elevation valley bottoms, and peak spring runoff typically occurs during the month of May or prior (**Appendix A, Figure A-15**).

Several factors influence the surface water hydrology of the Nevada Creek TPA including natural patterns of precipitation and snowmelt, and human activities including a mainstem dam. Stream gage data for several gage stations provide the basis for describing the basin hydrology (**Appendix A, Figure A-13; Table 3-4**); however, most of the stations have short periods of record that do not overlap such that it is impossible to compare conditions throughout the basin for any given time frame.

Table 3-4. USGS Stream Gage Data for the Nevada Creek Planning Area

USGS Site Number	Site Name	Years Represented	Drainage Area (sq mi)
12335500	Nevada Creek above Reservoir near Helmville	1939-2001	116
12336000	Nevada Creek near Finn	1934-1939	144
12337000	Nevada Creek near Helmville	1946-1949	165
12337800	Nevada Creek at mouth near Helmville	2001-2003	308
12337500	Douglas Creek near Helmville	1946-1947	85

The Nevada Creek watershed is relatively low in elevation resulting in an earlier spring runoff than other, higher elevation streams such as the North Fork of the Blackfoot River. In general, the hydrology of streams within the Nevada Creek TPA reflects peak runoff yields in May, followed by a rapid reduction in flow volume in July (**Appendix A, Figure A-16**). The gage data upstream of Nevada Reservoir show a distinct trend in reduced spring runoff since 1990. A comparison of averaged 1940-1990 data with 1990-2001 data indicate that the mean monthly discharges measured on Nevada Creek above Nevada Lake since 1940 have remained relatively constant for the mid-summer to early spring (July through March) time frame. In contrast, average spring (April through June) runoff was significantly lower between 1990 and 2001 relative to the prior 40 years (**Appendix A, Figure A-16**).

Nevada Reservoir, constructed in 1938, provides storage for downstream irrigators in the lower Nevada and Douglas Creek drainages. A topographic reservoir survey performed in 1938 estimated the original as-built reservoir capacity at 12,723 acre-feet. A re-survey of the reservoir in 2000 measured a capacity of 11,152 acre feet, which reflects a loss in storage capacity of 1,571 acre feet (12% of total capacity) in 62 years.

The controlled release of water from Nevada Reservoir for irrigation uses downstream typically begins in mid-May and continues through September 30 (DNRC, 2001). The current management of dam releases has altered the hydrology of Nevada Creek below the dam by storing spring runoff and releasing that water later in the irrigation season, resulting in prolonged, above-average flows throughout summer months in the channel segments immediately downstream from the reservoir. Further downstream, two major diversions, which feed the Nevada Douglas canal and the North Helmville Canal, capture the majority of flows released from Nevada Reservoir. Combined, these diversions are permitted to withdraw up to 65 cfs, although the exact amount actually diverted has not been recorded. The Nevada Douglas canal is a trans-basin diversion, crossing Cottonwood Creek before discharging into Douglas Creek. The North Helmville canal crosses several smaller streams including Chimney, Wilson, and Wasson Creeks before discharging into the Blackfoot River upstream of the intersection of Highways 141 and 200. Although there is currently no mandate for minimum flow releases from the dam, the DNRC has an agreement with Montana Fish, Wildlife, and Parks on a recommended 12-40 cfs minimum outlet discharge.

One of the longest records available for stream gaging stations in the area is from the mouth of the Blackfoot River near Bonner. Data from this gage show that average peak flows prior to 1980 were substantially higher than those since 1980. From 1940 to 1983, the average annual flood discharge was 9,807 cfs (**Appendix A, Figure A-18**). Over the last 22 years, the average annual peak discharge at Bonner has declined to 7,137 cfs. On average, Blackfoot River peak flows have been about 30% lower during the last 20 years as compared to 1940-1983.

Over the past 20 years on the Blackfoot River near Bonner, the largest reductions in mean monthly discharge relative to the prior 44 years have occurred during the months of May through July, or during spring runoff (**Appendix A, Figure A-19**). As this gage is located near the mouth of the Blackfoot River, downstream from the Middle Blackfoot TPA, it is difficult to ascertain whether this trend applies to the Middle Blackfoot or Nevada Creek TPAs. However, available data from the Clearwater River depict the same general temporal trends as the Blackfoot River near Bonner. This suggests that at least part of the MBPA has experienced this decrease in mean monthly discharge.

Peak flows in the Nevada Creek watershed have also declined in recent years **(Appendix A, Figure A-17)**. Over the 50 year period between 1940 and 1990, average annual peak discharges were 651 cfs, and annual peak flows exceeded 1000 cfs a total of 10 times or at an average frequency of once every five years. The last 15 years have seen much lower peak flows; since 1990, annual peak discharges have averaged 347 cfs, and measured flows on upper Nevada Creek have exceeded 800 cfs only once on July 4, 1998.

Stream flow trends in the Blackfoot River Basin indicate that the last 20 years have been characterized by markedly low rates of spring runoff relative to the 50 years prior. The only event to exceed 11,000 cfs at Bonner during the last 20 years occurred on May 18, 1997, when a discharge of 15,800 cfs was recorded at the gage. For the 20 years prior, 11,000 cfs was exceeded a total of eight times. The basin-wide reduction in both annual peak and mean monthly discharges in the Blackfoot River Basin correlates to overall climate trends described in **Section 3.4**. Over the past 100 years it has been estimated that in areas of Montana, precipitation has declined about 20% (EPA, 1997).

3.6 Stream Geomorphology

The Middle Blackfoot TPA encompasses a diverse geomorphic landscape which has been strongly imprinted by Pleistocene-age glacial processes. During that time, south-flowing glaciers filled the steep mountainous canyons north of the Blackfoot River Valley. Where the glaciers flowed into the valley, they formed large stands of relatively stable ice, called piedmont glaciers (Alt and Hyndman, 1986). Melting of the ice resulted in the formation of braided stream networks below the ice stands and on their margins, causing the formation of coarse grained, relatively flat, alluvial outwash plains. Hummocky moraines formed adjacent to the outwash plains. The town of Ovando is located on a smooth outwash plain that is adjacent to such moraines. Some of these glacial features near Ovando date to the Bull Lake Glaciation (between 70,000 and 130,000 years ago). Others were formed by the much more recent Pinedale glaciation, which ended 10,000 years ago.

The Clearwater River valley is also floored by glacial outwash sediment. South of Clearwater Junction, glacial moraines form hummocky topography that was formed during the Bull Lake Glaciation. To the north along the Clearwater River, glacial deposits are much younger, having been deposited during the Pinedale Glaciation. Salmon Lake lies in a glacial depression north of the remnants of a natural earth dam that was formed as a moraine during Pinedale time. Numerous other lakes along the Clearwater River occupy glacial depressions that formed when isolated ice stands melted following the Pinedale Glaciation maximum.

The glacial history of the valley has had a strong influence on the modern condition of streams in the Middle Blackfoot TPA. Streams that originate in the mountains to the north, such as Monture Creek and North Fork Blackfoot River, flow through glacial deposits as well as Proterozoic Belt rocks. In the mountainous headwater areas, streams flow through relatively steep, narrow valley bottoms that are laterally confined and support narrow riparian corridors (A/B channel types [Rosgen, 1996]). Sediment contributions in the headwater areas may be derived from unstable valley wall hill slopes, such as on the North Fork of the Blackfoot River, where valley wall erosion in an area referred to as “the big slide” constitutes a prominent local sediment source. As the channels emerge from the mountains into the Blackfoot River Valley, they transition into sinuous gravel bed streams (C channel types [Rosgen, 1996]) that locally access glacial deposits on the stream valley margins. Where the North Fork Blackfoot River flows along the northwest edge of Kleinschmidt Flat, 80 to 100 ft high eroding cliffs form the boundary (DNRC, 2001). As a result, the streams that originate in the mountains on the north side of the valley contribute large bedload volumes to the mainstem of the Blackfoot River.

Numerous smaller channels flow toward the Blackfoot River from the north, including Ward Creek and Rock Creek. Ward Creek flows through hummocky glacial terrain that creates stream corridor conditions that alternate between confined glacial hummocks (B channel types) and intervening open meadows (E channel types). Rock Creek flows across Kleinschmidt Flat, which is broad flat underlain by glacial outwash deposits. The sediments of Kleinschmidt Flat consist of unsorted, coarse deposits that have high permeabilities and infiltration rates. Synoptic gage measurements on Rock Creek document seepage losses on the main portion of Kleinschmidt Flat and substantial seepage flow gains on the lower end of the creek near its confluence with North Fork Blackfoot River (DNRC, 2001). The North Fork Blackfoot River flows along the northeastern margin of Kleinschmidt Flat against high bluffs of glacial till.

Glacial features of the valley appear to play a major role in seepage losses, as well as contribution of base flows to channels as they flow southward towards the Blackfoot River. The topographically diverse, porous glacial terrain results in extensive interactions between groundwater and surface water systems. As a result, infiltrated flow in the upper reaches reemerges as surface flows in the lower stream reaches.

Within the two main sub-watersheds of the Nevada Creek TPA, Nevada Creek and Douglas Creek, upper watershed streams originate in moderate elevation conifer forests and emerge into high alluvial valleys. The headwaters areas harbor typically confined, entrenched (B type, Rosgen, 1996) channels in which riparian corridors are narrow and conifers line the active channel. Intermittent meadow areas with relatively wide valley bottoms and increased access to floodplain area commonly occur between the confined channel segments. Historic deposition of fine sediment in these lower energy reaches has resulted in the formation of sinuous channels with fine-grained margins (E type, Rosgen, 1996) that commonly support dense willow stands. As the tributaries of upper Nevada Creek and upper Douglas Creek exit the confined headwaters environments and enter relatively broad alluvial valleys, they transition into lower gradient, more sinuous channels bound by variably dense willow corridors.

3.7 Vegetation

The USGS GAP vegetation analysis serves as a source of vegetation cover type information at a watershed scale. This dataset is a national scale interpretation and reclassification of satellite imagery collected in the early 1990s.

Vegetation cover types in the Nevada Creek TPA differ somewhat from other portions of the larger Blackfoot River watershed (**Table 3-6; Appendix A, Figure A-20**). Grasslands are a major cover type, comprising over 40% of the watershed area. In contrast, grasslands account for only 11% to 12% of upper and middle Blackfoot River TPAs. Mixed alpine forest, lodgepole pine, and Douglas fir stands remain the dominant cover type in the higher, forested portions of the watershed. Combined, these upland forests comprise about 48% of the watershed, a considerably smaller proportion than the other Blackfoot River TPAs. Riparian cover types comprise about 4% of the entire watershed. Similar to GAP database derived numbers for the Middle Blackfoot TPA, riparian cover is likely underestimated, and the majority of lands in agricultural production most likely are reported as grasslands.

Vegetation types in the GAP database for the Middle Blackfoot TPA describe rural, forested watersheds (**Appendix A, Figure A-21**). Dominant cover types in higher elevations include coniferous forests comprised of lodgepole pine, mixed mesic forests, mixed subalpine, and Douglas fir/lodgepole pine communities (**Table 3-5**). Valley portions of the watershed consist primarily of low to moderate cover grasslands and mixed mesic shrubs. Riparian areas account for only 2% of the watershed area, although this is probably an underestimate of riparian cover due to the relatively coarse spatial resolution of the dataset and the thin, linear nature of riparian stands. Agricultural lands reported in the GAP database only include easily identifiable row crops and do not accurately represent the true distribution of other agricultural lands, such as hay meadows and pastures. The majority of lands in agricultural production most likely are reported as grasslands in the GAP database. Standing burnt forest comprises 9.1% or approximately 64,000 acres.

Table 3-5. Major Vegetation Cover Types in the Middle Blackfoot Planning Area

Vegetation Cover Type	Percent Area
Riparian	2.1%
Coniferous and Deciduous Forest	65.9%
Standing Burnt Forest	9.1%
Mesic and Xeric Shrubs	7.2%
Grasslands	11.2%
Agricultural (Crops)	1.5%
Rock, Barren, Quarries	2.0%

Reference: USGS GAP

Table 3-6. Major Vegetation Types in the Nevada Creek Planning Area

Vegetation Cover Type	Percent Cover
Coniferous and Deciduous Forest	48.5%
Grasslands	40.6%
Mesic and Xeric Shrubs	5.8%
Riparian	3.7%
Rock, Barren, Quarries	1.1%
Agricultural (Crops)	0.3%
Standing Burnt Forest	0.0%

Reference: USGS GAP

3.8 Land Ownership

The Middle Blackfoot TPA is mostly in public ownership, with the USFS the largest administrator of these lands (**Appendix A, Figure A-23; Table 3-7.**). The State of Montana; Montana Fish, Wildlife, and Parks; and the U.S. Fish and Wildlife Service combined administer over 78,000 acres. Plum Creek Timber Company is the largest private landowner in the Middle Blackfoot TPA, managing approximately 20% of the area. Other private lands account for the remaining land ownership.

Table 3-7. Land Ownership in the Middle Blackfoot Planning Area

Owner	Percent Area
U.S. Forest Service	51.7%
Montana State	5.2%
U.S. Bureau of Land Management	3.8%
Plum Creek Timber Company	20.4%
Montana Fish Wildlife & Parks	2.4%
Private land (undifferentiated)	16.2%
U.S. Fish & Wildlife Service	0.3%

Approximately 65% of the Nevada Creek TPA is privately owned (**Appendix A, Figure A-22; Table 3-8**) of which 5% is managed by Plum Creek Timber Company. The U.S. Forest Service is the largest administrator of public lands, controlling approximately 17% of the area, followed closely by the U.S. Bureau of Land Management (BLM) with 15%. The State of Montana; Montana Fish, Wildlife and Parks; and the U.S. Fish and Wildlife Service administer the remainder of the area.

Table 3-8. Land Ownership in the Nevada Creek Planning Area

Owner	Percent Area
Private land (undifferentiated)	59.6%
U.S. Forest Service	17.1%
U.S. Bureau of Land Management	14.7%
Plum Creek Timber Company	4.9%
Montana State Lands	3.1%
Montana Fish Wildlife & Parks	0.4%
U.S. Fish & Wildlife Service	0.1%

Under an agreement with the Nature Conservancy, Plum Creek Timber Company is selling a portion of their holdings in the Blackfoot Watershed. Transfer of these lands began in 2004 and will conclude in 2007. Working with the Blackfoot Challenge and local communities, the Nature Conservancy has begun a disposition process which is expected to conclude in 2012.

3.9 Land Uses

Land uses in the Middle Blackfoot TPA are typical of rural watersheds in western Montana. Primary land uses include agriculture, recreation (fishing, boating, camping, and hunting), timber production, and a small amount of historic mining. Urban or residential development is limited. Seeley Lake and Ovando are the only towns and, according to 2000 census data, have populations of 1,436 and 71 people respectively. Most other residents in the watershed reside on widely spaced ranches. Census block group data from 2000 indicates 2,478 people live in the planning area.

Unfortunately, there are no available accurate digital datasets of land use for the Middle Blackfoot and Nevada Creek TPAs. The USGS National Land Cover Database (NLCD) provides a partial assessment of land uses in these planning areas. This dataset is similar to the GAP vegetation database in that it relies on interpretation of satellite imagery. However, the NLCD dataset reports some land cover types that can be equated with land uses. Descriptions of land use and their extent (notably agricultural uses such as pasture, hay production, and grazing), are likely underestimated due to difficulties in interpreting satellite imagery.

According to the NLCD, agricultural uses (hay production/pastures) occur in less than 3% of the Middle Blackfoot TPA. However, grasslands which make up 11.2% of the vegetation cover in this planning area are likely used for grazing. Plum Creek Timber Company and the USFS have been engaged in timber harvest and grazing activities for a number of years (**Appendix A, Figure A-25**). Their timber harvest, grazing, and agricultural activities in the Middle Blackfoot TPA occur primarily in foothills and montane portions of the watershed. Lolo National Forest data have the longest period of record and provide information on historic harvest activity trends. These data indicate a gradual increase in harvested acres from 1910 until the late 1970s and a subsequent steady decline in acreage harvested since the late 1970s (**Appendix A, Figure A-26, A-27**). Mining is another land use in the Middle Blackfoot TPA with 11 historic mining prospects. Mining activities in the Middle Blackfoot TPA are very low when compared to other areas of the Blackfoot watershed. Recreation activities such as fishing, hunting, camping, and boating are popular in the Middle Blackfoot TPA. The Blackfoot River regularly rates within the top ten recreational fisheries in the region.

Land use in the Nevada Creek TPA is primarily agricultural (**Appendix A, Figure A-24**) with 8.2% of the area identified as being pasture or in hay production. Grasslands, which make up 40.6% of the vegetative cover, are likely used for grazing. The majority of land in the planning area is privately owned (65%); therefore, the majority of streams have limited recreational access. Population is sparse in the Nevada Creek TPA. The largest town in the area, Helmville, has a population of 24 persons. Most other residents in the watershed reside on widely spaced ranches. Census block group data from 2000 indicates 231 persons reside in the planning area.

Timber harvest activity data provided by the Helena National Forest and Plum Creek Timber Company indicate harvest or thinning activities took place on approximately 4% of the watershed area from 1997-2003. The majority of Plum Creek activities occurred in the headwaters of the Douglas Creek drainage. Historically, timber harvest on National Forest lands took place mostly in the headwaters of Jefferson Creek and Buffalo Gulch, in the northeastern portion of the watershed. Historic timber harvest data indicate a shift from a cycle of three to five consecutive years of timber harvest punctuated by one to two years of no activity to a cycle of one year of harvest punctuated by two to three years of no activity (**Appendix A, Figure A-26**). The shift appears to have taken place around 1990.

Historically, mining was a significant land use in the NCPA with 49 abandoned mines and prospects identified in the U.S. Bureau of Mines, Montana Bureau of Mines and Geology, and Montana DEQ abandoned mines databases. Placer mining was substantial, accounting for 26 of the 49 occurrences. Most of this activity took place along the northeast flank of the planning area boundary.

3.10 Fisheries and Aquatic Life

The Middle Blackfoot TPA supports 21 species among eight families of fishes (**Table 3-9**).

Table 3-9. Fish Species Found in the Middle Blackfoot Planning Area

Family/Common Name	Scientific Name	Introduced/Native	Status
Salmonidae			
Bull trout	*Salvelinus confluentus*	Native	Threatened
Westslope cutthroat trout	*Oncorhynchus clarki lewisii*	Native	Species of special concern
Brook trout	*Salvelinus fontanalis*	Introduced	
Rainbow trout	*Oncorhynchus mykiss*	Introduced	
Brown trout	*Salmo trutta*	Introduced	
Kokanee	*Oncorhynchus nerka*	Introduced	
Mountain whitefish	*Prosopium williamsoni*	Native	
Pygmy whitefish	*Prosopium coulteri*	Native	

Table 3-9. Fish Species Found in the Middle Blackfoot Planning Area

Family/Common Name	Scientific Name	Introduced/Native	Status
Cyprinidae			
Redside shiner	*Richardsonius balteatus*	Native	
Peamouth	*Mylocheilus caurinus*	Native	
Longnose dace	*Rhinichthys cataractae*	Native	
Northern pikeminnow	*Ptychocheilus oregonensis*	Native	
Centrarchidae			
Bluegill	*Lepomis macrochirus*	Introduced	
Pumpkinseed	*Lepomis gibbosus*	Introduced	
Largemouth bass	*Micropterus salmoides*	Introduced	
Catostomidae			
Largescale sucker	*Catostomus macrocheilus*	Native	
Longnose sucker	*Catostomus catostomus*	Native	
Cottidae			
Slimy sculpin	*Cottus cognatus*	Native	
Esocidae			
Northern pike	*Esox lucius*	Introduced	
Percidae			
Yellow perch	*Perca flavescens*	Introduced	
Gasterosteidae			
Brook stickleback	*Culaea inconstans*	Introduced	

The Middle Blackfoot TPA provides substantial habitat for bull trout, a species listed as threatened under the Endangered Species Act in 1998. The Middle Blackfoot TPA contains eight streams listed as “core” areas for the recovery of fluvial bull trout by the Montana Bull Trout Scientific Group (1995). These areas include the Cottonwood Creek, Monture Creek, North Fork Blackfoot River, Morrell Creek, Placid Creek, Deer Creek, West Fork Clearwater River, and East Fork Clearwater River drainages. Factors leading to the decline of bull trout include habitat degradation, isolation, and introduced salmonids. Previous studies suggest bull trout populations in the Blackfoot River are partially separated into an upper and lower component (Swanberg, 1996 and Swanberg and Burns, 1997). These studies indicate an apparent separation of the two populations exists between the North Fork and Nevada Creek based on repeated sampling revealing no bull trout in this reach of the Blackfoot River mainstem (Pierce and Podner 2000). However, recent telemetry studies (2002-2003) indicate an overlap in winter habitat use by both upper and lower bull trout populations.

Fluvial bull trout spend much of their adult life in the mainstem of the Blackfoot River, while spawning and rearing in tributary streams. During high flows, bull trout may migrate over 60 miles into headwater areas. Fluvial bull trout currently inhabit 420 miles of water or 22% of the perennial streams in the Blackfoot River watershed (http://montanapartners.fws.gov/mt5b.htm).

The Middle Blackfoot TPA also provides substantial habitat for westslope cutthroat trout, another species showing extensive population declines in the past century. Listed as a species of special concern in Montana, westslope cutthroat trout are under review for federal listing under the ESA. Sampling efforts indicate this species is present in all major headwater streams. Factors contributing to the decline of this species include habitat degradation, hybridization with nonnative rainbow trout, and competition with the introduced brook trout.

Several additional game species exist in the Clearwater River drainage, which provides both river and lake sport fisheries. Historically, kokanee, westslope cutthroat trout, brown trout, yellow perch, and largemouth bass, along with low numbers of bull and rainbow trout, provided the bulk of the sport fishery. Illegal introduction of northern pike in the late 1980s or early 1990s has had profound impacts on both game and nongame species in Seeley, Salmon, and Inez Lakes (Berg, 2003). Beaver activity and artificial outlet structures presently inhibit expansion of northern pike into Alva and Inez Lakes; however, these structures could succumb to high water events, allowing passage for pike. Natural and artificial fish passage barriers preclude movement of northern pike into Marshall, Rainy, and Clearwater Lakes, presently managed for westslope cutthroat and bull trout fisheries (Berg, 2003).

The Nevada Creek TPA supports 11 species of fishes in five families (**Table 3-10**).

Table 3-10. Fish Species Found in the Nevada Creek Planning Area

Family/Common Name	Scientific Name	Introduced/Native	Status
Salmonidae			
Bull trout	*Salvelinus confluentus*	Native	Threatened
Westslope cutthroat trout	*Oncorhynchus clarki lewisii*	Native	Species of special concern
Brook trout	*Salvelinus fontanalis*	Introduced	
Rainbow trout	*Oncorhynchus mykiss*	Introduced	
Brown trout	*Salmo trutta*	Introduced	
Mountain whitefish	*Prosopium williamsoni*	Native	
Cyprinidae			
Redside shiner	*Richardsonius balteatus*	Native	
Longnose dace	*Rhinichthys cataractae*	Native	
Catostomidae			
Largescale sucker	*Catostomus macrocheilus*	Native	
Longnose sucker	*Catostomus catostomus*	Native	
Cottidae			
Slimy sculpin	*Cottus cognatus*	Native	

The Nevada Creek drainage historically provided habitat for bull trout, a federally listed threatened species under the Endangered Species Act (ESA). Information on recent status of bull trout in the watershed indicates the potential for its persistence in this watershed is questionable. Fisheries investigations since 1999 found low numbers of bull trout numbers in the Nevada Creek TPA, with reproduction only documented in upper Nevada Creek (Pierce et al., 2002a). Despite this historical presence, sampling efforts by Montana Fish, Wildlife, and Parks (FWP) in 2001 revealed no bull trout in upper Nevada Creek suggesting extirpation of bull trout in the drainage. Factors potentially leading towards local extinction in headwaters streams such as upper Nevada Creek include isolation, habitat degradation, and presence of nonnative brook trout (Dunham and Rieman, 1999 and Rieman and McIntyre, 1993).

Westslope cutthroat trout (WCT), a species of special concern in Montana, exist in most upper tributaries within the Nevada Creek basin. In most streams, WCT population density decreases in the downstream direction (Pierce et al., 2002a). Douglas Creek is potentially an important basin for the conservation of westslope cutthroat trout. Genetic sampling between 1999 and 2001 in Murray and Cottonwood Creeks in the Douglas Creek drainage indicated no introgression with hybridizing species. Genetic analysis on several other Nevada Creek tributaries is pending. The presence of genetically pure westslope cutthroat trout populations is an important consideration in the management and conservation of this species.

Introduced salmonids occur throughout the Nevada Creek drainage. Brown trout exist below the Nevada Creek dam, but are not present upstream of the reservoir. Rainbow trout, historically stocked in Nevada Reservoir, are present in Nevada Creek and in lower reaches of tributaries upstream and downstream of the reservoir (Pierce et al., 2002a). Rainbow trout presence is a cause for concern for the conservation of westslope cutthroat trout, as these species easily hybridize. Brook trout are present in only three streams including Cottonwood Creek, Washington Creek, and upper Nevada Creek. This species is of considerable concern in the persistence of both westslope cutthroat trout and bull trout in headwater streams, and its apparent absence in many streams should be maintained to promote conservation of native salmonids. Overall, degraded habitat combined with dewatered reaches, high water temperatures, and poor water quality threaten the long-term viability of fish populations within the Nevada Creek Basin.

Since 1990, the Big Blackfoot Chapter of Trout Unlimited; Montana Fish, Wildlife, and Parks; the U.S. Fish and Wildlife Service; and many other cooperators have engaged in an aggressive native fish recovery effort in the Blackfoot Watershed. Over 200 fisheries related restoration projects have been completed on 41 tributaries as part of this effort which continues today. Overall this effort has been very successful, but issues such as extended drought, the emergence of whirling disease, and habitat degradation continue to threaten the health of Blackfoot fisheries and aquatic life.

SECTION 4.0
TMDL ASSESSMENT PROJECTS AND DATA SOURCES

Several projects conducted specifically for TMDL development, as well as existing information provided the data necessary to complete TMDLs in the Middle Blackfoot and Nevada Creek TPAs. TMDL projects conducted between 2003 and 2006 include:

- Phase 1 TMDL Assessment
- Base Parameter Field Assessment and Data Analysis
- Bank Erosion Field Assessment and Data Analysis
- Metals Assessment
- Roads Assessment
- SWAT Model Development
- Final TMDL Development

The following sections provide a brief description of these projects.

4.1 Phase 1 TMDL Assessment

TMDL development for the Middle Blackfoot and Nevada Creek TPAs began in June 2003 with a Phase 1 TMDL assessment (DTM and AGI, 2004a). This consisted of compilation and review of existing data, development of watershed characterization reports, assessment of data gaps, analysis of aerial photography within a GIS, and field reconnaissance.

Compilation of existing data facilitated completion of watershed characterization reports for both planning areas summarized in **Section 3.0** of this document. In addition, analysis of the compiled data allowed assessment of data gaps and development of a field assessment plan implemented in the summer of 2004 (DTM and AGI, 2004b).

The aerial assessment and field reconnaissance provided a framework for reach based assessment of 303(d) Listed streams, by segmenting these streams based on channel morphology, vegetation, or land use characteristics. Subsequent projects also utilized this reach framework. Maps showing reach delineations are shown in **Figures A-28 and A-29**, and summary results of the aerial assessment are tabulated in **Appendix B**.

4.2 Base Parameter Field Assessment and Data Analysis

The primary data source for habitat impairments in the Middle Blackfoot and Nevada Creek TPAs is the base parameter data collection effort conducted in July 2004. Base parameters are a suite of standard measures of stream channel morphology, stream habitat, vegetation composition, and near stream land use aimed at supporting water quality planning and/or TMDL development for siltation, habitat alterations, temperature, and nutrients. Detailed descriptions of the data collection methodology are contained within the Quality Assurance Project Plan and Sampling and Analysis Plan (DTM and AGI, 2004b) and a report on analysis of these data (DTM and AGI, 2005). The base parameter methodology builds upon earlier field assessments performed to support the development of water quality restoration plans and TMDLs for the adjacent Blackfoot River headwaters TPA. Analysis of the data collected allowed development of statistical norms for these parameters by channel type. From this analysis, Montana DEQ developed targets for these parameters based on departure from the norms.

Field crews collected base parameter data at 32 sites on nine streams within the Nevada Creek TPA **(Appendix A, Figure A-30)**. In the Middle Blackfoot TPA, field crews collected base parameter data from 22 sites on nine streams.

Table 4-1. Data Collected During the 2004 Base Parameter and Erosion Inventory Assessment

Parameter	Measure	Definition	Use in Target Development
Channel Dimensions	Bankfull width	Cross sectional width of channel at bankfull condition	Width:depth ratio
	Mean bankfull depth	Bankfull depth averaged from 5 equidistant points on cross section	Width:depth ratio
	Max bankfull depth	Bankfull depth averaged from 5 equidistant points on cross section	Width:depth ratio
	Flood prone width	Floodplain width at 2 times max bankfull depth	Entrenchment ratio
Riparian Vegetative Cover	Percent channel length with given vegetation type	Stationed mapping of vegetation assemblage	Percent shade
Channel Morphology/ Habitat	Habitat unit extent	Stationed mapping of pools, riffles, runs, and glides	Percent pool length
	Residual pool depth	Measure of elevation difference between deepest point in pool and downstream hydraulic control.	Residual pool depth
Woody Debris	Individual pieces of woody debris	Count of individual pieces of woody debris exceeding two inches in diameter and three feet in length	Woody debris concentration
	Woody debris aggregate extent	Count and length measure of woody debris aggregates	Woody debris aggregate density
Substrate	Pebble Counts	Substrate measurements in riffles	Percent fines in riffles
	Percent Fines Grid	Percent surface fines measurement in pool tailouts	Percent surface fines
Land Use	Land use categorization	Categorization of primary apparent land use along topbank, riparian buffer and floodplain area	
Reach Classification	Rosgen Level II classification	Channel classification based on measured cross section parameters, slope, and substrate	Data stratification and extrapolation

4.3 Bank Erosion Inventory

Concurrent with the base parameter assessment conducted in 2004, field crews inventoried eroding banks to determine the amount of sediment they contribute to the overall sediment load (DTM and AGI, 2005).

4.3.1 Data Collection

The bank erosion inventory recorded the location and characteristics of stream banks with discernable bank erosion within assessed reaches. These data provide the basis for developing a sediment source assessment and load allocation from eroding banks. For tributary streams, this inventory was performed on 1000 foot transects along both banks of the stream coincident with base parameter data collection. For the mainstem Blackfoot River, all eroding banks were mapped and assessed by a field crew floating the river. Reaches Blkft2 through Blkft8 were mapped in this fashion. Reaches Blkft1 and Blkft9 through Blkft11 have extrapolated bank erosion values (see **Section 4.3.2** below).

The erosion site assessment includes description of each eroding bank within a given assessment reach, including the following:

- length
- height
- location (mapped)
- BEHI rating
- BEHI rating condition
- bank materials
- topbank vegetation type
- topbank vegetation density
- proximal land use

The bank condition evaluation utilized the BEHI method (Rosgen, 2000) and incorporated the following parameters into numerical ratings.

- Bank height/bankfull height ratio
- Root depth/bank height ratio
- Root density percent
- Bank angle
- Surface protection percent

Eroding bank lengths were measured by tape along the thalweg of the stream. Bank height was measured using a stadia rod extended from the toe of the eroding bank to the top of the bank. Location is recorded using the continuous stationing method. The Bank Erosion Hazard Index (Rosgen, 2000), which allows the determination of the severity of mapped eroding streambanks, was performed according to procedures laid out in the Quality Assurance Project Plan and Sampling and Analysis Plan (DTM and AGI, 2004).

4.3.2 Data Analysis

Analysis of stream bank erosion inventory data involved five tasks:

- Calculation of erosion rates based on condition and distribution of eroding banks mapped at assessment sites.
- Extrapolation of these rates to reaches of 303(d) streams not assessed.
- Determination of erosion rates of streams not on the 303(d) List.
- Calculation of the total sediment load from bank erosion.
- Estimation of the natural and anthropogenic components of the sediment load.

Results of the data analysis are in **Section 5.5.2**. Detailed descriptions of the data analysis and extrapolation methodologies are in DTM and AGI, 2005.

4.4 Roads Assessment

In 2005, the Blackfoot Challenge, Montana DEQ, and River Design Group, Inc. conducted a field assessment of roads in the Nevada Creek and Middle Blackfoot TPAs (RDG, 2006). The assessment included:

- A quantitative assessment of road surface erosion loading for unpaved roads.
- A semi-quantitative analysis of potential road impacts on LWD, sinuosity, and entrenchment.
- A quantitative analysis of the amount of road fill at risk from culvert failures.
- A semi-quantitative summary of culvert impacts on fish passage.

Road surface erosion data collection followed the Washington Foresdt Practices Board method (WA Forest Practices Board, 2001) and sampled approximately five percent of road/stream crossings present. Data analysis conducted in 2005 and 2006 included extrapolation of data to un-assessed road/stream crossings and summarizing results by ownership, geology, precipitation regimes, and TMDL stream. Results are in **Section 5.5.3**.

4.5 Metals Assessment

Assessment of the metals-related impairment status and completion of TMDLs for streams within the Middle Blackfoot and Nevada Creek TPAs used both existing data sources, and data from recent investigations conducted to support TMDL development. Given the existing data set and the historic 303(d) Listings for metals within these drainages, initial metals TMDL tasks involved compiling relevant metals water quality data for the Nevada Creek drainage and for Kleinschmidt Creek, including data provided by DEQ, and data available on the EPA STORET and USGS NWIS water quality databases (Hydrometrics, 2006). Additional monitoring programs designed and implemented between 2003 and 2006 addressed data gaps identified during the initial data compilation.

The EPA STORET search revealed several water quality monitoring locations in the Nevada Creek watershed and on Kleinschmidt Creek, sampled by DEQ, the U.S. Forest Service, and the

Bureau of Land Management for metals. The search of the USGS NWIS database showed three historic monitoring locations on Nevada Creek:

- immediately upstream of Nevada Creek Reservoir
- immediately downstream of the reservoir
- at the mouth of Nevada Creek near the Blackfoot River

Supplemental data collection activities were conducted in the Nevada Creek watershed and on Kleinschmidt Creek in 2003 and 2005, to address data gaps identified during the data compilation effort. Metals data (both water and sediment) was collected in 2003 in accordance with a 2003 scope of work and contract document, and in 2005 with a Sampling and Analysis Plan (Hydrometrics, 2005b).

Montana DEQ sampling from 1974 on Nevada Creek used analysis technology available at the time that is not suitable for modern water quality assessment. An early 1970s study prepared for the Montana Department of Fish, Wildlife, and Parks (Spence, 1975) was cited in the Sufficient Credible Data Source Checklist for Kleinschmidt Creek. This report included data that resulted in the 303(d) Listing of Kleinschmidt Creek for copper in 2000 and 2002. Kleinschmidt Creek was removed in the 2004 303(d) List after these data were determined to be not credible by DEQ.

Three primary data sources supported metals TMDL development in the Middle Blackfoot and Nevada Creek TPAs: (1) DEQ Assessment Data, (2) USGS Data, and (3) Supplemental Metals Data collected by Hydrometrics under contract to the Blackfoot Challenge. A summary of these data is below.

4.5.1 DEQ Assessment Data

As part of water body assessment activities in the Blackfoot River drainage, DEQ collected water samples for metals analysis from seventeen streams in the Middle Blackfoot and Nevada Creek TPAs, from 2001 through 2004. DEQ collected 23 samples from several locations on six streams. In addition to the water samples, streambed sediment samples were collected for total metals analysis at six locations. The DEQ metals data is described for individual water bodies in **Table 6-2**. Complete results are in Hydrometrics, 2006.

4.5.2 USGS Data

The USGS collected water samples at three sites in the Nevada Creek TPA at regular intervals for a suite of parameters including metals. These data include the following sites and dates:

- Nevada Creek Above Reservoir – 2 samples collected in 1980, 9 samples collected in 2003-2004.
- Nevada Creek Below Reservoir – 11 samples collected in 2004-2005.
- Nevada Creek At Mouth – 22 samples collected in 1995-2005.

A summary of the USGS metals data, with descriptive locations is in **Appendix F.** A complete listing of all data is in Hydrometrics, 2006.

4.5.3 Supplemental Metals Data (Hydrometrics)

Hydrometrics, Inc., personnel collected supplemental water quality samples in the Nevada Creek TPA and on Kleinschmidt Creek in 2003 and 2005. The purpose of this sampling was to obtain seasonal information on metals concentrations and loads to address data gaps. Field crews collected 29 water samples and 7 stream sediment samples from ten streams. Location descriptions for sampling locations are in **Appendix F**. All supplemental metals data is also found in Hydrometrics, 2006.

4.6 SWAT Modeling

Development and use of a SWAT (Soil and Water Assessment Tool) time step simulation model provided information to assess nutrient and sediment loads (DTM, 2006). **Section 5.5.1** presents results of SWAT modeling supporting the sediment source assessment, and **Section 7.0** has additional information on nutrient modeling and results.

SWAT is a watershed scale model that predicts the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods. SWAT is a time step simulation model. For a detailed description of SWAT, refer to Neitsch et al. 2002.

SWAT can simulate a single watershed or a system of hydrologically connected watersheds over time. For the Blackfoot River, the watershed was subdivided into a series of 65 sub-basins based on 303(d) Listings, natural changes in topography and geology, or major changes in land use or vegetation. Each sub-basin contains a series of Hydrologic Response Units (HRUs) which are unique combinations of soils and land cover types. Calibration of the model, performed by Montana DEQ, required an iterative adjustment of a series of parameters to maximize the degree of agreement between simulated observed measurements. After calibration, a series of nine-year simulations (1996-2004) provided sediment and nutrient loading data for each 303(d) List stream, as well as non-303(d) streams.

Analysis of the sediment and nutrient load data then provided portions of the sediment and nutrient source assessment, provided a basis for allocation of sediment loads, and allowed a coarse evaluation of load reduction strategies for meeting nutrient water quality targets.

4.7 Temperature Assessment and Modeling

Assessment of thermal conditions of 303(d) List streams consisted of three parts: analysis of temperature monitoring data collected by Montana FWP from 1994-2004, assessment of shade from aerial photography and field measurements, and temperature modeling using the Stream Network Temperature (SNTEMP) model (DTM and AGI, 2006b).

SNTEMP, the Stream Network Temperature Model, is a mechanistic heat transport model that predicts daily mean and maximum water temperatures at the end of a stream network (Theurer et al., 1984, Bartholow, 2004). Model simulations occur over a single time step, such as a day, and evaluate the effects of changing shade, stream geometry, and flow on instream temperature. The model requires inputs describing stream geometry, hydrology, meteorology, and stream shading. SNTEMP models multiple, linked stream segments to predict water temperature at the end of the network and at points within the network. It allows for variability in flow, shade, and other factors at multiple locations within the modeled stream. Effects on stream temperature from one set of stream conditions can then propagate downstream to a stream segment with different conditions. This allows for basin-wide modeling of stream temperatures.

After calibration of a series of SNTEMP models, model simulations predicted the amount of increased shade required to keep peak temperatures within the legally allowable increase of either 0.5ºF or 1ºF above natural conditions (see **Section 8.2**). Detailed information on the methodology and temperature condition is in DTM and AGI, 2006.

4.8 Data Source Summary

The projects described above and additional data sources provided the information necessary to determine the water quality impairment status of water bodies on the 303(d) List, develop TMDL targets, and develop load allocations. The following table lists critical data sources contributing toward TMDL development for the Middle Blackfoot and Nevada Creek TPAs.

Table 4-2. Data Sources Used for TMDL Development in the Nevada Creek and Middle Blackfoot Planning Areas

Author	Date	Title	Stream(s)	Reach(es)	Pollutant Category	Parameter
DTM Consulting, Inc.	2006a	SWAT Model Development for the Blackfoot River Watershed, Montana	All	All	Nutrients, Sediment	TN, TP, Hillslope sediment
DTM Consulting, Inc. and Applied Geomorphology, Inc.	2006b	Temperature Analysis and Modeling of 303(d) List Streams in the Blackfoot River Watershed, Montana	Nevada Creek, Douglas Creek, Murray Creek, Cottonwood Ck, Blackfoot River, Kleinschmidt Creek	Nev 1-14, Doug 1-9, Murr 1-3, CttnNev 1-3, Blkft 1-11, Klein 1-3	Temperature	Temperature, shade, width, flow
DTM Consulting, Inc. and Applied Geomorphology, Inc.	2006c	Development of Temperature Modeling Data, and Preliminary Temperature Modeling, Blackfoot River Watershed, Montana	Nevada Creek, Douglas Creek, Murray Creek, Cottonwood Ck	Nev 1-14, Doug 1-9, Murr 1-3, CttnNev 1-3	Temperature	Temperature, shade, width, flow
River Design Group, Inc.	2006	Middle Blackfoot and Nevada Creek TMDL Roads Assessment	All	All	Sediment	Erosion from roads
EPA	2006	STORET Database	All		Nutrients, Temperature, Sediment, Metals	NH4, NO2/3, TKN, TN, SRP, TP, TSS Temperature, periphyton
USGS	2006	NWIS (National Water Information System)	All		Nutrients, Temperature, Sediment, Metals	NH4,NO2/3, TKN, TN, SRP, TP, TSS Temperature,
DTM Consulting, Inc. and Applied Geomorphology, Inc.	2005	Analysis of Base Parameter and Erosion Inventory Data for Middle Blackfoot and Nevada Creek TMDL Development	All	All	Sediment, Habitat	Width/Depth, substrate, pool frequency, pool depth, woody debris, entrenchment, vegetation
Blackfoot Challenge	2005	McNeil Sediment Core Data	Blanchard Creek, Cottonwood Creek, Monture Creek		Sediment	Substrate

Table 4-2. Data Sources Used for TMDL Development in the Nevada Creek and Middle Blackfoot Planning Areas

Author	Date	Title	Stream(s)	Reach(es)	Pollutant Category	Parameter
Bollman, W.	2005	A Biological Assessment of Sites in the Blackfoot River Watershed, Pre-Restoration: Powell County, Montana. Report by Wease Bolman, Rithron Associates to Land & Water Consulting, Inc.	Warren Creek, Kleinschmidt Creek	Warr2, Warr3, Klein2, Klein3	Sediment, Habitat, Nutrients	Periphyton
Weber, E	2005	Blackfoot Watershed Water Quality Status and Trends Monitoring Project	Nevada Creek, Blackfoot River, North Fork Blackfoot River, Monture Creek, Clearwater River	Nev7, Nev14, Blkft4, Blkft9, Mont11	Nutrients	Chlorophyll *a*
DTM Consulting, Inc.	2004	Field Updated Quality Assurance Project Plan and Sampling and Analysis Plan, Middle Blackfoot and Nevada Creek TPAs	All	All	Sediment, Habitat	Width/Depth, substrate, pool frequency, pool depth, woody debris, entrenchment, vegetation
Weber, E.	2005	Blackfoot Watershed Water Quality Status and Trends Periphyton Monitoring	Nevada Creek, Blackfoot River, North Fork Blackfoot River, Monture Creek, Clearwater River	Nev7, Nev14, Blkft4, Blkft9, Mont11	Sediment, Habitat, Nutrients	Periphyton
Applied Geomorphology, Inc. and DTM Consulting, Inc.	2004	Aerial Assessment, Nevada Creek and Middle Blackfoot TPAs	All	All	Sediment, Habitat, Nutrients, Temperature	Channel morphology, vegetation, land use
Helena National Forest	1987-2004	McNeil Sediment Core Data	Blackfoot River, Kleinschmidt Creek, Monture Creek, Nevada Spring Creek, Rock Creek		Sediment	Substrate
Montana FWP	2004	FWP Temperature Database	Nevada Creek, Douglas Creek, Cottonwood Ck, Kleinschmidt Creek, Blackfoot River		Temperature	Temperature
Hydrometrics, Inc.	2004	Nevada Creek TMDL 2003 Nutrient/Metals Sampling, Project Summary Report	Nevada Creek, Washington Creek, Jefferson Creek,		Nutrients, Metals	NO3, NO2/3, TKN, TN, OP, TP, As, Fe

Table 4-2. Data Sources Used for TMDL Development in the Nevada Creek and Middle Blackfoot Planning Areas

Author	Date	Title	Stream(s)	Reach(es)	Pollutant Category	Parameter
Montana Fish, Wildlife, and Parks	2002	The Blackfoot River Fisheries Inventory, Restoration and Monitoring Progress Report for 2001	Washington Creek, Jefferson Creek, Nevada Creek, Kleinschmidt Creek, Warren Creek, North Fork Blackfoot River, Monture Creek, Blackfoot River	All	Habitat	
Montana Fish, Wildlife, and Parks	2001	Blackfoot River Fisheries Inventory, Monitoring and Restoration Report 2001	Cottonwood Creek, Murray Creek, Douglas Creek, Nevada Creek, Yourname Creek, Wales Creek, Kleinschmidt Creek, Monture Creek, Cottonwood Creek, Blanchard Creek, Blackfoot River	All	Habitat, Temperature	Temperature, Fish Population
Montana Fish, Wildlife, and Parks	1999	Blackfoot River Restoration Project: Monitoring and Progress Report 1997-1998	Blackfoot River, Blanchard Creek, Chamberlain Creek, Cottonwood Creek, Kleinschmidt Creek, Monture Creek, Rock Creek, Warren Creek, Douglas Creek, McElwain Creek	All	Habitat, Temperature	Temperature, Fish Population
Montana Fish, Wildlife, and Parks	1990	Inventory of Fishery Resources in the Blackfoot River and Major Tributaries	Blackfoot River, Chamberlain Creek, Cottonwood Creek, Monture Creek, Nevada Spring Creek, Nevada creek, Rock Creek, Wales Creek,		Habitat	

SECTION 5.0
SEDIMENT AND HABITAT IMPAIRMENTS

This section discusses indicators of habitat impairments and indicators and sources of sediment impairments in the Nevada Creek and Middle Blackfoot TPAs. This includes a summary of target values developed for selected sediment and habitat parameters, an analysis of the departure of stream conditions from those targets and a determination of the final water quality impairment status with regard to sediment and habitat. A sediment source assessment quantifies yearly sediment loadings by stream and estimates the anthropogenic component of each source of sediment.

The lake and reservoir impairments caused by sediment and habitat are discussed separately in **Section 7.0** that addresses nutrient impairment. Nevada Lake and Salmon Lake have been listed as impaired due to siltation. Because sediment commonly has a nutrient component, the targets developed for lakes and reservoirs integrate the influences of both pollutants and do not allow a stand-alone assessment of sediment impairment. For this reason, the sediment and nutrient impairment status for lakes and reservoirs are treated together in a separate section. The following sections describe sediment and habitat related stream impairments, targets, and target departures.

5.1 Sediment and Habitat Water Quality Goals and Indicators

The development of a TMDL requires the establishment of quantitative water quality goals referred to as targets. The sediment and habitat related TMDL targets for a waterbody must represent the applicable numeric or narrative water quality standard for each pollutant of concern. For many pollutants with established numeric water quality standards, the water quality standard is the TMDL target. Sediment, however, is a pollutant having narrative rather than numeric standards, as described in **Section 3.2**. Numeric sediment and habitat targets were developed using the primary and secondary reference approaches, also explained in **Section 3.2**.

The targets applied in this chapter are numeric values or ranges of values for parameters that describe the channel substrate composition, channel morphology, and aquatic habitat quality. These targets are intended to meet narrative water quality standards and provide full beneficial use support for water bodies impaired by excess sediment, sediment-caused habitat alterations, and flow alterations affecting sediment transport. The beneficial uses impaired by sediment and habitat conditions in the Nevada Creek and Middle Blackfoot TPAs are aquatic life, cold water fisheries, and primary contact recreation. The variety of target parameters reflects the multitude of variables that affect these uses. The parameters describe bankline vegetation conditions, channel shape, floodplain access, channel substrate condition, pool habitat quality, and aquatic insect health. Use support decisions often rely upon information on these same parameters because of their influence on stream function, aquatic biota, and aesthetic appearance.

The best target parameters have a strong, measurable link to support of aquatic life, fishery, and contact recreation uses. They are ideally developed from data describing reference water bodies where all sediment and habitat conditions are functioning at their potential given historic land uses and the application of all reasonable land, soil, and water conservation practices. The targets may often provide useful monitoring parameters for assessing restoration success. The determination of water quality impairment status is a process of comparing the numeric targets to the existing conditions measured on each stream for the same parameters. This comparison is referred to as a departure analysis.

5.1.1 Sediment and Habitat Targets and Indicators

A range of targets and indicators have been developed for comparisons with existing sediment and habitat conditions. Each target includes a rationale for its application. All targets developed in this document are subject to further interpretation and modification through time as target parameters are monitored together with water quality and other measures. This adaptive management approach to target adjustments or modifications is further described in **Section 9.1.6. Appendix F** provides detailed reference parameter development information for the target parameters listed below. As described below, targets fall into three categories based mainly on the strength of the linkage between the parameter and support for beneficial uses impaired by specific sediment sources.

1. ***Type I Targets***: Type I targets must be satisfied to ensure full support of the beneficial use. Not meeting a Type I target indicates the stream is impaired if additional indicators also point toward less than full support of beneficial uses. Type I targets include pool frequency, residual pool depth, percent fines <6mm in riffles (pebble count), percent fines <2mm in riffles (pebble count), and McNeil Core subsurface fines<6.35mm (**Table 5-1**).

2. ***Type II Targets***: Type II targets can assist with impairment determinations, similar to Type I targets. The Type II targets can substitute for Type I targets under some conditions, such as where Type I target data is lacking for a given stream segment and Type II targets provide sufficient information for making impairment determinations. Where sufficient Type I target data is available, a Type II target may be a supplemental indicator as described below. Parameters used for Type II targets include: width to depth ratio, macroinvertebrate populations, woody vegetation extent, percent surface fines <6mm in pool tailouts, McNeil Core subsurface fines <2mm, and McNeil Core subsurface fines <0.85 mm (**Table 5-1**).

3. ***Supplemental Indicators***: Supplemental indicators provide supporting information for the Type I and Type II targets, and cannot be independently used to make an impairment determination. Supplemental indicators include: woody debris aggregate extent, pool habitat extent, and entrenchment ratio (**Table 5-1**).

Upon approval of this document, the TMDL targets will become the water quality goals used to assess sediment impairment. Although supplemental indicators have a lesser role in determining impairment status, they are used here and in future assessments in cases where one or more Type I and II targets are not met and the values of supplemental indicators provide useful use support evidence. Other appropriate technical and science-based information may also be appropriate to investigate target departures or make needed target modifications.

Table 5-1. Parameters Utilized to Define Sediment/Habitat Related Targets and Supplemental Indicators

Parameter	Target Type	Impairment Linkages	How Measured
Pool Frequency (Pools/Mile)	Type I	Siltation, Habitat, Flow Alteration	Base Parameter habitat unit mapping
Residual Pool Depth	Type I	Siltation , Habitat, Flow Alteration	Base Parameter habitat unit mapping
Percent <6mm in riffles	Type I	Siltation, Habitat, Flow Alteration	Wolman Pebble Count
Substrate: Percent <2mm in riffles	Type I	Siltation, Habitat, Flow Alteration	Wolman Pebble Count
Substrate Fines <6.35 mm	Type I	Siltation, Habitat, Flow Alteration	McNeil Cores
Width:Depth Ratio	Type II	Siltation, Habitat,	Standard bankfull cross section measures
Macroinvertebrate Populations	Type II	Siltation, Habitat	Standard DEQ protocols
Woody Vegetation Extent	Type II	Siltation, Habitat, Flow Alteration,	Base Parameter green line vegetation mapping
Percent Surface Fines <6mm in Pool Tailouts	Type II	Siltation, Habitat, Flow Alteration	Median for 4 observations from Viewing Bucket
Substrate fines <2mm	Type II	Siltation, Habitat, Flow Alteration	McNeil Cores
Substrate fines <0.85 mm	Type II	Siltation, Habitat, Flow Alteration	McNeil Cores
Pool Extent	Supplemental Indicator	Habitat	Base Parameter habitat unit mapping
Entrenchment Ratio (Median of 3 measurements)	Supplemental Indicator	Siltation	Standard bankfull cross section measures
Woody Debris Aggregate Extent	Supplemental Indicator	Siltation , Habitat	Base Parameter habitat unit mapping

5.1.1.1 Target Rationale

The following section describes the rationale associated with the application of each target and supplemental indicator.

Type I Targets
Type I targets must be satisfied under most conditions to ensure full support of the beneficial use. The Type I target parameters include pool frequency, residual pool depth, percent fines <6mm in riffles (pebble count), percent fines <2mm in riffles (pebble count), and subsurface fines<6.35mm (McNeil Core).

Pool Frequency and Depth
Pools provide critical habitat for cold-water fish. The frequency and character of pools in a stream channel reflect sediment transport and storage processes. The pool frequency and residual pool depth targets address excess sediment loading associated with pool infilling or reduced natural pool formation. The parameters also serve as beneficial use support objectives for habitat listings, as a loss of pools from excess sediment results in a direct reduction in fish habitat

quantity and quality. Pool frequency and residual depth also address impairment due to flow alteration as the lack of pools exacerbates the negative impact of reduced flows and flow volume affects pool formation and depth maintenance.

Fine Sediment Concentrations

Excess fine sediment, or "Sedimentation/Siltation" on Montana's 303(d) List of impairment causes, often leads to excess subsurface fines in spawning gravels or excess surface fines in riffles. Excessive surface and substrate fines may limit fish egg and embryo survival. Excess surface fines may also reduce macroinvertebrate richness, thus limiting aquatic life and negatively affecting cold-water fish that rely on macroinvertebrates as a food source.

Increases in the percentage of <6.35 mm fraction of fine sediment in spawning gravels correlates to a decreased success in fry emergence (Weaver and Fraley, 1991). Reductions in macroinvertebrate richness has been associated with percent <2mm surface fines concentrations in excess of 20% as measured by pebble count (Relyea, et al, 2000).

Fine sediment on the channel bed surface and within the underlying substrate can be evaluated in several ways. McNeil core samples determine the fine sediment fraction in the upper several inches of substrate, usually in pool tailouts where spawning is likely to occur. For pool tailouts, McNeil coring is a consistent method for evaluating the impacts of fines on spawning success. Pebble counts are another method and typically evaluate surface fines in riffles.

Measures of substrate reflect conditions of sediment transport and its effect on channel morphology. Excessive sedimentation may be the result of excess sediment loading, or a loss in sediment transport capacity due to either altered channel morphology or reduced flows. Substrate parameters are therefore linked to siltation, sedimentation, habitat, and flow alteration impairment causes.

Type II Targets

Type II targets can assist with the impairment determination, similar to Type I targets. Type II targets include: width to depth ratio, macroinvertebrate populations, woody vegetation extent and the percentages of surface fines <6mm in pool tailouts, subsurface fines <2mm (McNeil Core), and subsurface fines <0.85 mm (McNeil Core).

Width to Depth Ratio

Bankfull width to depth ratio is an important indicator of stream condition. The parameter is one of several used to classify streams segments and thereby stratify datasets. If the width to depth ratio is out of the appropriate range for a given stream type, the channel may be degraded. Commonly, stream channels become over-widened due to human impacts associated with livestock trampling or riparian vegetation removal. In such cases, the increased width to depth ratio results in reduced sediment transport capacity, increased fine sediment deposition, and reduction in sediment sorting and channel complexity. As such, width to depth ratio links to siltation and habitat impairments.

Macroinvertebrates
Several macroinvertebrate metrics have documented relationships with the health of the aquatic life community. Macroinvertebrate assessment models in use by the Water Quality Planning Bureau (WQPB) of the Montana Department of Environmental Quality (DEQ) are the Multimetric Indices (MMI) for mountain and low valley landscapes and the River Invertebrate Prediction and Classification System (RIVPACS). Macroinvertebrate metrics provide a standard water quality target that applies to water bodies in Montana, as they are a direct indication of the beneficial use support for aquatic life.

Fine Sediment Concentrations
Fine sediment concentrations measured as percent surface fines <6mm in pool tailouts, subsurface fines <2mm (McNeil Core), and subsurface fines <0.85 mm (McNeil Core) can be used to support the Type I substrate targets. Similar to the Type I substrate targets, these Type II targets are linked to substrate, habitat, and flow alteration impairments. The percent <6mm pool tailout surface fines parameter has been applied as a Type II target due to the variable nature of pool tailout surface fines as a function of flow, season, and local hydraulic conditions. Therefore, the percent <6mm surface fines in pool tailouts is more useful for identifying sediment transport problems when reviewed in the context of data such as pool depth and frequency that describe substrate habitat conditions within the reach.

The targets for the McNeil Core data have been statistically developed from a suite of McNeil Core samples collected in the area. For the <6mm McNeil Core fraction, the internally-derived target is very similar to that identified as necessary to support salmonid fry emergence, which supports the application of the parameter as a Type I target (EPA, 1998 and Idaho DEQ, 2004). In contrast, the McNeil Core targets developed for the <0.85 and <2mm size fractions are lower than values described as necessary to fully support embryo development and egg to fry emergence survival (McBain and Trush, 2001; EPA, 1998). The McNeil Core fine sediment fractions (<2mm and <0.85 mm) in the NCPA and MBPA are naturally low. The values may well represent a higher local potential for aquatic habitat but the inherent variability of these measures warrants their interpretation together with supporting data, thus their designation as Type II targets. This application will ensure that the targets are used to maximize the natural substrate condition potential that exists in the region, without defining impairment status to the same extent as a Type I target.

Woody Vegetation Extent
Riparian vegetation is an important component for fisheries and aquatic life. A significant reduction in riparian vegetation will cause reduced instream cover and woody debris contributions. Reduced riparian vegetation can also result in reduced bank integrity, causing channel over-widening and siltation. Vegetation clearing, continuous riparian grazing, or loss of base flows will reduce woody vegetation extent. Therefore, woody vegetation extent is a Type II target parameter for sediment, habitat, and flow alteration impaired streams.

Supplemental Indicators
Supplemental indicators provide supporting information when used in combination with the Type I and Type II targets. Supplemental indicators include woody debris aggregate extent, pool habitat extent, and entrenchment ratio.

Woody Debris Aggregate Extent
Instream woody debris is an important component of stream channel complexity and habitat quality. Woody debris in a stream channel helps maintain bed stability, dissipate flow energy, create local scour pools, and sort sediment into complex habitat features. A lack of woody debris can be linked to sediment impairment from reduced local scouring of bed substrate. A lack of woody debris also is linked to habitat impairments due to reduced pool formation and lack of instream cover.

Pool Habitat Extent
Pool habitat extent can support the Type I and Type II substrate targets. However, the quantitative relationships between pool extent and beneficial use support status is not well defined, therefore it is applied as a supplemental indicator that is likely linked to sediment, habitat, and flow alteration impairments.

Entrenchment Ratio
Entrenchment ratio is a measure of floodplain connectivity and extent. The parameter is a primary component of the channel classification scheme used for this TMDL planning effort (Rosgen, 1996). In cases where entrenchment values alone result in a reclassification of a C or E channel type to an F channel, degradation due to loss of floodplain connectivity is likely. Streams may become entrenched due to downcutting and resultant severing of the active channel from its floodplain. A loss of floodplain connectivity results in reduced flow energy dissipation on the floodplain, which can cause increased channel erosion and sedimentation. Therefore, entrenchment ratio is a supplemental indicator for siltation impairments.

Lack of floodplain access may also be caused by persistent and prolonged flow diversion that reduces bankfull depth and, therefore, the value for twice bankfull depth that is used to determine flood prone channel width and entrenchment ratio. Entrenchment ratio is therefore a supplemental indicator for impairment due to flow alteration. The lack of floodplain access also reduces the volume of water stored in the floodplain aquifer, thus lowering riparian ground water elevations and restricting the extent of riparian vegetation establishment. This linkage makes entrenchment ratio a useful indicator of impairment caused by alteration in streamside vegetative covers.

5.1.1.2 Nevada Creek Planning Area Reference Values

This section contains the specific values developed as TMDL targets and supplemental indicator values for the Nevada Creek TPA. The targets stratify by major stream type (Rosgen, 1996). The data sources used to develop the targets include base parameter data (DTM and AGI, 2005), macroinvertebrate data, and McNeil Core data (**Section 5.2**). Base parameter site locations are shown in **Appendix A, Figure A-30**. Supporting information on the development of target and supplemental indicator values for the Nevada Creek TPA are in **Appendix F**. The process of collecting and stratifying base parameter data (DTM and AGI, 2005) often required dividing a listed stream segment into two or more assessment reaches symbolized by the first four letters of the stream name followed by a sequential number that increases downstream. For example "Wash1" is an assessment reach of upper Washington Creek from which base parameter data were collected. These assessment reaches are referred to in the first column of the target departure analysis tables and departure discussions that follow for both the Nevada Creek and the Middle Blackfoot River TPAs.

Table 5-2. Sediment/Habitat Targets and Supplemental Indicator Support Objectives, Nevada Creek Planning Area

Parameter	Target Type	Channel Type	Target Value	Basis
Minimum Pool Frequency (Pools/Mile)	Type I	B	20	NCPA 75th percentile; Reference stream median
		C	≥46 for streams <30ft topwidth; ≥26 for streams >30 ft topwidth)	75th percentile for streams <30 ft topwidth; Measured Nev7 value and 5-7 width multiplier for >30 ft topwidth
		E	≥40	NCPA 75th percentile
Mean Residual Pool Depth (feet)	Type I	B	≥0.6	NCPA 75th percentile
		C	≥2	NCPA 75th percentile; MBPA 75th percentile
		E	≥1.5	NCPA 75th percentile
Substrate: Percent <6mm in riffles measured by Pebble Count	Type I	B	≤20	BDNF 75th percentile
		C	≤22	BDNF median
		E	≤36	MBPA reference 75th percentile; BDNF 74th percentile (E4 streams)
Substrate: Percent <2mm in riffles measured by Pebble Count	Type I	B	≤10	NCPA reference 75th percentile
		C	≤7	NCPA 25th percentile
		E	≤20	NCPA 25th percentile
McNeil Cores Measured Percent <6.35 mm	Type I	B	≤27	25th percentile for all data collected 2003-2006
		C	≤27	25th percentile for all data collected 2003-2006
Width to Depth Ratio	Type II	B	12 to 16	Minimum: B type classification Maximum: Beaverhead/Deerlodge National Forest (BDNF) 75th percentile; NCPA 75th percentile
		C	12 to 20	Minimum: C type classification Maximum: NCPA median
		E	6 to 11	Minimum: E type classification, NCPA 25th percentile Maximum: E type classification, NCPA 75th percentile
Macroinvertebrate Populations	Type II	All	≥48	Low Valley Site Classification Multimetric Index
			≥63	Mountain Site Classification Multimetric Index
			≥0.8	RIVPACS
Woody Vegetation Extent	Type II	B	> 88 %	NCPA 75th percentile
		C	> 61%	NCPA 75th percentile
		E	> 74%	NCPA 75th percentile
Percent Surface Fines <6mm, Pool Tailouts	Type II	B	≤17	NCPA 75th percentile
		C	≤23	NCPA reference 75th percentile

Table 5-2. Sediment/Habitat Targets and Supplemental Indicator Support Objectives, Nevada Creek Planning Area

Parameter	Target Type	Channel Type	Target Value	Basis
(VB), Median of four observations		E	≤82	NCPA 25th percentile
McNeil Cores Measured Percent <2mm	Type II	B	≤12	25th percentile for all data collected 2003-2006
		C	≤15	25th percentile for all data collected 2003-2006
McNeil Cores Measured Percent <0.85 mm	Type II	B	≤6	25th percentile for all data collected 2003-2006
		C	≤6	25th percentile for all data collected 2003-2006
Pool Extent	Supp. Indicator	B	≥10	NCPA reference 75th percentile
		C	35	NCPA 75the percentile; MBPA 75th percentile
		E	29	NCPA 75th percentile
Entrenchment Ratio	Supp. Indicator	F	>2.2	Channel classification; reduce entrenchment to that of C or E channel type
Woody Debris Aggregate Extent	Supp. Indicator	B	>3 %	NCPA 75th percentile
		C	>7%	NCPA 75th percentile
		E	>12%	MBPA reference 75th percentile

5.1.1.3 Middle Blackfoot Planning Area Reference Values

This section contains the specific values developed as TMDL targets and supplemental indicator values for the Middle Blackfoot TPA. The targets stratify by major stream type (Rosgen, 1996). The data sources used to develop the targets include base parameter data (DTM and AGI, 2005), macroinvertebrate data, and McNeil Core data (**Section 5.3**). Base parameter site locations are shown in **Appendix A, Figure A-30**. Main stem Blackfoot River surface substrate targets were developed separately from those for tributaries because of assumed differences in sediment transport caused by the larger discharge. Main stem targets were developed from base parameter pebble count and view bucket data collected within main stem assessment reaches. Supporting information on the development of target and supplemental indicator values for the Middle Blackfoot TPA are in **Appendix F**.

Table 5-3. Sediment/Habitat Targets and Supplemental Indicator Support Objectives, Middle Blackfoot Planning Area

Parameter	Target Type	Channel Type	Target Value	Basis
Minimum Pool Frequency (Pools/Mile)	Type I	B	≥20	NCPA 75th percentile; Reference stream median
		C	55 for <40 ft topwidth 33 for >40 ft topwidth	MBPA 75th percentile
		E	≥40	NCPA 75th percentile; MBPA reference 75th percentile
Minimum Residual Pool Depth (feet)	Type I	B	≥0.6	NCPA 75th percentile
		C	2.0 for <40 ft topwidth 4.1 for >40 ft topwidth	NCPA 75th percentile; MBPA 75th percentile
		E	≥1.5	MBPA reference 75th percentile
Substrate: Percent <6mm in riffles measured by Pebble Count	Type I	B	≤20	BDNF 75th percentile
		C	≤22 (Tributaries)	BDNF median (C4 streams)
		C/F	≤10 (Main Stem)	Median for all main stem assessment data, 2004
		E	≤36	BDNF 75th percentile (E4 streams); MBPA reference 75th percentile
Substrate: Percent <2mm in riffles measured by Pebble Count	Type I	B	≤10	NCPA reference 75th percentile
		C	≤11 (Tributaries)	MBPA 75th percentile
		C/F	≤7 (Main Stem)	Median for all main stem assessment data, 2004
		E	≤34	MBPA reference 75th percentile
McNeil Cores Measured Percent <6.35 mm	Type I	B	≤27	25th percentile for all data collected 2003-2006
		C	≤27	25th percentile for all data collected 2003-2006
Width to Depth Ratio	Type II	B	12 to 16	Minimum: B type classification Maximum: Beaverhead/Deerlodge National Forest (BDNF) 75th percentile; NCPA 75th percentile
		C	12 to 19 Qbf width <40 ft 12 to 29 Qbf width >40 ft	Minimum: B type classification Maximum: MBPA median
		E	6 to 11	Minimum: E type classification, MBPA 25th percentile Maximum: E type classification, MBPA 75th percentile
MacroInvertebrate Populations	Type II	All	≥48	Low Valley Site Classification Multimetric Index (MMI)
			≥63	Mountain Site Classification Multimetric Index (MMI)
			≥0.8	RIVPACS
Woody Vegetation Extent	Type II	B	>88 %	NCPA 75th percentile
		C	>84%	MBPA 75th percentile
		E	>69%	MBPA 75th percentile
Percent Surface Fines <6mm, Pool Tailouts (VB), Median of four observations	Type II	B	≤17	NCPA 75th percentile
		C	≤20	MBPA 75th percentile
		C/F	≤25 (Main Stem)	Median for all main stem data collected
		E	≤48	MBPA reference 75th percentile

Table 5-3. Sediment/Habitat Targets and Supplemental Indicator Support Objectives, Middle Blackfoot Planning Area

Parameter	Target Type	Channel Type	Target Value	Basis
McNeil Cores Measured Percent <2mm	Type II	B	≤12	25th percentile for all data collected 2003-2006
		C	≤15	25th percentile for all data collected 2003-2006
McNeil Cores Measured Percent <0.85 mm	Type II	B	≤6	25th percentile for all data collected 2003-2006
		C	≤6	25th percentile for all data collected 2003-2006
Woody Debris Aggregate Extent	Supp. Indicator	B	>3 %	NCPA 75th percentile
		C	>8%	MBPA 75th percentile
		E	>12%	MBPA reference 75th percentile
Pool Extent (Percent of total channel length)	Supp. Indicator	B	≥10	NCPA reference 75th percentile
		C	≥35	NCPA 75th percentile; MBPA 75th percentile
		E	≥19	MBPA reference 75th percentile
Entrenchment Ratio	Supp. Indicator	F	>2.2	Channel classification; reduce entrenchment to that of C or E channel type

5.1.2 Departure Assessment

The departure summary for each stream describes a comparison of measured site values to targets. The departure assessment identifies whether or not a target condition is satisfied, and also highlights the magnitude of the difference between the site parameter value and the associated target. In the following sections, comparisons between site conditions and target values are presented in tabular format, with departure tables provided for each listed stream segment that has relevant data available. For each listed stream segment, individual tables are presented for each of the channel types assessed on that stream, as the target values are dependent on channel type. In several cases, multiple assessment sites are summarized within a single table. This occurs where, within a single listed stream segment, assessment data are available from multiple reaches that are of a common channel type. These compilations identify the assessment reaches by their channel type and reach name in the left most column of the table. Where there are multiple sites compiled within a single departure table, the "Site Value" listed in the table reflects the value from the assessment reach with the ***highest level of departure*** from the target. The "Target Met?" column on the table identifies whether or not the target value is achieved, and where multiple assessment sites are represented, identifies those sites that do not meet the target.

In addition to sediment/habitat related data derived from the base parameter assessment, macroinvertebrate data and McNeil Core data are included in the departure tables. Any supplemental data that can be used to help assess water quality impairment status, such as periphyton analyses or restoration monitoring data, are included as separate data summary tables.

5.1.3 Water Quality Impairment Status Assessment

The departures of current stream conditions from targets form the basis for defining the water quality impairment status of a given stream segment. This water quality impairment status is presented in the following sections in narrative form, providing a determination of any required sediment TMDLs as well as the need to address non-pollutant concerns such as flow or habitat alterations in the WQRP. The determination of water quality impairment status considers first the degree to which Type I parameters that are linked to the pollutant/pollution of concern are met. Type II parameters and supplemental indicators are then similarly evaluated with respect to site departures. Wherever relevant supplemental data exist, that information can be utilized to support the impairment status determination. Impairment is concluded when the departure assessment does not clearly describe a fully supporting stream. As a result, the impairment status determination tends to be conservative in cases where the results are ambiguous.

5.2 Water Quality Impairment Status: Nevada Creek Planning Area

The following sections contain a comparison of site conditions to targets and use support objectives for the Nevada Creek TPA. This comparison, or departure analysis, assists with the final water quality impairment determinations presented below.

5.2.1 Washington Creek

Washington Creek is a second order tributary to Nevada Creek. The stream has two segments on the 303(d) List, upper and lower Washington Creek. Upper Washington Creek extends from the headwaters to Cow Gulch, and is approximately 7 miles long. Lower Washington Creek extends from Cow Gulch to the mouth and is approximately 4 miles long.

5.2.1.1 Upper Washington Creek

The 2006 Integrated 305(b)/303(d) Water Quality Report for Montana concluded that there is not sufficient credible data to determine the aquatic life, cold water fishery, or drinking water beneficial use support status of upper Washington Creek in 2006 (**Section 2.0**). This conclusion stems from a score of zero for biological data collected on upper Washington Creek and the conclusion that a single sample for common ions and metals analysis was insufficient to determine drinking water use support. The biological score does not reflect knowledge of a benthic macroinvertebrate sample and a periphyton sample collected from site C03WASHC10 on September 28, 2003. Site C03WASHC10 is located on upper Washington Creek just upstream from the Cow Gulch confluence. Consideration of these samples in the sufficient and credible data determination would have resulted in a score of three (3) for data from two biological assemblages and an overall score of six (6) in the sufficient credible data assessment (DEQ, 2006). This score meets the sufficient credible data threshold allowing use support determinations for aquatic life and cold water fisheries (DEQ, 2006). The macroinvertebrate MMI and RIVPACS scores from upper Washington Creek are included in the departure analysis in **Table 5-4** and use support for aquatic life and cold water fisheries is assessed in the following discussion.

Because the biological data was not assessed, the 2006 Integrated 305(b)/303(d) Water Quality Report for Montana (DEQ, 2006) lists low flow alterations and physical substrate habitat alterations as causes of partial support for primary contact recreation (**Section 2.0**). The impairment sources include dredge mining and impacts from abandoned mine lands. An unsegmented Washington Creek appeared on the 1996 303(d) List as nonsupporting of aquatic life, cold-water fishery, drinking water, and contact recreation due to flow alterations, habitat alterations, and siltation (**Section 2.0**).

An aerial photo assessment of upper Washington Creek in 2004 divided the segment into two reaches (**Appendix A; Appendix B**). The upper reach, Wash1, is a high gradient, entrenched headwater stream with stable bedrock and boulder banks. Dense conifer forest bounds the stream. Wash2 is located downstream, and consists of a disturbed valley bottom that was historically placer mined. The channel is relatively straight and entrenched, and placer mine spoils commonly line the channel margin.

Washington Creek contains resident westslope cutthroat trout and resident brook trout throughout the drainage. Fisheries-related impairments identified on Washington Creek include channel alterations from past placer mining, irrigation withdrawals, lack of instream complexity, and bank damage from livestock and road crossings (Pierce, et al., 2002b). A survey of the Nevada Creek drainage (McGuire, 1995) noted bank instability and habitat alterations due to placer mining, channelization, riparian vegetation removal, and channel dewatering caused by perching of the channel above the original floodplain elevation. Mining disturbances include a straightened channel with berms approximately 8 to 10 feet high that have stabilized over time (Pierce, et al., 2002a). Some restoration of the mining impacted streams segments took place in 2001 and 2002 (Blackfoot Challenge, 2005).

Departures

Assessment data collected in Wash1 in 2004 indicate that the upper portion of Washington Creek meets Type I targets of riffle surface substrate and pool frequency (**Table 5-4**). However, McNeil Core data collected downstream in the placer-mined portion of the reach exceed the Type I substrate target threshold, and residual pool depths do not meet the target value. Three out of five Type I targets are met on upper Washington Creek.

Table 5-4. Sediment/Habitat Indicator Values and Targets, Upper Washington Creek

Channel Type/Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Wash1	**Riffle substrate: <6mm (%)**	**1**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**1**	**≤10**		√
	McNeil Cores <6.35 mm (%)	**34.3**	**≤27**		**X**
	Pool Frequency (pools/mile)	**79.2**	**≥20**		√
	Residual Pool Depth (ft)	**0.5**	**≥0.6**		**X**
	Median W:D Ratio	8.8	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	16	≤17		√
	McNeil Cores <2mm (%)	17.7	≤12		X
	McNeil Cores <0.85 mm (%)	6.9	≤6		X
	Woody Vegetation Extent (%)	96	≥88		√
	MMI (Wash2)	49.9	≥48		√
	RIVPACS O/E (Wash2)	0.78	≥0.8		X
	Pool Extent (%)	14	≥10	Supp. Indicator	√
	Woody Debris Aggregate Extent (%)	3.3	≥3		√

The Type II target comparisons in upper Washington Creek also have mixed results. Targets for width:depth ratio, pool tailout surface fines percentage, woody vegetation extent, and the MMI are all met. However, Type II McNeil Core data and RIVPACS macroinvertebrate results do not meet target values. Four out of seven Type II targets are met on upper Washington Creek. Beneficial use support objectives developed for the supplemental indicators of pool extent and woody debris aggregate extent are met on the assessed reaches of upper Washington Creek

Periphyton metric scores and associated impairment levels with regard to aquatic life and cold water fisheries are given in **Table 5-5**. The pollution and siltation indices registered some degree of impairment. The siltation index rating of moderate impairment can be interpreted as an indication of partial support for aquatic life and fisheries (DEQ, 2006).

Table 5-5. Periphyton Metric Scores for Upper Washington Creek

Metric	Metric Scores Washington Creek Site C03WASHC10	Impairment
Species Richness	55	None
Diversity Index	4.54	None
Pollution Index	2.48	Minor
Siltation Index	42.02	Moderate
Disturbance Index	3	None
% Dominant Species	17.53	None

Reference: Bahls 2004

Water Quality Impairment Status
The compiled assessment data indicate departure of five parameters from target values on upper Washington Creek, including several fractions of McNeil Core percent fines, residual pool depth, and macroinvertebrates. Of these data, the residual pool depth and macroinvertebrate RIVPACS metric are very close to target values and are probably within the margin of error for the measurement methods. However, McNeil Core data from upper Washington Creek indicate sedimentation/siltation impairment in all three particle size fractions and the high siltation index value from the periphyton analysis also suggests elevated fine sediment. To achieve full support of the aquatic life and cold water fishery beneficial uses, a sediment TMDL based on the 1996 siltation listing is required on upper Washington Creek.

The percent fines measured in the McNeil cores also support the habitat and flow alteration listing on upper Washington Creek. As these impairments reflect pollution rather than pollutants, they are addressed in the WQRP (**Section 10.0**).

5.2.1.2 Lower Washington Creek

Lower Washington Creek, from Cow Gulch to the mouth is considered partially supporting of aquatic life, the cold water fishery, and primary contact recreation (**Section 2.0**). The 2006 sediment/habitat related causes for these impairments are low flow alteration and sedimentation/siltation (**Section 2.0**). Listed sources of impairment include agriculture, highway/road runoff, impacts from abandoned mine lands, and streambank modifications/destabilization.

Lower Washington Creek consists of a single reach (Wash3), which is an F type stream channel that is slightly entrenched (**Appendix A; Appendix B**). Results of the aerial assessment (**Appendix B**) indicate that the reach has been locally straightened and cleared of riparian vegetation. Several irrigation diversions remove water from this reach. The habitat and macroinvertebrate assessment of Nevada Creek by McGuire (1995) noted poor fish habitat quality, reduced channel capacity, and siltation within the reach. The Restoration Action Plan for the Blackfoot River Watershed (Blackfoot Challenge, 2005) describes impairments to the cold-water fishery related to bank damage from livestock and channel alterations at the mouth.

Departures
Field observations indicate that Wash2 is an E channel type that has become somewhat entrenched. As such, E channel type targets apply to this stream. Type I riffle fines targets are met within the reach, but habitat unit targets of pool frequency and residual pool depth are not (**Table 5-6**). Type II targets are largely not met in Wash3. Macroinvertebrate data for lower Washington Creek indicate substantial departures from established targets. Channel morphology targets of width to depth ratio and entrenchment are currently not met on the reach, indicating degraded channel morphology. None of the supplemental indicators are met.

Table 5-6. Sediment/Habitat Indicator Values and Targets, Lower Washington Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
F (E) Wash3	**Riffle substrate: <6mm (%)**	**21**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**10**	**≤20**		√
	Pool Frequency (pools/mile)	**26.4**	**≥40**		**X**
	Residual Pool Depth (ft)	**0.8**	**≥1.5**		**X**
	Median W:D Ratio	12.2	6-11	Type II	X
	Median pool tailout surface fines <6mm (%)	32	≤82		√
	Woody Vegetation Extent (%)	63	≥74		X
	MMI	14.6	≥48		X
	RIVPACS O/E	0.51	≥0.8		X
	Entrenchment Ratio	1.9	>2.2	Supp. Indicator	X
	Pool Extent (%)	18	≥29		X
	Woody Debris Aggregate Extent (%)	3.8	≥12		X

Water Quality Impairment Status
The substrate indicators on lower Washington Creek do not support the sedimentation impairment listing, as E channel types in the region are typically fine grained in nature. However, Type I habitat unit targets of pool frequency and residual pool depth show substantial departure from target values, suggesting a sediment-related impairment (**Table 5-6**). Furthermore, macroinvertebrate data show significant aquatic life use impairment. On lower Washington Creek, the Low Valley MMI metric score of 14.6 reflects a severe impairment condition. This score includes a high value for Percent Crustacea and Mollusca (Value 53.4, Score 0.0), which reflects an abundance of primarily collectors, scrapers, and filterers which are more tolerant of fine sediment than other taxa groups (Feldman, 2006). Thus the Type II macroinvertebrate indicators provide some support of the sedimentation listing, and the measured stream channel habitat indicators support both the sedimentation and flow alteration listings. As such, a sediment TMDL is appropriate for lower Washington Creek. Flow alteration is addressed as pollution in the WQRP.

5.2.2 Jefferson Creek

Jefferson Creek is a second order tributary to Nevada Creek. The stream has been listed as two segments. Upper Jefferson Creek is approximately 5.5 miles long and extends from the headwaters to 1 mile above the mouth of Madison Gulch. Lower Jefferson Creek is approximately 2 miles long, extending from 1 mile above Madison Gulch to its confluence with Nevada Creek.

5.2.2.1 Upper Jefferson Creek

Upper Jefferson Creek extends from its headwaters to 1 mile above Madison Gulch. The stream segment is considered partially supporting of aquatic life and the cold water fishery. Other uses are fully supported (**Section 2.0**). The 2006 sediment/habitat related causes for this stream segment are alterations in streamside vegetative cover and sedimentation/siltation (**Section 2.0**). Listed sources of impairment include channelization, placer mining, range land grazing, and streambank modification/destabilization.

Upper Jefferson Creek consists of a single reach, referred to as Jeff1 (**Appendix A; Appendix B**). Results of the aerial assessment (**Appendix B**) indicate that this reach is characterized by extensive placer mining disturbance along a narrow valley bottom. Riparian degradation along the channel margin is evident throughout the reach, and dredge spoils entrench the relatively straight channel. Linear woody vegetation trends on the spoils indicate some vegetative colonization of the mining debris. McGuire (1995) noted channel alterations due to mining, dewatered reaches in perched channels, major erosion, and channel stability problems. High levels of fine sediment in substrate cores were also noted. Pierce, et al (2002a) noted 8-10 ft high berms on both sides of the straightened and entrenched channel. Due to the poor condition of the riparian vegetation in this reach, woody debris recruitment is absent, and channel complexity and associated fish habitat are poor (Pierce, et al., 2002a). Fisheries-related impairments identified by Pierce, et al (2002b) include poor road crossings (a crushed, undersized culvert), channel alterations (mining disturbance), lack of instream complexity, and low instream flows. Fish populations sampled by Pierce, et al (2002a) indicate a westslope cutthroat dominated stream.

Departures

The Type I riffle substrate targets, McNeil Core substrate <6.35mm, pool frequency, and residual pool depth are all unmet on upper Jefferson Creek (**Table 5-7**). Type II targets regarding McNeil Core substrate values and woody vegetation extent are also not met. The Type II macroinvertebrate indicators show a moderate level of impairment for the site classified as mountains, whereas the low valley site shows a severe impairment for the Predictive Model Results (0.29) and an unimpaired condition for the Low Valley MMI (51.6). Based on guidance provided by Feldman (2006), the impairment indicators from the mountain site and low valley RIVPACS results render the site impaired.

Table 5-7. Sediment/Habitat Indicator Values and Targets, Upper Jefferson Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Jeff1	**Riffle substrate: <6mm (%)**	**13**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**11**	**≤10**		**X**
	McNeil Cores <6.35 mm (%)	**46.7**	**≤27**		**X**
	Pool Frequency (pools/mile)	**13.2**	**≥20**		**X**
	Residual Pool Depth (ft)	**0.3**	**≥0.6**		**X**
	Median W:D Ratio	12.8	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	10	≤17		√
	McNeil Cores <2mm (%)	31.7	≤12		X
	McNeil Cores <0.85 mm (%)	16.2	≤6		X
	Woody Vegetation Extent (%)	35.6	≥88		X
	MMI (valley)	51.6	≥48		√
	MMI (mtn)	53.8	≥63		X
	RIVPACS O/E (valley)	0.29	≥0.8		X
	RIVPACS O/E (mtn)	0.57	≥0.8		X
	Pool Extent (%)	1	≥10	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	2	≥3		X

Water Quality Impairment Status

The departures of the Type I habitat and substrate targets indicates that the siltation/sedimentation listing for upper Jefferson Creek is warranted (**Table 5-7**). Similarly, when the targets are applied to the habitat impairment as beneficial use support objectives, departures indicate that upper Jefferson Creek is impaired with regard to habitat as well. As such, a sediment TMDL is required for upper Jefferson Creek, and recommendations for achieving habitat that will provide full beneficial use support are included in the WQRP.

5.2.2.2 Lower Jefferson Creek

Lower Jefferson Creek extends from 1 mile above Madison Gulch to the mouth. This stream segment is considered partially supporting of the cold water fishery, aquatic life, and contact recreation uses (**Section 2.0**). The 2006 sediment/habitat and contact recreation related 303(d) Listings for lower Jefferson Creek are alterations in streamside vegetative cover, low flow alterations, sedimentation/siltation, and suspended/bedload solids (**Section 2.0**). Listed sources included channelization, dredge mining, riparian grazing, stream bank modifications/destabilization, and irrigated crop production.

Lower Jefferson Creek consists of a single reach. Jeff2 is an entrenched, F4 channel that flows through irrigated hayfields and pasture. Measured width to depth ratios indicate that E channel targets are appropriate for the reach. Results of the aerial assessment (**Appendix B**) indicate a reduction in channel definition in the downstream direction through the reach due to dewatering. McGuire (1995) noted eroding stream banks, channelization, and heavy grazing impacts within the reach. High accumulations of fine sediment in low velocity areas have also been identified (Pierce, et al, 2002a).

Jefferson Creek has been identified as a low priority fisheries restoration stream in the Nevada Creek TPA, although some grazing management and off-stream watering work has been performed immediately above the highway in an effort to increase streamflows (Blackfoot Challenge, 2005).

Departures

The data summarized in Tabl indicate that lower Jefferson Creek does not meet Type I targets of pool frequency and residual pool depth. However, the Type I riffle substrate targets are met by existing conditions. The Type II macroinvertebrate targets indicate severe and moderate impairments for the MMI and RIVPACS assessment models, respectively. None of the supplemental indicator beneficial use support objectives are met in Jeff2.

Table 5-8. Sediment/Habitat Indicator Values and Targets, Lower Jefferson Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
F (E) Jeff2	**Riffle substrate: <6mm (%)**	**0**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**0**	**≤20**		√
	Pool Frequency (pools/mile)	**13.2**	**≥40**		**X**
	Residual Pool Depth (ft)	**0.8**	**≥1.5**		**X**
	Median W:D Ratio	6.5	6-11	Type II	√
	Median pool tailout surface fines <6mm (%)	14	≤82		√
	Woody Vegetation Extent (%)	47	≥74		X
	MMI	32.6	≥48		X
	RIVPACS O/E	0.51	≥0.8		X
	Entrenchment Ratio	1.1	>2.2	Supp. Indicator	**X**
	Pool Extent (%)	3	≥29		X
	Woody Debris Aggregate Extent (%)	1	≥12		X

Water Quality Impairment Status

The substrate indicators on lower Jefferson Creek do not support the sedimentation impairment listing as riffle substrate within the reach was notably devoid of fine sediment during the 2004 base parameter assessment effort (DTM and AGI, 2005). However, other parameters that are linked to sediment loading conditions, including pool frequency, residual pool depth, and entrenchment ratio all support the sediment related impairment listings on lower Jefferson Creek. In addition, the severe impairment status rendered by the MMI macroinvertebrate metrics indicates an overall impairment to aquatic life in the reach. Based on sedimentation-related habitat and channel morphology parameters, a sediment TMDL is required for lower Jefferson Creek.

Measured departures of pool frequency and residual pool depth from the beneficial use support objectives support the habitat alteration and flow alteration listings on lower Jefferson Creek. The WQRP (**Section 10.0**) addresses these impairments.

5.2.3 Gallagher Creek

Gallagher Creek is a second order tributary to upper Nevada Creek. The stream is approximately 7 miles long, but the 303(d) Listed segment of Gallagher Creek extends for 3.1 miles from the BLM property line to its confluence with Nevada Creek. This stream segment is considered partially supporting of the cold-water fishery, aquatic life, and contact recreation uses (**Section 2.0**). The 2006 sediment and habitat related 303(d) Listings for Gallagher Creek are alterations in streamside vegetation, low flow alterations, and sediment/siltation. Low flow alterations are also listed as one of the causes for the lack of full support of contact recreation. Sources of impairment include agriculture and range land grazing (**Section 2.0**).

Gallagher Creek consists of two reaches (**Appendix A, Appendix B**). The upstream reach is a confined, cobble dominated, moderately entrenched B channel that flows through a dense conifer forest. The upper reach is stable with large amounts of woody debris and low sediment levels (Pierce, et al, 2002a). Downstream, the creek emerges from the confined headwaters onto an open terrace/alluvial fan complex. The lowermost 2 ½ miles of Gallagher Creek consists of a C/E channel type that flows through an actively grazed and cultivated valley bottom. The channel has a grassy floodplain with a narrow fringe of moderately dense riparian shrubs along the stream banks. Within this lower reach, there is a downstream reduction in woody vegetation density and channel definition. Streamside vegetation alteration and flow alterations are evident on the aerial photography (**Appendix B**). Gallagher Creek supports only resident westslope cutthroat trout. Fisheries-related impairments identified on the lower reaches include localized livestock-induced stream bank damage and an undersized culvert (Pierce, et al, 2002b).

Departures
The data summarized in **Table 5-9** indicate that Gallagher Creek does not meet pool frequency, residual pool depth, and riffle substrate fraction <2mm Type I targets. The Type II macroinvertebrate targets indicate severe and moderate impairments for the MMI and RIVPACS assessment models, respectively. None of the supplemental indicator beneficial use support objectives are met in reach Gall2.

Table 5-9. Sediment/Habitat Indicator Values and Targets, Gallagher Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E Gall2	**Riffle substrate: <6mm (%)**	**22**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**22**	**≤20**		**X**
	Pool Frequency (pools/mile)	**0**	**≥40**		**X**
	Residual Pool Depth (ft)	**0**	**≥1.5**		**X**
	Median W:D Ratio	4.9	6-11	Type II	√
	Woody Vegetation Extent (%)	44	≥74		X
	MMI	31.2	≥48		X
	RIVPACS O/E	0.58	≥0.8		X
	Pool Extent (%)	0	≥29	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	0.3	≥12		X

Water Quality Impairment Status
A compilation of data from lower Gallagher Creek indicates that the stream condition currently does not meet targets or beneficial use support objectives for parameters related to sediment and habitat. Type I targets not met include percent riffle surface fines less than 2mm and less than 6mm, pool frequency, and residual pool depth. No pools were mapped within the reach. Of the two macroinvertebrate assessment model results presented in **Table 5-9**, the MMI score depicts a severe impairment, and the RIVPACS results reflect a moderate impairment (Feldman, 2006). The mapped extent of woody vegetation within the reach is approximately 41% below the Type II target value. None of the supplemental indicators meet beneficial use support objectives. The combined departures of targets and supplemental indicators on Gallagher Creek support the current 303(d) Listings related to sediment, habitat, and low flow alterations. As such, a sediment TMDL is necessary. Recommendations for achieving flow and habitat conditions that provide for full beneficial use support are provided in the WQRP (**Section 10.0**).

5.2.4 Buffalo Gulch

Buffalo Gulch is a second order tributary to Nevada Reservoir. The 303(d) Listed segment of Buffalo Gulch extends from its headwaters to its mouth. This stream segment is considered partially supporting of the cold water fishery and aquatic life (**Section 2.0**). The 2006 sediment/habitat related 303(d) Listings for Buffalo Gulch are physical substrate habitat alterations and sedimentation/siltation. Sources of impairment include forest road construction and use, livestock grazing or feeding operations, and silviculture activities (**Section 2.0**).

Buffalo Gulch consists of three reaches (**Appendix A; Appendix B**). The uppermost reach, Buff1, is a B channel type bounded by dense conifer forest. Aerial assessment results indicate that timber harvest of the uplands has been extensive, and that logging roads encroach on the Buffalo Gulch valley bottom. Downstream, Buff2 marks an abrupt reduction in vegetative cover relative to upstream. This reach break also marks a geologic boundary between Proterozoic sediments upstream and Tertiary-age volcanic rocks in Buff2. Historic placer mining left tailings intermittently along the channel margin. Extensive bank trampling in portions of the reach caused a shift from a relatively narrow and deep E channel to a wide, shallow C channel (Pierce, et al, 2002a). Montana FWP described fish habitat in this reach as poor (Pierce, et al, 2002a).

Buff3 consists of the lowermost portion of Buffalo Gulch as it approaches the upper end of Nevada Creek Reservoir. Within this approximately 1 mile long reach, the creek flows through a willow-dominated valley bottom that is grazed and cultivated for hay. Lower Buffalo Gulch supports moderate densities of resident westslope cutthroat trout and low densities of rainbow trout (Blackfoot Challenge, 2005). Montana FWP described this reach as a meandering, gravel dominated channel with low sediment levels bounded by a dense riparian shrub community (Pierce, et al, 2002a).

Fisheries-related impairments identified in the lower 3 miles of Buffalo Gulch (Buff2 and Buff3) include livestock-induced stream bank damage, riparian vegetation suppression, and lack of instream wood/complex fish habitat (Pierce, et al, 2002b).

Departures
All of the Type I substrate targets are met within Buff2. However, the Type II parameter of pool tailout surface fines shows a high level of departure from the target value (**Table 5-10**). Pool frequency (Type I target) is notably low in the reach. McNeil Core data are near target values but show elevated levels of the less than 2mm fraction. Supplemental indicators of pool extent and woody vegetation extent are not met. Macroinvertebrate data are available for both Buff2 and Buff3; the samples show moderate levels of impairment for both MMI and RIVPACS results in Buff2. Downstream, in reach Buff3, the macroinvertebrate data show an unimpaired condition for the MMI results and moderately impaired condition for the RIVPACS method.

Table 5-10. Sediment/Habitat Indicator Values and Targets, Buffalo Gulch

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Buff2	**Riffle substrate: <6mm (%)**	**10**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**6**	**≤10**		√
	McNeil Cores <6.35 mm (%)	**26.2**	**≤27**		√
	Pool Frequency (pools/mile)	**6.6**	**≥20**		**X**
	Residual Pool Depth (ft)	**0.7**	**≥0.6**		√
	Median W:D Ratio	7.8	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	100	≤17		**X**
	McNeil Cores <2mm (%)	14.7	≤12		**X**
	McNeil Cores <0.85 mm (%)	9.7	≤6		**X**
	Woody Vegetation Extent (%)	49	≥88		**X**
	MMI	46.4	≥48		**X**
	RIVPACS O/E	0.65	≥0.8		**X**
	MMI (Buff3)	52	≥48		√
	RIVPACS O/E (Buff3)	0.58	≥0.8		**X**
	Pool Extent (%)	1	≥10	Supp. Indicator	**X**
	Woody Debris Aggregate Extent (%)	4.4	≥3		√

Water Quality Impairment Status
Type I substrate measurements do not support a sedimentation listing on Buffalo Gulch. However, the measured departures from Type 1 pool frequency and Type II macroinvertebrate and substrate targets on Buffalo Gulch suggest that the reach has a sediment-related impairment. Therefore, a sediment TMDL is proposed for Buffalo Gulch to promote the achievement of full beneficial use support of the cold water fishery and aquatic life. Similarly, when the targets are applied as beneficial use support objectives, habitat degradation is evident in parameters related to pool frequency and woody vegetation extent. Recommendations for treating pollution related to habitat degradation on Buffalo Gulch are provided in the WQRP (**Section 10.0**).

5.2.5 Braziel Creek

Braziel Creek is a second order tributary to Nevada Creek, and its confluence with Nevada Creek is located just downstream of Nevada Lake. The 303(d) Listed segment of Braziel Creek is 2.8 miles lon, extending upstream from its mouth. This stream segment is considered partially supporting of the cold water fishery and aquatic life (**Section 2.0**). The 2006 sediment/habitat related 303(d) Listings for Braziel Creek are alterations in streamside vegetative cover and sedimentation/siltation (**Section 2.0**). Sources of impairment include rangeland grazing, silviculture, and highway/road/bridge runoff.

Braziel Creek consists of three reaches (**Appendix A; Appendix B**). Aerial assessment results (**Appendix B**) indicate that the uppermost reach (Braz1) is a B channel that flows through densely forested headwaters. Within Braz2, logging access roads border the valley bottom and riparian clearing is evident from the aerial assessment. The channel has several road crossings in this reach. Braz3 is the lower-most reach on the listed stream, and reflects the emergence of Braziel Creek onto an alluvial fan. Within this reach, sparse and altered woody riparian vegetation, channelization, and reduction in channel form are all evident from the aerial assessment.

Departures

A comparison of existing conditions with Level I targets indicates that at Braz2 percent surface fines targets are currently met (**Table 5-11**). However, Type I targets of pool frequency and residual pool depth are not met under current conditions. Residual pool depths are notably low in the reach, indicating excess sedimentation. Macroinvertebrate metrics indicate a moderate level of impairment with respect to aquatic life.

Table 5-11. Sediment/Habitat Indicator Values and Targets, Braziel Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Braz2	**Riffle substrate: <6mm (%)**	**11**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**10**	**≤10**		√
	Pool Frequency (pools/mile)	**19.8**	**≥20**		**X**
	Residual Pool Depth (ft)	**0.2**	**≥0.6**		**X**
	Median W:D Ratio	10.8	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	7	≤17		√
	Woody Vegetation Extent (%)	82.5	≥88		X
	MMI	41.2	≥48		X
	RIVPACS O/E	0.57	≥0.8		X
	Pool Extent (%)	2	≥10	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	0.6	≥3		X

Water Quality Impairment Status

The residual pool depth data for Braziel Creek indicate potential impairments with respect to both habitat and sediment. Additionally, 2003 reassessment data collected from Braz3 indicate that beneficial use support objectives are not met due in part to excess sedimentation (**Section 2.4**). A sediment TMDL is required for Braziel Creek to achieve full support of the cold water fishery and aquatic life beneficial uses. Recommendations for addressing pollution associated with habitat degradation are provided in the WQRP (**Section 10.0**).

5.2.6 Nevada Creek

Nevada Creek is a large tributary to the Blackfoot River. The stream has been divided into two listed segments, referred to as Upper Nevada Creek and Lower Nevada Creek. Upper Nevada Creek consists of 19 miles of channel located immediately upstream of Nevada Reservoir, and Lower Nevada Creek extends from the reservoir to the Blackfoot River.

5.2.6.1 Upper Nevada Creek

Upper Nevada Creek is a third order stream that extends from its headwaters approximately 19 miles to Nevada Reservoir. This stream segment is considered partially supporting of the cold water fishery, aquatic life, and contact recreation uses (**Section 2.0**). Sediment/habitat related 303(d) Listings for upper Nevada Creek are alterations in streamside vegetative cover, physical substrate habitat alterations, and suspended/bedload solids (**Section 2.0**). Sources include agriculture, riparian grazing, and placer mining.

Upper Nevada Creek consists of six reaches (**Appendix A; Appendix B**). Nev1 is a B channel that encompasses approximately 4 miles of the stream in its headwaters area. Within this reach McGuire (1995) notes minimal bank erosion and good overhanging cover. The reach is highly confined and densely forested. Downstream, in reach Nev2, the valley bottom widens, and hillslope timber harvesting is evident from the aerial assessment (**Appendix B**). McGuire (1995) includes descriptions of historic placer mining and subsequent channel recovery, as well as some bank instability and increased grazing intensities relative to upstream conditions. Access roads encroach on the channel margin, and the valley bottom is used for cultivating hay as well as for pasture. The valley bottom widens out at the upper end of reach Nev3, which was described in 1993 as having 85% grass and forb utilization, active bank erosion, and high width to depth ratios (McGuire, 1995). Results of the aerial assessment indicate road encroachment within Nev3. Nev4 is a sparsely vegetated C channel segment and was described in 1993 as having active bank erosion and livestock holding corrals in the stream corridor (McGuire, 1995). Nev5 extends downstream to the Washington Creek confluence similarly shows evidence of streamside vegetation alteration. Segments of Nev5 have been channelized against the valley margin (**Appendix B**). Within this reach, McGuire, (1995) notes heavy grazing, raw, eroding banks, and excess sedimentation. From the Washington Creek confluence to Nevada Reservoir, Nev6 was described in 1993 as having widespread bank erosion and heavy sedimentation. Results of the recent aerial assessment indicate streamside vegetation alteration and some channelization within the reach.

Fish population sampling on upper Nevada Creek indicate a reduction in bull trout, mountain whitefish, and WSCT since 1957 (Pierce, et al, 2002a). Non-native rainbow trout and brook trout now dominate the lower reaches of upper Nevada Creek. Fisheries-related impairments identified on upper Nevada Creek include irrigation impacts (low flow), channel alterations/instability, lack of instream complexity, and degraded stream banks resulting from excessive livestock access to riparian areas (Pierce, et al, 2002b). Restoration work slated for implementation in 2005 on upper Nevada Creek includes local stream channel reconstruction, grazing management, and riparian plantings (Blackfoot Challenge, 2005).

Departures

Compiled assessment data for reach Nev2 indicate that this B type channel segment meets targets for all parameters with the exception of the supplemental indicator of pool extent (**Table 5-12**). In contrast, the C channel types show a higher level of departure of existing sediment/habitat related conditions relative to target conditions (**Table 5-13**). Although amounts of the 6mm size fraction meet substrate targets, Type I parameters of percent <2mm surface fines in riffles, pool frequency, and residual pool depth do not meet target values for any of the assessed reaches. Regarding Type II targets, the C channel reaches of upper Nevada Creek appear over-widened, have excess pool tail sediment and have little woody bankline vegetation.

Table 5-12. Sediment/Habitat Indicator Values and Targets, Upper Nevada Creek B Channel Types

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Nev2b	**Riffle substrate: <6mm (%)**	**2**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**1**	**≤10**		√
	Pool Frequency (pools/mile)	**20**	**≥20**		√
	Residual Pool Depth (ft)	**0.7**	**≥0.6**		√
	Median W:D Ratio	16	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	4	≤17		√
	Woody Vegetation Extent (%)	89	≥88		√
	Pool Extent (%)	7	≥10	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	3.1	≥3		√

Table 5-13. Sediment/Habitat Indicator Values and Targets, Upper Nevada Creek C Channel Types

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
C 1)Nev3 2)Nev5b 3)Nev5c(f) 4)Nev6 5)Nev6b	**Riffle substrate: <6mm (%)**	**15**	**≤22**	**Type I**	√
	Riffle substrate: <2mm (%)	**15**	**≤7**		**X** $_{(3,4)}$
	McNeil Cores <6.35 mm (%)	**27**	**≤27**		√
	Pool Frequency (pools/mile)	**7**	**≥46**		**X** $_{(3,4)}$
	Residual Pool Depth (ft)	**1.2**	**≥2**		**X** $_{(1,2,3,4,5)}$
	Median W:D Ratio	22	12-20	Type II	X $_{(1)}$
	Median pool tailout surface fines <6mm (%)	47	≤23		X $_{(2,3)}$
	McNeil Cores <2mm (%)	14.4	≤15		√
	McNeil Cores <0.85 mm (%)	6	≤6		√
	Woody Vegetation Extent (%)	0	≥61		X $_{(2,3,4,5,)}$
	Entrenchment Ratio	1.4	>2.2	Supp. Indicator	X $_{(3)}$
	Pool Extent (%)	1	≥35		X $_{(1,2,3,4)}$
	Woody Debris Aggregate Extent (%)	0	≥7		X $_{(2,3,4,5)}$

From site with highest departure from target

Water Quality Impairment Status

The failure of Upper Nevada Creek C channel types to meet percent surface fines targets for riffle substrate <2mm and pool tailouts <6mm supports the suspended solids listing for the segment. This is also supported by Type I pool frequency and residual pool depth departures. The pool frequency value of 7 pools per mile in Nevada 6 is notably low, and residual pool depth targets are not met in any of the C channel types. A sediment TMDL is therefore proposed for upper Nevada Creek. The habitat parameter departures from beneficial use support objectives indicate that the habitat alteration listing for C type channels of upper Nevada Creek is warranted, and recommendations for addressing this pollution are provided in the WQRP (**Section 10.0**). Channel morphology and woody debris supplemental indicators also weigh the evidence in favor of sediment and habitat impairments. Therefore, a sediment TMDL is required for upper Nevada Creek.

5.2.6.2 Lower Nevada Creek

Lower Nevada Creek, which extends from Nevada Reservoir to its mouth, is a large third order tributary to the mainstem Blackfoot River. The stream segment is considered nonsupporting of aquatic life, cold water fishery, and contact recreation due to sediment and habitat related impairment causes (**Section 2.0**). The sediment/habitat related 303(d) Listings for lower Nevada Creek are low flow alterations, physical substrate habitat alterations, and sedimentation/siltation (**Section 2.0**). Sources of impairment include agriculture and bank modification/destabilization.

Lower Nevada Creek consists of eight stream reaches (**Appendix A; Appendix B**). Nev7 is a C type channel that extends from the reservoir outlet approximately 3.3 miles downstream. Aerial assessment results indicate that Nev7 has highly irregular banklines and local channelized segments. The habitat assessment of McGuire (1995) noted heavy sedimentation, bank instability, little instream cover, and poor fisheries habitat in this reach. The lower end of Nev7 is marked by the Douglas Creek Canal diversion. Below this diversion structure, Nev8 is an entrenched F type channel segment that has also been locally channelized. Nev9 flows through a widening valley bottom as an E channel type; the assessment of McGuire (1995) noted good stability and dense woody riparian vegetation within this reach. Nev10 is a sinuous E type channel with locally active secondary channels in a dense willow corridor. Portions of the reach have been channelized. Nev11 flows through a sparsely vegetated willow corridor, and damage to streamside vegetation is evident throughout the reach. This reach has been described as having a shallow, wide channel, lack of woody vegetation, bank trampling, active erosion, and heavy sedimentation. Nev12 flows through a moderately dense willow corridor, in which locations of ice scour, meander cutoffs, minor instability, and beaver activity causing flooding and inaccessibility to meadows by livestock have been noted. Nev13 extends to the Nevada Spring Creek confluence. This stream segment consists of a very sinuous C type channel that flows through a very narrow riparian corridor, which has been described as having poor bank stability, raw banks, and hoof shear (McGuire, 1995). From Nevada Spring Creek to the Blackfoot River, Nev14 is a very sinuous C channel that forms recumbent bends of high meander amplitude. Aerial assessment results indicate little evidence of active channel migration or recent bendway cutoffs within the reach (**Appendix B**).

Low densities of rainbow trout and brown trout are present below Nevada Reservoir, but are absent from the remainder of lower Nevada Creek (Pierce, et al, 2002b). Fisheries-related impairments identified on lower Nevada Creek include irrigation impacts (entrainment and dewatering), channel alterations, lack of instream complexity, degraded riparian vegetation due to excessive livestock access, and low water quality (Pierce, et al, 2002b). Fish population surveys conducted within the Douglas Creek Canal in 1998 and 1999 found nine species of fish including WSCT, brown trout, mountain whitefish, and rainbow trout (Pierce, et al, 2001). Low levels of whirling disease were detected in lower Nevada Creek in 2003 (Blackfoot Challenge, 2005). Lower Nevada Creek has been described has having historically likely been a beaver/willow complex that has been converted to hay/grazing meadows through control of beaver (Pierce, et al, 2001). Restoration projects on lower Nevada Creek have included grazing management and installation of fish ladders on irrigation diversions (Blackfoot Challenge, 2005).

Departures

A compilation of Base Parameter data for lower Nevada Creek indicates that none of the Type 1 targets are met on E channel types, and only the residual pool depth target is met on the C type channels (**Table 5-14 and Table 5-15**). Type II targets and supplemental indicators are largely unmet as well. Additional 2004 periphyton data for lower Nevada Creek (**Table 5-16**) indicate minor impairment conditions measured by the siltation index (Weber, 2005).

Table 5-14. Sediment/Habitat Indicator Values and Targets, Lower Nevada Creek E Channel Types

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
E 1)Nev9 2)Nev12 3)Nev12b	**Riffle substrate: <6mm (%)**	**100**	**≤36**	**Type I**	**X** (2,3)
	Riffle substrate: <2mm (%)	**100**	**≤20**		**X** (2,3)
	Pool Frequency (pools/mile)	**0**	**≥40**		**X** (1,2,3)
	Residual Pool Depth (ft)	**1.4**	**≥1.5**		**X** (3)
	Median W:D Ratio	14	6-11	Type II	X (1)
	Median pool tailout surface fines <6mm (%)	100	≤82		X (3)
	Woody Vegetation Extent (%)	57	≥74		X (2)
	Pool Extent (%)	0	≥29	Supp. Indicator	X (1,2,3)
	Woody Debris Aggregate Extent (%)	0	≥12		X (1,2,3)

From site with highest departure from target

Table 5-15. Sediment/Habitat Indicator Values and Targets, Lower Nevada Creek C Channel Types

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
C 1)Nev7 2)Nev8(f) 3)Nev13 4)Nev14	**Riffle substrate: <6mm (%)**	**100**	**≤22**	**Type I**	**X** (3,4)
	Riffle substrate: <2mm (%)	**100**	**≤7**		**X** (3,4)
	Pool Frequency (pools/mile)	**0**	**≥46 (Nev8) ≥26 (Nev 7, 13, 14)**		**X** (2,3,4)
	Residual Pool Depth (ft)	**2**	**≥2**		√
	Median W:D Ratio	29	12-20	Type II	X (1,2,4)
	Median pool tailout surface fines <6mm (%)	46	≤23		X (1,2)
	Woody Vegetation Extent (%)	0	≥61		X (1,3)
	Entrenchment Ratio	1.2	>2.2	Supp. Indicator	X (3,4)
	Pool Extent (%)	0	≥35		X (1,3,4)
	Woody Debris Aggregate Extent (%)	0	≥7		X (1.3)

From site with highest departure from target

Table 5-16. Periphyton Metrics for Lower Nevada Creek

Metric	Score		Impairment
	B-5 Nevada Cr below Reservoir	B-6 Nevada Cr at mouth	
Species Richness	46	59	None
Diversity Index	4.20	4.46	None
Pollution Index	2.52	2.52	None
Siltation Index	29.63	26.26	Minor
Disturbance Index	0.64	10.37	None
% Dominant Species	15.94	25.77	None (B-5); Minor(B-6)

Reference: Weber, 2005

Water Quality Impairment Status

The consistent departure of Type I parameters from target values supports the sedimentation/siltation listing for lower Nevada Creek, and a sediment TMDL is therefore necessary. When applied as beneficial use support objectives to habitat-related pollution, departures also indicate that the habitat listing is warranted, and recommendations to address this non-pollutant are provided in the WQRP (**Section 10.0**).

5.2.7 Nevada Spring Creek

Nevada Spring Creek is a spring-fed stream that flows just over 3 miles to its junction with Nevada Creek. The listed portion of Nevada Spring Creek extends its full length from its headwaters to its mouth. Nevada Spring Creek is nonsupporting of aquatic life, the cold-water fishery and contact recreation (**Section 2.0**). Sediment/habitat related 303(d) Listings are alterations in streamside vegetative cover and sedimentation/siltation (**Section 2.0**). Sources included grazing in riparian zones, impacts from hydrostructures, and flow regulation/modification.

Nevada Spring Creek is comprised of two reaches. The upstream reach, Nev1, is a sinuous channel that was markedly overwidened on 1995 aerial photography (**Appendix A; Appendix B**). Variable channel widths and sediment storage patterns that indicate excessive supply suggest bank instability and channel widening in 1995. Nev2 consists of the lowermost 0.7 miles of channel; this reach displays less widening and apparent instability relative to upstream in the 1995 aerial photography. The reach supports sparse woody riparian vegetation stands. The habitat assessment of lower Nevada Creek by McGuire (1995) found Nevada Spring Creek to be overwidened with extensive bank trampling and a narrow riparian buffer.

Fish population surveys conducted in 2000 and 2001 indicate that Nevada Spring Creek is dominated by brown trout, although low densities of westslope were also identified as present (Pierce, et al, 2001). Fisheries-related impairments identified by Pierce, et al (2002b) include irrigation impacts (dewatering and fish passage), channel alterations, lack of instream complexity, and damaged riparian vegetation.

The Blackfoot Challenge (2005) reports 21 completed projects on Nevada Spring Creek since 1990. Extensive channel restoration has occurred since 2001. These projects include improvements to fish passage, irrigation efficiency, fish habitat, riparian vegetation, instream flows, and wetlands enhancement in addition to channel reconstruction. FWP reconstructed the entire channel between 2001 and 2003 and reduced the width to depth ratio of the channel from 22 to 3.2 (Pierce et al., 2004). Restoration efforts on Nevada Spring Creek have resulted in an increase in brown trout densities by a factor of four, and evidence of use by young of year WSCT within a year of project completion.

The base parameter assessment of July 2004 did not include sites on Nevada Spring Creek because data from ongoing restoration monitoring by FWP was thought sufficient to assess use support. Pierce and others (2004) reported pre- and post-project restoration conditions on Nevada Spring Creek from 1.6 miles below the source to its mouth. Two of the monitored parameters correspond to Type I and Type II targets developed for E channel types in the Nevada Creek TPA. These two target comparisons are made in **Table 5-18**. The targets for pool frequency and width:depth ratio are met by post restoration conditions measured in Nevada Spring Creek.

Table 5-17. Sediment/Habitat Indicator Values and Targets for E-Channel Types Measured In Nevada Spring Creek after Channel Restoration

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
E Nev Spr1 Nev Spr2	**Pool Frequency (pools/mile)**	93.5	≥40	Type I	√
	Riffle substrate: <6mm (%)	Upper Site: 31 Lower Site: 67	≤36	Type I	√ X
	Median W:D Ratio	3.2	6-11	Type II	√
	Woody Vegetation Extent (%)	0.1	≥74	Type II	X

Pierce and others (2004) reported a post-restoration mean pool depth of 3.7 feet. This value compares favorably with the residual depth of 1.5 feet, but gives no indication of low flow pool depth conditions.

Post-restoration McNeil core samples were collected on September 29, 2004, from a site within the upper restored reach. The size fraction percentages less than 6.35mm and 2.4mm are low relative to the other E channel types for which McNeil core data are available (**Table 5-18**). The fraction less than 0.84mm, at 18.2%, is comparable to that for the other two E channel types. However, all three streams are listed as impaired due to sedimentation/siltation, so no comparison can be made with data from an unimpaired E channel.

Table 5-18. McNeil Core Data from a Restored Reach of Nevada Spring Creek Compared With McNeil Core Data from Two Other E Channels in the Planning Area

Stream Name	Channel Type	Percent ≤6.35 mm	Percent ≤2.40 mm	Percent ≤0.84 mm
Nevada Spring Creek	**E4**	38.3	26.2	18.2
Kleinschmidt Creek	**E6**	47.1	34.5	23.5
Rock Creek	**E4**	45.1	29.8	17.8

Post-restoration monitoring of the surface substrate on Nevada Spring Creek included two Wolman pebble counts from a site about 0.6 miles for the source and from another site about 1 mile farther downstream. Estimated values for the percent surface fines ≤6mm are 31% for the upstream site and 67% for the downstream site. The upper site meets the Type I target of 36% ≤6mm and the downstream site far exceeds this target.

Departures
Post-restoration data indicate that restoration has improved channel conditions sufficiently to meet width:depth ratio and pool frequency targets on Nevada Spring Creek. The mean pool depth data suggest that residual pool depth targets are met in the reach, although the two measurements cannot be directly compared. The Wolman pebble count from the upstream-most site appears to meet the surface substrate riffle target of ≤36 for percent fines less than 6mm, however, the 67% less than 6mm measured at the downstream-most site indicates a sediment transport deficiency. Macroinvertebrate MMI and RIVPACS scores are not available for the listed stream segment. Results of the aerial assessment indicate that the Type II target of >74 percent woody vegetation extent is not being met. The woody vegetation extent on Nevada Spring Creek is less than 1%. No data is available for comparison with the pool tailout surface fines ≤6mm target. Data for comparison with the supplemental indicators of pool extent (≥29%) and woody debris extent (≥12%) are not available.

Water Quality Impairment Status
Although departure analysis with two Type I targets and two Type II targets shows improvement in post-restoration channel habitat, data are not available for a sufficient number of the remaining targets to conclude full support for impaired uses. Comparisons of existing riffle surface substrate measurements with targets indicate an increasing sediment transport problem with distance downstream that continues to support the sedimentation/siltation listing. A sediment TMDL is, therefore, required. The sparse nature of the woody vegetation indicates that an altered streamside vegetation condition persists, requires more time for recovery and warrants a habitat impairment listing. Recommendations to address this non-pollutant are provided in the WQRP (**Section 10.0**).

5.2.8 Black Bear Creek

Black Bear Creek is a small first order tributary to Bear Creek in the upper Douglas Creek watershed. The 303(d) Listed segment of Black Bear Creek extends upstream from its mouth to a point 2.8 miles upstream. This stream segment is considered nonsupporting of aquatic life, cold water fishery, and contact recreation (**Section 2.0**). The 2006 sediment/habitat related 303(d) Listings for Black Bear Creek are alterations in streamside vegetation cover, sedimentation/siltation, and suspended/bedload solids (**Section 2.0**). Sources of impairment include riparian grazing, managed pasture grazing, silviculture, and forest road construction/use.

Black Bear Creek consists of 4 reaches (**Appendix A; Appendix B**). BlkBr1 and BlkBr2 are in the confined, forested headwaters area of the drainage. These stream segments show evidence of road encroachment and riparian vegetation alteration (**Appendix B**). At the upstream end of BlkBr3, the channel enters a more open valley that is bound by Tertiary-age sedimentary rocks. Within this reach, the channel definition as visible on aerial photography diminishes, and woody riparian vegetation is notably sparse. Blkbr4 flows through a narrow valley that is bound by benches comprised of Tertiary-age sediments. The reach has a narrow riparian fringe and relatively limited floodplain extent.

As of 2002, Black Bear Creek did not support fish Pierce, et al (2002b). Riparian impairments described by Pierce, et al (2002b) include livestock induced stream bank degradation and riparian vegetation suppression, a crushed and undersized culvert, and reduced instream flow from irrigation.

Departures
Black Bear Creek shows significant departure from 100% of its Type I targets, and three out of four Type II targets are unmet (**Table 5-19**).

Table 5-19. Sediment/Habitat Indicator Values and Targets, Black Bear Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E BlkBr4	**Riffle substrate: <6mm (%)**	**100**	**≤36**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**100**	**≤20**		**X**
	Pool Frequency (pools/mile)	**6.6**	**≥40**		**X**
	Residual Pool Depth (ft)	**0**	**≥1.5**		**X**
	Median W:D Ratio	5.1	6-11	Type II	√
	Woody Vegetation Extent (%)	53	≥74		X
	MMI	33.9	≥48		X
	RIVPACS O/E	0.36	≥0.8		X
	Pool Extent (%)	6	≥29	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	25	≥12		√

Water Quality Impairment Status
The measured departures of existing versus target conditions on Black Bear Creek support the habitat and sediment-related listings. As such, available data indicate that a sediment TMDL is necessary. Recommended approaches to addressing pollution related to habitat degradation are provided in the WQRP (**Section 10.0**).

5.2.9 Douglas Creek

Douglas Creek is a major third order tributary to lower Nevada Creek. The stream is approximately 22 miles long, and has been divided into two segments on the 303(d) List. These two segments include upper Douglas Creek, which extends from its headwaters to the Murray Creek confluence, and lower Douglas Creek, which extends from the Murray Creek confluence to the mouth.

5.2.9.1 Upper Douglas Creek

Upper Douglas Creek is considered partially supporting of aquatic life, cold water fishery, and contact recreation (**Section 2.0**). The 2006 sediment/habitat related 303(d) cause listings for upper Douglas Creek are alteration in streamside vegetative cover, low flow alterations, and sedimentation/siltation (**Section 2.0**). Sources of impairment include riparian grazing, rangeland grazing, irrigated crop production, and flow alterations from water diversions.

Between its headwaters and Murray Creek, upper Douglas Creek consists of four reaches (**Appendix A; Appendix B**). Doug1 and Doug2 are relatively confined B type channels that are bound by moderate to dense conifer forest. Logging access roads locally occupy the valley bottom, and upland areas have been harvested for timber. Downstream of Doug2, the creek flows into a wide valley that is used for hay cultivation and pasture. Doug3 and Doug4 occupy the open valley portion of upper Douglas Creek, and E type channels in these reaches are sparsely vegetated with riparian shrubs. Doug3 has numerous irrigation impoundments and associated diversions; Doug4 is a sinuous channel that is locally incised (**Appendix B**).

Douglas Creek supports a pure population of WSCT in the headwaters, but the fishery below the headwaters area has been described as impaired (Pierce, et al, 1999). Fisheries impairments identified as present throughout the drainage include lack of complex fish habitat (instream wood), livestock induced stream bank degradation and riparian vegetation suppression, elevated sediment and nutrient levels, elevated temperature, channel degradation related to instability and road construction, and reduced instream flows from irrigation. Restoration projects completed on Douglas Creek since 1990 have included improvement to fish passage, riparian vegetation, and range/riparian habitat (Blackfoot Challenge, 2005).

Departures
Assessment results from a B type channel in upper Douglas Creek indicates that three out of four Type I targets are not met in this reach (**Table 5-20**). Downstream, on an E channel segment, none of the Type I targets are met (**Table 5-21**). Within this reach, the Type II macroinvertebrate MMI and RIVPACS metrics show a moderate and severe impairment, respectively.

Table 5-20. Sediment/Habitat Indicator Values and Targets, Upper Douglas Creek B Channel Types

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Doug2	**Riffle substrate: <6mm (%)**	**19**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**19**	**≤10**		**X**
	Pool Frequency (pools/mile)	**13.2**	**≥20**		**X**
	Residual Pool Depth (ft)	**0.5**	**≥0.6**		**X**
	Median W:D Ratio	12.6	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	17	≤17		√
	Woody Vegetation Extent (%)	100	≥88		√
	Pool Extent (%)	3	≥10	Supp. Indicator	**X**
	Woody Debris Aggregate Extent (%)	2.5	≥3		**X**

Table 5-21. Sediment/Habitat Indicator Values and Targets, Upper Douglas Creek E Channel Types

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E Doug3	**Riffle substrate: <6mm (%)**	**39**	**≤36**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**26**	**≤20**		**X**
	Pool Frequency (pools/mile)	**6.6**	**≥40**		**X**
	Residual Pool Depth (ft)	**0.6**	**≥1.5**		**X**
	Median W:D Ratio	6.80	6-11	Type II	√
	Woody Vegetation Extent (%)	77	≥74		√
	MMI	42.4	≥48		**X**
	RIVPACS O/E	0.36	≥0.8		**X**
	Pool Extent (%)	37	≥29	Supp. Indicator	√
	Woody Debris Aggregate Extent (%)	17	≥12		√

Water Quality Impairment Status

The departures of measured stream conditions from Type I targets in both B and E channel types support the sediment/habitat related listings on upper Douglas Creek. As such, a sediment TMDL is required for the sedimentation listing, and pollution concerns regarding flow and habitat alterations are addressed in the WQRP (**Section 10.0**).

5.2.9.2 Lower Douglas Creek

Lower Douglas Creek extends from Murray Creek to its confluence with Nevada Creek. This stream segment is considered nonsupporting of aquatic life, cold water fishery, and contact recreation (**Section 2**). The 2006 sediment/habitat related 303(d) Listings for lower Douglas Creek are alteration in streamside vegetative cover, low flow alterations, and sedimentation/siltation (**Section 2.0**). Relevant sources of impairment include riparian grazing, rangeland grazing, riparian habitat loss, irrigated crop production, and flow alterations from water diversions.

Between Murray Creek and its mouth, lower Douglas Creek consists of five reaches (**Appendix A; Appendix B**). Doug5, just below Murray Creek flows through a narrow valley that is confined by volcanic rocks, and the creek is further encroached on by Montana Highway 271. In places, the stream has been channelized against the valley wall. Doug6 flows through a wider, less confined stream valley that supports dense riparian shrubs. The Douglas Creek Canal augments flows over a short distance within Doug6. Doug7 has moderately dense vegetation, and the stream valley is bound by terraces. Doug8, which flows to the Cottonwood Creek confluence, is sparsely vegetated and channel definition within the reach is poor relative to that upstream. There is an off-channel storage reservoir on the upstream end of the reach, and aerial assessment results suggest that secondary channels within this reach are used to convey irrigation water to adjacent fields (**Appendix B**). Doug9 consists of a highly sinuous channel with a narrow riparian zone.

Fisheries impairments identified as present throughout the Douglas Creek drainage include lack of complex fish habitat (instream wood), livestock induced stream bank degradation and riparian vegetation suppression, elevated sediment and nutrient levels, elevated temperature, channel degradation related to instability and road construction, and reduced instream flows from irrigation (Pierce, et al, 2002b). Restoration projects completed on Douglas Creek since 1990 have included improvement to fish passage, riparian vegetation, and range/riparian habitat (Blackfoot Challenge, 2005).

Departures

Compiled assessment data from C type channels on lower Douglas Creek indicates that most Type I and Type II targets are unmet under current conditions (**Table 5-22**). The only Type I indicator met on lower Douglas Creek is the riffle substrate <6mm value. Type I targets of riffle substrate <2mm, pool frequency, and residual pool depth all show departure from target values. None of the Type II targets are met within lower Douglas Creek. Macroinvertebrate data collected from adjacent reaches show moderate levels of impairment in Doug4, and downstream in Doug8, the RIVPACS score of 0.26 indicates a severe impairment with respect to aquatic life.

Table 5-22. Sediment/Habitat Indicator Values and Targets, Lower Douglas Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
C 1)Doug5(f) 2)Doug7	**Riffle substrate: <6mm (%)**	**18**	**≤22**	**Type I**	√
	Riffle substrate: <2mm (%)	**18**	**≤7**		**X** (1)
	Pool Frequency (pools/mile)	**26.4**	**≥46**		**X** (1)
	Residual Pool Depth (ft)	**1.2**	**≥2**		**X** (1,2)
	Median W:D Ratio	35.2	12-20	Type II	**X** (1.2)
	Median pool tailout surface fines <6mm (%)	44	≤23		**X** (1)
	Woody Vegetation Extent (%)	39.4	≥61		**X** (1)
	MMI (Doug4)	41.3	≥48		**X**
	RIVPACS O/E (Doug4)	0.46	≥0.8		**X**
	MMI (Doug8)	38.3	≥48		**X**
	RIVPACS O/E (Doug8)	0.26	≥0.8		**X**
	Entrenchment Ratio	2.5	>2.2	Supp. Indicator	√
	Pool Extent (%)	71	≥35		√
	Woody Debris Aggregate Extent (%)	2.8	≥8		**X** (1)

From site with highest departure from target

Water Quality Impairment Status

The departures of existing condition measurements from both Type I and Type II target values supports the sediment and habitat-related listings on lower Douglas Creek. A sediment TMDL is required to address the sedimentation listing, and recommendations to address pollution related to habitat and flow alterations are presented in the WQRP (**Section 10**).

5.2.10 Cottonwood Creek

Cottonwood Creek is a second order tributary to lower Douglas Creek, and the listed stream segment extends from the south fork of Cottonwood Creek to the mouth. The available data were deemed insufficient to determine the beneficial use support status for Cottonwood Creek with regard to aquatic life and the cold water fishery (**Section 2.0**). The stream is considered nonsupporting of primary contact recreation due to flow alterations. The 2006 sediment/habitat related 303(d) Listing for Cottonwood Creek is low flow alteration, and the listed source of impairment is agriculture (**Section 2.0**).

Cottonwood Creek is comprised of three reaches (**Appendix A; Appendix B**). CttnNev1 flows through a series of corrals, and field observations indicate substantial dewatering through the reach. CttnNev2 flows through a narrow cottonwood corridor, and numerous diversions are present within the reach. CttnNev3 flows across an open valley, sub-parallel to Douglas Creek. It has a narrow riparian fringe, and the bounding floodplain area is extensively irrigated. Riparian degradation is evident within all three reaches on the aerial photography (**Appendix B**).

The upper reaches of Cottonwood Creek support high densities of resident WSCT and brook trout, and the lower reaches support only long nose suckers (Pierce, et al, 2002b). Fisheries-related impairments identified for the lower reaches of Cottonwood Creek include livestock induced stream bank degradation and riparian vegetation suppression, lack of complex fish habitat (instream wood), undersized road crossing culverts, and dewatering (Pierce, et al, 2002b). Additional identified impairments in the lower reaches of Cottonwood Creek include channel over-widening and excess sedimentation in the streambed (Pierce, et al, 2001).

Restoration projects that have been implemented on Cottonwood Creek since 1990 have included improvements to fish passage, riparian vegetation, range/riparian habitat, and irrigation conditions. Some channel restoration has been implemented, and some livestock confinements have been removed from streamside areas (Blackfoot Challenge, 2005).

Departures

Cottonwood Creek meets Type I targets for riffle substrate and pool frequency (**Table 5-23**). However, the measured value for residual pool depth is approximately 50% of the Type I target value. Type II targets of pool tailout surface fines and woody vegetation extent are not met on Cottonwood Creek, and supplemental indicators similarly do not meet target values.

Table 5-23. Sediment/Habitat Indicator Values and Targets, Cottonwood Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E CttnNev2	**Riffle substrate: <6mm (%)**	**13**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**6**	**≤20**		√
	Pool Frequency (pools/mile)	**52.8**	**≥40**		√
	Residual Pool Depth (ft)	**0.6**	**≥1.5**		**X**
	Median W:D Ratio	8.2	6-11	Type II	√
	Median pool tailout surface fines <6mm (%)	98	≤82		**X**
	Woody Vegetation Extent (%)	39	≥74		**X**
	Pool Extent (%)	20	≥29	Supp. Indicator	**X**
	Woody Debris Aggregate Extent (%)	0	≥12		**X**

Water Quality Impairment Status
Although a total of four out of seven Type I and Type II target values on Cottonwood Creek are met by existing conditions, the departures of the Type I residual pool depth value and Type II woody vegetation extent value are significant indicators of excess sediment and bank instability.

Although the above target comparisons present a mixed interpretation of sediment transport function and the assessment record lacks both chemical and biological data, evidence provided by the 2004 base parameter assessment together with past reports of livestock caused bank damage and woody vegetation removal are sufficient to conclude that a sediment TMDL is required for Cottonwood Creek. Reports of dewatering and the observed number of diversions support the flow alteration cause for non-support of contact recreation that is addressed as pollution in the WQRP (**Section 10**).

5.2.11 McElwain Creek

McElwain Creek is a second order tributary to lower Nevada Creek, and the listed stream segment extends 2 miles upstream from the mouth. McElwain Creek is considered partially supporting of aquatic life, cold water fishery, and contact recreation (**Section 2.0**). The 2006 sediment/habitat related 303(d) Listings for McElwain Creek are alteration in streamside vegetative cover, low flow alterations, and sedimentation/siltation. Sources of impairment include riparian grazing, irrigated crop production, and flow alterations from water diversions (**Section 2.0**).

McElwain Creek consists of a single reach that is of an E/F channel type (**Appendix A; Appendix B**). The reach begins at a reservoir which appears to capture and divert much of the natural streamflow derived from the headwaters (**Appendix B**). The channel definition within the listed channel segment is poor, and is locally manifested as an indistinct swale in the valley bottom. Riparian degradation is evident on the aerial photography.

McElwain Creek supports pure resident WSCT with densities decreasing in the downstream direction (Pierce, et al, 2002b). Fisheries-related impairments identified on McElwain Creek include poor road crossings and drainage, irrigation impacts (fish passage and dewatering), riparian degradation, and excessive livestock access to stream banks (Pierce, et al, 2002b). Restoration work completed on McElwain Creek since 1990 has included the removal of streamside feedlots and improvement of riparian habitat conditions (Blackfoot Challenge, 2005).

Departures
Measured sediment/habitat related parameters on McElwain Creek currently do not meet any of the Type I or Type II targets established for E channel types in the watershed (**Table 5-24**).

Table 5-24. Sediment/Habitat Indicator Values and Targets, McElwain Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
E 1) McEl1 2)McEl1b(f)	**Riffle substrate: <6mm (%)**	**100**	**≤36**	**Type I**	**X** (1)
	Riffle substrate: <2mm (%)	**100**	**≤20**		**X** (1)
	Pool Frequency (pools/mile)	**19.8**	**≥40**		**X** (1,2)
	Residual Pool Depth (ft)	**0.3**	**≥1.5**		**X** (1,2)
	Median W:D Ratio	18.1	6-11	Type II	X (2)
	Median pool tailout surface fines <6mm (%)	100	≤82		X (1,2)
	Woody Vegetation Extent (%)	22.4	≥74		X (1,2)
	Entrenchment Ratio	2.5	>2.2	Supp. Indicator	√
	Pool Extent (%)	4	≥29		X (1,2)
	Woody Debris Aggregate Extent (%)	2.1	≥12		X (1,2)

From site with highest departure from target

Water Quality Impairment Status

The consistent departure of measured parameters from support objectives on McElwain Creek indicate that the sediment, habitat, and flow alteration listings are warranted. A sediment TMDL is therefore required for the listed stream segment, and treatment of the non-pollutants of habitat and flow alteration is addressed in the WQRP (**Section 10**).

5.2.12 Murray Creek

Murray Creek is a second order tributary to Douglas Creek. The stream is approximately 8 miles long, and the 303(d) Listed segment of Murray Creek extends from its headwaters to its confluence with Douglas Creek. This stream segment is considered partially supporting of the cold water fishery and aquatic life (**Section 2.0**). The 2006 sediment/habitat related 303(d) Listings for Murray Creek are alteration in streamside vegetative cover, low flow alterations, and sedimentation/siltation. Sources of impairment include flow alterations from water diversions, riparian grazing, irrigated crop production, range land grazing, stream bank destabilization/modification, and silviculture (**Section 2.0**). Murray Creek is considered nonsupporting of primary contact recreation, due partly to flow alterations.

Murray Creek consists of three reaches (**Appendix A; Appendix B**). The upstream reach is a confined, densely forested reach that flows through basaltic geology. Murr2 has increasing extents of timber harvested hillslopes, and both road encroachment and riparian degradation are evident on aerial photographs (**Appendix B**: aerial assessment). The downstream limit of Murr2 marks the emergence of the stream into an open valley; within this lowermost reach Murr3 is characterized by numerous diversions and a narrow riparian fringe. Channel definition decays in the downstream direction within Murr3. Murray Creek supports low densities of genetically pure WSCT in the middle and upper reaches with densities increasing in the upstream direction. Fisheries-related impairments identified in the middle and lower reaches of Murray Creek include poor road crossings, dewatering, fish entrainment at diversions, lack of instream complexity, and degraded stream banks due to excessive livestock access to riparian areas (Pierce, et al, 2002b). According to the Blackfoot Challenge (2005), no restoration projects have been performed on the creek over the past 15 years.

Departures
The data available for Murray Creek include macroinvertebrate analysis results and pebble count data collected from two sites in September of 2003 representing reaches Murr2 and Murr3 (**Table 5-25**). The riffle substrate targets were not met for either size fraction at either sample location. Existing conditions are at least twice the target values at both sites. The macroinvertebrate data show conditions very close to impairment thresholds in the confined B channel type of Murr2. The MMI and RIVPACS metrics for samples collected downstream in Murr3 show moderate and severe levels of impairment, respectively.

Table 5-25. Sediment/Habitat Indicator Values and Targets Murray Creek

Channel Type/ Reach	Parameter		Site Value	Target	Target Type	Target Met? √=Yes X=No
B Murr2	**Riffle substrate: <6mm (%)**		41	≤20	Type I	**X**
	Riffle substrate: <2mm (%)		30	≤10		**X**
	Macroinvertebrates	MMI	48.9	≥48	Type II	√
		RIVPACS O/E	0.78	≥0.8		**X**
E Murr3	**Riffle substrate: <6mm (%)**		82	≤36	Type I	**X**
	Riffle substrate: <2mm (%)		57	≤20		**X**
	Macroinvertebrates	MMI	41.5	≥48	Type II	**X**
		RIVPACS O/E	0.44	≥0.8		**X**

Water Quality Impairment Status
No Type I substrate targets are met on Murray Creek. Type II macroinvertebrate targets from Murr3 suggest that the aquatic life beneficial use is not met. The data indicate a sediment impairment and a TMDL is thus required for Murray Creek. The data also support the development of restoration strategies to address problems related to flow alterations and habitat alterations (**Section 10**).

5.3 Water Quality Impairment Status: Middle Blackfoot Planning Area

The following section contains a comparison of site conditions to targets and use support objectives for the Middle Blackfoot TPA. This comparison, referred to as a departure analysis, is used to assist with the final water quality impairment determinations presented in following sections.

5.3.1 Blackfoot River (Nevada to Belmont)

There are two 303(d) Listed segments of the Blackfoot River within the Middle Blackfoot TPA. The upstream segment extends for 21.9 miles from Nevada Creek downstream to Monture Creek. The downstream segment extends for 23.9 miles from Monture Creek to Belmont Creek. The Middle Blackfoot TPA includes all of the Nevada Creek to Monture Creek segment plus the upper 11 miles of the segment between Monture and Belmont creeks. The reach from the mouth of the Clearwater River to Belmont Creek is part of the Lower Blackfoot River TPA and, as such, is outside the scope of this document. This assessment addresses the mainstem Blackfoot River between Nevada Creek and the Clearwater River.

Both segments of the Blackfoot River were listed as impaired due to siltation on the 1996 303(d) List, providing partial support for aquatic life and cold water fisheries and full support for primary contact recreation (**Section 2.0**). Sources related to the 1996 listings include agriculture and silviculture. There are no sediment/habitat related listings for either of these two reaches on the 2006 list of impairment causes (**Section 2.0**).

Assessment reaches on the Blackfoot River mainstem include Blkft0, located just upstream of the Nevada Creek mouth; sitesBlkft1 through Blkft8 located between Nevada and Monture creeks; and sites Blkft9, Blkft10 and Blkft11 from Monture Creek to the Clearwater River (**Appendix A, Appendix B**). Substrate data collected at these sites includes pebble counts in runs and percent fines less than 6mm measured with a view bucket in pool tails.

Reaches Blkft1 and Blkft2 extend through fine-textured, Quaternary lakebed sediments that transition to gravelly glacial till from Blkft3 through Blkft6 near the mouth of Warren Creek. Quaternary alluvium dominates the river corridor sediments from reach Blkft 7 through reach Blkft11. Some evidence of woody riparian vegetation removal exists within pastureland and hay fields immediately downstream of the bridge on the Helmville-Ovando cutoff road in reaches Blkft2, Blkft3, and Blkft4. The extent of lake sediments naturally contributes fine-textured materials to the channel though these reaches. The river corridor deepens through reach Blkft5 making the river bank less accessible and natural riparian vegetation conditions appear intact between Blkft5 through reach Blkft7. By reach Blkft8, hay fields encroachment on the left bank has probably thinned the natural woody riparian community. Riparian vegetation appears to be minimally affected within the segment between Monture Creek and the mouth of the Clearwater River

Departures

The comparison of surface substrate pebble count data with targets developed from those data indicate excess fine sediment in riffles for reaches Blkft0 through Blkft4 (**Table 5-26**). A similar pattern is reflected in the view bucket data collected from pool tails. An abrupt improvement occurs at reach Blkft5, below which all substrate targets are met. Macroinvertebrate MMI and RIVPACS metrics collected above the Monture Creek confluence indicate no impairment with respect to aquatic life at that site. However, the macroinvertebrate data alone do not fully address the 1996 siltation impairment listing on the Blackfoot River.

An analysis if periphyton data (Weber, 2005) assessed the degree of use support using six metrics for diatom algae. Samples were collected from three Blackfoot main stem locations: above the mouth Nevada Creek near Helmville, at the Raymond Bridge crossing, and at the Scotty Brown Bridge crossing. The metric scores for the two main stem locations below the mouth of Nevada Creek indicate minor impairment and full use support (**Table 5-27**). The disturbance index and percent dominant species at the Scotty Brown site and the siltation index above Nevada Creek and at the Raymond Bridge site depressed the scores slightly.

Table 5-26. Sediment/Habitat Indicator Values and Targets, Blackfoot River

Channel Type/ Reach	Parameter Type	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
C Blkft0	Substrate Surface	**Riffle substrate: <6mm (%)**	13	≤10	Type I	**X**
		Riffle substrate: <2mm (%)	9	≤7		**X**
		Median Pool tailout fines <6mm (%)	22.5	≤25	Type II	√
C Blkft1	Substrate Surface	**Riffle substrate: <6mm (%)**	17	≤10	Type I	**X**
		Riffle substrate: <2mm (%)	17	≤7		**X**
		Median Pool tailout fines <6mm (%)	21	≤25	Type II	√
F Blkft2	Substrate Surface	Median Pool tailout fines <6mm (%)	38.5	≤25	Type II	**X**
C Blkft3	Substrate Surface	Median Pool tailout fines <6mm (%)	22	≤25	Type II	√
C/F Blkft4	Substrate Surface	**Riffle substrate: <6mm (%)**	25	≤10	Type I	**X**
		Riffle substrate: <2mm (%)	16	≤7		**X**
		Median Pool tailout fines <6mm (%)	39	≤25	Type II	**X**
C/F Blkft5	Substrate Surface	Median Pool tailout fines <6mm (%)	23	≤25	Type II	√
C/F Blkft7	Substrate Surface	**Riffle substrate: <6mm (%)**	6	≤10	Type I	√
		Riffle substrate: <2mm (%)	5	≤7		√
		Median Pool tailout fines <6mm (%)	23.5	≤25	Type II	√
C Blkft8	Substrate Surface	**Riffle substrate: <6mm (%)**	0	≤10	Type I	√
		Riffle substrate: <2mm (%)	0	≤7		√
		Median Pool tailout fines <6mm (%)	5	≤25	Type II	√
	Macroinvertebrates	MMI	70.6	≥48	Type II	√
		RIVPACS O/E	1.23	≥0.8		√
C Blkft9	Substrate Surface	**Riffle substrate: <6mm (%)**	4	≤10	Type I	√
		Riffle substrate: <2mm (%)	4	≤7		√
		Median Pool tailout fines <6mm (%)	1	≤25	Type II	√

Table 5-27. 2004 Periphyton Metrics for Blackfoot River

Metric	Score		Impairment
	B-7 Blackfoot River at Raymond Bridge	**B-10 Blackfoot River at Scotty Brown Bridge**	
Species Richness			None
Diversity Index	4.83	4.56	None
Pollution Index	2.56	2.69	None
Siltation Index	31.6	14.13	Minor (B-7)
Disturbance Index	3.48	26.37	Minor (B-10)
% Dominant Species	24.49	26.37	Minor (B-10)

Reference: Weber, 2005

Water Quality Impairment Status

Results of the base parameter data analysis (DTM and AGI, 2005) indicate that the Blackfoot River has a broad range of substrate conditions that reflect variations in channel morphology and tributary inputs. The departures from main stem substrate targets indicate elevated fine sediment in the reaches immediately below the mouth of Nevada Creek. Both pebble count and view bucket data for reaches Blkft1 through Blkft4 indicate fine sediment deposits in runs and pool tails in the portion of the segment upstream of the mouth of Frazier Creek. Lakebed sediments in these reaches provide some natural loading of fine sediment. However, the greater accessibility to the channel for adjacent roadways and cropland upstream of reach Blkft5 increases the likelihood of sediment loading from roads, farmland, and other developed land along the eight miles of channel between Nevada Creek and the Raymond Bridge. This increased likelihood of human-caused loading, together with the **Table 5-26** target departures, are justification for a sediment impairment listing and the requirement for a sediment TMDL on the main stem segment between Nevada and Monture creeks.

The channel substrate data for the Monture Creek to Clearwater River segment indicate low levels of fine sediment. All substrate targets are met in reach Blkft9. Multi-metric index and RIVPACS target values are not currently available for macroinvertebrate data collected at a site near the Scotty Brown Bridge as part of the Blackfoot Watershed Water Quality Status and Trends monitoring effort. Based on an assessment of six macroinvertebrate metrics, the site scored as representing 72% of the maximum, three percentage points short of a score of 75% that represents full use support (BFC 2005). However, diatom association metric scores for the same site indicated full support for aquatic life (Weber, 2005). Although a weight of evidence interpretation of the assessment results indicates that fine sediment is not seriously affecting beneficial uses, the mixed biological results and an assumed anthropogenic component to stream bank erosion within the segment from Monture Creek to the Clearwater point to the need for a sediment TMDL.

5.3.2 Yourname Creek

Yourname Creek is a second order tributary to the Blackfoot River. The stream is considered partially supporting of aquatic life, cold water fishery, and contact recreation (**Section 2.0**). The listed stream segment of Yourname Creek extends from the headwaters to the mouth at the Blackfoot River. The 2006 sediment/habitat related 303(d) Listings for this stream segment are flow alteration, alteration in stream-side vegetative covers, and sedimentation (**Section 2.0**). Listed sources of impairment include riparian grazing, irrigated crop production, and rangeland grazing.

Yourname Creek consists of four reaches within this listed stream segment (**Appendix A; Appendix B**). Reach Your1 is a relatively steep, confined headwaters channel bounded by dense conifers. No evidence of impairment was identified in this reach as part of the Aerial Assessment (**Appendix B**). In reach Your2, the channel lies within a relatively narrow valley bounded by basalts. The valley wall hill slopes have been timber harvested, and a road network dissects these areas. A primary access road closely follows the stream corridor. Reach Your3 supports a continuous narrow riparian fringe in what appears to be a partially cleared alluvial valley bottom (Aerial Assessment: **Appendix B**). In the lowermost reach (Your4), there is a distinct loss in channel definition below irrigation diversions as the creek approaches the Blackfoot River. Alteration of riparian vegetation is evident in the lowermost two reaches.

No restoration projects have been implemented between 1990 and 2005 on Yourname Creek (Blackfoot Challenge, 2005).

Departures

Due to access limitations, base parameter data from 2004 are not available for Yourname Creek. However, substrate pebble count and macroinvertebrate data were collected at the lower end of the listed stream segment (Your4) as part of a DEQ assessment in 2003. The pebble count results and MMI and RIVPACS metrics are given in **Table 5-28**.

The pebble count results do not meet E channel targets for either particle size fraction. The macroinvertebrate scores indicate a moderate level of water quality impairment. Analysis of a periphyton sample collected in September, 2003 from the upper end of reach Your4 indicated slight impairment due to siltation, but full use support (Bahls 2004).

Table 5-28. Sediment/Habitat Indicator Values and Targets, Yourname Creek

Channel Type/ Reach	Parameter Type	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E Your4	Surface Substrate	**Riffle substrate: <6mm (%)**	51	≤36	Type I	**X**
		Riffle substrate: <2mm (%)	44	≤34		**X**
	Macroinvertebrates	MMI	45.6	≥48	Type II	X
		RIVPACS O/E	0.69	≥0.8	Type II	X

Water Quality Impairment Status

The departures of measured substrate particle size distribution and macroinvertebrate metric targets support the sediment impairment determination and the development of a sediment TMDL on Yourname Creek. Additionally, recommendations to address the non-pollutant listings of habitat and flow alteration on Yourname Creek are provided in the WQRP (**Section 10**).

5.3.3 Wales Creek

Wales Creek is a second order tributary to the Blackfoot River. The listed segment of Wales Creek extends from a privately owned on-channel reservoir outlet to the mouth at the Blackfoot River. The confluence of Wales Creek at the Blackfoot River is approximately ¼ mile upstream of Raymond Bridge. The stream is partially supporting of aquatic life, cold-water fishery, and contact recreation (**Section 2.0**). The 303(d) Listings for Wales Creek that relate to sediment/habitat are low flow alteration, alteration in streamside or littoral vegetative covers, and sedimentation (**Section 2.0**). Sources include agriculture, range land grazing, irrigated crop production, and upstream impoundment.

Wales Creek has one reach, which begins at the on-channel reservoir (**Appendix A; Appendix B**). Within this reach, there has been extensive hillside logging, and an access road closely bounds the stream corridor. Results of the aerial assessment indicate that a substantial amount of instream flows are diverted into the reservoir. The valley bottom area located south of the reservoir is flood irrigated. Between the reservoir and the mouth at the Blackfoot River, Wales Creek maintains a narrow woody riparian fringe.

The fisheries species composition within Wales Creek consists of fluvial westslope cutthroat trout and brown trout below the reservoir in the listed stream segment, and genetically pure, resident westslope cutthroat trout above the reservoir. Fisheries-related impairments on Wales Creek include habitat fragmentation from the reservoir, dewatering below the reservoir, and stream bank damage from excessive livestock access to riparian areas (Pierce, et al, 2002b).

Departures

Due to access limitations, base parameter data from the 2004 assessment are not available for Wales Creek. As with Yourname Creek, however, substrate pebble count and macroinvertebrate data are available from a DEQ assessment in 2003. The assessment site values for substrate and macroinvertebrate target parameters are compared with targets in **Table 5-29**.

Table 5-29. Sediment/Habitat Indicator Values and Targets, Wales Creek

Channel Type/ Reach	Parameter Type	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E/Wales1	Surface Substrate	**Riffle substrate: <6mm (%)**	67	≤36	Type I	**X**
		Riffle substrate: <2mm (%)	58	≤34		**X**
	Macroinvertebrates	MMI	45.5	≥48	Type II	X
		RIVPACS O/E	0.57	≥0.8		X

The site conditions show significant departure from the E channel pebble count targets for both particle size fractions. The macroinvertebrate scores indicate a moderate level of water quality impairment. Analysis of a periphyton sample collected in September, 2003 from a site about one quarter mile above the mouth also indicated moderate impairment and partial support for aquatic life due to siltation (Bahls 2004).

Water Quality Impairment Status
The departures of measured substrate and macroinvertebrate metrics from Type I and II targets support the development of a sediment TMDL on Wales Creek. Additionally, recommendations to address the non-pollutant listings of flow alteration and alteration in vegetative covers on Wales Creek are provided in the WQRP (**Section 10**).

5.3.4 Frazier Creek

Frazier Creek is a second order tributary to the Blackfoot River. The listed segment of Frazier Creek extends from its headwaters to its mouth, a distance of approximately 3.6 miles. Frazier Creek is considered nonsupporting of aquatic life, cold water fishery, and contact recreation (**Section 2.0**). The sediment/habitat related 303(d) Listings for Frazier Creek are alteration in streamside or littoral vegetative covers, low flow alterations, and sedimentation/siltation (**Section 2.0**). Sources include grazing in riparian or shoreline zones, flow alterations from water diversions, irrigated crop production, and hydrostructure impacts to fish passage.

Frazier Creek consists of three reaches (**Appendix A; Appendix B**). Fraz1 is located in the headwaters, where the creek flows through a highly confined, densely forested valley bottom. Results of the aerial assessment identified no indicators of degradation within this reach (**Appendix B**). Fraz2 flows through a semi-confined valley with harvested hillslopes and a forest access road network. Road encroachment along the channel margin is evident on the aerial photography. Fraz3 is characterized by two on-line impoundments, and a poorly discernable channel along much of its course.

Frazier Creek supports genetically pure WSCT, and no other fish species (Pierce, et al, 2002b). Fisheries-related impairments identified on Frazier Creek include reduced instream flows, channel alterations, stream channel fragmentation preventing fish passage, and livestock grazing impacts to riparian areas.

Departures
An assessment site on lower Frazier Creek indicates that two out of four Type I targets are unmet in this reach (**Table 5-30**). The stream meets Type I substrate targets, however Type I targets related to habitat units are not met. Residual pool depths are notably low in the reach, indicating a potential sedimentation/siltation impairment. High pool tailout surface fines values similarly indicate excess sediment. The Type II macroinvertebrate RIVPAC metric for this reach shows a severe impairment.

Table 5-30. Sediment/Habitat Indicator Values and Targets, Frazier Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E Fraz3	**Riffle substrate: <6mm (%)**	**13**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**11**	**≤34**		√
	Pool Frequency (pools/mile)	**19.8**	**≥40**		**X**
	Residual Pool Depth (ft)	**0.4**	**≥1.5**		**X**
	Median W:D Ratio	9.8	6-11	Type II	√
	Median pool tailout surface fines <6mm (%)	95	≤48		X
	Woody Vegetation Extent (%)	55	≥69		X
	MMI	58	≥48		√
	RIVPACS O/E	0.43	≥0.8		X
	Pool Extent (%)	8	≥19	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	6	≥12		X

Water Quality Impairment Status

The departures of measured stream conditions from Type I targets support the sediment/habitat related listings on Frazier Creek. As such, a sediment TMDL is required for the sedimentation listing, and pollution concerns regarding flow and vegetative cover alterations are addressed in the WQRP (**Section 10**).

5.3.5 Ward Creek

Ward Creek is a second order tributary to two large lakes (Browns and Kleinschmidt Lakes) in the Blackfoot Valley. The listed segment of Ward Creek extends from its headwaters to Browns Lake. Ward Creek is considered partially supporting of aquatic life and the cold water fishery, and fully supporting of contact recreation (**Section 2.0**). The sediment/habitat related 303(d) Listings for Ward Creek are physical substrate/habitat alterations, and sedimentation/siltation (**Section 2.0**). Causes include agriculture, silviculture, and unpaved roads or trails.

Ward Creek consists of eight reaches (**Appendix A; Appendix B**). Ward1, in the stream's headwaters, flows through a confined, densely forested valley that displays no indicators of degradation on aerial photography (**Appendix B**). In Ward2, the channel emerges into hummocky glacial terrain, and areas adjacent to the channel have been clearcut. Ward Creek then flows through broad, open meadows within Ward3, where adjacent valley walls show evidence of extensive timber harvesting. The channel definition within Ward3 is highly variable, indicating potential local dewatering (**Appendix B**). Ward4 is bound by numerous access roads, and the channel is relatively confined by harvested valley walls. In Ward5, the channel flows through open meadows in which the channel has been relocated and channelized on the valley margin. The valley bottom is grazed and cultivated for hay, and several diversion headgates are present on the channel. Ward6 extends to Highway 200, and consists of a narrow straight channel with a small on-line impoundment. Below Highway 200, Ward7 consists of a small meandering E type channel with locally dense woody riparian vegetation. This section of densely vegetated valley bottom correlates to the headwater spring area of Kleinschmidt Creek. Ward8 extends from the Road #112 crossing to Browns Lake and supports minimal woody vegetation in the riparian zone.

Ward Creek supports resident brook trout, but no native salmonids. Fisheries-related impairments on Ward Creek include lack of stream complexity, as well as degraded stream banks and riparian areas due to excessive riparian livestock access (Pierce, et al, 2002b).

Departures

Assessment data for Ward5, which is a C channel type, indicated that none of the targets or supplemental indicators are met in the assessment reach (**Table 5-31**). Further downstream in Ward8, which is an E type channel, Type I targets related to stream substrate and pool frequency are met, while residual pool depth is not (**Table 5-32**).

Table 5-31. Sediment/Habitat Indicator Values and Targets Ward Creek C Channel Type

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
C Ward5	**Riffle substrate: <6mm (%)**	**43**	**≤15**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**43**	**≤11**		**X**
	Pool Frequency (pools/mile)	**19.8**	**≥55**		**X**
	Residual Pool Depth (ft)	**0.9**	**≥2**		**X**
	Median W:D Ratio	27.4	12-19	Type II	X
	Median pool tailout surface fines <6mm (%)	37	≤20		X
	Woody Vegetation Extent (%)	25	≥84		X
	Pool Extent (%)	8	≥35	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	1	≥8		X

Table 5-32. Sediment/Habitat Indicator Values and Targets, Ward Creek E Channel Type

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E Ward8	**Riffle substrate: <6mm (%)**	**5**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**5**	**≤34**		√
	Pool Frequency (pools/mile)	**40**	**≥40**		√
	Residual Pool Depth (ft)	**0.5**	**≥1.5**		**X**
	Median W:D Ratio	4.5	6-11	Type II	√
	Median pool tailout surface fines <6mm (%)	71	≤48		X
	Woody Vegetation Extent (%)	69.4	≥69		√
	Pool Extent (%)	14	≥19	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	0	≥12		X

Water Quality Impairment Status

The departures of measured stream conditions from Type I targets support the sediment/habitat related listings on Ward Creek. As such, a sediment TMDL is required for the sedimentation listing, and pollution concerns regarding habitat alterations are addressed in the WQRP (**Section 10**).

5.3.6 Kleinschmidt Creek

Kleinschmidt Creek is a first order spring creek tributary to Rock Creek, draining the southern margin of Kleinschmidt Flat. The listed segment of the creek extends upstream from the mouth for a distance of 1.5 miles. Kleinschmidt Creek is considered partially supporting of aquatic life and the cold water fishery (**Section 2.0**). The sediment/habitat related 303(d) Listings for Kleinschmidt Creek are alteration in streamside vegetative cover, and sedimentation/siltation (**Section 2.0**). Sources include riparian grazing, managed pasture grazing, and hydromodification.

Kleinschmidt Creek consists of three reaches (**Appendix A; Appendix B**). Klein1 originates at the spring-fed headwaters of the creek, and flows through densely vegetated wetlands that provide seepage flows to the stream channel. The valley margins consist of hummocky glacial deposits that are locally forested. Within Klein 2, which begins at the first Highway 200 crossing, severe riparian degradation is evident on the aerial photography (**Appendix B**). Numerous road crossings are present in the reach. Klein3 flows from the last road crossing to the mouth. Within this reach, seepage from the margin of Kleinschmidt flat is evident in air photos, and much of this reach has been restored.

Kleinschmidt Creek supports very low densities of juvenile brook trout and fluvial WSCT along with higher densities of brook trout and brown trout (Pierce, et al, 2002b). Fisheries-related impairments described for upper Kleinschmidt Creek include lack of riparian vegetation, excessive livestock access to riparian areas, and feedlot runoff (Pierce, et al, 2002b). A high level of whirling disease has been identified in Kleinschmidt Creek. A major stream restoration project was completed on the lower 1.5 miles of Kleinschmidt Creek in 2000. Restoration efforts performed since 1990 have addressed issues related to fish passage, spawning conditions, channel morphology, fish habitat, riparian vegetation, wetlands, range habitat, and streamside feedlots (Blackfoot Challenge, 2005).

Departures

Assessment results indicate that in Klein2, which is located upstream of the restored reach of Kleinschmidt Creek, none of the Type I targets are met (**Table 5-33**). The departures of site conditions from target values are very high for parameters related to both substrate and habitat. The RIVPACS macroinvertebrate metric from Klein3 depicts a moderate level of impairment. Additional macroinvertebrate data reported by Bollman (2005) suggests that water quality degradation within Klein2 has been severe enough to disrupt the functional balance of the benthic assemblage, and that possible causes for this imbalance include thermal stress, nutrient enrichment, and sediment deposition (**Table 5-34**).

Table 5-33. Sediment/Habitat Indicator Values and Targets, Kleinschmidt Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
E Klein2 (Macros from Klein3)	**Riffle substrate: <6mm (%)**	**100**	**≤36**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**100**	**≤34**		**X**
	Pool Frequency (pools/mile)	**0**	**≥40**		**X**
	Median W:D Ratio	6.4	6-11	Type II	√
	Woody Vegetation Extent (%)	11	≥69		X
	MMI	56.9	≥48		√
	RIVPACS O/E	0.675	≥0.8		X
	Pool Extent (%)	0	≥19	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	4	≥12		X

Table 5-34. 2004 Kleinschmidt Creek Macroinvertebrate Metrics

Macroinvertebrate Metric	Klein2	
	Metric Value	Metric Score
Ephemeroptera (mayfly) taxa richness	0	0
Plecoptera (stonefly) taxa richness	0.3	1
Trichoptera (caddisfly) taxa richness	4.7	3
Number of sensitive taxa	0.3	1
Percent filter feeders	4.81	3
Percent tolerant taxa	50.41	0
Total Score (Max = 18)		8
Percent of Max		44.4
Impairment Classification	Moderate	
Use Support	Partial	

Reference: Bollman, 2005

Water Quality Impairment Status

The departures of measured stream conditions from Type I targets support the sediment/habitat related listings on Kleinschmidt Creek. As such, a sediment TMDL is required for the sedimentation/siltation listing, and pollution concerns regarding habitat alterations are addressed in the WQRP (**Section 10**).

5.3.7 Rock Creek

Rock Creek, which is a second order stream, is the largest valley tributary to the North Fork Blackfoot River. The listed segment of Rock Creek extends from its headwaters to its mouth, a distance of approximately 9 miles. Rock Creek is considered partially supporting of beneficial uses related to aquatic life and the cold water fishery (**Section 2.0**). The sediment/habitat related 303(d) Listings for Rock Creek are alteration in streamside vegetative covers, low flow alterations, and sedimentation/siltation (**Section 2.0**). Sources include riparian grazing, range land grazing, irrigated crop production, and silviculture.

Rock Creek is made up of seven reaches between its headwaters and the North Fork Blackfoot River confluence (**Appendix A; Appendix B**). Rock1 flows through glacial deposits above Kleinschmidt Flat, and in this area the stream corridor is bound by dense conifer forest. No indicators of degradation are apparent in this reach on the aerial photography. Rock2 consists of a geomorphic transition zone as the creek flows onto Kleinschmidt Flat. There is some rural residential development in the area, and riparian degradation is evident. Rock3 flows through a narrow riparian corridor along the margin of Kleinschmidt Flat. The hillslopes against the flat have been harvested for timber. Much of Rock3 has been restored as an E type channel; restoration elements include channel shaping, bank armoring, and woody debris placement. Rock4 continues to follow the eastern margin of Kleinschmidt Flat, although riparian densities are high relative to upstream. A road closely follows the channel in this reach. In Rock5, the channel crosses onto Kleinschmidt Flat, and as it flows onto the glacial deposits of the flat, flow infiltration into the coarse sediment is evident on the air photos (**Appendix B**). The channel is relatively straight, and supports minimal woody vegetation on its banks. Rock6 begins at a fenceline in the middle of Kleinschmidt Flat where there is an abrupt reduction in woody riparian corridor extent relative to upstream conditions. Rock7 extends to the North Fork Blackfoot River. The channel gains surface flow in this reach, as evidenced by increased channel dimensions and increased woody riparian corridor extent relative to Rock6 (**Appendix B**). Rock7 has been largely restored as a C channel type with placed boulders, woody debris, and constructed pool/riffle sequences.

Rock Creek provides rearing of bull trout, WSCT, brown trout, rainbow trout, and resident brook trout. Rock Creek has been identified as having a high fisheries restoration priority. As a result, the entire length of Rock Creek has been a focus of Middle Blackfoot watershed restoration efforts since the early 1990s. Restoration activities have included channel and floodplain reconstruction, grazing management, shrub plantings, culvert replacements, and instream flow enhancement using a flood to sprinkler conversion (Blackfoot Challenge, 2005).

Departures

Assessment data from Rock3 and Rock4 are shown in **Table 5-35**. Rock3 is an E channel type, and Rock4 is entrenched sufficiently to be characterized as an F channel. Based on channel sinuosity, slope, and adjacent reach characteristics, Rock4 is described as a degraded E channel type, and as such, E channel targets have been applied to the reach. The assessment data available for the two reaches indicate that although Type I targets related to substrate are met on both Rock3 and Rock4, the Type I pool frequency target is not met on Rock4, and the residual pool depth target is not met on either reach. The assessed C channel type (Rock7), which is in a restored reach, meets residual pool depth and riffle substrate Type I targets, but not those established for McNeil Core <6mm fraction or pool frequency (**Table 5-36**).

Table 5-35. Sediment/Habitat Indicator Values and Targets, Rock Creek E Channel Types

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
E 1)Rock 3 2)Rock 4 F(e)	**Riffle substrate: <6mm (%)**	**27**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**13**	**≤34**		√
	Pool Frequency (pools/mile)	**13.2**	**≥40**		**X** (2)
	Residual Pool Depth (ft)	**1.3**	**≥1.5**		**X** (1,2)
	Median W:D Ratio	11.9	6-11	Type II	X (2)
	Median pool tailout surface fines <6mm (%)	86	≤48		X (2)
	Woody Vegetation Extent (%)	50	≥69		X (1)
	MMI	45.6	≥48		X (1)
	RIVPACS O/E	0.57	≥0.8		X (1)
	Entrenchment	1.6	>2.2	Supp. Indicator	X (2)
	Pool Extent (%)	8	≥19		X (2)
	Woody Debris Aggregate Extent (%)	1	≥12		X (1,2)

From site with highest departure from target

Table 5-36. Sediment/Habitat Indicator Values and Targets, Rock Creek C Channel Type

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
C Rock7	**Riffle substrate: <6mm (%)**	**15**	**≤15**	**Type I**	√
	Riffle substrate: <2mm (%)	**9**	**≤11**		√
	McNeil Cores <6.35 mm (%)	**46.3**	**≤27**		**X**
	Pool Frequency (pools/mile)	**39.6**	**≥55**		**X**
	Residual Pool Depth (ft)	**2**	**≥2**		√
	Median W:D Ratio	21.3	12-19	Type II	X
	Median pool tailout surface fines <6mm (%)	18	≤20		√
	McNeil Cores <2mm (%)	31	≤15		X
	McNeil Cores <0.85 mm (%)	15.6	≤6.5		X
	Woody Vegetation Extent (%)	37.0	≥84		X
	MMI	70	≥48		√ (1)
	RIVPACS O/E	0.82	≥0.8		X (1)
	Pool Extent (%)	37	≥35	Supp. Indicator	√
	Woody Debris Aggregate Extent (%)	3	≥8		X

Water Quality Impairment Status

Riffle substrate Type I targets are met on Rock Creek. However, McNeil Core data from Rock7 shows a significant excess in fine sediment within this reach. Pool frequency targets are not met in two of the three assessed reaches, and residual pool depth targets are met in only the C channel type. The combined McNeil Core and habitat parameter departures on assessed reaches of Rock Creek support the 2006 sedimentation/siltation 303(d) Listing. Consequently, a sediment TMDL for Rock Creek is warranted. Additionally, the pollution-related listings of altered vegetative cover and low flow alterations are supported by measured departures from the range of Type I and Type II targets as well as supplemental indicators. These pollution-related impairments do not require a TMDL but are addressed in the WQRP (**Section 10**).

5.3.8 North Fork Blackfoot River

The North Fork Blackfoot River is a large, fourth order tributary to the Blackfoot River. Listed in 1996 as impaired due to siltation, the stream was identified as fully supporting of all beneficial uses in 2000 through 2006. The delisting is justified in the assessment record by strong long-term recovery of bull trout redd numbers and numbers of all sizes of bull trout and WSCT since 1989. These improvements are attributed to installation of screening devices preventing entrainment of fish in five irrigation diversions, implementation of riparian grazing BMPs within the lower reaches, conservation easements placed along 8 miles of the North Fork and stabilizing 950 ft of unstable channel within the lower reaches (DEQ 2006).

McNeil core data collected in 1992 are available for two sites on the North Fork located one and one half miles upstream of the Lake Creek confluence within the Lolo National Forest. The mean values for each of three particle size fractions at the two sites are compared to McNeil core targets for B channel types in **Table 5-37**. Four of the six results show elevated fine sediment relative to the target values. These data were collected about one mile downstream of the Scapegoat Wilderness boundary making human-caused impairment unlikely. Fine sediment conditions may have reflected loads from areas that burned in 1988.

Five macroinvertebrate samples were collected from North Fork tributaries during the 1980s and 1990s. The MMI and RIVPACS values from these sites are compared to the mountain index targets in **Table 5-37**. Eight of ten macroinvertebrate score targets are met among the five sites

Table 5-37. McNeil Core Sediment Fractions and Macroinvertebrate Assessment Scores, North Fork Blackfoot River

Sample Site	Parameter Type	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
North Fork above Lake Creek T16WR11WS23	Substrate	**McNeil Cores <6.35 mm (%)**	30	≤27	Type I	**X**
		McNeil Cores <2.0 mm (%)	19	≤12	Type II	**X**
		McNeil Cores <0.85 mm (%)	10	≤6		**X**
North Fork above Lake Creek T16WR11WS14		**McNeil Cores <6.35 mm (%)**	22	≤27	Type I	√
		McNeil Cores <2.0 mm (%)	14	≤12	Type II	**X**
		McNeil Cores <0.85 mm (%)	6	≤6		√
Dry Fork N.F. Blackfoot	Macro-invertebrate Metrics	MMI	0.75	≥63	Type II	√
		RIVPACS	1.15	≥0.8		√
Meadow Creek		MMI	0.85	≥63		√
		RIVPACS	1.0	≥0.8		√
East Fork Meadow Creek		MMI	0.63	≥63		√
		RIVPACS	0.47	≥0.8		**X**
Sourdough Creek		MMI	0.86	≥63		√
		RIVPACS	1.06	≥0.8		√
Lake Creek		MMI	74	≥63		√
		RIVPACS	0.74	≥0.8		**X**

Table 5-38. North Fork Blackfoot River Periphyton Metrics

Metric	Score	Impairment
	B-8 North Fork Blackfoot River above Dry Gulch	
Species Richness	68	None
Diversity Index	4.43	None
Pollution Index	2.79	None
Siltation Index	11.8	None
Disturbance Index	34.93	Minor
% Dominant Species	34.93	Minor

Reference: Weber, 2005

Periphyton data collected on the North Fork in August of 2004 shows no or slight impairment with respect to the siltation index and full support for aquatic life (Weber, 2005; **Table 5-38**).

Water Quality Impairment Status

Due to the strength of the biological data from fish surveys and analysis of macroinvertebrate and periphyton samples toward support for fisheries and aquatic life, the North Fork of the Blackfoot River is not considered impaired due to human sources and a sediment TMDL is not required.

5.3.9 Warren Creek

Warren is a relatively small second order tributary to the Blackfoot River. The listed segment of Warren Creek extends from its headwaters to its mouth. The stream is considered partially supporting of beneficial uses of aquatic life, cold water fishery, and contact recreation (**Section 2.0**). The 303(d) Listings for Warren Creek that relate to sediment/habitat are flow alterations and fish passage barriers (**Section 2.0**). Sources include channelization, agriculture, and irrigated crop production.

The listed segment of Warren Creek is made up of 12 reaches (**Appendix A; Appendix B**). The uppermost reach, Warr1, flows off the flank of Ovando Mountain, from bedrock onto glacial deposits of the Blackfoot River Valley. Within this reach the stream channel is moderately confined and bound by dense conifer forest (**Appendix B**). In Warr2, the stream flows into a broad valley with open meadows. As Warren Creek approaches Highway 200 in Warr3, there is an abrupt reduction in woody riparian density. Flow diversions and channelization are evident on the aerial photography in Warr3. Warr4 is a short channelized reach downstream of Highway 200, in which the channel is bound by berms formed from excavated sediment, resulting in a largely entrenched cross section. Warr5 has a severely degraded riparian corridor, and loss of channel definition is evident within the reach. In Warr6, the channel has been relocated northward of its historic course, and the current channel course is bordered by a well defined but narrow riparian thread. The channel definition in Warr7 is highly variable, and valley bottom wetlands coupled with increasing channel definition in the downstream direction suggest groundwater seepage inputs into the reach. From Rd 104 downstream, Warr8 is characterized by a marked increase in woody riparian cover relative to upstream. The riparian cover extent is substantially less downstream in Warr9, which consists of a very sinuous channel with a severely degraded riparian corridor. Groundwater seepage is evident in Warr10 in the form of a boggy valley bottom and a multiple active channel threads. Warr11 consists of a sinuous channel with localized channelized segments through irrigated fields and a severely degraded riparian corridor. Approaching the Blackfoot River, Warr12 is entrenched within the northern valley wall of the Blackfoot River.

Surveyed fish populations in Warren Creek document a mixed species composition of brook trout, brown trout, and low numbers of WSCT (Pierce, et al, 2002b). Fisheries-related impairments identified on Warren Creek include poor condition road crossings, irrigation impacts (dewatering and passage), channelization, lack of instream complexity, and degraded riparian vegetation due to excessive livestock access to stream banks (Pierce, et al, 2002b).

Warren Creek has been identified as a high priority fisheries restoration stream in the Middle Blackfoot watershed. A total of 34 restoration projects have been completed on Warren Creek since 1990 (Blackfoot Challenge, 2005). These projects include improvements related to fish passage, fish habitat, riparian vegetation, instream flow, wetlands, range/riparian habitat, and irrigation conditions. The restoration projects have also protected spawning habitat, restored channel morphology, and removed feedlots from streamside areas. Additional recent restoration efforts on Warren Creek have included riparian enhancement/grazing management and offsite watering in an effort to improve conditions related to habitat, substrate, temperature, and increased flows.

Departures

Compiled assessment data for five Warren Creek reaches indicate that all of the reaches meet riffle substrate Type I targets (**Table 5-39).** The highest riffle substrate percent fines measurements were made in Warr2, and these values meet the Type I targets. With regard to Type I targets related to habitat units, however, none of the assessed reaches meet target values. The largest departure for pool frequency is within Warr12, which contained no pools. Warr5, which appears on the air photos to be affected by dewatering, has the lowest residual pool depth value at 0.7.

Macroinvertebrate data were collected in November 2004 in Warr3 and Warr5 in an effort to assess human-caused impairments prior to stream restoration activities (Bollman, 2005) **Table 5-40**. MMI and RIVPACS metric values are not yet available for these samples. The data have been evaluated using a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman, 1998).

Results of the bioassessment approach applied by Bollman (2005) indicate that in Warr5 the caddisfly and clinger taxa imply clean stony substrate habitats that "were probably not excessively contaminated with deposited sediments." However, taxa richness and predator diversity values suggest monotonous or disrupted instream habitats. The stonefly richness implies stable streambanks, unaltered channel morphology, and functional riparian zones. Macroinvertebrate data from Warr3 suggest that water quality conditions in this reach are somewhat better than in Warr5, although slight impairment and partial support for aquatic life were evident. According to Bollman (2005), the Warr3 data caddisfly and clinger taxa results indicate a lack of influence by sediment deposition. However, the overall taxa richness and predator taxa results suggest that instream habitat diversity and complexity were limited.

Table 5-39. Sediment/Habitat Indicator Values and Targets, Warren Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
E 1)Warr2 2)Warr3 3)Warr5 4)Warr9 5)Warr12	**Riffle substrate: <6mm (%)**	**17**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**11**	**≤34**		√
	Pool Frequency (pools/mile)	**0**	**≥40**		**X** $_{(1,2,3,4,5)}$
	Residual Pool Depth (ft)	**0.7**	**≥1.5**		**X** $_{(1,2,3,4,5)}$
	Median W:D Ratio	12.4	6-11	Type II	$X_{(1)}$
	Median pool tailout surface fines <6mm (%)	63	≤48		$X_{(1)}$
	Woody Vegetation Extent (%)	0	≥69		$X_{(2,3,4,5)}$
	Pool Extent (%)	0	≥19	Supp. Indicator	$X_{(1,2,3,5)}$
	Woody Debris Aggregate Extent (%)	0	≥12		$X_{(3,4,5)}$

From site with highest departure from target

Table 5-40. 2004 Warren Creek Macroinvertebrate Metrics

Macroinvertebrate Metric	Warr3		Warr5	
	Metric Value	Metric Score	Metric Value	Metric Score
Ephemeroptera (mayfly) taxa richness	2.25	1	1	0
Plecoptera (stonefly) taxa richness	3.5	3	4.5	3
Trichoptera (caddisfly) taxa richness	6.75	3	6.25	3
Number of sensitive taxa	2	2	0.5	1
Percent filter feeders	48.61	0	37.85	0
Percent tolerant taxa	26.93	1	37.01	0
Total Score (Max = 18)		10		7
Percent of Max		55.6		38.9
Impairment Classification	Slight		Moderate	
Use Support	Partial		Partial	

Reference: Bollman 2004

Water Quality Impairment Status

The target departure in **Table 5-39** that addresses fine sediment explicitly is the 63% view bucket result in reach Warr2. Field notes recorded during the assessment describe common fine sediment accumulations in both pool tailouts and slower flowing water upstream of debris jams. This condition was believed to result from historic logging in the riparian zone. Within the only assessed reaches having definable pools (Warr1 and Warr2), those pools are accumulating fine sediment. The habitat downstream of Warr2 has been homogenized by channelization and removal of woody vegetation to the point where pools or stream channel obstructions that might create pools are minimal. However, the large percentages of filter feeders within reaches Warr3 and Warr5 and the corresponding low metric scores for both reaches (**Table 5-40)**. suggest that fine sediment is affecting aquatic life farther downstream. The record of fine sediment in observed pools and the larger percentages of filtering organisms suggests a fine sediment supply that justifies the listing of the stream for sedimentation/siltation and development of a sediment TMDL.

No specific data are available to address the current status of fish passage barriers on Warren Creek. As recent restoration efforts have focused on improving fish passage, it is possible that identified barriers have been remedied. However, to ensure the full support of the cold water fishery, the issue of fish passage barriers is addressed in the WQRP. With regard to the flow alteration listing, pool habitat-related measurements indicate potentially detrimental effects of flow alterations. As such, it is also appropriate to address the flow alteration listing in the WQRP (**Section 10.0**).

5.3.10 Monture Creek

Monture Creek is a fourth order tributary to the Blackfoot River. The listed segment of Monture Creek extends from its headwaters to its mouth at the Blackfoot River. The stream is considered partially supporting of aquatic life and the cold water fishery uses (**Section 2.0**). The 2006 303(d) Listing for Monture Creek is alteration in streamside vegetative cover, and the listed source of impairment is riparian grazing (**Section 2.0**). The 1996 303(d) List included a siltation impairment listing on Monture Creek.

Monture Creek consists of 13 stream reaches (A**ppendix A; Appendix B**). Mont1 through Mont4 flow through a largely confined, forested valley bottom. Mont5 extends to the USFS Rd 107 bridge and consists of a moderately sinuous stream that has active bar formation and lateral channel migration. Mont5 has extensive woody debris jams, and local vegetation patterns indicate historic riparian timber harvesting (**Appendix B**). Mont6 extends from the bridge to the Dunham Creek confluence; this reach consists of a pool-riffle channel with active sediment storage in both point bars and mid-channel bars. Within this reach, the relatively open valley bottom suggests historic riparian timber harvest. Riparian harvest is also evident in Mont7, which consists of a sediment-laden channel with active channel migration and bar formation. In Mont8, the stream emerges from the forested valley to flow through wetland complexes and against actively irrigated hayfields. Mont9 continues to flow through wetland complexes, and the channel locally abuts glacial deposits that form the west valley wall. Mont10 extends to Highway 200 and consists of a sinuous channel that intermittently abuts glacial deposits to the east. Abandoned channel segments support emergent wetlands in this reach. Below Highway 200, Mont11 follows a forested hillslope on its eastern valley margin, and there is evidence of riparian degradation through the reach (**Appendix B**: Aerial Assessment). Mont 12 consists of a pool/riffle channel that is bound by a moderately dense willow corridor, and Mont13 is entrenched into the valley margin of the Blackfoot River. Results of the aerial assessment indicate that riparian degradation is evident along Monture Creek from Mont5 to the confluence with the Blackfoot River.

Monture Creek supports populations of bull trout, WSCT, rainbow trout, brown trout, and brook trout (Pierce, et al, 2002b). According to Montana Fish, Wildlife, and Parks (Pierce, et al, 2002b), most fisheries impairments for Monture Creek were corrected in the 10 years prior to 2002. However, as of 2002, localized impairments identified on lower Monture Creek include channel alterations, lack of instream complexity, degraded riparian vegetation, livestock damage to stream banks, and a low level infection of whirling disease. Completed restoration projects on Monture Creek as of 2005 include spawning habitat protection, channel restoration, streamside feedlot removal, and improvements to fish habitat, riparian vegetation, instream flows, wetlands, range/riparian habitat, and irrigation practices (Blackfoot Challenge, 2005). Additional restoration activities slated for implementation in 2005 includes grazing management efforts from 0.5 to 1.5 miles upstream of the Blackfoot River confluence in an effort to improve habitat and reduce sediment accumulations in the stream channel. This area corresponds to reaches Mont12 and Mont13.

Departures

Compiled assessment data for Monture Creek indicate that Type I pebble count targets for riffle substrate are met on all Monture Creek reaches; however, McNeil Core Type I targets are not met in reach Mont5 (**Table 5-41**). The Type I targets of pool frequency and residual pool depth are not met on multiple reaches.

The base parameter assessment data reflects 2004 conditions; subsequent restoration in reach Mont12 may have significantly improved conditions within this reach. Periphyton data collected in August 2004 show only minor sediment impacts and full use support in Monture Creek (Weber, 2005, **Table 5-42**).

Table 5-41. Sediment/Habitat Indicator Values and Targets, Monture Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
C 1)Mont5 2)Mont7 3)Mont10 4)Mont12	**Riffle substrate: <6mm (%)**	**13**	**≤15**	**Type I**	√
	Riffle substrate: <2mm (%)	**11**	**≤11**		√
	McNeil Cores <6.35 mm (%)	**32.7**	**≤27**		**X** (1)
	Pool Frequency (pools/mile)	**13.2**	**≥33**		**X** (3,4)
	Residual Pool Depth (ft)	**1.4**	**≥2**		**X** (1,4)
	Median W:D Ratio	38.5	12-29	Type II	X (2,3)
	Median pool tailout surface fines <6mm (%)	22	≤20		X (4)
	McNeil Cores <2mm (%)	18.8	≤15		X (1)
	McNeil Cores <0.85 mm (%)	8.6	≤6		X (1)
	Woody Vegetation Extent (%)	78	≥84		X (1,3,4)
	MMI	59.4	≥48		√
	RIVPACS O/E	0.69	≥0.8		X (3)
	Pool Extent (%)	21	≥35	Supp. Indicator	X (2,4)
	Woody Debris Aggregate Extent (%)	7	≥8		X (1,3)

From site with highest departure from target

Table 5-42. 2004 Periphyton Metrics for Monture Creek

Metric	Score	Impairment
	B-9 Monture Cr near Ovando	
Species Richness	59	None
Diversity Index	3.96	None
Pollution Index	2.43	Minor
Siltation Index	9.03	None
Disturbance Index	16.82	None
% Dominant Species	33.33	Minor

Reference: Weber, 2005

Water Quality Impairment Status

The 2006 303(d) Listing for Monture Creek is alteration in streamside vegetative cover. The stream was listed for siltation in 1996. The woody vegetation extent target for the C channel types is met on only one reach of Monture Creek (Mont7). The values of this supplemental indicator, in combination with significant departures from the Type I targets of pool frequency and residual pool depth, support the 2006 listing of altered streamside vegetation cover.

Type I riffle substrate targets are met on Monture Creek. However McNeil Core and view bucket results in pool tails suggest excess fines in Mont5 and Mont12. The departures from pool frequency and depth are also exceeding targets in these reaches and in reach Mont10. Despite the persistence of these fine sediment indicators, increases in both bull trout and WSCT redd numbers from 74 in 1999 to 101 in 2002 and concurrent fisheries monitoring showed a strong positive trend in juvenile bull trout counts (Pierce et al 2004). However, the magnitude and extend of the target departures suggest that the stream has a higher potential for fine sediment transport and pool formation that warrants a sedimentation/siltation listing and development of a sediment TMDL.

Periphyton data show no impairment with respect to the siltation index. Further improvement in fine sediment indicators are expected with restoration and recovery of affected stream-side vegetation in the reaches between Mont6 and Mont11. Details addressing the impairment of stream-side vegetative covers will be addressed in **Section 10.0**.

5.3.11 Chamberlain Creek

Chamberlain Creek is a second order tributary to the Blackfoot River. The stream was listed in 1996 as impaired by flow alterations, habitat alterations, and suspended solids. The assessment record for these listings specifically mentions several sediment sources including channel diversions, riparian grazing damage, and road sediment. In 1989 an off-channel pond was constructed about 500 meters upstream from the mouth and the channel modified to divert the stream into the pond. Between 1990 and 1997 the pond was relocated, and the diversion was removed. Large woody debris placement and riparian grazing management changes have occurred within a mile of the mouth. Approximately 3000 acre-feet of flow were donated for instream flow and the formerly diverted Pearson Creek tributary was reconnected to Chamberlain Creek augmenting flow by an additional cubic foot per second. Additional flow augmentation followed conversion of flood irrigation to sprinkler methods. Road drainage and crossing improvements further reduced sediment loading. In 2000 Chamberlain Creek was determined to be fully supporting all beneficial uses and has maintained use support since 2000. Therefore, Chamberlain Creek was not included in the 2004 base parameter assessment. The stream was not listed as impaired in 2006 (**Section 2.0**). No sediment TMDL will be required for Chamberlain Creek.

5.3.12 Cottonwood Creek

Cottonwood Creek is a major third order tributary to the Blackfoot River. The stream was identified as fully supporting of all beneficial uses (**Section 2.0**) and thus does not have 303(d) impairment listings for 2006 (**Section 2.0**). In 1996 however, Cottonwood Creek was listed for flow alterations, habitat alterations, and siltation.

Cottonwood Creek consists of six reaches (**Appendix A; Appendix B**). The uppermost reach, CttnBlk0, is located above the original listed stream segment. This reach was assessed as part of the 2004 base parameter assessment due to concerns regarding use support for a cold water fishery. CttnBlk0 is characterized by a manipulated, relatively straight channel that flows through a harvested valley bottom. In CttnBlk1, the channel flows on the eastern margin of a topographic depression that appears to be glacial in origin. Much of the reach has had timber harvesting on the channel margins. CttnBlk2 flows through a densely vegetated willow bottom within a moderately confined valley. Numerous wetland complexes are located within the reach. In CttnBlk3, the valley bottom widens significantly, and willows are discontinuous but locally dense. CttnBlk4 has been channelized, and in-stream irrigation structures divert flows into an off-stream storage reservoir. CttnBlk5 extends to Highway 200, and this reach is characterized by multiple channels and broad wetland areas with dense willow margins. Below Highway 200, CttnBlk6 flows through an entrenched valley as it approaches the base level control of the Blackfoot River.

The lower reaches of Cottonwood Creek support low densities of rainbow and brown trout (Pierce, et al, 2002b). Moderate numbers of brown and brook trout have been identified in the middle reaches, and the upper reaches of the stream contain moderate densities of WSCT and low numbers of bull trout. The stream has been identified as a bull trout core area (Pierce, et al, 2002b). Fisheries impairments identified in the middle and lower reaches of Cottonwood Creek include lack of complex fish habitat (instream wood), livestock induced stream bank degradation, riparian vegetation suppression, and whirling disease.

Restoration projects completed on Cottonwood Creek since 1990 have addressed issues related to irrigation ditch losses, streamside feedlots, fish passage, riparian vegetation, instream flows, wetlands, range/riparian habitat, and irrigation (Blackfoot Challenge, 2005). A water lease was implemented in 1997 to improve fish passage in native fish migration corridors. In lower Cottonwood Creek, an open ditch was shut down in 2003 with conversion of flood irrigated lands to a sprinkler irrigation system.

Departures

The use support in Cottonwood Creek is based upon measured values from three assessment reaches: CttnBlk0, CttnBlk2 and CttnBlk4. Additional McNeil core data were available from CttnBlk3. Pool frequency is the only Type I target met in the headwaters reach. This reach meets no Type I targets relating to substrate particle size and has only half of the expected residual pool depth, another Type I target (**Table 5-43**). These data suggest that excess fine sediment is being delivered to the channel and filling pools. The reach has an adequate number of pools, but they are small and the extent of this habitat feature is limited.

Conditions improve downstream in the relatively short CttnBlk2 reach, in which all Type I targets are met. Woody vegetation extent is the only unmet Type II target in this intermediate reach, which was identified as providing potential reference parameter conditions. Just downstream, McNeil core data from CttnBlk3 do not meet Type I or Type II substrate targets. All measured McNeil core fractions show substantial departure from target values. Reach CttnBlk4 is largely channelized with considerable removal of woody riparian vegetation and two significant diversions. CttnBlk4 does not meet any Type I targets, reflecting conditions of excess fine sediment and relatively low channel complexity.

Table 5-43. Sediment/Habitat Indicator Values and Targets, Cottonwood Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
C 1)CttnBlk0 2)CttnBlk2 3)CttnBlk4	**Riffle substrate: <6mm (%)**	**18**	**≤15**	**Type I**	**X (1,3)**
	Riffle substrate: <2mm (%)	**16**	**≤11**		**X (1,3)**
	McNeil Cores <6.35 mm (%) (CttnBlk3)	**37.1**	**≤27**		**X**
	Pool Frequency (pools/mile)	**19.8**	**≥55**		**X (3)**
	Residual Pool Depth (ft)	**1.1**	**≥2**		**X (1,3)**
	Median W:D Ratio	18.9	12-19	Type II	√
	Median pool tailout surface fines <6mm (%)	10	≤20		√
	McNeil Cores <2mm (%) (CttnBlk3)	21.5	≤15		X
	McNeil Cores <0.85 mm (%) (CttnBlk3)	11.8	≤6		X
	Woody Vegetation Extent (%)	54	≥84		X (1,2)
	Pool Extent (%)	8	≥35	Supp. Indicator	X (1,3)
	Woody Debris Aggregate Extent (%)	0	≥8		X (1,2,3)

From site with highest/closest departure from target

Water Quality Impairment Status

Although Cottonwood Creek was determined to be fully supporting of the aquatic life and cold water fishery beneficial uses in 2006, the departure from target conditions indicates that the stream has a higher potential for fisheries use support. The substrate and habitat data collected within the assessed reaches indicate that the 1996 siltation listing is still warranted, and that a sediment TMDL is appropriate for the formerly listed stream segment. The data also support the flow and habitat related listings of 1996, and these pollution-related impairments are addressed in the WQRP.

5.3.13 Richmond Creek

Use support on Richmond Creek was essentially unassessed in 1996 except for its “threatened” fisheries support status attributed to organic loading and siltation. The drainage was extensively traversed with roadways and logged during the 1970s and 1980s. DEQ conducted an assessment of Richmond Creek in 2003, and applicable targets from that assessment are compared to reach values in **Table 5-44**.

Table 5-44. Sediment/Habitat Indicator Values and Targets, Richmond Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
B Site C03RHMDC01	**Riffle substrate: <6mm (%)**	**37**	**≤20**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**33**	**≤10**		**X**
	Macroinvertebrate Populations, MMI	0.84	≥0.63	**Type II**	√
	Macroinvertebrate Populations, RIVPACS	1.03	≥0.8		√

Departure
Fine sediment accumulations remain a problem in Richmond Creek as evidenced by the 2003 substrate data. Both fine sediment size fractions exceed target values established for B channel types by substantial margins. However, Type II macroinvertebrate metric scores for the 2003 sample indicate full support for aquatic life. An analysis of 2003 periphyton data concluded an elevated siltation index for Richmond Creek but only a minor degree of impairment (Bahls 2004).

Water Quality Impairment Status
Failure of the stream to meet the only measured Type I target parameters is justification for a finding of partial use support for aquatic life and cold water fisheries and a sediment TMDL is required for Richmond Creek.

5.3.14 West Fork Clearwater River

All uses except fisheries were unassessed on the West Fork Clearwater River in 1996. The cold water fishery use was listed as threatened. The 2004 stream bank erosion and base parameter assessment was not conducted on the West Fork. Available Type I and Type II target data from two sites assessed in 2003 by DEQ are compared with B and C channel type targets in **Table 5-45**.

Table 5-45. Sediment/Habitat Indicator Targets For West Fork Clearwater River

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
B Sites C03CLR WF10	**Riffle substrate: <6mm (%)**	**28**	**≤20**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**20**	**≤10**		**X**
	Macroinvertebrate Populations, MMI	0.79	≥0.63	Type II	√
	Macroinvertebrate Populations, RIVPACS	1.17	≥0.8		√
B Site C03CLR WF20	**Riffle substrate: <6mm (%)**	**25**	**≤20**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**25**	**≤10**		**X**
	Macroinvertebrate Populations, MMI	0.85	≥0.63	Type II	√
	Macroinvertebrate Populations, RIVPACS	0.97	≥0.8		√

From site with highest/closest departure from target

Departure
Departures for the West Fork Clearwater River are similar to those on Richmond Creek, in that Type I substrate targets are not met and Type II macroinvertebrate targets are met. Periphyton samples from both streams indicate full support for aquatic life. However, the West Fork was determined to be fully supporting of aquatic life and cold water fisheries uses in 2006, whereas Richmond Creek was listed as impaired (**Section 2.0**). This finding stems from the characterization of the West Fork riffle substrate values for percent fines ≤6mm and ≤2mm as being "in appropriate ranges," whereas the larger departures between site values and targets on Richmond Creek (**Table 5-44**) exceeded this unspecified threshold.

Water Quality Impairment Status

The target for riffle surface substrate less than 6mm for B channel types in the Middle Blackfoot TPA (≤20 percent) reflects the 75th percentile of a reference data set representing 40 B streams in the Beaverhead-Deerlodge National Forest. Because data were available from only one B stream type (Buck Creek) in the Middle Blackfoot for this size fraction, a reference dataset from another southwest Montana mountain range was substituted. Despite the difference between Richmond Creek and the West Fork Clearwater in the degree of target departure for the ≤6mm fraction, consistent application of the target indicates elevated fine sediment in both cases.

The targets for riffle surface substrate less than 2mm for B channel types represent minimally impacted upper reaches in the Nevada Creek watershed. As Buck Creek was the only assessed B channel type in the Middle Blackfoot, the 75th percentile value derived from reference B channels in Nevada Creek were used to develop the target. The Beaverhead Deerlodge National Forest data could not be used in target development because it does not include measured <2mm gradations.

The <2mm percent fines values in the West Fork are 2.5 times greater than the target values developed from minimally impacted reaches of Nevada Creek. Measured values on the West Fork for the <6mm fraction exceed targets developed from reference streams in the Beaverhead Deerlodge National Forest. These data suggest use support limitations due to fine sediment accumulations. A consistent use support conclusion requires that a sediment TMDL be completed for the West Fork Clearwater River, in a similar fashion as Richmond Creek.

5.3.15 Deer Creek

Deer Creek is a first order stream draining into Seeley Lake. The listed segment extends for 10.3 miles from the headwaters to the mouth. Use support on Deer Creek was unassessed in 1996 except for the “threatened” listing for the cold water fishery due to organic loading and siltation. The cold water fishery use is partially supported due to sedimentation/siltation on the 2006 listing. The identified sources of the impairment are construction and use of forest roads and silviculture harvesting (**Section 2.0**). DEQ assessed Deer Creek in 2003 at two sites: one about 7 miles above the mouth (C03DEERC10) and a second about 0.5 mile above the mouth (C03DEERC20). Similar to the West Fork of the Clearwater and Richmond Creek, Deer Creek assessment data for target parameters consists of riffle pebble counts and macroinvertebrate metrics. The values are compared to targets in **Table 5-46**.

Table 5-46. Sediment/Habitat Indicator Targets For Deer Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No
E Sites C03DEERC10	**Riffle substrate: <6mm (%)**	**29**	**≤36**	**Type I**	√
	Riffle substrate: <2mm (%)	**29**	**≤34**		√
	Macroinvertebrate Populations, MMI	0.71	≥0.63	Type II	√
	Macroinvertebrate Populations, RIVPACS	1.00	≥0.8		√
E Site C03DEERC20	**Riffle substrate: <6mm (%)**	**42**	**≤36**	**Type I**	**X**
	Riffle substrate: <2mm (%)	**36**	**≤34**		**X**
	Macroinvertebrate Populations, MMI	0.77	≥0.63	Type II	√
	Macroinvertebrate Populations, RIVPACS	1.00	≥0.8		√

Departure
All targets are met at the upper site. The lower site exceeds both Type I substrate targets indicating excess fine sediment. Periphyton samples collected at both sites indicate minor impairment and full use support.

Water Quality Impairment Status
The mixed results for substrate fine sediment leave some question as to whether the lower reach of the stream has recovered from historic fine sediment delivery. Therefore, a sediment TMDL is required for Deer Creek.

5.3.16 Buck Creek.

Buck Creek is a small first order tributary to Placid Creek, which flows into the Clearwater River just upstream of Salmon Lake. In 1996, the cold water fishery use on the stream was listed as impaired due to siltation (**Section 2.0**).The listed segment of Buck Creek extends from its headwaters to its mouth, a distance of approximately 2.5 miles.

Habitat and channel stability assessments of Buck Creek were completed during 1990, 1992, and 1996 using methods developed by Pfankuch (1978). A macroinvertebrate assessment of Buck Creek was completed by DHES in 1991 using a rapid bioassessment protocol developed by Plafkin and others (1989). DEQ conducted the stream bank erosion and base parameter assessment on a characteristic B channel reach of Buck Creek in July of 2004. **Table 5-47** contains a comparison of the site values with B channel targets.

Table 5-47. Sediment/Habitat Indicator Values and Associated Targets, Buck Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
B Buck1	**Riffle substrate: <6mm (%)**	**4**	**≤20**	**Type I**	√
	Riffle substrate: <2mm (%)	**4**	**≤10**		√
	Pool Frequency (pools/mile)	**52.8**	**≥20**		√
	Residual Pool Depth (ft)	**0.7**	**≥0.6**		√
	Median W:D Ratio	10.5	12-16	Type II	√
	Median pool tailout surface fines <6mm (%)	2	≤17		√
	Woody Vegetation Extent (%)	73	≥88		**X**
	Pool Extent (%)	11	≥10	Supp. Indicator	√
	Woody Debris Aggregate Extent (%)	4	≥3		√

Departure
The compiled assessment data for Buck Creek indicate that all targets are met, with the exception of woody vegetation extent.

Water Quality Impairment Status
The overall performance of Buck Creek with regard to Type I and Type II targets suggests that the stream is capable of supporting beneficial uses. Most importantly, the measured Type I parameters on Buck Creek do not support the 1996 siltation listing. Although the reach appears to be on a natural recovery trend following historic disturbances, field observations indicate that the stream is prone to dewatering due to flow infiltration into disturbed substrate. DEQ attempted an assessment of Buck Creek in August of 2004, but the stream channel was dry. The conifers in the current riparian woody vegetation have been replaced by shrubs.

Since all Type I targets, two of three Type II targets, and both supplemental indicators have been met, no sediment TMDL is proposed for Buck Creek in this document.

5.3.17 Blanchard Creek

Blanchard Creek is a second order tributary to the lower Clearwater River. The listed segment of Blanchard Creek extends for 2.3 miles from the North Fork confluence to the mouth. Blanchard Creek is considered partially supporting of aquatic life, cold water fishery, and non-supporting for contact recreation (**Section 2.0**). The 2006 sediment/habitat-related 303(d) Listings for Blanchard Creek are alteration in streamside vegetative cover, low flow alteration, and sedimentation/siltation (**Section 2.0**). Sources include agriculture, riparian grazing, flow alterations from water diversions, and highway/road/bridge runoff.

Blanchard Creek consists of two reaches (**Appendix A, Figure 29**). Blan1 flows through a confined valley with harvested hillslopes. Extensive dewatering has been observed in the reach. The stream channel emerges on to an alluvial fan in Blan2, and the riparian corridor is locally degraded due to proximal land uses (**Appendix B**).

Blanchard Creek supports WSCT, rainbow trout, and brown trout. Fisheries related impairments identified on Blanchard Creek include dewatering, channel alterations, road drainage problems, livestock induced stream bank degradation, and riparian vegetation suppression (Pierce, et al, 2002b). Past restoration projects on Blanchard Creek involved the installation of diversions with fish ladders and flow enhancement between 1990 and 2002 (Blackfoot Challenge, 2005). Additionally, some grazing improvements have been implemented on State lands.

Departures
Compiled assessment data for Blanchard Creek indicate that the stream meets Type I targets related to substrate, but does not meet those related to habitat units (**Table 5-48**). Type II targets are similarly split; whereas targets related to substrate and MMI macroinvertebrate metrics are met, those regarding width to depth ratio, woody vegetation extent, and RIVPACS macroinvertebrate metrics are not. Supplemental indicators do not achieve target levels on the reach.

Table 5-48. Sediment/Habitat Indicator Values and Targets, Blanchard Creek

Channel Type/ Reach	Parameter	Site Value	Target	Target Type	Target Met? √=Yes X=No
C Blan1	**Riffle substrate: <6mm (%)**	**6**	**≤15**	**Type I**	√
	Riffle substrate: <2mm (%)	**5**	**≤11**		√
	McNeil Cores <6.35 mm (%)	**22.3**	**≤27**		√
	Pool Frequency (pools/mile)	**19.8**	**≥55**		**X**
	Residual Pool Depth (ft)	**0.7**	**≥2**		**X**
	Median W:D Ratio	22.9	12-19	Type II	X
	Median pool tailout surface fines <6mm (%)	2	≤20		√
	McNeil Cores <0.85 mm (%)	6.3	≤6		√
	Woody Vegetation Extent (%)	42	≥84		X
	MMI	57.4	≥48		√
	RIVPACS O/E	0.65	≥0.8		X
	Pool Extent (%)	8	≥35	Supp. Indicator	X
	Woody Debris Aggregate Extent (%)	2	≥8		X

Water Quality Impairment Status
The measured substrate values on Blanchard Creek meet Type I targets, suggesting that the 2006 sedimentation/siltation listing may not be warranted. However, the major departures of the Type I pool frequency and residual pool depth values indicate that sediment in excess of the channel transport capacity may be causing pool filling. Because of these measured departures in parameters that are linked to excess sediment, a sediment TMDL for Blanchard Creek is required. The data also support the vegetation and low flow alterations listings, and, as such, these types of pollution are addressed in the WQRP (**Section 10.0**).

5.4 Sediment and Habitat TMDL Summary

Table 5-49 summarizes the needed sediment TMDLs and sediment and habitat impairments described in **Sections 5.2 and 5.3** for the Nevada Creek and Middle Blackfoot TPAs. The table identifies 31 sediment related impairments for TMDL development; and 24 habitat and 17 flow related impairments to be addressed in the WQRP.

Table 5-49. Sediment TMDL Summary for Streams in the Middle Blackfoot-Nevada Creek TMDL Planning Area

Stream Name	Sediment TMDL Developed? (Y/N)
Upper Washington Creek	Y
Lower Washington Creek	Y
Upper Jefferson Creek	Y
Lower Jefferson Creek	Y
Gallagher Creek	Y
Buffalo Gulch	Y
Upper Nevada Creek	Y
Braziel Creek	Y
Black Bear Creek	Y
Murray Creek	Y
Upper Douglas Creek	Y
Cottonwood Creek (Douglas Creek)	Y
Lower Douglas Creek	Y
Nevada Spring Creek	Y
McElwain Creek	Y
Lower Nevada Creek	Y
Yourname Creek	Y
Wales Creek	Y
Frazier Creek	Y
Ward Creek	Y
Kleinschmidt Creek	Y
Rock Creek	Y
North Fork Blackfoot River	N
Warren Creek	Y
Monture Creek	Y
Blackfoot River (Nevada Cr. to Monture Cr.)	Y
Chamberlain Creek	N
Cottonwood Creek (Blackfoot R.)	Y
Richmond Creek	Y
West Fork Clearwater River	Y
Deer Creek	Y
Buck Creek	N
Blanchard Creek	Y
Blackfoot River (Monture Cr. To Clearwater R.)	Y

5.5 Sediment Source Assessment

Erosion is the main source of non-point source sediment that results in siltation and habitat impairments. In addition, eroded sediment can carry nutrients, particularly phosphates, and contribute to eutrophication of lakes and streams. The two major types of erosion are geological erosion and erosion from human and animal activities (Ward and Trimble, 2004). Geological erosion results in the long-term development of topographic features such as stream channels, valleys, and canyons and contributes to soil formation. Tillage, road drainage, and vegetation removal by humans and grazing animals may cause accelerated erosion. Other variables affecting erosion include climate, geology, soil properties, vegetation, and topography.

Sources of sediment delivered to streams in the Blackfoot River watershed include hillslope erosion, road disturbances, and stream bank erosion, each having some degree of human influence. Three source assessments examine sediment delivery in the Middle Blackfoot and Nevada Creek TPAs: (1) a computational model addressing hillslope erosion, (2) a field inventory conducted in 2004 assessed stream bank erosion and habitat alterations (DTM and AGI, 2005) and, (3) a roads assessment conducted in 2005 that measured sediment related to road crossings (RDG, 2006).

Indicators of sediment impairment for each stream on the 303(d) List include stream substrate and habitat measurements as described in **Section 5.10. Sections 5.2 and 5.3** list the indicators of sediment and habitat impairment for each 303(d) Listed stream in the Nevada Creek and Middle Blackfoot TPAs respectively.

5.5.1 Hillslope Erosion

Hillslope erosion occurs throughout the Blackfoot River watershed in areas ranging from steep, forested headwaters, to relatively flat agricultural valley bottoms. Natural hillslope erosion can accelerate as a result of human disturbances such as silviculture, agricultural practices, and livestock grazing. Hillslope erosion in the Middle Blackfoot-Nevada Creek TPA was evaluated through use of the Soil and Water Assessment Tool (SWAT) model (Neitsch et al. 2002).

SWAT was developed for the USDA Agricultural Research Service to predict the affects of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds. Input data describing the climate, soil properties, topography, vegetation, and land management practices are processed by SWAT to model long-term water and sediment movement, crop growth, and nutrient cycling. SWAT calculates erosion caused by rainfall and runoff using the Modified Universal Soil Loss Equation (MUSLE) Williams 1975). MUSLE is a modified version of the Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith (1965, 1978). In the MUSLE, sediment yield is a function of the following:

- surface runoff volume
- peak runoff rate
- area
- soil erodibility
- land cover and management
- soil support practices
- topography
- soil rock content

The SWAT model required the partitioning of the Blackfoot River watershed into 65 subbasins having similar climate. The subbasins ranged in size from one to 130 square miles. The Nevada Creek TPA contains 21 of the subbasins and the Middle Blackfoot TPA contains 25. The remaining 19 subbasins are in the Upper and Lower Blackfoot TPAs. Each subbasin was further divided into areas of representative soil and land cover conditions called hydrologic response units (HRU) that are the principal, uniform landscape response area used in the SWAT model. The Blackfoot River watershed contained 633 HRUs.

For this investigation, 12 calibration parameters that govern snow accumulation and melt, precipitation/runoff, and subsurface flow processes in SWAT were calibrated on the Blackfoot Watershed using the model's auto-calibration tool. Based on available precipitation and temperature data from ten National Weather Service and NRCS SNOTEL climatic stations within or near the watershed, hydrologic model parameters in SWAT were calibrated for a period of record from 2002 to 2004 at five USGS stream gaging locations:

- Nevada Creek above the reservoir
- Nevada Creek below the reservoir
- Blackfoot River above Nevada Creek
- North Fork of the Blackfoot River
- Blackfoot River at Bonner

Manual adjustments were made at each of the five locations to fine tune the auto-calibration. Available stream flow data at Nevada Creek above the reservoir, the North Fork of the Blackfoot River, and the Blackfoot River near Bonner from 1998 to 2001 were used for model validation. The same five sites used for the hydrologic calibration were used to calibrate parameters governing sediment re-entrainment in channels and nitrogen and phosphorus movement within the watershed. The sediment and nutrient data available at any one of the five model nodes were limited to between five and 16 measured values for the calibration parameters. The calibration period for sediment, nitrogen, and phosphorus was 2002 through 2004.

After calibration, the SWAT simulations for sediment, nitrogen, and phosphorus movement covered the period from January 1, 1996, through December 31, 2004. Results for the nine-year period were averaged to generate the annual sediment yields tabled below.

5.5.1.1 Nevada Creek Planning Area

Table 5-50 lists the results for 303(d) stream segments in a downstream direction. The values for sediment yield in the table are added cumulatively from the headwaters of the planning area to the mouth of Nevada Creek. The SWAT model simulation for the years 1996-2004 predicts a mean annual total of 26,876 tons of sediment delivered from the Nevada Creek TPA through hillslope erosion. Modeled results for SWAT subbasins constituting a portion of a listed segment are combined to give a total for that segment. For example, sediment yield for Upper Nevada Creek comprises values for subbasins delineating the Nevada Creek headwaters, Halfway Creek, and intervening Nevada Creek segments upstream of Nevada Lake.

Table 5-50. Cumulative SWAT Modeling Results for Hillslope Erosion in the Nevada Creek Planning Area

Stream Name	Hillslope Sediment Yield (tons/yr)
Upper Washington Creek	407
Lower Washington Creek	428
Upper Jefferson Creek	482
Lower Jefferson Creek	484
Gallagher Creek	459

Table 5-50. Cumulative SWAT Modeling Results for Hillslope Erosion in the Nevada Creek Planning Area

Stream Name	Hillslope Sediment Yield (tons/yr)
Buffalo Gulch	1,002
Upper Nevada Creek	4,498
Braziel Creek	182
Black Bear Creek	328
Murray Creek	6,486
Upper Douglas Creek	9,749
Cottonwood Creek	8,319
Lower Douglas Creek	21,057
Nevada Spring Creek	0
McElwain Creek	507
Lower Nevada Creek	26,876

In general, steep headwater areas produce sediment at higher rates than flat valley bottoms. The five largest contributors of hillslope derived sediment are Cottonwood Creek, Murray Creek, Lower Douglas Creek, Upper Douglas Creek, and Upper Nevada Creek which collectively contribute approximately 85% of the hillslope sediment from listed streams in the Nevada Creek TPA.

5.5.1.2 Middle Blackfoot Planning Area

Table 5-51 contains the simulated hillslope erosion results for the Middle Blackfoot TPA. As with the case above for Nevada Creek, the values in the table are entered cumulatively from the headwaters segments to the Blackfoot River below the mouth of the Clearwater River. The SWAT model simulated an annual average of 87,233 tons of hillslope sediment delivered from 303(d) Listed stream basins. Note that the largest contributor of hillslope derived sediment is the North Fork Blackfoot River. The combined contribution form listed and unlisted portions of the North Fork drainage contribute approximately 65% of the hillslope sediment in the Middle Blackfoot TPA.

Table 5-51. Cumulative SWAT Modeling Results for Hillslope Erosion in the Middle Blackfoot Planning Area

Stream Name	Hillslope Sediment Yield (tons/yr)
Yourname Creek	732
Wales Creek	174
Frazier Creek	103
Ward Creek	176
Kleinschmidt Creek	205
Rock Creek	20,602
North Fork Blackfoot River	73,642
Warren Creek	270
Monture Creek	1,928

Table 5-51. Cumulative SWAT Modeling Results for Hillslope Erosion in the Middle Blackfoot Planning Area

Stream Name	Hillslope Sediment Yield (tons/yr)
Blackfoot River (Nevada Creek to Monture Creek)	103,757
Chamberlain Creek	1,081
Cottonwood Creek	2,950
Richmond	91
West Fork Clearwater	1392
Deer Creek	2,770
Buck Creek	225
Blanchard Creek	410
Unlisted Clearwater Watershed	25,198
Blackfoot River (Monture Creek To Clearwater River)	114,021
Totals	**139,306**

The **Table 5-51** total contains loading estimates from both listed and unlisted streams. Unlisted portions of the Nevada Creek TPA are small and are included as tributary loading to listed waters. For Example, Halfway Creek is treated as a tributary to Upper Nevada Creek, Chimney Creek is treated as a tributary to Lower Douglas Creek, and loading from several small unlisted tributaries flowing from the east into Lower Nevada Creek are included in Lower Nevada Creek loading.

Unlisted tributaries in the Middle Blackfoot TPA include the North Fork Blackfoot River and a significant part of the Clearwater River drainage. **Table 5-51** specifies approximately 25,200 tons/year from unlisted Clearwater streams. SWAT estimated 25,182 tons/year of hillslope loading from the Blackfoot upstream of Nevada Creek. This brings the estimated drainage basin total to 164,448 tons in the Blackfoot River mainstem below the mouth of the Clearwater River.

5.5.2 Streambank Erosion

The base parameter and streambank erosion inventory project undertaken in 2004 (DTM and AGI, 2005) included direct measurement of sediment from eroding banks on representative reaches of 303(d) Listed streams. These reaches correspond to those given in the target departure tables described in **Sections 5.2 and 5.3** for each listed stream segment. For listed streams that were not directly assessed in the field, measured values from listed streams were extrapolated to similar streams. Bank erosion for unmeasured, non-303(d) Listed streams was modeled based upon the relationship between measured values from unlisted streams and volume of upstream precipitation. The model output is an estimate of bank erosion from “typical” stream conditions and is the basis for extrapolation of loads in reaches judged as representing average conditions given current land uses. **Appendix C** describes the model development methods. The following tables and discussion describe the streambank erosion assessment results.

5.5.2.1 Nevada Creek Planning Area

The Nevada Creek streambank erosion assessment results are given in **Table 5-52**. The stream names and assessment reaches for each stream are listed in a downstream direction. As with the hillslope erosion estimates in **Table 5-50**, the values for sediment load in the table are added cumulatively from the headwaters of the planning area to the mouth of Nevada Creek.

The inventory accounted for a total of 10,687 tons of sediment delivered from 303(d) Listed streams. Erosion rates generally increase downstream with the notable exceptions of Jefferson Creek and Lower Nevada Creek that suggest a large headwaters load in Upper Jefferson and significant loading to Nevada Creek from both below the dam and near the mouth (**Appendix A, Figure A-31**). As with the hillslope erosion source assessment, the results indicate that Douglas Creek, Nevada Creek, and Murray Creek are significant sediment contributors, comprising 73% of the total from impaired segments.

Table 5-52. Nevada Creek Planning Area Streambank Erosion Rates and Impaired Segment Sediment Loads

Stream Name	Reach Code	Reach Length (miles)	Erosion Rate (tons/mile/yr)	Cumulative Reach Load (tons/yr)	Cumulative Segment Load (tons/yr)
Upper Washington Creek	Wash1	3.6	4.4	16	296
	Wash2	3	93	280	
Lower Washington Creek	Wash3	4.4	169.7	754	1,050
Upper Jefferson Creek	Jeff1	5.8	92.5	536	536
Lower Jefferson Creek	Jeff2	1.8	0.7	1.3	537
Gallagher Creek	Gall1	2.5	4	10	100
	Gall2	2.9	31.1	89.5	
Buffalo Gulch	Buff1	2	4	8.1	158
	Buff2	3.7	22.5	82.7	
	Buff3	1.1	62	67.6	
Upper Nevada Creek	Nev1	4.4	4	17.4	3,480
	Nev2	1.9	14.5	27.8	
	Nev3	1.8	126.9	232.4	
	Nev4	2.3	93	212.5	
	Nev5	6.3	118	741.8	
	Nev6	4.2	95.7	402.6	
Braziel Creek	Braz1	1.7	0.6	1	262
	Braz2	2.2	104.8	233.4	
	Braz3	0.4	62	27.4	
Black Bear Creek	BlkBr1	2.1	0.3	0.6	113
	BlkBr2	2.5	0.4	1	
	BlkBr3	1	15.7	15.8	
	BlkBr4	3.1	30.9	94.8	
Murray Creek	Murr1	3.4	0.5	1.7	615
	Murr2	2.1	62	128.5	
	Murr3	3.8	126	484.6	

Table 5-52. Nevada Creek Planning Area Streambank Erosion Rates and Impaired Segment Sediment Loads

Stream Name	Reach Code	Reach Length (miles)	Erosion Rate (tons/mile/yr)	Cumulative Reach Load (tons/yr)	Cumulative Segment Load (tons/yr)
Upper Douglas Creek	Doug1	3.9	0.5	1.9	996
	Doug2	4	0.8	3.2	
	Doug3	4.7	9.4	43.8	
	Doug4	1.7	126	220	
Cottonwood Creek	CttnNv1	1.9	31	59.9	309
	CttnNv2	3.1	41.6	128.7	
	CttnNv3	2.9	41.6	120.7	
Lower Douglas Creek	Doug5	3.3	243.8	805.8	4,224
	Doug6	2.7	344	944.1	
	Doug7	2	445.1	902.7	
	Doug8	2.8	36	102.3	
	Doug9	1.5	109	163.8	
Nevada Spring Creek	-	2.9	8.5	25	25
McElwain Creek	McEl1	3	109.3	333	333
Lower Nevada Creek	Nev7	4.3	181.3	781.4	10,687
	Nev8	3.6	109.4	391	
	Nev9	3.6	8.5	30.3	
	Nev10	4.1	7	28.8	
Lower Nevada Creek	Nev11	1.5	59	90	10,687
(continued)	Nev12	3.6	5.2	18.7	
	Nev13	4.3	3.4	14.7	
	Nev14	7.3	138.3	1009.4	

Nevada Spring Creek that was listed as impaired for sediment in both 1996 and 2006 was not included in the base parameter and streambank erosion assessment of 2004 and, therefore, has no corresponding assessment reach in **Table 5-52**. As described in **Section 2.4**, complete stream channel reconstruction occurred during 2001 through 2003. During the planning of the 2004 streambank erosion inventory, the scale and degree of the completed restoration was deemed sufficient to address accelerated sediment loading from the banks of this spring-fed stream. Although evidence presented in **Section 5.2.7** documents continued fine sediment impairment and woody streambank vegetation limitations, these conditions are likely remnants from past grazing practices and restoration earth work and probably do not represent a degrading trend in bank condition.

A modeled value for bank erosion for Nevada Spring Creek would exaggerate loading since the stream flow is predominantly spring-fed rather than a response to precipitation. Other E channel types in the Nevada Creek TPA from **Table 5-52** have rates of 8.5 tons/miles/year (Nev9), 30.9 (BlkBr4), 22.5 (Buff2), and 9.4 (Doug3). Since Nev9 also has an altered hydrology (from diversion), the Nev9 rate of 8.5 tons/miles/year may be a reasonable estimate. This gives 24.7 tons/year when multiplied by the 2.9 mile listed channel length for Nevada Spring Creek.

Table 5-52 contains loading estimates from impaired channels only. A GIS based model, developed as part of the base parameter and streambank erosion assessment, was used to estimate the bank erosion component from non-303(d) streams (**Appendix C**). The modeled streambank erosion from all unlisted streams in the Nevada Creek TPA was 3,468 tons/year. The modeled load plus the **Table 5-52** total of 10,687 tons/year gives a total of 14,155 tons/year.

5.5.2.2 Middle Blackfoot Planning Area

Table 5-53 lists the results of the streambank erosion inventory for the Middle Blackfoot TPA. As with the Nevada Creek TPA figures in **Table 5-52**, the stream names and assessment reaches for each stream are listed in downstream order. The values in the total stream load column are added cumulatively from the headwaters of the planning area to its down stream end below the mouth of the Clearwater River and include the loading from the Nevada Creek TPA.

The streams in **Table 5-53** that have erosion rates and loads reported by reach were assessed as part of the 2004 base parameter and streambank erosion assessment described in **Appendix C**. Loading to streams without reach based assessments was estimated using the modeled relationship between measured values from unlisted streams and volume of upstream precipitation described in **Appendix C**. The modeled loads were calculated for Richmond Creek, West Fork Clearwater River, Deer Creek, Buck Creek, and the lower Clearwater River.

Due to their higher discharge, the main stem Blackfoot River segments, Monture Creek, and the North Fork Blackfoot River have higher erosion rates than tributary streams (**Appendix A, Figure A-32**). Monture, Ward, and Rock creeks have a trend of increased loading in middle reaches relative to headwater reaches and reaches nearer the mouth. Loading in Cottonwood Creek generally decreased downstream. Loading in Frazier and Yourname creeks generally increases downstream.

Table 5-53. Middle Blackfoot Planning Area Stream Bank Erosion Sediment Loads

Stream Name	Reach Code	Reach Length (miles)	Erosion Rate (tons/mile/yr)	Reach Load (tons/yr)	Cumulative Segment Load (tons/yr)
Yourname Creek	Your1	4.4	4	17.4	274
	Your2	2.8	4	11.3	
	Your3	0.7	31	20.2	
	Your4	2.1	109	225	
Wales Creek	Wale1	2.4	109	266.7	267
Frazier Creek	Fraz1	1.2	0.03	0.04	0.3
	Fraz2	2.2	0.04	0.1	
	Fraz3	1.3	0.08	0.1	
Ward Creek	Ward1	2	0.02	0	77
	Ward2	0.8	0.03	0	
	Ward3	2.9	23	65.6	
	Ward4	1.4	0.12	0.2	
	Ward5	1.9	0.14	0.3	
	Ward6	0.8	0.14	0.1	
	Ward7	0.6	0.14	0.1	
	Ward8	1.3	7.8	10.6	
Kleinschmidt Creek	Klein1	1.7	0.15	0.3	80
	Klein2	1.6	0.7	1.1	
	Klein3	1.9	0.7	1.3	

Table 5-53. Middle Blackfoot Planning Area Stream Bank Erosion Sediment Loads

Stream Name	Reach Code	Reach Length (miles)	Erosion Rate (tons/mile/yr)	Reach Load (tons/yr)	Cumulative Segment Load (tons/yr)
Rock Creek	Rock1	0.3	0.03	0	227
	Rock2	0.9	0.15	0.1	
	Rock3	2.3	0.39	0.9	
	Rock4	1.6	50	79.9	
	Rock5	1.1	50	57.4	
	Rock6	1.5	5	7.3	
	Rock7	2.6	0.5	1.3	
North Fork Blackfoot River					6,561
Warren Creek	Warr1	3.4	0.05	0.2	85
	Warr2	2.1	0.5	1.1	
	Warr3	1.7	8.5	15.1	
	Warr4	0.6	8	5	
	Warr5	1.1	7	7.4	
	Warr6	0.9	7	6.3	
	Warr7	1	7	6.7	
	Warr8	1.1	7	7.7	
	Warr9	0.6	0.24	0.1	
Warren Creek	Warr10	1.1	6	6.6	85
(continued)	Warr11	1.2	11	13.3	
	Warr12	1.4	10.5	15.1	
Monture Creek	Mont1	3.9	0.34	1.3	770
	Mont2	1.1	0.54	0.6	
	Mont3	7.5	0.98	7.4	
	Mont4	4.6	26	118.6	
	Mont5	1.4	64.1	90.4	
	Mont6	1.7	71.2	120.4	
	Mont7	1.2	78.2	95.5	
	Mont8	1.4	30	43.2	
	Mont9	2.3	30	68	
	Mont10	3.1	30	94	
	Mont11	1.6	30	47.4	
	Mont12	1.3	34.5	44.85	
Blackfoot River (Nevada Creek to Monture Creek)	Blkft1	1.6	893.5	1429.6	29,940
	Blkft2	2.8	893.5	2501.8	
	Blkft3	2.3	1154.0	2654.2	
	Blkft4	1.7	97.4	165.6	
	Blkft5	4.9	458.1	2244.7	
	Blkft6	3.0	302.3	906.9	
	Blkft7	3.3	154.0	508.2	
	Blkft8	1.7	520.3	884.5	
Chamberlain Creek					240
Cottonwood Creek	CttnBlk0	6.3	16.6	104.6	296
	CttnBlk1	3.1	16.6	51.4	
	CttnBlk2	2.2	16.6	35.9	
	CttnBlk3	2.9	14	41.2	
	CttnBlk4	1.3	11.6	14.8	
	CttnBlk5	3.1	11.6	35.8	
Richmond Creek			3		3

Table 5-53. Middle Blackfoot Planning Area Stream Bank Erosion Sediment Loads

Stream Name	Reach Code	Reach Length (miles)	Erosion Rate (tons/mile/yr)	Reach Load (tons/yr)	Cumulative Segment Load (tons/yr)
West Fork Clearwater River			371		371
Deer Creek			124		124
Buck Creek			5		5
Blanchard Creek	Blan1	1.8	21.9	39.7	59
	Blan2	0.9	21.9	19.2	
Lower Clearwater River				2,871	3,433
Blackfoot River (Monture Creek to Clearwater River)	Blkft9	4.3	520.3	2,237.3	37,911
	Blkft10	2.0	520.3	1,040.6	
	Blkft11	4.7	154.0	723.8	

Measured, extrapolated, and modeled contributions to streambank erosion from both listed and unlisted streams in the combined Middle Blackfoot-Nevada Creek total to 37,911 tons/year. To this figure are added 3,468 tons/year from unlisted streams in the Nevada Creek TPA, bringing the total streambank erosion load to 41,379 tons/year.

5.5.3 Sediment from Road Crossings

Surface erosion occurs when detachable soils on sufficiently steep slopes are exposed to overland flow or the impact of rainfall (WA Forest Practices Board, 1997). Road construction and use can expose bare soils to these processes and result in sediment delivery to streams. In addition, roads often encroach on streams, impact habitat or shade, or create fish passage barriers. **Section 2.0** of this document lists roads as one of the probable causes of sediment or habitat impairment for several of the 303(d) List streams in the Nevada Creek and Middle Blackfoot TPAs.

In summer 2005, field crews assessed sediment production from a sub-sample of road crossings in the two planning areas (RDG, 2006). This assessment followed protocols adapted from the Washington Forest Practices Board Watershed Assessment Methodology (WA Forest Practices Board, 1997). The sub-sample of crossings was selected to represent typical crossing conditions. Data from surveyed crossings was summarized by road ownership, precipitation zone, and surficial geology. Mean road erosion values were calculated for broad ownership, precipitation and surface geology categories identified by GIS analysis. These mean erosion values were extrapolated to unsurveyed road crossings in corresponding ownership, precipitation, and geology categories and added to the values for surveyed crossings to obtain an estimate of road erosion from both surveyed and unsurveyed crossings. The report on this project (RDG, 2006) quantifies these erosion values. In addition, to impacts from existing crossings, the RDG report estimates loading from culvert failure and identifies potential fish passage barriers.

5.5.3.1 Nevada Creek Planning Area

Table 5-54 lists the results of the road sediment inventory for the Nevada Creek TPA from the headwaters to the mouth of Nevada Creek. The stream drainages in the Nevada Creek TPA listed for sediment related impairments contain an estimated 718 road-stream crossings producing an estimated 790 tons/year of sediment. Road-stream crossings in the Douglas Creek drainage had the highest relative impact with an estimated 330 crossings producing approximately 520 tons/year of sediment.

Table 5-54. Road Crossing Sediment Loading for the Nevada Creek Planning Area

Stream Name	Number of Surveyed Crossings	Number of "Possible" Crossings	Road Surface Erosion Sediment from Surveyed Crossings (tons/yr)	Surveyed and Extrapolated Road Sediment Load (tons/yr)
Upper Washington Creek	6	9	2	8
Lower Washington Creek	2	8	2	7
Upper Jefferson Creek	14	21	7	8
Lower Jefferson Creek	3	4	2	1
Gallagher Creek	0	7	0	12
Buffalo	20	39	5.6	23
Upper Nevada Creek	7	18	2.2	29
Braziel Creek	3	13	7.4	31
Black Bear Creek	1	12	2.9	60
Murray Creek	1	50	0	100
Upper Douglas Creek	13	111	33	153
Cottonwood Creek	4	69	0.4	32
Lower Douglas Creek	7	88	17	167
Nevada Spring Creek	0	5	0	8
McElwain Creek	3	24	4	35
Roads on Non-Listed Streams	34	201	11	104
Lower Nevada Creek	4	39	1.3	12
Totals	122	718	97.8	790

Reference: RDG, 2006

5.5.3.2 Middle Blackfoot Planning Area

Table 5-55 lists the results of the road sediment inventory for the Middle Blackfoot TPA. The drainages listed for sediment related impairments contain an estimated 1818 road-stream crossings contributing approximately 1,684 tons/year of sediment. The estimated 43 crossings on Warren Creek contribute the largest amount of sediment of the 303(d) List tributaries. In the Middle Blackfoot, approximately 800 stream crossings that produce about 338 tons of sediment annually occur within non-303(d) stream segments.

Table 5-55. Road Sediment Loads for the Middle Blackfoot Planning Area

Stream Name	Number of Surveyed Crossings	Number of "Possible" Crossings	Road Sediment Load from Surveyed Crossings (Tons/Yr)	Surveyed and Extrapolated Road Sediment Load (Tons/Yr)
Yourname Creek	1	33	0	69
Wales Creek	1	4	0	6
Frazier Creek	1	8	1	10
Ward Creek	2	16	2	14
Kleinschmidt Creek	0	8	0	13
Rock Creek	5	29	3	20
N. F. Blackfoot River	7	79	25	117
Warren Creek	2	43	18	238
Monture Creek	6	121	14	172
Blackfoot River (Nevada Creek to Monture Creek)	0	39	0	62
Chamberlain Creek	5	109	1	140
Cottonwood Creek	27	177	20	183
Richmond Creek	2	11	0	5
W. F. Clearwater River	2	81	0	42
Deer Creek	48	68	30	39
Buck Creek	12	12	15	15
Blanchard Creek	79	97	87	111
Non 303(d) Listed Clearwater Streams	120	800	80	338
Blackfoot River (Monture Creek to Clearwater River)	3	83	3	90
Totals	323	1,818	299	1,684

Reference: RDG, 2006

Additional sediment loading due to culvert failure during high flow events is a possibility in both planning areas. A single crossing failure has the potential to greatly increase the annual sediment load to a stream. The 2005 assessment of sediment loading from culvert failure is described below.

5.5.4 Sediment from Culvert Failure

In addition to sediment from road surface erosion, sediment can also enter channels at road crossings as a result of culvert failure that directly adds road fill material to the stream. Risk of culvert failure is highest where the ratio of culvert diameter to bankfull channel width (constriction ratio) is less than one. Fill volumes and constriction ratios were measured at 73 culvert crossings in the Middle Blackfoot-Nevada Creek TPA as part of the 2005 TMDL field assessment (RDG 2006). Constriction ratios were less than 1 in 55 of the 73 sites. Data from these 55 sites were extrapolated to the sub-planning area level in the report by River Design Group (2006). A mean mass of 62.4 tons from 17 sites in the Nevada Creek sub-planning area was extrapolated to 718 sites for a total of 44,803 tons. A mean fill mass of 115.6 tons per site for 38 sites in the middle Blackfoot was extrapolated to 1818 sites for a total of 210,161 tons. The larger volume in the middle Blackfoot is likely due to the larger fill volumes required for crossings in its steeper terrain compared to that of the Nevada Creek watershed.

Current annual loading from culvert failure was estimated based on the assumption of a one percent annual failure rate. Lacking detailed analysis of failure rates, the one percent value is an estimated point of departure. Adjustments to this failure rate and the resulting loads are warranted when the results of more a detailed culvert failure analysis are available for the planning area. This assumption gave an annual load of 448 tons in the Nevada Creek TPA and 2,102 tons for the middle Blackfoot TPA. Estimates of culvert failure loading and loading reductions per listed segment are described in **Section 9.1.4.**

5.5.5 Sediment Source Summary

The four components of the sediment source assessment, hillslope, bank erosion, and road surface erosion at crossings and culvert failure, combined give the estimated total sediment load for each of the two planning areas. Figures for the total estimated sediment loading is summarized in **Table 5-56**. In both of the planning areas the proportions of the total sediment load attributable to hillslope, bank erosion, and roadways are in fair agreement. Hillslope erosion processes mobilize from 70 to 80 percent of the total load, bank erosion contributes from 20 to 30 percent, and roadways contribute about three percent of total erosion.

Table 5-56. Sediment Loading Summary (Tons/Yr) for the Combined Middle Blackfoot-Nevada Creek TMDL Planning Area

Erosion Source	Nevada Creek	Middle Blackfoot	Total
Hillslope erosion load	26,876	112,430	139,306
Bank erosion load	10,687	27,221	37,908
Road surface erosion load	790	1,684	2,474
Culvert failure load	448	2,102	2,550
Totals (Planning Area)	38,801	143,431	182,232

The higher values for the Middle Blackfoot are most likely due to its larger area of approximately 1076 square miles compared to the approximate 356 square miles of the Nevada Creek TPA. The total sediment loads translate to an erosion rate of about 0.19 tons/acre/year. This value is similar to literature values for forested landscapes reported by Dunne and Leopold (1978) that average about 0.18 tons/acre/year.

SECTION 6.0
METALS IMPAIRMENTS

This section discusses the metals-related water quality impairment status and potential impairment sources for water bodies within the Middle Blackfoot and Nevada Creek Planning Areas. Water quality goals for metals are discussed in general terms in **Section 2.5.2**. The surface water quality standards for metals are the benchmarks used in making beneficial use support decisions, determining impairment, the need for TMDLs, and setting water quality restoration targets. **Section 6.2** contains the discussion of the water quality impairment status and supporting data for metals-listed water bodies. Based on the available data, potential metals sources are evaluated in **Section 6.3**.

6.1 Metals Water Quality Goals

For most metals aquatic life criteria are established for both acute and chronic conditions, with the chronic standard being most stringent (lower). While the water quality standards state that the acute aquatic criteria may not be exceeded in B-1 waters at any time, the chronic aquatic criteria may be exceeded on an instantaneous basis as long as the average concentration of that parameter measured over any 96-hour (or longer) period does not exceed the chronic aquatic criteria. Both the human health standards and aquatic life standards apply to surface waters. Water quality data were compared to either the aquatic life standard or human health standard, whichever is more stringent.

Due to a lack of information regarding average metals concentrations for any 96-hour or longer period from the planning area, the more stringent chronic aquatic criteria were used in evaluating impairment. The aquatic life standards for several metals (cadmium, chromium, copper, lead, nickel, silver zinc) are a function of water hardness. As hardness decreases (the water becomes more dilute), the applicable numeric standard also becomes more stringent. In most cases, stream water hardness decreases with increasing flow during spring runoff resulting in lower applicable aquatic life standards. Thus, evaluations of impairment status and sources in this section have been conducted for varying flow conditions to account for the range of typical hydrologic and associated water quality conditions.

As discussed in **Section 2.5.2** the iron and manganese human health standards listed in Circular DEQ-7 are not based on specific numeric values since these metals are not categorized as toxins or carcinogens. Instead, Circular DEQ-7 states that concentrations of these parameters “must not reach values that interfere with the uses specified in the surface and groundwater standards.” Circular DEQ-7 further states that the secondary maximum contaminant levels (MCL) established by EPA (based on protection of aesthetic issues such as taste, odor, staining) of 300 μ/L (micrograms per liter, or parts per billion) for iron and 50 μg/L for manganese may be considered as guidance in determining if a certain concentration interferes with the specified uses. These secondary MCL guidance values are only applicable as indicators of an impaired drinking water use if available data suggest that they would be consistently exceeded after conventional treatment. A review of the available data for the Middle Blackfoot and Nevada Creek TMDL Planning Areas suggests that a high percentage of the iron and manganese present in area water bodies is in the particulate phase, and thus would be removed by conventional treatment. Therefore, for the purposes of this TMDL document, the secondary MCL guidance values for iron and manganese are not applied and are not considered further in the evaluation of impairment status. The chronic aquatic life standard of 1,000 µg/L for iron is considered applicable and is used as the metals water quality goal for iron.

Table 2-6 contains the water quality goals or targets for metals that have been identified as constituents of concern in the Middle Blackfoot-Nevada Creek planning areas (**Section 2.2**). They include aluminum, arsenic, cadmium, copper, iron, lead, and mercury. The criteria are based on Circular DEQ-7 numeric or narrative criteria, and on metals concentrations expressed as total recoverable, except for aluminum, which is based on the dissolved concentration. Note that, for the hardness-dependent metals included in the list (cadmium, copper, and lead), representative high and low flow hardness values based on observed data for the planning area have been used to calculate example criteria; in actuality, hardness-dependent criteria vary with the hardness measured for individual samples.

6.2 Water Quality Impairment Status

The beneficial use support status of water bodies included in the 1996 and 2006 303(d) List for the Middle Blackfoot-Nevada Creek TMDL Planning Area are summarized above in **Section 2.2**, **Tables 2-1 and 2-2**. Probable causes and sources of impairment for these water bodies are presented in **Table 2-3** and are further discussed in **Section 2.3** for the Middle Blackfoot and **Section 2.4** for Nevada Creek. These preceding discussions present the entire range of probable impairment causes and potential sources. This section focuses on those water bodies within the Middle Blackfoot and Nevada Creek TMDL planning areas that are or have been listed as impaired due to one or more metals. Available data for these water bodies is summarized in terms of observed departures from water quality standards and in terms of the relationship of water chemistry with the annual stream hydrograph. These data are then used to evaluate the impairment status of the water body.

Table 6-1 presents the metals-related 303(d) Listing history for water bodies in the planning area, from the 1996 303(d) List through the most recent 2006 303(d) List. Comprehensive listing information was presented previously in **Tables 2-2 and 2-3; Table 6-1** shows only those water bodies that include metals as a probable cause of impairment. As noted in **Section 2.2**, this TMDL document addresses the most current listings (2006) and the 1996 listings. Listings for the intervening years shown in **Table 6-1** are for comparison only.

Metals data for the Middle Blackfoot-Nevada Creek TMDL Planning Area used to develop the 303(d) Listings is described in **Sections 2.3 and 2.4**, and is listed in **Appendix F**. The primary data sources for evaluating metals-related impairment include the following:

- USGS data collected at the Nevada Creek gaging station (1233550) located above Nevada Creek Reservoir
- Reassessment data collected by DEQ during 2003
- Kleinschmidt Creek, Nevada Creek, and associated tributary drainage data collected by Hydrometrics in 2003 and 2005 under contract with the Blackfoot Challenge, to support development of this TMDL document

Table 6-1. Metals-Related 303(d) Listing History for Middle-Blackfoot-Nevada Creek TMDL Planning Area

Waterbody	Probable Impairment Causes				
	1996	2000	2002	2004	2006
Jefferson Cr. (lower)	Not listed				aluminum, iron
Douglas Cr. (upper)	Not listed				arsenic
Murray Cr.	Not listed				arsenic
Douglas Cr. (lower)	Not listed				arsenic
Nevada Cr. (upper)	Not Listed	Metals	Metals	Metals	cadmium, lead, mercury
Kleinschmidt Cr.	Not listed	copper	copper	arsenic	arsenic, copper

Table 6-2 summarizes the seasonal (high and low flow) water quality standard exceedences identified for the Middle Blackfoot and Nevada Creek TMDL Planning Areas (**Appendix F**). Observed exceedences of water quality goals for metals are confined to the parameters listed in **Table 2-6**.

Note that a number of the water bodies listed in **Table 6-2** are not listed as impaired due to the metals in **Table 6-1**; the rationale for impairment determinations for individual streams within the planning area is presented below for those water bodies listed in **Table 6-1**. **Section 6.2.1** discusses the additional exceedences noted in **Table 6-2**. Finally, **Section 6.2.2** summarizes available stream sediment chemistry data for the Middle Blackfoot and Nevada Creek TMDL Planning Areas and its relationship to water quality.

Table 6-2. Metals Standard Exceedence Summary for Middle Blackfoot and Nevada Creek TMDL Planning Areas for Low (L) and High (H) Flow Sampling Events

Waterbody	Aluminum	Arsenic	Cadmium	Copper	Iron	Mercury	Lead
Halfway Cr		1 (L)			1 (H)		
Washington Cr (Lower)		1 (L)			1 (H), 1 (L)		
Jefferson Cr (Lower)*	1 (H)				1 (H)		
Buffalo Gulch		1 (L)					
Nevada Cr (Upper)*				2 (H)	2 (H)	2 (H)	1 (H)
Wilson Cr	1 (H)	1 (L)					
Black Bear Cr		1 (L)			1 (L)		
Murray Cr*		1 (L)					
Douglas Cr (Upper)*		2 (L)					
Cottonwood Cr (Nevada)					1 (H)		
Douglas Cr (Lower)*		1 (L)			1 (H)		
Nevada Cr (Lower)		1 (L)		1 (H)	2 (H)		1 (H)
Wales Cr		1 (L)					
Frazier Cr		1 (L)					
Kleinschmidt Cr*		1 (L)					
Richmond Cr		1 (L)					

*Denotes water body listed in 2006 303(d) List as impaired due to metals.

Lower Washington Creek
Washington Creek is a second order tributary to Nevada Creek. The stream has upper and lower listed segments. Upper Washington Creek extends from the headwaters to Cow Gulch and is approximately 7 miles long. Lower Washington Creek extends from Cow Gulch to the mouth and is approximately 4 miles long.

Three metals samples were collected in lower Washington Creek at the Highway 141 crossing in 2003 and 2005, two during high flow and one during low flow conditions. Results for the samples showed two exceedences of the chronic aquatic life standard for iron: 1,380 µg/L in October 2003 and 2,450 µg/L in May 2005). The remaining result was 970 µg/L during June 2003, very close to the 1,000 µg/L standard. Upper Washington Creek was also sampled in October 2003, and the low flow iron concentration of 20 µg/L in this sample implies a source of iron within lower Washington Creek. Although Washington Creek is not currently listed as impaired by metals concentrations, a review of available data suggests that an impairment listing for iron is warranted and a TMDL for iron is required.

Lower Jefferson Creek
Jefferson Creek is a second order tributary to Nevada Creek. Only the lower portion is listed as impaired due to metals (aluminum and iron). Lower Jefferson Creek was sampled at the Dalton Mountain Road Crossing three times for metals, twice in 2003 (high and low flow) and once in 2005 (high flow). Sample results showed high flow exceedence for aluminum (June, 2003) and iron (May, 2005), supporting the impairment listing. During the 2003 low flow monitoring event on Jefferson Creek, samples were collected from both the upper and lower segments of the stream. No metals water quality standard exceedences were observed in either segment during this event. However, the metals data indicated that iron and manganese concentrations were substantially higher in the lower segment compared with the upper segment, suggesting a source within the lower portion of Jefferson Creek. Lower Jefferson Creek is considered impaired due to aluminum and iron, and TMDLs are required.

Upper Nevada Creek
Nevada Creek is a large tributary to the Blackfoot River. Upper Nevada Creek is listed as impaired due to cadmium, lead, and mercury on the 2006 303(d) List.

Four samples collected from site NCSW-1 (located at the Highway 141 crossing on Nevada Creek) in 2003 and 2005 showed one water quality exceedence for iron (2,620 µg/L) during a high flow sampling event in May 2005. The remainder of the metals water quality standards exceedences observed in upper Nevada Creek have occurred at USGS gaging station 12335500, located upstream of Nevada Lake reservoir. USGS data and supplemental data collected by other entities at this site show the following metals standard exceedences:

- one iron exceedence (high flow) in May 2005
- two copper exceedences (both high flow) in June 1980 and May 2005
- two mercury exceedences (both high flow) in June and July 1980
- one lead exceedence (high flow) in May 2005

Although iron is not listed as an impairment cause in the 2006 303(d) List, a TMDL is proposed for iron based on the two high flow chronic aquatic life exceedences during May of 2005 at both the Highway 141 crossing and at USGS station 12335500.

Similar to iron, copper, which has shown two standards exceedences, is not listed as an impairment cause in the most recent 303(d) List. Lead, which has shown one water quality standard exceedence, was listed in 2006 as an impairment cause. A review of the data shows that total recoverable copper and lead concentrations in upper Nevada Creek appear to be directly related to iron concentrations (i.e., elevated copper and lead concentrations coincide with elevated iron concentrations) (see **Section 6.3** below). Therefore, in addition to iron, copper, and lead TMDLs are proposed for upper Nevada Creek.

Although cadmium is listed in the 2006 303(d) report as an impairment cause for upper Nevada Creek, the rationale for this listing is unclear. During the data compilation process, no exceedences of the water quality standard for cadmium were discovered for upper Nevada Creek. Further review of the impairment status of upper Nevada Creek for cadmium is recommended. No cadmium TMDL is proposed in this document.

The mercury exceedences in upper Nevada Creek were reported in samples collected over 25 years ago, and no mercury analyses had been conducted on samples from the stream since that time. Based on the date of the sampling (1980), it was considered possible that analytical methods were not sufficiently advanced to accurately determine mercury at such low concentrations (<0.5 µg/L). In order to further evaluate the potential presence of mercury in Nevada Creek, paired samples were collected at site 12335500 in May 2005 using USGS clean sampling techniques. One sample was submitted to the primary analytical laboratory, and a split sample was submitted for low-level mercury analysis at ACZ Laboratories in Steamboat Springs, Colorado. The result for the low-level analysis was 0.0156 µg/L, in agreement with the result from the primary laboratory of <0.1 µg/L. These results indicate that mercury concentrations in upper Nevada Creek under high flow conditions in 2005 were less than the human health standard of 0.05 µg/L. Based on these more recent sampling results, mercury impairment of upper Nevada Creek is undetermined, and no TMDL for mercury is proposed.

Upper Douglas Creek
Douglas Creek is a major third order tributary to lower Nevada Creek. The stream is approximately 22 miles long, and has been divided into upper and lower segments that extend above and below the mouth of Murray Creek. Both the upper and lower segments are listed as impaired due to arsenic.

Metals water quality samples in upper Douglas Creek have been collected at several locations, including two samples (from separate locations) obtained by DEQ in 2003 and two samples collected by Hydrometrics in 2005. Combined data from these sampling events show two water quality standard exceedences, both for arsenic during low flow conditions.

Low-level arsenic concentrations that exceed the 10 µg/L human health standard are common throughout the Nevada Creek drainage (**Appendix F; Table 6-2**). Given naturally occurring geologic sources of arsenic in the drainage basin and the widespread nature of the low-level concentrations, natural weathering processes may be responsible for existing concentrations as discussed further in **Section 6.3 below**. Further evaluation of arsenic sources is needed in upper Douglas Creek to clarify its impairment status. Arsenic TMDLs are not proposed in this document.

Murray Creek
Murray Creek is a second order tributary to Douglas Creek. The stream is approximately 8 miles long, and the 303(d) Listed segment of Murray Creek extends from its headwaters to its confluence with Douglas Creek. Metals data for Murray Creek is limited to a single sample collected by DEQ in September 2003; the arsenic concentration of 16 µg/L in this sample exceeds the current human health standard of 10 µg/L. As is discussed in **Section 6.3**, the arsenic present in the 2003 sample probably results from naturally occurring sources. Due to the lack of additional data, there is insufficient information at this time to determine that Murray Creek is impaired due to elevated arsenic concentrations. Therefore, an arsenic TMDL is not proposed for Murray Creek.

Lower Douglas Creek
The lower segment of Douglas Creek consists of the section from the Murray Creek confluence to Nevada Creek. Four samples (two high flow and two low flow samples) were collected at the Ovando-Helmville county road crossing west of Helmville. The four samples showed one low flow arsenic exceedence and one high flow iron exceedence. One of the four samples showed a chronic aquatic life standard exceedence for iron. Further assessment of iron loading in Douglas Creek is recommended to verify the results of the single analysis result. Thus, an iron TMDL for Douglas Creek is not proposed in this document. The single exceedence for arsenic may be related to weathering of arsenic bearing parent materials in the drainage as described in **Section 6.3**. Thus, further assessment of arsenic loading to lower Douglas Creek is recommended, and an arsenic TMDL is not proposed.

Kleinschmidt Creek
Kleinschmidt Creek is a first order spring creek tributary to Rock Creek draining the southern margin of Kleinschmidt Flat. The listed segment of the creek extends upstream from the mouth for a distance of 1.5 miles. Arsenic and copper are both included in the 2006 303(d) List as impairment causes.

The credible metals water quality data available for Kleinschmidt Creek was limited to a single sample collected near the mouth of the creek (site C03KLSMC01) in September 2003 by DEQ. The result showed an exceedence of the surface water human health standard for arsenic. Previous sampling (Spence, 1975) noted an exceedence of the aquatic life standard for copper in a sample collected in February 1969 (20 µg/L copper). This data was subsequently deemed not credible by DEQ, and the listing for copper was removed in 2004. Additional sampling of Kleinschmidt Creek was conducted in 2005 during high and low flow conditions to further investigate the metals-related impairments.

The 2005 sampling showed total recoverable arsenic concentrations below the laboratory reporting limit (<5 µg/L) at three monitoring locations along Kleinschmidt Creek. Additional data for copper was also collected in 2005, with all results either below or equal to the reporting limit of 1 µg/L. These results suggest that standards for arsenic and copper are not typically exceeded in Kleinschmidt Creek. The 2005 results indicate that impairment of Kleinschmidt Creek due to arsenic or copper concentrations warrants further consideration. No TMDLs for arsenic and copper are proposed.

6.2.1 Additional Metals Water Quality Standard Exceedences

As noted above in this section, samples from a number of streams in the Middle Blackfoot and Nevada Creek TMDL planning areas have exceeded metals standards, but the streams were not listed for metals-related impairment in 2006. These water bodies include Black Bear Creek, Buffalo Gulch, Cottonwood Creek (tributary to Nevada Creek), Frazier Creek, Halfway Creek, lower Nevada Creek, Richmond Creek, Wales Creek, lower Washington Creek, and Wilson Creek. The analysis results contained exceedences for aluminum, arsenic, copper, iron, and lead (**Table 6-2**).

In general, the small size of the metals datasets for these sites prevents conclusive metals impairment determinations. The entire record consists of a single analysis result for Buffalo Gulch and Murray, Cottonwood, Wales, Frazier, and Richmond creeks. In Wilson Creek, for example, one of three samples for dissolved aluminum exceeded the 87 µg/L chronic aquatic life standard (290 µg/L in June 2003). For these water bodies, additional monitoring is recommended to better assess metals impairment. The proposed metals monitoring for the Middle Blackfoot and Nevada Creek Planning Areas is described in **Section 10** of this document.

Low-level arsenic concentrations in surface water have been noted throughout the planning area, both in listed and unlisted streams. The unlisted streams in which elevated arsenic was detected include Black Bear Creek, Buffalo Gulch, Frazier Creek, Halfway Creek, lower Nevada Creek, Richmond Creek, Wales Creek, lower Washington Creek, and Wilson Creek. All observed exceedences of the arsenic surface water standard in the planning area have been under low flow conditions (**Table 6-2**) and range from 11 µg/L to 25 µg/L. A review of potential arsenic sources suggests that weathering of geologic material in the drainage may be a primary source of naturally occurring arsenic. Additional discussion of arsenic sources is included in **Section 6.3** below.

Other metals standard exceedences in the planning area are primarily for iron under high flow conditions. Exceptions are one high flow exceedence each for copper and lead in lower Nevada Creek and a low flow iron exceedence in Black Bear Creek (**Table 6-2**). The metals impairment status of these unlisted streams will remain undetermined until more data are available. Monitoring recommendations for resolving metals impairment questions are proposed in **Section 10.0**.

Data analysis for both the mainstem and Nevada Creek tributaries generally suggests that metals concentrations are directly related to suspended sediment concentration. Reductions in sediment loading will, therefore, address a significant percentage of the metals loading. **Section 6.5** includes a description of the relationship between metals concentrations and suspended sediment.

6.2.2 Stream Bed Sediment Metals

The water quality standard that applies to sediments allows no increases above naturally occurring concentrations which will or are likely to create a nuisance or impede aquatic life support or other beneficial uses. This standard does not apply to metals concentrations in sediment. Jones et al. (1997) summarized screening level thresholds for metals concentrations in sediment. The data for metals concentrations in sediment collected in 2003 in Nevada Creek drainage and in Kleinschmidt Creek is compared with these thresholds in **Appendix F**. Most of the sediment metals concentrations are well below the screening levels. Arsenic in sediment appears somewhat elevated in lower Washington Creek with 52.3 ppm, falling just under the probable effect level of 57 ppm. Upper Nevada Creek at 30.7 ppm and Wilson Creek at 21.7 are in excess of the Region IV screening value and the 1996 solid waste toxicity criterion.

The benchmark values cited by Jones et al. (1997) were derived by a variety of methods. The sediment particle size fractions on which the rating criteria are based are not specified in the reference. The 2003 metals data from the planning area data applies to the <63 µm sediment fraction, as the samples were wet-sieved in the field to exclude the sand-sized fraction. It is likely that some of the cited benchmark values are intended for bulk sediments. This introduces some uncertainty into the use of these benchmarks as a screening tool for the Nevada Creek Kleinschmidt Creek samples. Trace elements are typically concentrated in the fine sediments. Threshold values based on bulk samples would include the metals contribution from less reactive sand fractions and could lead to applying restrictive threshold for results from finer fractions. The results are used here as supplemental indicators of impairment. Their interpretation here suggests the need for periodic, seasonal arsenic sampling in lower Washington Creek and upper Nevada Creek surface waters, but does not alter impairment conclusions based upon the larger, though still limited, surface water monitoring record.

6.2.3 Metals TMDL Summary

Due to the likelihood of naturally elevated arsenic concentrations throughout the planning area, arsenic TMDLs are not proposed in Murray Creek and Douglas Creek. New analytical results for arsenic and copper in Kleinschmidt Creek do not support TMDL development for these metals. New analytical results for mercury do not support TMDL development for upper Nevada Creek. **Table 6-3** contains a summary of the metals listings in the Nevada Creek and Middle Blackfoot planning areas and identifies those selected TMDL development.

Table 6-3. Water Bodies and Corresponding Metals Listings in the Middle Blackfoot-Nevada Creek TMDL Planning Area

Stream Name	Impairment Cause/s	TMDL Developed? (Y/N)
Lower Washington Creek	Iron	Y
Lower Jefferson Creek	Aluminum, Iron	Y
Upper Nevada Creek	Iron, Copper, Lead	Y
Upper Nevada Creek	Cadmium, Mercury	N
Murray Creek	Arsenic	N
Upper Douglas Creek	Arsenic	N
Lower Douglas Creek	Arsenic	N
Kleinschmidt Creek	Arsenic, Copper	N

6.3 Metals Source Assessment

The source assessment activities for metals in the Middle Blackfoot and Nevada Creek TMDL planning areas consisted of an initial compilation of relevant data for the Nevada Creek drainage and for Kleinschmidt Creek that included data collected by DEQ and data available on the EPA STORET and USGS NWIS water quality databases (Hydrometrics, 2006). Additional monitoring programs were designed and implemented in 2003 and 2005 to address data gaps identified during the initial compilation. The search of the USGS NWIS database yielded one monitoring location on upper Nevada Creek useful for TMDL development, gaging station number 12335500 located upstream of Nevada Lake reservoir.

The sources of metals to the aquatic environment can be divided into two general categories according to Drever (1988), that include contributions from the natural weathering of rocks and soils and introductions from human activities such as mining metal ore processing and metals sources associated with pest control or waste disposal. A wide variety of human activities can act as sources of metals to aquatic systems, either directly or through atmospheric cycles. Stumm and Morgan (1996) indicate that the atmospheric pathway has become a “key medium” in the transfer of trace metals to aquatic systems, globally supplying more than 70% of the lead, 30% of the mercury and 20% of the cadmium flux into surface waters annually. Anthropogenic sources of metals include many industrial processes including burning of fossil fuels, smelting of ores, discharge of municipal sewage or industrial process water, mining, and others. Release of trace metals to groundwaters and surface waters through natural weathering is dependent on the particular mineral form present and on the intensity of chemical weathering (Drever, 1988). Chemically resistant minerals will obviously release metals at a much lower rate than reactive materials such as metal sulfides.

Regardless of the ultimate source of metals, once introduced to the aquatic system, concentrations are controlled by numerous physical and chemical factors, including primarily pH, complexation with organic and inorganic ligands (metal speciation), and adsorption. Langmuir et al. (2004) note that, with few exceptions, metals concentrations in natural aquatic systems are not sufficiently elevated to the point where equilibrium solubility controls have an effect on water column concentrations, adsorption, and co-precipitation reactions (affected by solution pH and complexation) are largely the determining factors.

As noted previously in **Section 6.2.1**, low-level arsenic concentrations and occasional water quality standard exceedences are common in streams throughout the Middle Blackfoot and Nevada Creek TMDL planning areas. All the arsenic exceedences observed to date have occurred during low flow conditions (**Table 6-2**) suggesting that, unlike iron, copper, and lead, arsenic concentrations are not closely related to high flow/high TSS events and may be a function of groundwater base flow concentrations. The USGS and Hydrometrics data sets for Nevada Creek and tributaries include 72 analysis results for arsenic, with only nine results being below the applicable detection limit. The average concentration for this data set is 5.7 µg/L; the median concentration is 5.0 µg/L. The DEQ 2003 reassessment data includes 21 analyses for arsenic with 2 results below the detection limit, an average concentration of 9.3 µg/L and a median concentration of 7.0 µg/L.

A number of placer mines are present in the upper reaches of Nevada Creek and several tributary drainages including Douglas Creek, Washington Creek, Jefferson Creek, and Wilson Creek. Among these, the Pearl Mine located in the Weasel Creek headwaters tributary of Douglas Creek is noted on the USGS topographic map. These mines could potentially function as sources of sediment-bound arsenic and other metals to area surface waters. However, the wide distribution of detectable arsenic concentrations throughout the planning area is not consistent with relatively localized sources such as mine disturbances.

Smedley and Kinniburgh (2002) conducted a thorough review of arsenic sources, geochemical behavior, and distribution in natural waters. They cite a range of “baseline” concentrations for arsenic in river water of from 0.13 to 2.1 µg/L. The andesitic and basaltic bedrock types that are predominant in the Nevada Creek drainage south of Nevada Creek and the argillites, siltites and quartzites that predominate north of Nevada Creek (Lewis, 1998) contribute arsenic to area surface waters through weathering and so influence groundwater compositions. Volcanic rocks are often cited as sources of elevated arsenic concentrations, and argillaceous deposits typically show higher average arsenic concentrations than most other rock types (Smedley and Kinniburgh, 2002). As noted in the **Section 5.2** discussions of Buffalo Gulch and Douglas Creek, the volcanic rocks and associated sediments present in the Nevada Creek drainage are highly erosive. Surface water concentrations of arsenic are likely controlled by sorption to river sediments and dilution. Potential anthropogenic sources noted by Smedley and Kinniburgh (2002) include pesticides, herbicides, crop desiccants, livestock (poultry) feed additives, mining activity, wood preservation, and atmospheric deposition from fossil fuel burning.

Thus, the low arsenic concentrations in Nevada Creek and tributaries may include both “natural” and anthropogenic contributions. The widespread nature of detectable arsenic concentrations in Nevada Creek and the generally low concentrations suggest that much of the arsenic load in Nevada Creek may be natural in origin. Regardless of the ultimate source of arsenic, it is likely that arsenic concentrations within planning area streams are controlled by dilution and sorption. During higher flows, dilution and sorption to suspended sediments containing iron and manganese act to reduce arsenic concentrations in surface water. Under lower flow conditions, the effects of dilution and sorption are reduced and concentrations of arsenic are slightly higher.

With the exception of the two elevated arsenic concentrations detected in Douglas Creek, the 12 other streams with elevated arsenic concentrations have but a single arsenic analysis result.

Impairment due to arsenic is better assessed with a more robust data set considering the vast extent of natural bedrock and sediment sources of arsenic in the planning area. Therefore, seasonal monitoring for arsenic is recommended over the development of arsenic TMDLs based upon minimal available data.

6.4 Metals Loading

As concluded in **Section 6.2.3**, metals TMDLs are proposed for lower Washington Creek, lower Jefferson Creek, and upper Nevada Creek. **Table 6-4** contains the measured metal concentrations, corresponding hardness values, stream discharge rates, and current loading rates for metals impaired streams and select tributaries for each sampling event. Hardness values are given for corresponding copper and lead analyses only, as the standards for these two metals are hardness-dependent. The last column on the right in the table contains the load in pounds per day calculated from each measured concentration multiplied by the corresponding flow rate and a unit conversion factor (5.4). The sampling sites are illustrated in **Appendix F, Figure F-1**.

Table 6-4. Metals Concentrations, Water Hardness, Stream Discharge, And Current Daily Loading Values For Metals Impaired Streams and Select Tributaries.

Stream Name	Sample Site	Metal	Sample Date	Result (mg/L)	Hardness	Discharge (cfs)	Load (lbs/Day)
Halfway Creek	HCSW-1	Fe	05/12/2005	**2.77**		3.41	51
			08/25/2005	0.31		0.15	0.25
Lower Washington Creek	WASW-1	Fe	06/12/2003	0.970		3.11	16.27
	WASW-1		10/01/2003	**1.38**		.024	0.18
	WASW-1		05/11/2005	**2.45**		17.1	225.98
Lower Jefferson Creek	JCSW-1	Fe	06/12/2003	0.22		2.05	2.43
	JCSW-1		10/01/2003	0.51		0.67	1.84
	JCSW-1		05/11/2005	**2.06**		4.15	46.11
	JCSW-1	Al	06/12/2003	**0.27**		2.05	2.99
	JCSW-1		10/01/2003	<0.01		0.67	0.02
	JCSW-1		05/11/2005	<0.01		4.15	0.11
Gallagher Creek	GCSW-1	Fe	08/25/2005	0.23		0.26	0.32
Upper Nevada Creek	NCSW-1	Fe	06/12/2003	0.24		30.6	39.61
	NCSW-1		10/01/2003	0.34		4.75	8.71
	NCSW-1		05/11/2005	**2.62**		103	1455.62
	NCSW-1		08/25/2005	0.29		3.61	5.65
	NCSW-2	Fe	08/25/2005	0.29		8.21	12.84
	12335500	Fe	05/14/2003	0.27		81	75.73
	12335500		05/11/2005	**7.27**		142	5568.44
	12335500		06/06/2003	0.37		81	162
	12335500		08/25/2005	0.27		7.8	11.36
	NCSW-1	Cu	06/12/2003	<0.001	84	30.6	0.08
	NCSW-1		10/01/2003	<0.001	120	4.75	0.01
	NCSW-1		08/25/2005	<0.001	131	3.61	0.01
	NCSW-2	Cu	08/25/2005	0.004	131	8.21	0.18
	12335500	Cu	05/11/2005	**0.010**	84	142	7.66
	12335500		08/25/2005	<0.001	129	7.8	0.02
	NCSW-1	Pb	06/12/2003	<0.001	84	30.6	0.08
	NCSW-1		10/01/2003	<0.001	120	4.75	0.01
	NCSW-1		08/25/2005	<0.001	131	3.61	0.01
	NCSW-2	Pb	08/25/2005	<0.001	131	8.21	0.02
	12335500	Pb	05/11/2005	**0.006**	84	142	4.01
	12335500		08/25/2005	0.0007	129	7.8	0.03
Values With Bolded Type Exceed Standards							

The June 2003 data show minor metals contributions to Nevada Creek from Washington Creek and Jefferson Creek. A source of iron other than Washington and Jefferson creeks is indicated by the difference between iron loading to upper Nevada Creek between site NCSW-1 (40 lbs/day iron) and USGS site 12335500 above Nevada Lake reservoir (162 lbs/day). Only about 19 lbs/day iron was transported to Nevada Creek from Washington Creek and Jefferson Creek during the June 2003 monitoring event, leaving approximately 100 lbs/day of the 162 lbs/day iron load at site 12335500 unaccounted for. Although site 12335500 was sampled six days (06/06/2003) before the other sites, and some flow and metal loads likely changed at site 12335500 between June 6th and June 12th, the loading difference between sites NCSW-1 and 12335500 strongly suggests a significant intervening source of iron. Additional water quality sampling was conducted in 2005 to better delineate loading sources in this reach of Nevada Creek.

The October 2003 data for upper Nevada Creek (NCSW-1) shows no source of metals loading in excess of standards. The October iron concentration (0.34 mg/L) is less than the chronic aquatic life criterion of one mg/L and Cu and Pb concentrations were less than the method detection limits of 0.001 mg/L. The October iron analysis result of 1.38 mg/L in lower Washington Creek exceeded the standard.

In May 2005, an additional monitoring site on the upper Nevada Creek tributary of Halfway Creek was added to test whether this stream was a source of loading to Nevada Creek. The results show that iron in Halfway Creek did exceed the standard in May. However, the combined iron loads from Halfway Creek (HCSW-1), upper Nevada Creek (NCSW-1), lower Washington Creek (WASW-1), and lower Jefferson Creek (JCSW-1) accounted for only about 30% of the 5,598 lbs/day iron load calculated from the result at USGS station 12335500. There remains a significant high flow loading source for iron above Nevada Lake that remains unaccounted for. A comparison of total recoverable and dissolved iron concentrations in Washington Creek and Jefferson Creek indicates that about 95% of loading is derived from the particulate phase. Therefore, the relatively high May 2005 iron concentrations are believed to be related to the suspended solids concentrations during spring stream flows.

Two additional sites in upper Nevada Creek drainage were added to the monitoring schedule for August 2005 sampling to further investigate metals loading sources to upper Nevada Creek. These were site GCSW-1 on Gallagher Creek and site NCSW-2 on upper Nevada Creek just above the confluence with Gallagher Creek. From upstream to downstream, the August 2005 iron loads at Nevada Creek sites NCSW-1, NCSW-2, and 12335500 were 6, 13, and 11 lbs/day. Thus, half the iron load upstream of the reservoir originated from the relatively short stream segment between NCSW-1 and NCSW-2. The similar downstream trend in streamflow rates at 3.6, 8.2, and 7.8 cfs at the three respective sites, and the relatively consistent metals concentrations among the three sites suggests that groundwater recharge to the stream is the source of the low flow iron loading in this section of Nevada Creek. Halfway Creek and Gallagher Creek were not significant contributors of metals loading to Nevada Creek in August 2005. No water quality exceedences were observed for Nevada Creek upstream of the reservoir in August 2005.

The metals source assessment in upper Nevada Creek identified a number of potential source areas:

- Upper Nevada Creek above Highway 141
- Segments of lower Washington Creek and lower Jefferson Creek, between the monitoring sites sampled in 2003
- Nevada Creek between Highway 141 and the reservoir

Since the majority of water quality exceedences are for iron, a redox-active metal, the source(s) of iron may be driven by redox changes. These changes may be either seasonal or year-round with changing flows of high-gradient oxic waters from higher elevation reaches through lower-gradient anoxic wetland areas adjacent to lower elevation valley bottom reaches. Other possible sources of iron and manganese loading include recharge from mineralized groundwater related to either natural or human-caused conditions and erosion and entrainment of stream bank and streambed sediments during high flow conditions.

6.5 The Metals-Suspended Solids Relationship

Figure 6-1 shows the graph of total recoverable iron concentrations as a function of total suspended solids (TSS) for data collected in upper Nevada Creek. The linear fit of the data suggests that suspended sediment concentration is a good predictor of total recoverable iron concentration, having an R^2 value of 0.90. The fitted curve in the figure depicts a linear relationship, but appears curved due to the logarithmic Y-axis. During the May 2005 monitoring, dissolved and total recoverable iron concentrations were measured in Washington and Jefferson creeks. Greater than 95% of the iron was present as a particulate in these streams, indicating that water column iron concentrations are primarily derived from suspended sediments that vary with stream discharge. Therefore, control of sediment sources should, to a large extent, mitigate iron water quality exceedences throughout the drainages.

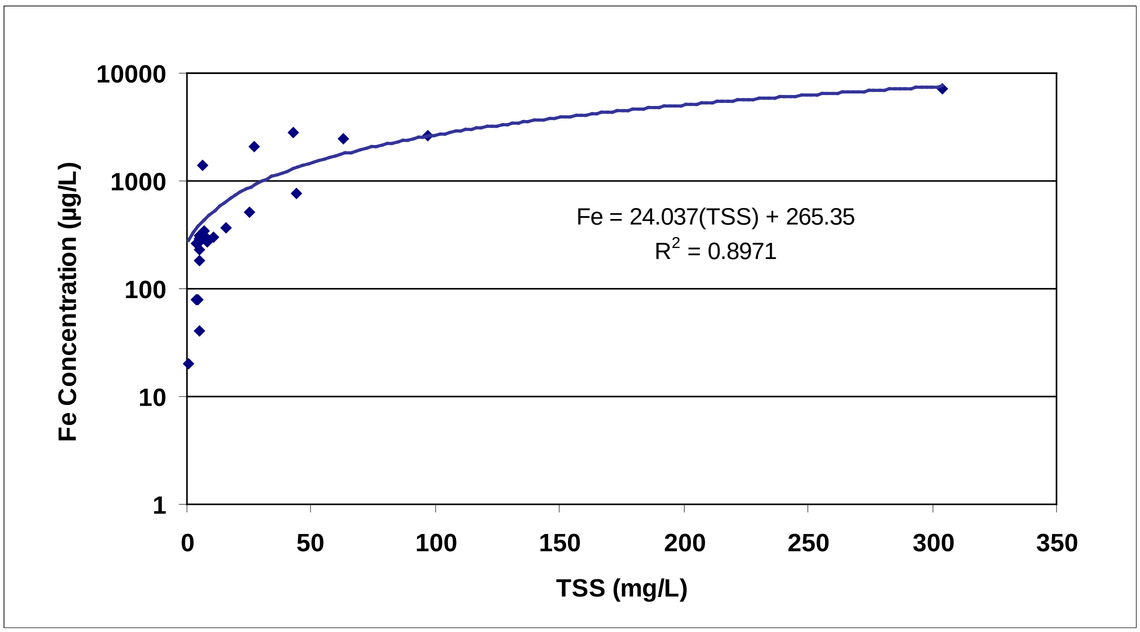


Figure 6-1. Linear Regression of Total Recoverable Iron Concentrations with Total Suspended Solids Concentrations for Upper Nevada Creek

Dissolved aluminum concentrations are primarily related to pH and the presence of complexing agents such as fluoride, sulfate, and organic ligands. The stream pH observed with the high-flow aluminum exceedences in Jefferson Creek and Wilson Creek was above neutral (7.66 and 7.91); therefore, the most likely source of aluminum in these stream reaches is solubilization from sediments or stream bank soils, perhaps through organic complexation.

SECTION 7.0
NUTRIENT IMPAIRMENTS

Nutrients are elements or compounds essential for the growth and survival of organisms. Most living cells require large amounts of nutrients, such as nitrogen, phosphorus, carbon, hydrogen, oxygen, potassium, and calcium (macronutrients), and small amounts of micronutrients such as manganese, copper, and chloride. Nutrients circulate in cycles that involve exchanges between the organic and inorganic components of the environment, as well as between plants and animals. In these cycles, each nutrient undergoes chemical transformations that determine its availability to different organisms. Therefore, the supply of nutrients within an ecosystem has a substantial influence on both the abundance of plant and animal life and the types and variety of species that can inhabit an ecosystem.

Human activities can increase the biologically available supply of two key nutrients, nitrogen and phosphorus. An oversupply of nutrients, known as eutrophication, encourages excessive plant production in aquatic ecosystems. Several impairments often result from excessive plant growth related to nutrient loadings. These occur when dead plant matter settles to the bottom of a stream or lake, stimulating microbial breakdown processes that consume oxygen. Eventually, dissolved oxygen is depleted, often to the point where fish and other species can no longer survive. This condition is often worse at night when plants cease releasing oxygen produced during photosynthesis. The breakdown of dead organic matter can also produce un-ionized ammonia. From this, fish may suffer reductions in hatching success, growth rate, and morphological development as well as injury to gill tissue and organs.

Phosphorus compounds are the main cause of eutrophication in freshwater ecosystems. However, excessive concentrations of some nitrogen-based nutrients, such as nitrates and ammonia, also can be directly toxic to plants and animals and can stimulate the growth of algae.

Framework, Phased Nutrient TMDLs

It is acknowledged that nutrient data for the Middle Blackfoot – Nevada Creek TPA are limited and impairment decisions are based on a preliminary numeric translation of Montana’s narrative nutrient standards. As a result, the level of certainty associated with the nutrient impairment decisions, nutrient TMDLs, and nutrient allocations is low and, upon potential adoption of numeric nutrient standards in the future, may need to be revised. The following nutrient TMDLs and allocations are presented as a framework starting point from which watershed stakeholders can voluntarily begin to address water quality problems in the Middle Blackfoot – Nevada Creek TPA. The nutrient targets are considered interim values that may need to be revised in the future and compliance with the targets is currently considered voluntary. An adaptive management strategy to facilitate revision of the nutrient targets, TMDLs, and allocations is presented in **Section 9.3.5**.

The 2006 303(d) List includes 16 stream segments and one lake listed specifically for nutrient parameters in the Middle Blackfoot and Nevada Creek planning areas (**Table 7-1**).

The following sections discuss the methods by which Montana’s narrative nutrient standards have been interpreted for the purposes of this TMDL document followed by a summary of the available water quality data and a preliminary assessment of the potentially significant sources of nutrients within the TPA.

Table 7-1. Water Bodies on the Montana 2006 303(d) List for Nutrient Related Parameters

TMDL Planning Area	Waterbody	Montana Waterbody ID	Impairment Listing
Nevada Creek	Black Bear Creek	MT76F003_060	TP TKN
	Braziel Creek	MT76F003_040	TP
	Douglas Creek (lower)	MT76F003_082	TP TKN
	Douglas Creek (Upper)	MT76F003_081	TP NO2NO3 TKN Chlorophyll-*a*
	Gallagher Creek	MT76F003_030	TP TKN
	Jefferson Creek (lower)	MT76F003_022	TP
	McElwain Creek	MT76F003_050	TP NO2NO3
	Murray Creek	MT76F003_120	TP NO2NO3 TKN Chlorophyll-a
	Nevada Creek (lower)	MT76F003_012	TP TKN
	Nevada Creek (Upper)	MT76F003_011	TKN
	Nevada Creek Reservoir (i.e., Nevada Lake)	MT76F007_020	TP TKN
Middle Blackfoot River	Blackfoot River (Monture Creek to Belmont Creek)	MT76F001_32	TP TN
	Blackfoot River (Nevada Creek to Monture Creek)	MT76F001_31	TP TN
	Frazier Creek	MT76F004_010	TP TKN
	Salmon Lake	MT76F007_030	None (Fully Supporting)
	Seeley Lake	MT76F007_010	None (Fully Supporting)
	Wales Creek	MT76F004_050	TP NO_3+NO_2-N Chlorophyll-*a*
	West Fork Clearwater River	MT76F005_040	Chlorophyll-*a*
	Yourname Creek	MT76F004_080	TP

TP – Total Phosphorus; TKN – Total Kjeldahl Nitrogen; NO_3+NO_2–N - Nitrate + Nitrite Nitrogen

7.1 Interpretation of Montana's Narrative Nutrient Standards

7.1.1 Lower Nevada Creek and the Blackfoot River

The Blackfoot River is a tributary to the Clark Fork River. In the mainstem Clark Fork River from below the Warm Springs Creek confluence to the confluence with the Blackfoot River, the numeric water quality standards for total nitrogen, total phosphorus, and benthic chlorophyll a are as follows (ARM 17.30.631):

Parameter	Concentration
Total Phosphorus	0.02 mg/l
Total Nitrogen	0.3 mg/l
Summer Mean Benthic Chlorophyll-*a*	100 mg/m2
Maximum Benthic Chlorophyll-*a*	150 mg/m2

These are summer, or growing season, standards. In the absence of numeric nutrient criteria for the Middle Blackfoot-Nevada TPA, these values are applied as interim endpoint goals, or targets, for the mainstem of Nevada Creek downstream of the Nevada Reservoir Dam and for the mainstem Blackfoot River in the middle Blackfoot planning area. The adaptive management strategy outlined in **Section 9.3.5** will be used in the future, if necessary, to revise these interim values.

When evaluating compliance with these goals it is important to consider that high levels of phosphorous or nitrogen loading to a stream might not show up as elevated concentrations in the water column, particularly during growing season. This is because nutrient uptake by growing algae could occur to the extent that nutrient concentrations in the water column are significantly reduced within a given length of stream. Therefore, it is important to measure algae concentrations, represented by benthic chlorophyll a, at the same time that nutrient concentrations are being measured to provide an adequate characterization of water quality conditions. When subsequently evaluating compliance with the above endpoint goals, it is important to first evaluate compliance with the chlorophyll a values before drawing conclusions regarding compliance with either the total phosphorous or total nitrogen concentration values.

Furthermore, the total phosphorous and total nitrogen targets are to be applied as average or mean values, since occasional minor exceedences of these values do not equate to conditions necessary to cause nuisance algae growth.

7.1.2 Upper Nevada Creek and Tributaries

For the nutrient affected tributary streams and Nevada Creek upstream of the reservoir, Montana's narrative standards will be applied. These prohibit "conditions which produce undesirable aquatic life" (ARM 17.30.637). The narrative standard does not define what undesirable aquatic life is, nor does it provide nutrient concentrations appropriate to control it. In response to EPA's directive to states to develop numeric nutrient criteria, Montana submitted a nutrient plan to EPA in 2002 detailing how they will determine which beneficial uses are impacted, how undesirable aquatic life will be defined, and how numeric nutrient criteria will be developed. Since 2002, Montana has conducted a number of technical studies and is pursuing development of numeric criteria for nutrients. Montana may be ready to begin the formal rule making process as early as 2009.

In the interim, to facilitate a measurable comparison of ambient water quality data with the narrative standards and to establish end-point nutrient goals for the TMDLs, indicators of nutrient impairment and threshold values have been selected based on the results of the work that Montana has completed to date in an effort to ultimately develop numeric nutrient criteria (Suplee *et. al*., 2007; Suplee, 2006; Suplee, 2005). The indicators and threshold values are not water quality standards. Rather, they are considered interim values subject to modification in the future following the adaptive management strategy presented in **Section 9.3.5.**

The selected indicators for Upper Nevada Creek and the tributaries include total phosphorus (TP), total nitrogen (TN), and benthic chlorophyll-*a*. Interim threshold values for the nutrient parameters are presented in **Table 7-2**. These are growing season, or summer, values. The values represent average or mean concentration thresholds for both total phosphorous and total nitrogen, since occasional minor exceedences of these values do not equate to conditions necessary to cause nuisance algae growth.

These values are based on the 90th percentile of a reference database, stratified according to Omernik ecoregions (Omernik, 1987) and have been derived following current DEQ internal guidance (Suplee, 2005). Ecoregions are land areas of similar quality and quantity of natural resources. They are organized into four levels of increasing uniformity. The level three ecoregion covering the Blackfoot River Watershed is the Middle Rockies. The more specific level four ecoregion covering the Blackfoot is the Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire Mountains ecoregion. In accordance with DEQ internal guidance (Suplee, 2005) level four ecoregion targets have precedence if the number of samples on which they are based is sufficient. If not, level three targets are used. DEQ guidance (Suplee, 2005) indicates that for the Blackfoot River Watershed, the number of nutrient analysis results from ecoregion reference sites was sufficient to use the level four values for TP. However, insufficient data were available for TN at level four. As a result, the level three values have been selected.

Table 7-2. Nutrient Targets by Parameter, Ecoregion Level, and Season

Parameter	Ecoregion Level	Season	90th Percentile Target (mg/L)
TP	IV	June 21-September 30	0.01
TN	III	June 21-September 30	0.33

For benthic chlorophyll-*a*, the Clark Fork River values described above will also be applied to the tributaries and Upper Nevada Creek.

7.1.3 Nevada Creek Reservoir

Nevada Creek Reservoir has a beneficial use class of B-1 (i.e., suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.) (ARM 17.30.623). In the absence of sufficient data to fully understand nutrient dynamics and response in the reservoir, interim goals have been established based on protection of the use class (i.e., specifically "propagation of salmonid fishes"). This assumes that the reservoir is appropriately classified. The adaptive management strategy outlined in **Section 9.3.5** will be relied upon to evaluate the water quality potential of the reservoir and modify these interim targets in the future if necessary.

The interim indicators and threshold values for Nevada Creek Reservoir are shown in **Table 7-3**. The rational for these values is presented below.

Table 7-3. Interim Nevada Creek Reservoir Indicators and Threshold Values

Indicator	Threshold Value
TSI*	50
TP	0.02 mg/L
Chlorophyll-a	7.2 µg/L
Dissolved Oxygen	5.0 mg/L

1These values may be modified in the future following the adaptive management strategy outlined in Section 9.3.5
*TSI = Trophic Status Index.

7.1.3.1 Trophic State Index, Total Phosphorus, Chlorophyll-*a*

Secchi disk transparency, chlorophyll-*a*, and total phosphorus are often used to define the degree of eutrophication or trophic status of a lake (Carlson, 1977). The concept of trophic status is based on the fact that changes in nutrient levels (measured by total phosphorus) usually cause changes in algal biomass (measured by chlorophyll *a*) which in turn causes changes in lake clarity (measured by Secchi disk transparency). In Montana, the trophic state index (TSI) of a lake or reservoir can be directly linked to the beneficial use classification such as "growth and propagation of salmonid fishes." USEPA (2000) reported that salmonid fish in lakes and reservoirs tend to disappear at TSI values greater than 50. South Dakota (2005) found that lakes and reservoirs are fully supporting coldwater fisheries when the TSI value is less than 48.4.

Based on this information, a TSI target of 50 is proposed for Nevada Creek Reservoir. Using the formulas below (obtained from Carlson, 1977), a TSI score of 50.0 translates into a total phosphorus value of 0.024 mg/L and a chlorophyll-*a* value of 7.2 µg/L.

$$TSI(TP) = 10 \times (6 - \frac{Ln(48/TP)}{Ln2})$$, where TP is in µg/L (Carlson, 1997)

$$TSI(Chl) = 10 \times \left(6 - \frac{2.04 - 0.68(Ln(Chl))}{Ln2}\right)$$, where chlorophyll-*a* is in µg/L (Carlson, 1997)

7.1.3.2 Dissolved Oxygen

Low dissolved oxygen (DO) often occurs in lakes and reservoirs in response to excessive nutrient loading and therefore, is an indirect indicator of potential nutrient impairment. In addition, Montana has numeric standards for dissolved oxygen associated with the aquatic life use. The Montana Water Quality Standards (17.30.623 (2)(b) require that no person may violate the numeric freshwater aquatic life dissolved oxygen standards presented in **Table 7-4** (DEQ, 2006). A table of fish spawning times and schedule for the presence of early life stages of fish that are likely to occur may be found at http://www.deq.state.mt.us/wqinfo/Standards/SpawningTimesFWP.pdf. The Montana dissolved oxygen standard is 5.0 mg/L as a 7-day minimum concentration and is proposed as an interim indicator to assess the nutrient impairment in Nevada Creek Reservoir and also used directly to assess compliance with Montana's DO standards.

Table 7-4. Minimum Aquatic Life Standards (Class B-1) for Dissolved Oxygen (mg/L)

Time Period	Early Life Stages	Other Life Stages
30-day average	NA	6.5
7-day average	9.5 (6.5)	NA
7-day average minimum	NA	5
1-day minimum	8.0 (5.0)	4

These are water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.

7.2 Available Water Quality Data for the Nutrient Impaired Waters

As shown in **Table 7-1,** there are 13 streams (16 waterbody segments) and one lake in the Middle Blackfoot – Nevada Creek TPA that are listed as impaired on the 2006 303(d) List because of nutrients. The basis for the impairment determinations can be found online in Montana DEQ's "assessment records" at http://www.deq.state.mt.us/CWAIC/default.aspx.

The following sections present a summary of the available nutrient data to provide the reader with an understanding of current water quality conditions. **Section 7.4.1** presents the data for the mainstem Blackfoot River and Nevada Creek downstream of Nevada Creek Reservoir. **Section 7.4.2** presents the data for all of the remaining 303(d) Listed streams in the Middle Blackfoot – Nevada Creek TPA, and **Section 7.4.3** presents the data for Nevada Creek Reservoir. Tables and box plots of the available data are presented for each parameter.

7.2.1 Blackfoot River and Nevada Creek

The Blackfoot River from the confluence with Nevada Creek to the confluence with Belmont Creek was listed as impaired because of nutrients on the Montana 2006 303(d) List. Nevada Creek downstream of Nevada Creek Reservoir (i.e., "lower" Nevada Creek) was also listed as impaired because of nutrients. Because of their connectivity with the greater Clark Fork River watershed, the total phosphorus (TP) and total nitrogen (TN) targets developed for the Clark Fork River will be applied to both the Blackfoot River and lower Nevada Creek.

The available chlorophyll-*a* data for these streams are presented first (**Section 7.2.1.1**) followed by the available total phosphorus data (**Section 7.2.1.2**) and total nitrogen data (**7.2.1.3**).

Summary
Blackfoot River and Nevada Creek

In summary, chlorophyll-*a* values are above the instantaneous maximum target of 150 mg/m2 in Lower Nevada Creek and the Blackfoot River downstream of the confluence with Nevada Creek (at Raymond Bridge). The interim TP and TN targets were exceeded in all of the samples in Lower Nevada Creek. In the Blackfoot River, the interim summer TP target was only exceeded 29% of the time, and the interim summer TN target was not exceeded.

7.2.1.1 Chlorophyll-*a*

Recent chlorophyll-*a* samples (2001 to present) were obtained at two stations in the main stem Blackfoot River in or near the TMDL planning area. Additional data for the main stem are also available upstream and downstream of the planning area, but are not presented at this time. Recent chlorophyll-*a* data were also obtained at one station in lower Nevada Creek. **Table 7-5** summarizes the available chlorophyll-a data. As shown in **Table 7-5**, the instantaneous maximum (150 mg/m^2) chlorophyll-*a* target was exceeded in lower Nevada Creek and at one site in the Blackfoot River (Raymond Bridge). Insufficient data are available to calculate mean values for application of the “summer mean” (i.e., 100 mg/m^2) interim target value.

Table 7-5. Summary of Chlorophyll-*a* Data Collected in the Blackfoot River and Lower Nevada Creek (2001-2006)

Stream	Station Name	Station ID	Date	Value (mg/m2)
Blackfoot River	Blackfoot River above Nevada Cr near Helmville MT	12335100	8/13/03	118
	Blackfoot River at Raymond Bridge, near Ovando, MT	12337820	8/24/05	236
Lower Nevada Creek	Nevada Creek at mouth near Helmville, MT	12337800	8/13/03	185

7.2.1.2 Total Phosphorus

Recent total phosphorus samples (2001 to present) were obtained at four stations in the main stem Blackfoot River in or near the TMDL planning area. Additional data for the main stem are also available upstream and downstream of the planning area, but are not presented at this time. Recent TP data were also obtained at two stations in lower Nevada Creek. **Table 7-6** summarizes the stations with TP data and the number of samples per station. Data for the Blackfoot River and lower Nevada Creek were pooled and are presented as box plots in **Figure 7-1** along with the interim TP target discussed in **Section 7.1** (i.e., 0.02 mg/L)

As shown in **Figure 7-1,** the summer TP target of 0.02 mg/L was exceeded all of the time in lower Nevada Creek, but only during a small percentage of events (29 percent exceeding) in the Blackfoot River during the summer season. This pattern may be due to phosphorous uptake from the water column by growing algae, as evident by the elevated chlorophyll a concentrations (**Table 7-5**).

Table 7-6. Summary of Total Phosphorus Data Collected in the Blackfoot River and Lower Nevada Creek (2001-2006)

Stream	Station Name	Station ID	n
Blackfoot River	Blackfoot R above Nevada Creek near Helmville MT	12335100	20
	Blackfoot R at Scotty Brown Bridge near Ovando MT	12338700	12
	Blackfoot River at Raymond Bridge, near Ovando, MT	12337820	12
	Blackfoot River upstream of Aunt Molly Fishing Access	C03BKFTR03	1
Lower Nevada Creek	Nevada Creek at mouth near Helmville, MT	12337800	22
	Nevada Creek below reservoir near Helmville, MT	12336600	12

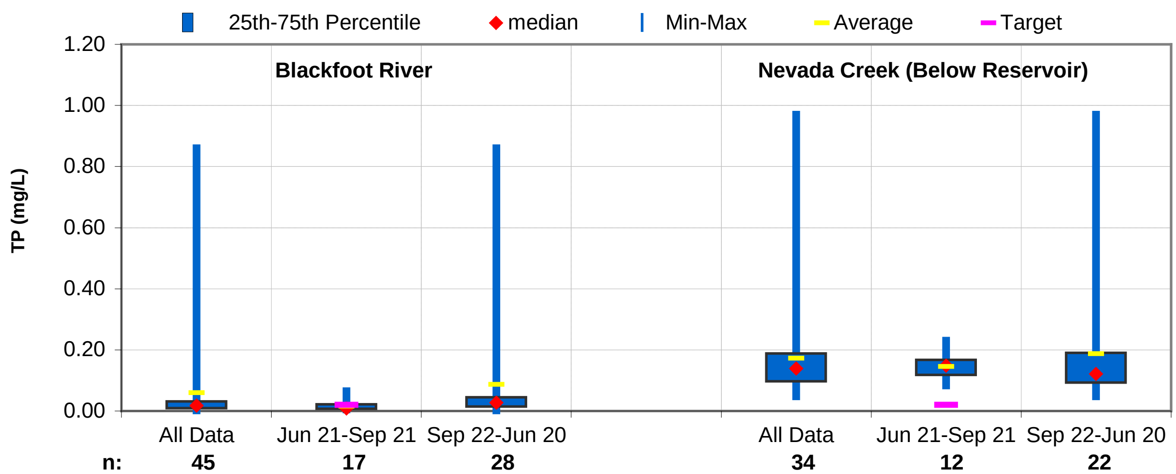


Figure 7-1. Total Phosphorus Data for the Mainstem Blackfoot River and Lower Nevada Creek

7.2.1.3 Total Nitrogen

Recent total nitrogen samples (2001 to present) were obtained at three stations in the main stem Blackfoot River in or near the TMDL planning area. Additional data for the main stem are also available upstream and downstream of the planning area, but are not presented at this time. Recent TN data were also obtained at two stations in lower Nevada Creek. **Table 7-7** summarizes the stations with TN data and the number of samples per station. Data for the Blackfoot River and lower Nevada Creek were pooled and are presented as box plots in **Figure 7-2** along with the TN target (0.30 mg/L) discussed in **Section 7.1.**

As shown in **Figure 7-2**, the summer TN target of 0.30 mg/L was exceeded all of the time in lower Nevada Creek, but during none of the sampling events in the Blackfoot River during the summer season. As explained above for phosphorus, this pattern may be due to nutrient uptake from the water column by growing algae, as evident by the elevated chlorophyll a concentrations.

Table 7-7. Summary of Total Nitrogen Data Collected in the Blackfoot River and Lower Nevada Creek (2001-2006)

Stream	Station Name	Station ID	n
Blackfoot River	Blackfoot River above Nevada Creek near Helmville MT	12335100	14
	Blackfoot River at Scotty Brown Bridge near Ovando MT	12338700	12
	Blackfoot River at Raymond Bridge, near Ovando, MT	12337820	12
Lower Nevada Creek –	Nevada Creek at mouth near Helmville, MT	12337800	15
	Nevada Creek below reservoir near Helmville, MT	12336600	12

Summary –
Tributaries and Upper Nevada Creek

Data for the tributaries are limited. In general, with the exception of the West Fork Clearwater River, the interim TP target was exceeded in all of the subject tributaries and Upper Nevada Creek. With the exception of Braziel, Jefferson, Upper Nevada Creek, and the West Fork Clearwater River, the interim TN target was exceeded at all of the sample stations at least once. None of the tributaries exceeded the instantaneous maximum chlorophyll-a target of 150 mg/m2 (where data were available).

An adaptive management strategy is presented in **Section 9.3.5** to facilitate developing a better understanding of the tributaries.

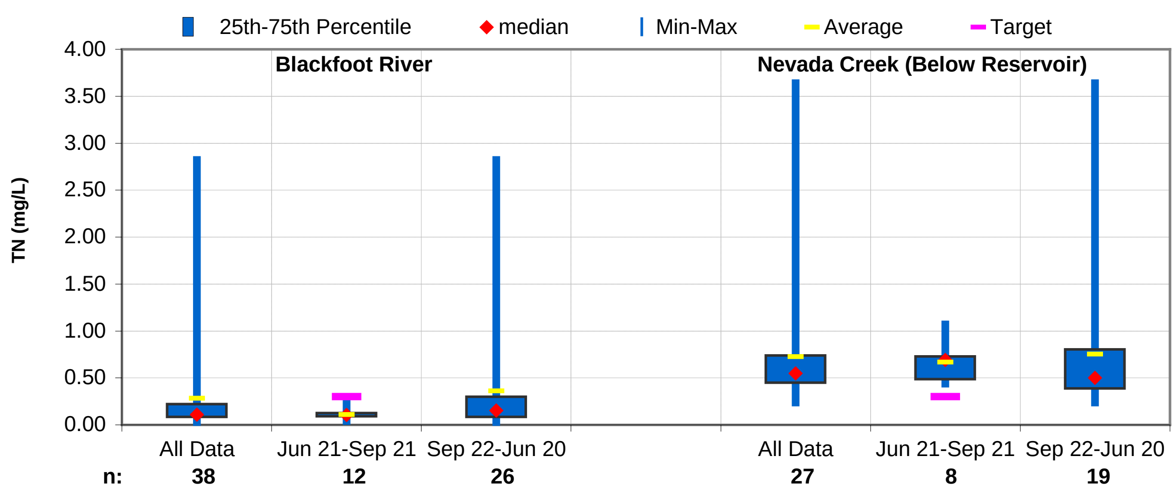


Figure 7-2. Total Nitrogen Data for the Mainstem Blackfoot River and Lower Nevada Creek

7.2.2 Tributaries to the Blackfoot River and Nevada Creek

Twelve additional streams in the Middle Blackfoot – Nevada Creek TPA were listed as impaired because of nutrients on Montana's 2006 303(d) List: Black Bear Creek, Braziel Creek, Douglas Creek, Frazier Creek, Gallagher Creek, Jefferson Creek, McElwain Creek, Murray Creek, Upper Nevada Creek, Wales Creek, West Fork Clearwater River, and Yourname Creek. Upper Nevada

Creek (i.e., upstream of Nevada Creek Reservoir) is presented in this section with the other tributary streams because it is separated from lower Nevada Creek by Nevada Creek Reservoir.

The available total phosphorus (TP), total nitrogen (TN)4, and chlorophyll data for each of the streams are presented in the following sections in comparison to the interim targets described in **Section 7.1**. Data for Nevada Creek Reservoir are also presented to provide context with the tributaries.

7.2.2.1 Total Phosphorus

Recent total phosphorus samples (2001 to present) were obtained at 18 stations located in the tributary streams. **Table 7-8** summarizes the stations and the number of TP samples per station. The data were pooled for each stream and are presented as box plots. **Figure 7-3** shows all of the available data, as well as data for the summer season only in comparison to the interim target (0.01 mg/L) discussed in **Section 7.1**. As shown in **Figure 7-3**, with the exception of the West Fork Clearwater River, the interim target was exceeded at all of the sample stations. It should be noted, however, that most streams have limited data, with most of the smaller tributaries having only one TP sample.

Table 7-8. Summary of the Available Total Phosphorus Data (2001-2006)

Stream	Station Name	Station ID	n
Black Bear Creek	Black Bear Creek 250 yds upstream from mouth Bear Creek	C03BKBRC10	1
Braziel Creek	Braziel Creek 50 yds upstream of Nevada Creek Rd crossing	C03BRZLC10	1
Clearwater River, West Fork	Clearwater River West Fork lower	C03CLRWF20	1
	Clearwater River West Fork upper	C03CLRWF10	1
Douglas Creek	Douglas Creek 0.25 mi upstream of Murray Creek confluence	C03DOUGC20	1
	Douglas Creek 150 yds upstream from second reservoir	C03DOUGC10	1
	Douglas Creek upstream of road crossing	DCSW-1	1
Frazier Creek	Frazier Creek 200 yds upstream of mouth	C03FRZRC10	1
Gallagher Creek	Gallagher Creek 150 yds upstream from Nevada Creek	C03GALGC10	1
Jefferson Creek	Jefferson Creek lower upstream of Dalton Mountain Rd crossing	JCSW-1	2
McElwain Creek	McElwain Creek at lowest road crossing in BLM land	C03MCEWC10	1
Murray Creek	Murray Creek 100 yds upstream from highest road crossing	C03MURYC10	1
	Murray Creek 100 yds upstream of lowest road crossing	C03MURYC20	1
Nevada Creek – Upper	Nevada Ck downstream of proposed restoration area	NCQR-NCWQ-2	1
	Nevada Ck upstream of proposed restoration area	NCQR-NCWQ-1	1
	Nevada Creek upstream of reservoir	12335500	12
Nevada Creek Reservoir1	Nevada Creek Reservoir at mid-lake (Reservoir)	C03NVDRS01	6
Yourname Creek	Yourname Creek 300 yds downstream from bridge	C03YRNMC20	1

[1]Data for Nevada Creek Reservoir are presented to provide context with the rest of the streams.

4 No TN data are available for the tributaries. TN has been calculated as the sum of NO_2+NO_3 and TKN (USGS, 2003)

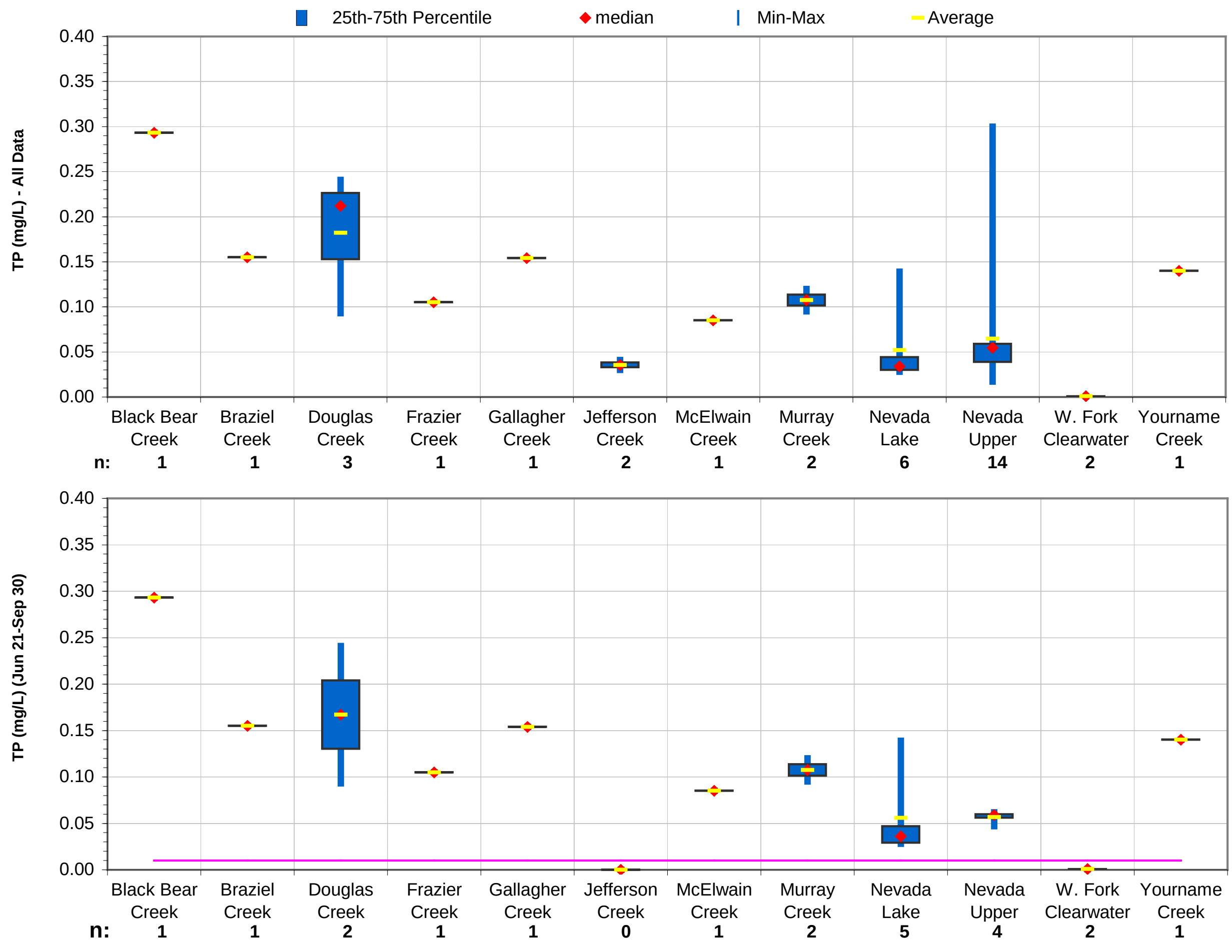


Figure 7-3. Summary of the Available Total Phosphorus Data in the Tributary Streams and Nevada Lake, 2001-2006

7.2.2.2 Total Nitrogen

No total nitrogen (TN) data are available for the tributary streams or Upper Nevada Creek. However, nitrate + nitrite (NO_3+NO_2) and total Kjeldahl nitrogen (TKN) were collected and TN has been calculated as the sum of these constituents (USGS, 2003). **Table 7-9** summarizes the stations and the number of cases where both NO_3+NO_2 and TKN were collected. **Figure 7-4** shows all of the available data and data for the summer season only (June 21 – September 30) in comparison to the interim target (0.33 mg/L) discussed in **Section 7.1**. As shown in **Figure 7-4**, with the exception of Braziel Creek, Jefferson Creek, and the West Fork Clearwater River, the interim target was exceeded at all of the sample stations at least once.

Interestingly, unlike TP where Nevada Reservoir and Upper Nevada Creek had similar values, TN is noticeably higher in the Reservoir compared to its primary tributary (Upper Nevada Creek). It should be noted, however, that most streams and the Reservoir have limited data, and the data were not all collected at the same time. Synoptic data would be necessary to make accurate relative comparisons.

Table 7-9. Summary of the Available TN Data (2001-present)

Stream	Station Name	Station ID	n
Black Bear Creek	Black Bear Creek 250 yds upstream from mouth Bear Creek	C03BKBRC10	1
Braziel Creek	Braziel Creek 50 yds upstream of Nevada Creek Road crossing	C03BRZLC10	1
Douglas Creek	Douglas Creek 0.25 mi upstream of Murray Creek confluence	C03DOUGC20	1
	Douglas Creek 150 yds upstream from second reservoir	C03DOUGC10	1
	Douglas Creek upstream of road crossing	DCSW-1	1
Frazier Creek	Frazier Creek 200 yds upstream of mouth	C03FRZRC10	1
Gallagher Creek	Gallagher Creek 150 yds upstream from mouth Nevada Creek	C03GALGC10	1
Jefferson Creek	Jefferson Creek lower upstream of Dalton Mountain Road crossing	JCSW-1	2
McElwain Creek	McElwain Creek at lowest road crossing in BLM land	C03MCEWC10	1
Murray Creek	Murray Creek 100 yds upstream from highest road crossing	C03MURYC10	1
	Murray Creek 100 yds upstream of lowest road crossing	C03MURYC20	1
Nevada Creek Reservoir1	Nevada Creek Reservoir at mid-lake (Reservoir)	C03NVDRS01	6
Upper Nevada	Nevada Creek downstream of proposed restoration area	NCQR-NCWQ-2	1
	Nevada Creek upstream of proposed restoration area	NCQR-NCWQ-1	1
	Nevada Creek upstream of reservoir	12335500	12
West Fork Clearwater River	Clearwater River West Fork lower	C03CLRWF20	1
	Clearwater River West Fork upper	C03CLRWF10	1
Yourname Creek	Yourname Creek 300 yds downstream from bridge	C03YRNMC20	1

[1]Data for Nevada Creek Reservoir are presented to provide context with the rest of the streams.

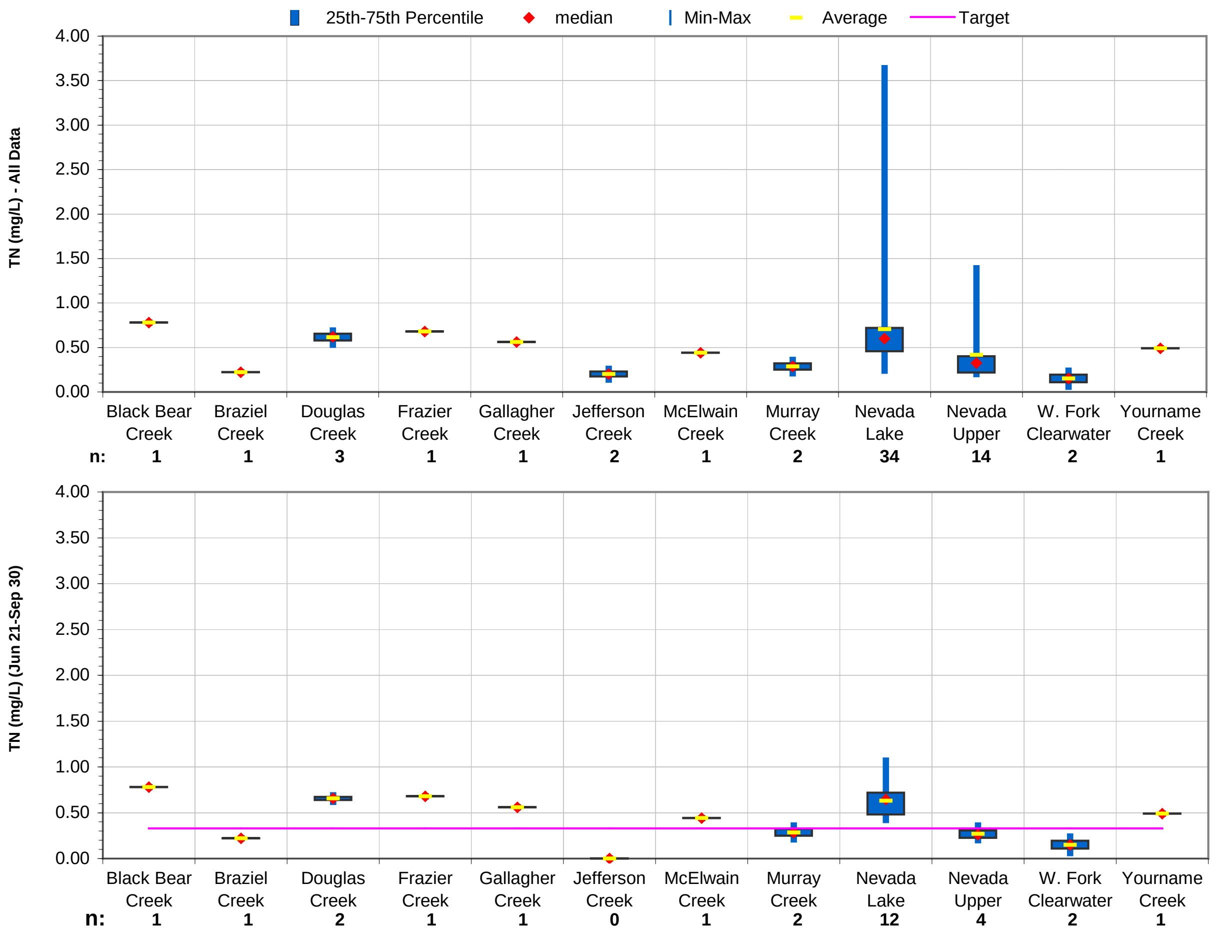


Figure 7-4. Summary of the Available Total Nitrogen Data for the Tributary Streams and Nevada Lake, 2001-2006

7.2.1.4 Chlorophyll-*a*

Recent chlorophyll-*a* samples (2001 to present) were obtained at 9 stations located in the tributary streams. **Table 7-10** summarizes the stations and the number of samples per station. The data were pooled for each stream and are presented as box plots in **Figure 7-5** along with the interim growing season target (maximum value of 150 mg/m^2) discussed in **Section 7.1**. Insufficient data are available to calculate mean values for comparison to the summer mean value (100 mg/m^2). Douglas and Yourname Creeks, however, are the only tributaries with data that approach or exceed the summer mean interim target value. As shown in **Figure 7-5**, the chlorophyll-*a* maximum target value is not exceeded in the tributary streams.

Table 7-10. Summary of Chlorophyll –*a* Data Collected in 303(d) Listed Segments in the Blackfoot River – Nevada Creek TPA (2001-present)

Stream	Station Name	Station ID	n
Black Bear Creek	Black Bear Creek 250 yds upstream from mouth Bear Creek	C03BKBRC10	1
Braziel Creek	Braziel Creek 50 yds upstream of Nevada Creek Road crossing	C03BRZLC10	1
Douglas Creek	Douglas Creek 0.25 mi upstream of Murray Creek confluence	C03DOUGC20	1
	Douglas Creek 150 yds upstream from second reservoir	C03DOUGC10	1
Frazier Creek	Frazier Creek 200 yds upstream of mouth	C03FRZRC10	1
Gallagher Creek	Gallagher Creek 150 yds upstream from mouth Nevada Creek	C03GALGC10	1
Murray Creek	Murray Creek 100 yds upstream from highest road crossing	C03MURYC10	1
	Murray Creek 100 yds upstream of lowest road crossing	C03MURYC20	1
Yourname Creek	Yourname Creek 300 yds downstream from bridge	C03YRNMC20	1

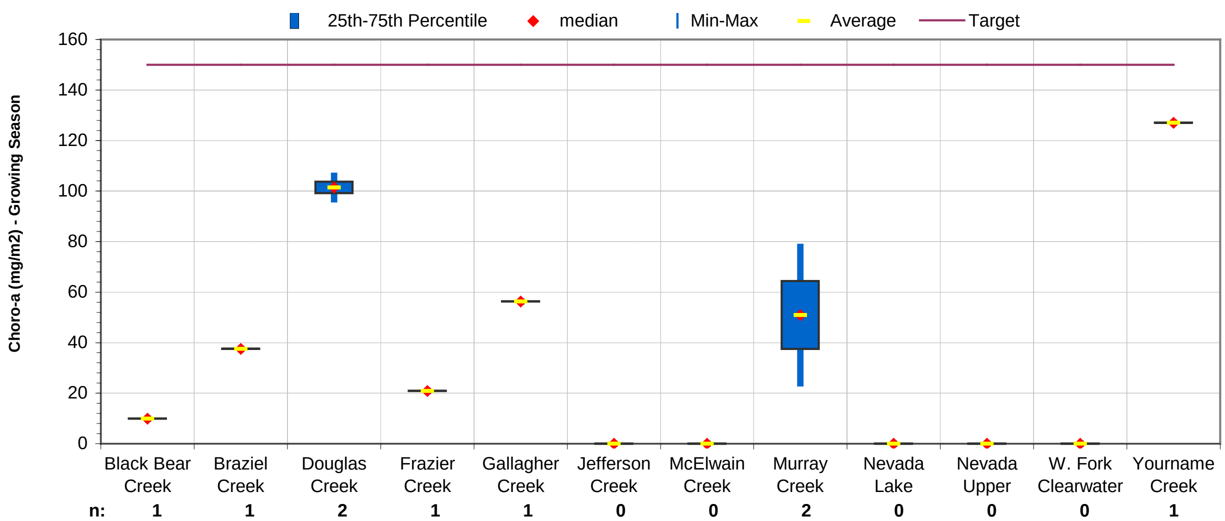


Figure 7-5. Summary of the Available Chlorophyll-*a* Data, 2001-2006

7.2.3 Nevada Creek Reservoir

Nevada Creek Reservoir (i.e., Nevada Lake) was listed as impaired because of nutrients on the Montana 2006 303(d) List. The following sections present the available dissolved oxygen and chlorophyll-*a* data for Nevada Creek Reservoir to show nutrient response within the lake.

7.2.3.1 Dissolved Oxygen

Recent dissolved oxygen data were obtained at one station located in the middle of Nevada Creek Reservoir (Station C03NVDRS01). Seven dissolved oxygen profiles were obtained between June 19, 2003, and September 21, 2005. Data show that dissolved oxygen concentrations generally decrease with depth and appear to be lowest in July and August (**Figure**

7-6). Three sampling events (July 14, 2003; July 19, 2004; and August 17, 2004) had dissolved oxygen concentrations at depth that were below the water quality standard of 5.0 mg/L.

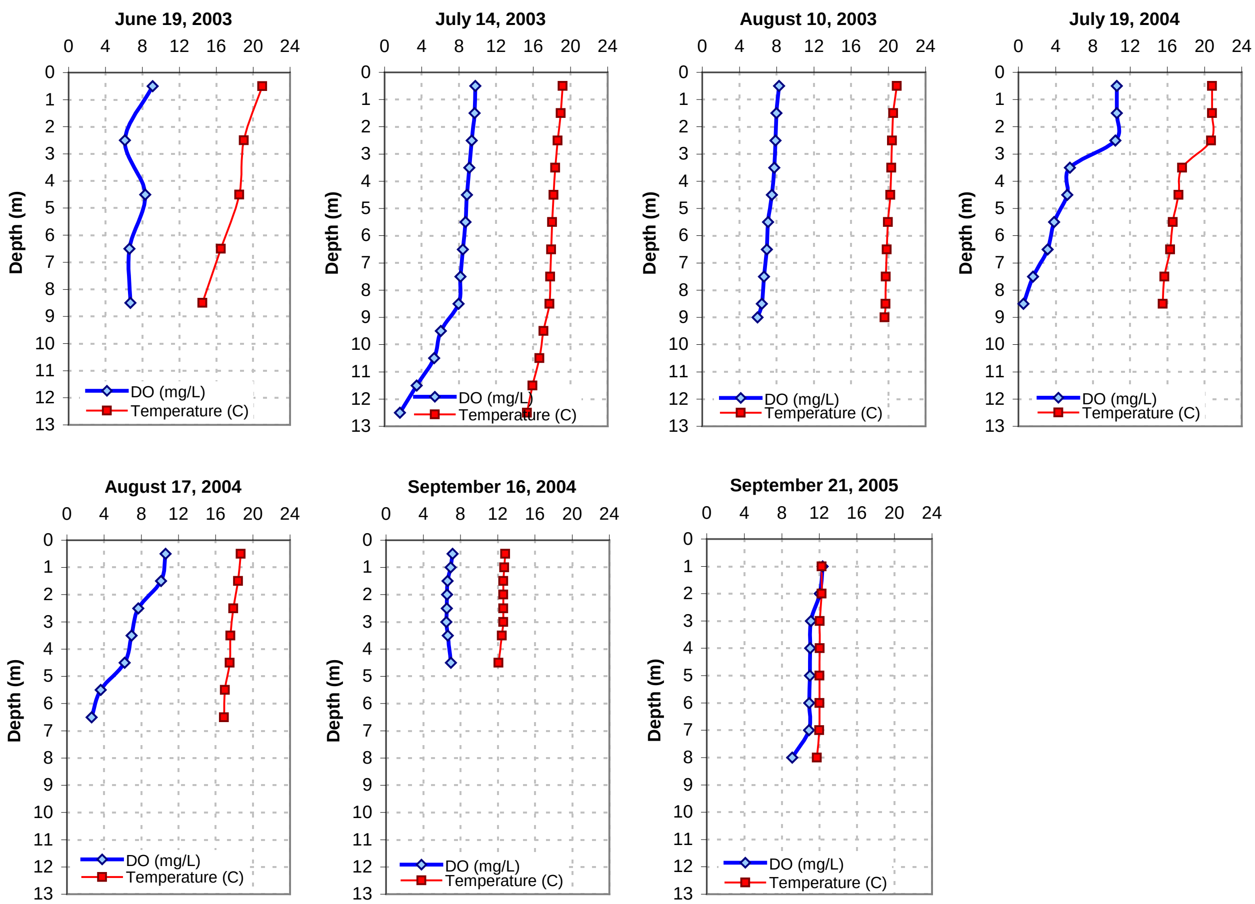


Figure 7-6. Dissolved Oxygen and Temperature Profiles for Nevada Creek Reservoir (Station C03NVDRS01)

7.2.3.2 Chlorophyll-*a*

Recent chlorophyll-*a* data (phytoplankton) were obtained at one station located in the middle of Nevada Creek Reservoir (Station C03NVDRS01). Six samples were obtained between June 19, 2003, and September 16, 2004, with an average value of 9.9 µg/L (**Table 7-11**). TSI values were calculated for each sample and ranged from 30.6 to 57.3 with an average value of 50.0. Half of the chlorophyll-*a* and TSI values exceed the targets of 7.2 µg/L and 50, respectively.

Table 7-11. Clorophyll –*a* Data for Nevada Creek Reservoir

Station ID	Station Name	Date	Value (µg/L)	TSI Value
C03NVDRS01	Nevada Creek Reservoir at mid-lake (Reservoir)	6/19/03	1.0	30.6
		7/14/03	7.0	49.7
		8/10/03	5.9	48.0
		7/19/04	13.5	56.1
		8/17/04	16.7	58.2
		9/16/04	15.2	57.3

7.2.3.3 Total Phosphorus

Recent total phosphorus data were obtained at one station located in the middle of Nevada Creek Reservoir at the surface (Station C03NVDRS01). Six samples were obtained between June 19, 2003, and September 16, 2004, with an average value of 0.052 mg/L (**Table 7-12**). TSI values were calculated for each sample and ranged from 52.2 to 75.3 with an average value of 58.3. All of the available TP and TSI values exceed the proposed targets of 0.024 mg/L and 50, respectively.

Table 7-12. TP Data for Nevada Creek Reservoir

Station ID	Station Name	Date	Value (µg/L)	TSI Value
C03NVDRS01	Nevada Creek Reservoir at mid-lake (Reservoir)	6/19/2003	0.032	54.1
		7/14/2003	0.029	52.7
		8/10/2003	0.036	55.8
		7/19/2004	0.028	52.2
		8/17/2004	0.047	59.7
		9/16/2004	0.139	75.3

Note that phosphorus data for Nevada Creek Reservoir were presented in **Section 7.2.2** along with data for the tributaries. The median TP concentration in Nevada Lake was lower than all of the 303(d) Listed tributary streams, including upper Nevada Creek. These lower values could be related to biological phosphorous uptake within Nevada Lake.

7.2.3.4 Total Nitrogen

Recent total nitrogen data were obtained at one station located in the middle of Nevada Creek Reservoir at the surface (Station C03NVDRS01). Six samples were obtained between June 19, 2003, and September 16, 2004, with an average value of 0.70 mg/L (**Table 7-13**). This is noticeably higher than the average influent from Upper Nevada Creek of 0.42 mg/L (see **Section 7.2.2**). However, data are limited and the data were not all collected at the same time. Synoptic data would be necessary to make accurate relative comparisons.

Table 7-13. TN Data for Nevada Creek Reservoir

Station ID	Station Name	Date	Value (µg/L)
C03NVDRS01	Nevada Creek Reservoir at mid-lake (Reservoir)	6/19/2003	0.4
		7/14/2003	0.54
		8/10/2003	0.47
		7/19/2004	0.69
		8/17/2004	0.77
		9/16/2004	1.31

7.3 Preliminary Nutrient Source Assessment

An attempt was made to set up and calibrate a SWAT model for the Middle Blackfoot – Nevada Creek TPA to simulate nutrient loading, fate, and transport. Unfortunately, an unsatisfactory calibration was obtained for nutrients and it is not possible at this time to quantify the nutrient loads from the potentially significant sources. Further, insufficient monitoring data exist to specifically isolate and determine the effect of individual nutrient sources or categories of sources. As a result, a preliminary source assessment has been conducted based on a review of available aerial photography and readily available GIS data.

The uncertainties associated with this preliminary approach are acknowledged. The adaptive management strategy provided in **Section 9.3.5** proposes future monitoring and modeling activities to identify, and ultimately quantify the relative importance of the potentially significant sources of nutrients.

Based on the preliminary assessment, the potentially significant anthropogenic sources of nutrients within the Middle Blackfoot – Nevada Creek TPA include:

- Dissolved loads of TP and TN from subsurface irrigation return flows
- Naturally occurring particulate and dissolved loads of TP and TN in both surface water and groundwater
- TP and TN loading from agricultural sources, principally livestock grazing, irrigated hay production, irrigation return flows, and livestock feeding
- Particulate bound TP and TN from road erosion
- Particulate bound TP and TN from timber harvest
- Particulate bound TP and TN from placer mining

Sources that occur at base flow conditions during the growing season are of principal concern. A simple GIS analysis was conducted to define the location and extent of the various sources. As shown in **Figure 7-7** and **Table 7-14**, agriculture is common throughout the watershed, and primarily consists of hay and pasture/grassland. Irrigated agriculture appears to be well represented by the NLCD land use classes “Hay/Pasture” and “Row Crops” (see **Figure 7-8**). From this analysis, the Blackfoot River Watershed (upstream of the confluence with the Clearwater River) has 40,692 acres of irrigated land which is primarily located in the Nevada Creek watershed (18,416 acres, 45 percent) and along the Blackfoot River valley near the confluence with Nevada Creek (**Figure 7-9**).

Specific data regarding grazing are not readily available for the Blackfoot River Watershed. According to the Census of Agriculture (2007), there are on average 18 cattle per square mile in Powell County. It is believed that cattle are concentrated in the areas denoted by grasslands/hay/pasture in **Figure 7-7**, although some grazing occurs throughout most of the watershed.

No nutrient point sources are currently located within the Middle Blackfoot-Nevada Creek planning area. The existing MPDES permitted point sources primarily consist of road construction and active mining activities in the Blackfoot River Headwaters planning area.

Several sections within this document describe the nature of the nutrient sources mentioned above. Grazing along streams, both during the growing season and other periods is considered a major source of nutrients. This is evident in the significant portion of sediment loading, including bank erosion, attributed to grazing (**Section 9.1.7**). Continuous, season-long livestock access to stream banks contributes sediment and nutrient loads from both bank trampling and direct, instream manure deposition. Furthermore, as identified in **Section 9.1.7**, grazing and crop production activities, and to a lesser extent logging and road development, have resulted in significantly reduced riparian health along nutrient impaired streams. This reduced riparian health significantly reduces the ability to filter sediment bound nutrients during runoff conditions. Perhaps more importantly, this reduced riparian health also significantly reduces ground water nutrient uptake, particularly during baseflow conditions where nutrient loading from ground water is a major source pathway. In summary, sediment delivery from roads and other upland sources described in **Section 9.0** is also a source of nutrients.

Table 7-14. Land Cover in the Blackfoot River Watershed

Land Use/Land Cover	Middle Blackfoot – Nevada Creek TPA		Blackfoot River Watershed Upstream of Clearwater River Confluence	
	Acres	%	Acres	%
Evergreen Forest	612,952	66.9%	860,322	69.5%
Grassland	127,757	13.9%	151,699	12.2%
Shrub/Scrub	105,545	11.5%	134,670	10.9%
Pasture/Hay	28,671	3.1%	35,097	2.8%
Woody Wetlands	14,521	1.6%	22,450	1.8%
Barren/Sand/Rock	6,622	0.7%	9,822	0.8%
Open Water	6,594	0.7%	6,915	0.6%
Row Crops	4,278	0.5%	5,595	0.5%
Developed, Open Space	3,805	0.4%	5,135	0.4%
Mixed Forest	3,195	0.3%	4,013	0.3%
Developed, Low Intensity	904	0.1%	1,548	0.1%
Deciduous Forest	826	0.1%	835	0.1%
Developed, Medium Intensity	122	0.0%	163	0.0%
Snow/Ice	50	0.0%	131	0.0%
Herbaceous Wetlands	18	0.0%	20	0.0%
Developed, High Intensity	7	0.0%	8	0.0%
Total	915,866	100.0%	1,238,423	100.0%

Source: 2001 National Land Cover Data

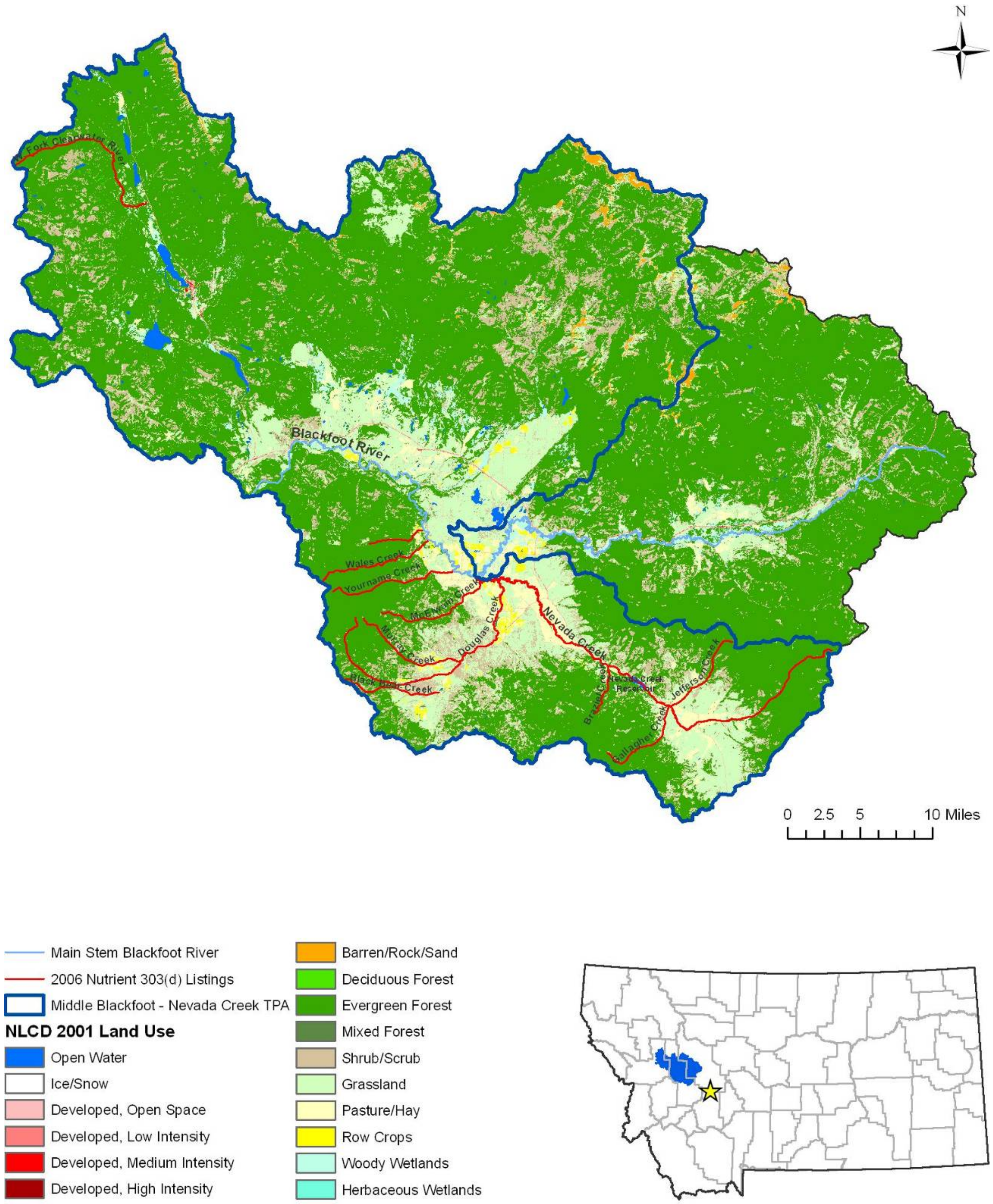


Figure 7-7. Land Use/Land Cover in the Blackfoot River Watershed Upstream of the Confluence with the Clearwater River

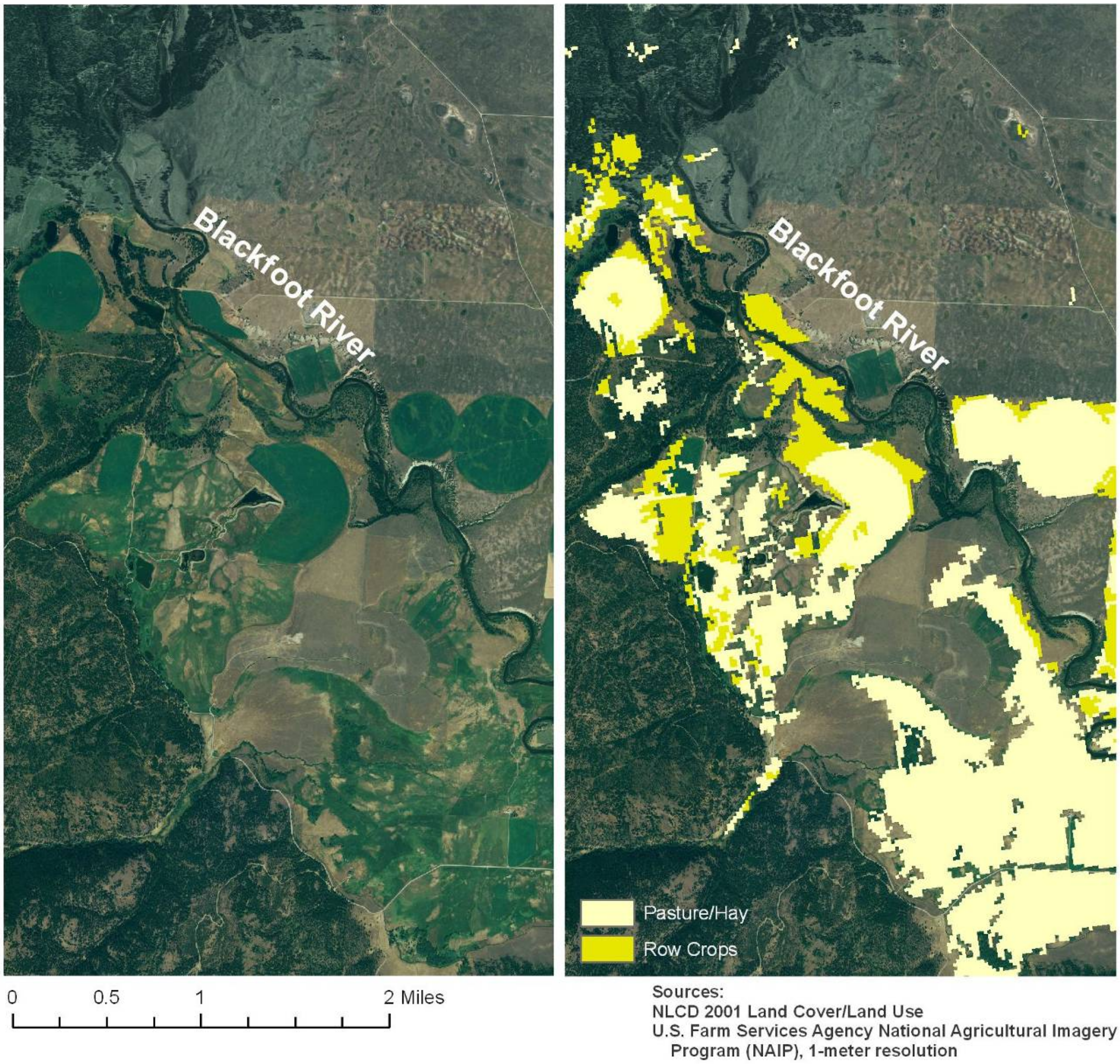


Figure 7-8. NLCD Land Use Approximation of Irrigated Agriculture, Blackfoot River near the Confluence with Nevada Creek

Figure 7-9. Irrigated Land in the Blackfoot River Watershed Upstream of the Confluence with the Clearwater River

SECTION 8.0
TEMPERATURE IMPAIRMENTS

Salmonids, such as trout, need cold waters for optimum health during various life stages (Heberling, 2000). Colder water holds more dissolved oxygen, so, as temperature rises, available dissolved oxygen for fish and other aquatic organisms decreases. Warm water also speeds up the growth of algae that consume dissolved oxygen, further reducing the amount available for fish. In addition, when water temperatures are above optimal levels, fish are physically stressed, their feeding habits and metabolism are affected, and they are more susceptible to fungal infections. For these reasons, temperature is a pollutant that affects the cold-water fisheries and aquatic life beneficial uses of Montana streams and requires development of TMDLs where temperature is a cause of impairment.

The following sections describe development of temperature targets for 303(d) temperature impaired streams, examine sources of temperature impairments, and present information on the temperature impairment status of these streams. There are six stream segments that have been listed as impaired for temperature on 303(d) Lists since 1996 in the Nevada Creek planning area and three stream segments in the Middle Blackfoot planning area (**Table 8-1, Appendix A, Figure A-34 and Figure A-35**).

Table 8-1. Streams on the 303(D) List for Temperature Since 1996

Planning Area	Stream	Montana Water Body ID
Nevada Creek	Upper Nevada Creek	MT76F003_011
	Lower Nevada Creek	MT76F003_012
	Murray Creek	MT76F003_120
	Cottonwood Creek	MT76F003_090
	Upper Douglas Creek	MT76F003_081
	Lower Douglas Creek	MT76F003_082
Middle Blackfoot	Kleinschmidt Creek	MT76F004_110
	Blackfoot River (Nevada Creek to Monture Creek)	MT76F001_31
	Blackfoot River (Monture Creek to Belmont Creek)	MT76F001_32

8.1 Temperature Target Development

Developing stream temperature targets requires interpretation of Montana's water quality standards for temperature, assessing current temperatures, determine naturally occurring temperatures, calculating the difference between current temperatures and naturally occurring temperatures to determine compliance with the temperature standard, and determining conditions for compliance with the temperature standard. **Section 2.2** describes the Montana Water Quality Standard for temperature in B-1 classified streams. This document describes the following steps in developing temperature targets that reflect the standard:

1. Compile, analyze, and summarize existing temperature data to determine locations and magnitudes of thermal loading.

2. Use the compiled data to construct and calibrate a series of temperature loading models of impaired stream segments.
3. Identify the critical temperature controlling target parameters and specify their values for existing stream temperature conditions.
4. Determine numeric values for temperature controlling target parameters that represent naturally occurring conditions.

Modeling is used to determine temperature conditions that relate to Montana's temperature standard. The model is calibrated to existing conditions and then used to simulate stream temperatures by applying temperature influencing conditions that represent a naturally occurring setting. These simulated temperatures determine the appropriate allowable increase specified by the standard (0.5°F or 1°F). The next simulation identifies the values of target parameters that are required to achieve allowable increases in stream temperatures. The need for a TMDL is determined by comparing current conditions to a condition representing all reasonable land, soil, and water conservation practices (naturally occurring condition). If there are differences between the two scenarios greater that the standards allow, a TMDL is needed; if not, no TMDL is required.

8.1.1 Existing Data Analysis

Montana FWP maintains a database of stream temperature data collected by sensors at 121 locations throughout the Blackfoot River Watershed. The data are typically hourly instantaneous measurements collected during the summer months from 1994-2005. Of the 121 monitored locations, 49 were located on 303(d) temperature listed streams or significant tributaries to those streams. The arrangement of these temperature data as model input files allowed assessment of typical, current water temperatures during summer hot periods. A complete summary of the existing temperature data can be found in DTM and AGI, 2006.

8.1.2 Model Construction and Calibration

Using selected FWP stream temperature data, a series of simulations, using the Stream Network Temperature (SNTEMP) model, were run to calibrate the model to the measured values and establish current conditions for temperature and its major controlling factors (DTM and AGI, 2006). SNTEMP is a mechanistic heat transport model that predicts daily mean and maximum water temperatures at the end of a stream network (Theurer et al., 1984 and Bartholow, 2004). Simulations occur over a single time step, such as a day, and can evaluate the effects of changing shade, stream geometry, and flow volume on stream temperature. The model requires inputs describing stream hydrology, meteorology, channel geometry, and shading.

The mean daily temperature during the hottest summer period for each stream represents the current temperature condition. The model also simulates maximum daily temperatures. However, SNTEMP is less reliable for assessing maximum temperature than for average daily temperature (Bartholow, 2004). Due to the higher uncertainty regarding simulated daily maximum temperatures, the model output for daily mean temperature was used to quantify the values of temperature target parameters.

8.1.3 Temperature Source Assessment

The purpose of a temperature source assessment is to identify influences that most significantly affect water temperature and to assess those influences that can be modified by management activities. Four processes commonly resulting from human activities were identified as having significant influences on temperature:

- Alteration of flow by diversion or reservoir storage.
- Stream channel shade reduction caused by removal of woody riparian vegetation.
- Solar heating of impounded water surfaces and.
- Alterations of stream geometry that increase the channel surface area exposed to air and sunlight.

The most temperature limiting period occurs during the summer when high air temperatures, reduced precipitation, low flows, and irrigation withdrawals combine to cause significant thermal loading. These sources are described below along with information on naturally occurring conditions.

8.1.3.1 Flow Diversion

In both the Nevada Creek and Middle Blackfoot planning areas, significant amounts of land receive irrigation water diverted from streams. In the Nevada Creek planning area, landowners irrigate approximately 17,500 acres, almost all by flood methods. In the Middle Blackfoot planning area, landowners irrigate approximately 16,100 acres, mostly by sprinkler, with a smaller proportion by flood irrigation.

Nevada Creek contains two temperature listed stream segments separated by Nevada Creek Reservoir. The reservoir covers approximately 337 acres and collects and stores water throughout the year from the upstream portion of the Nevada Creek planning area. The reservoir provides water for irrigators in the lower portion of the Nevada Creek planning area and a portion of the Middle Blackfoot planning area throughout the summer months. In addition, many significant tributary streams in the Nevada Creek and Middle Blackfoot TPAs also supply irrigation water.

Irrigation withdrawals during the hottest summer period decrease the volume of water in streams. The seasonal, climatic thermal inputs result in larger stream temperature increases as diversions reduce flow volume and return flows from flood irrigation systems likely return warmed water to the streams. Stream flow increases contributed during this period by relatively cool tributary and groundwater discharge, commonly reduce overall heating. Although opportunities for increasing stream flows are limited by naturally occurring low flow conditions and irrigation requirements, water storage and irrigation BMPs have been developed to help increase the amount of diverted water that is actually consumed by the crop while providing support for competing beneficial uses.

The Blackfoot Drought Response Plan is a voluntary irrigation water management plan within the Blackfoot River Watershed that seeks to adjust diversions in order to avoid low flow conditions harmful to cold water fisheries and aquatic life. The voluntary diversion reductions are triggered by low flow conditions in the Blackfoot River near the mouth. Under the plan, water supply evaluations are being conducted at the individual operator scale to quantify the potential for system and/or management modifications that could augment existing flows.

Currently, there is no water budget based plan operating within temperature impaired portions of the basin that seeks to evaluate and quantify the potential for operational modifications to augment flows. Therefore, it is difficult to determine whether Nevada Lake or other components of the irrigation water delivery system are being operated reasonably per the definitions of naturally occurring conditions and reasonable land, soil, and water conservation practices (ARM 17 30.602(19, 24)). It is possible that current system operations meet these definitions, but, lacking a means to evaluate system performance, the current operations cannot be assumed to represent naturally occurring conditions.

Since there is no means to evaluate achievable irrigation water use adjustments at this time, a conservatively low expectation of 15% flow augmentation is assumed possible. Flow augmentation of 15% is assumed to be a low expectation because past assessments of flood irrigation water delivery and application systems demonstrated potential for far greater water conservation. The U.S. Department of Agriculture (1997) has documented improvements to gravity flood systems that increase typical system efficiencies from 40%-65% up to 80%-90%. Critical cold water groundwater return to the stream system may also be affected by irrigation efficiency improvements. Similar efficiency improvements for gravity systems have been reported by Economic Research Station (1997) and Negri et al.(1989).

The potential for a 15% flow increase is assumed as a naturally occurring condition for those water bodies where dewatering occurs during periods of elevated summer temperatures. Based on available information regarding the exclusive early season timing of irrigation diversions from Nevada Creek above Nevada Creek Reservoir, a 15% flow increase is not available within this segment of Nevada Creek during early season because upper Nevada Creek diversions are discontinued at this time to serve downstream water rights.

8.1.3.2 Shade

This section summarizes the methods used to quantify shading influences for stream segments included in the models. One of the datasets required for the modeling describes the amount of total shade from topography, vegetation and channel morphology influences. Total shade calculated from each of these contributing factors provides a more accurate estimate of overall shade than a single total shade input value (Bartholow, 2004). Therefore, the individual shade components were derived from aerial photography, digital elevation data, base parameter assessment data, field photos, aerial assessment results, and existing literature.

Numerous reaches within the modeled stream networks have field assessment data that include vegetation type, extent, and channel cross section. These data, along with ground and aerial imagery, were used to develop an average canopy height (Vh), diameter (Vc), and offset (Vo) by vegetation type. Canopy filtering values were also developed for each vegetation type based on field photos and available literature. Field photos were examined for reaches without field data to identify vegetation type and the derived vegetation shade parameters were then applied to these types.

The extent of bankline vegetation was then digitized for each temperature impaired reach. The bankline extent of woody vegetation combined with the vegetation shade characteristics allowed calculation of a weighted average of the shade parameters based on the relative extent of the various vegetation types for each reach. These results combined with channel width and topographic shade measurements allowed calculation of a single shade value for each reach.

Lack of shade provided by riparian stream bank vegetation is a significant cause of elevated stream temperatures. Shade blocks or reduces the amount of solar energy that raises stream temperatures. In addition, thick vegetation creates a microclimate with lower temperatures and higher humidity than adjacent non-vegetated areas. Along most of the temperature listed stream segments, riparian vegetation has degraded to the extent that thermal loads are significant. Stream temperature modeling results described in DTM and AGI, 2006 indicate that shade is the most significant of the four factors listed in **Section 8.1.3** in reducing temperature increases for most stream segments. Therefore, replacement of shade through restoration of riparian vegetation is the principal temperature target chosen for streams on the 303(d) List in the Nevada Creek and Middle Blackfoot planning areas.

The amount of stream bank vegetation required to meet Montana's water quality standards for temperature varies among streams. Stream width and vegetation type determine how much shade the vegetation provides. For example, a narrow stream may need 70% stream bank vegetation whereas a wider stream may need 85% to provide an equivalent amount of channel shade. To meet water quality standards, stream bank vegetation must increase to a level that provides sufficient shade to keep water temperature within the increases allowed by the B-1 standard (between 0.5°F and 1°F).

8.1.3.3 Reservoir Operations and Heating

Reservoirs of impounded water can sometimes cause increased temperatures. Due to thermal stratification, reservoirs that deliver water from the bottom of the impoundment typically release cold water; those that release water from the top of the impoundment can deliver significantly warmed water. Nevada Reservoir is a bottom release reservoir and releases water significantly cooler than water in upper Nevada Creek that supplies the reservoir. Upper Douglas Creek has a series of three reservoirs. The downstream most reservoir is shallowest and releases water from the top. It is assumed that this reservoir causes a large portion of the measured 20^{o} F increase in temperature from above to below the three reservoirs. SNTEMP modeling of the stream segments between the reservoirs (DTM and AGI, 2006) indicates that the stream segments contribute approximately 5°F of the measured 20°F temperature increase. The remaining increase is from the reservoirs.

Montana water quality standards (ARM 17.30.602(19)) state, "Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural." However, modeling results indicate that a 15°F increase in stream temperature results from Douglas Creek reservoir operations. The target 20% reduction in thermal loading from the reservoirs (**Table 8-2**) assumes that system modifications to reduce the 15°F increase are possible and require consideration toward meeting the temperature standard in upper Douglas Creek.

8.1.3.4 Channel Morphology

Channel morphology can greatly influence stream temperatures. Stream bank riparian vegetation that overhangs a narrow stream provides a higher percentage of shade than does equivalent vegetation along a wider stream. The effects of this are two-fold. First, wide streams are inherently more susceptible to thermal heating simply due to their width. Second, increasing stream bank vegetation has a smaller mitigating effect on thermal gain within wider streams. As a result, the temperature target for a wide stream based on a 1°F allowable increase from a 95% stream bank vegetation natural condition may be close to the current condition.

Over-widening of the stream and riparian degradation increases the amount of un-shaded water surface. The amount of thermal input to the stream increases as a result. Restoring the width and streambank vegetation can greatly increase the percent shade covering the stream and improve temperature conditions.

The naturally occurring condition for width to depth ratios is defined as meeting and maintaining the width to depth ratio targets developed for sediment impairment conditions (**Section 5.0**) since these targets reflect achievable and desirable geomorphic conditions. Because width to depth targets are currently met in some areas, this parameter is not currently considered a significant source of temperature increases and is indirectly addressed because the same improvements to riparian cover that will increase shade should also result in achievement of naturally occurring geomorphic conditions where width to depth ratio targets are achieved.

In summary, the temperature target parameters include the following:

- An extent of woody bank vegetation that prevents stream temperature increases above those allowed by the standard for B-1 streams.
- 15% increase in channel flow volume provided by improvements to irrigation system efficiency achieved through operational improvements to storage, delivery and application system components and.
- 20% reduction in thermal heating from a series of storage reservoirs.
- Achievement of W:D ratio targets developed in response to sediment and habitat impairments.

Due to limitations of the model or lack of information, other human activities and natural occurrences were not included in this analysis. These include turbidity, dissolved organics, and beaver activity.

8.1.4 Determination of Naturally Occurring Temperatures

Thick stands of woody riparian vegetation cover stream banks locally along the 303(d) Listed streams. Examples of these conditions occur at the following locations:

- S ½ sections 29 and 30, Township 12 North, Range 8 West, upper Nevada Creek
- SW ¼ Section 24, Township 13 North, Range 11 West, lower Nevada Creek
- W ½ Section 20, Township 12 North, Range 12 West, upper Douglas Creek
- NW ¼ Section 33, Township 13 North, Range 11 West, lower Douglas Creek

Color infra-red images of these locations are contained in **Appendix G**.

In addition, 1950s and 1970s aerial photos indicate that dense stream bank vegetation was more abundant historically. Through the process of developing bankline vegetation extent as a shade parameter, conditions observed along relatively undisturbed stream banks was estimated as representing 95% steam bank woody vegetation extent. This estimate of reference condition applied to temperature impaired streams and significant tributaries, in the context of the SNTEMP model, markedly increased shade and reduced stream temperatures. This extent of woody bankline vegetation is considered achievable given successes reestablishing riparian areas where standard BMPs have been implemented.

A series of Stream Network Temperature (SNTEMP) models provide simulated stream temperatures under current conditions and under improved vegetation (shade) conditions. Because 95% woody bankline vegetation was assumed as the naturally occurring shade condition for all temperature impaired tributary segments, the temperature changes simulated under this shade condition were selected as representing the naturally occurring temperature. Potential flow improvements and reductions in W:D ratio may be more significant than simulated within the models, but cost constraints and the lack of flow and channel morphology data precluded running additional simulations.

8.1.5 Temperature Target Determinations

The following steps summarize the process of temperature target development through the use of model simulations:

1. Compile, analyze, and summarize existing temperature data to determine locations and magnitudes of thermal loading;
2. Develop shade data from existing stream assessment data as model input;
3. Construct and calibrate a series of SNTEMP and SSTEMP models of temperature impaired stream segments;
4. Simulate temperatures reflecting naturally occurring conditions for the temperature controlling target parameters;
5. Simulate conditions reflecting the temperature changes allowed by the standards to establish appropriate target parameter values.

Montana water quality standards for temperature allow an increase of 0.5°F to 1.0°F above the naturally occurring conditions. Therefore, the naturally occurring temperature plus the allowable increase represents compliance with the temperature standard. For example, on upper Nevada Creek, the simulated naturally occurring average daily temperature just above Nevada Reservoir is 60.66ºF. The 1ºF allowable increase brings this temperature to 61.66ºF. The current condition (mean daily temperature from the hottest summer period) is 64.15ºF. SNTEMP simulations indicate that 73% woody bankline vegetation along upper Nevada Creek is necessary to reduce the current conditions temperature to that allowed by the standard.

Table 8-2 below lists the results of the SNTEMP modeling, including current temperature conditions and the simulated natural conditions. The endpoints for mean daily and maximum daily temperatures derived from the model simulations are also presented in **Table 8-2** along with the values for temperature controlling target parameters. These values represent the shade, flow, W:D ratio and reservoir area necessary to suppress mid-summer temperature increases to those allowed by the standard. For most of the 303(d) temperature listed streams, temperatures defined by the allowable increase above naturally occurring conditions can be achieved through an increase in riparian shade. These include Cottonwood Creek, Nevada Creek above the reservoir, Murray Creek, and Kleinschmidt Creek. In addition, improvements in channel width (narrowing) and flow augmentation are included as targets for several streams. One stream (upper Douglas Creek) requires modification of a shallow reservoir system that contributes to a 20°F thermal gain. DTM and AGI, (2006) contains a detailed description of the temperature modeling effort.

Table 8-2. Impairment Sources, Modeling Results, and Targets for Temperature Impaired Streams in the Nevada Creek and Middle Blackfoot Planning Areas

Model Segment (Method)	Stream Name	Primacy Impairment Sources	Modeled Temperatures Mean Daily Max. Daily		B-1 Allowable Increase (°F)	Targets Reflecting Allowable Increase: a) Woody Vegetation Extent (%) b) Channel W:D Ratio c) Flow Enhancement (%) d) Thermal Loading Reduction (%)
			Current	Naturally-Occurring		
Upper Nevada (SNTEMP)	Upper Nevada Creek	Shade Removal	64.2 71.4	60.7 65.0	1	a) 73 % b) B Channel W:D - 12-16 b) C Channel W:D - 12-20
Lower Nevada (SNTEMP)	Lower Nevada Creek	Shade Removal Dewatering Over-widening	70.4 76.0	68.3 73.5	0.5	a) 80% b) C Channel W:D - 12-20 (Nev7, 8, 14) b) E Channel W:D - 6-11 (Nev12b) c) ≥15% (July 15th -August 15th)
	Cottonwood Creek	Shade Removal Dewatering	69.6 79.0	62.7 68.4	0.5	a) 91% c) ≥15% July 15th -August 15th
	Murray Creek	Shade Removal Dewatering	69.6 79.0	62.7 68.4	0.5	a) 91% c) ≥15% July 15th -August 15th
	Lower Douglas Creek	Shade Removal Dewatering	69.3 78.2	63.4 69.1	0.5	a) 89% b) C Channel W:D - 12-20 (Doug 5-7) c) ≥15% July 15th -August 15th
Upper Douglas (SSTEMP)	Upper Douglas Creek	Shade Removal Dewatering Reservoir Heating	68.4 78.0	63.4 69.0	0.5	a) 82% c) ≥15% July 15th -August 15th d) 20% Reservoir heating reduction
Kleinschmidt (SNTEMP)	Kleinschmidt Creek	Shade Removal	50.9 55.8	50.0 52.3	1	a) 69% (Reach above Highway 200)
Blackfoot Mainstem (SNTEMP)	Blackfoot River (Nevada Cr. to Monture Cr.)	Tributary Effects Dewatering	68.7 74.2	68.4 74.0	0.5	Current Conditions Within Allowable Increase
	Blackfoot River (Monture Cr. to Belmont Cr.)	Tributary Effects Irrigation Withdrawals	66.6 70.1	66.6 70.1	0.5	Current Conditions Within Allowable Increase

8.1.6 Adaptive Management for Temperature Targets

The target values in **Table 8-2** may need modification as knowledge about the relationship of target parameters and to temperature improves within the basin. As the level of certainty increases regarding naturally occurring shade, geomorphology, and flow conditions, the model inputs can be adjusted to better determine the appropriate target parameter values that represent compliance with water quality standards. Furthermore, the allowable deviation from naturally occurring conditions may also be refined to help adjust allocations and associated activities that are being pursued as part of water quality improvement activities in the watershed. Below are a few key considerations that could result in the need to modify target values as an adaptive management approach takes shape in the watershed:

- The expected level of woody bankline vegetation may decrease or increase due to improved modeling, a better understanding of achievable riparian conditions, or other factors.
- The ability to improve temperature via irrigation management improvements, including reservoir management modifications, may be more or less significant than currently implied.
- Modeling improvements may result in reduced uncertainty.

8.2 Water Quality Impairment Status

The following sections describe the current temperature conditions relative to targets for temperature controlling factors for each stream. The SNTEMP model simulated temperatures under naturally occurring conditions, current conditions, and target conditions reflecting allowable temperature increases. The departure between current conditions and target values determines the water quality impairment status. If the increase in stream temperatures under current conditions exceeds the increase allowed by the standard, the temperature targets are not met and a temperature TMDL is required.

8.2.1 Nevada Creek Planning Area

Six stream segments in the Nevada Creek planning area have been listed as impaired for temperature: upper Nevada Creek, lower Nevada Creek, Murray Creek, Cottonwood Creek, upper Douglas Creek, and lower Douglas Creek. Stream temperature data were available for all of these streams except Murray Creek. Due to similarities between Murray Creek and the Douglas Creek tributary of Cottonwood Creek, modeling results for Cottonwood Creek were used to develop targets for Murray Creek. The SNTEMP models utilized stream temperature data from the Montana FWP database, shade data derived from vegetation data measured during the base parameter assessment (DTM and AGI, 2005), and continuous or instantaneous USGS stream flow data or instantaneous summer stream flow observations. A report titled *Temperature Analysis and Modeling of 303(d) List Streams in the Blackfoot River Watershed, Montana* (DTM and AGI, 2006) fully describes this project.

8.2.1.1 Upper Nevada Creek

Above Nevada Reservoir, the only stream on the 2006 303(d) List for temperature impairments is upper Nevada Creek (**Table 2-3**). Upper Nevada Creek emanates from a forested headwater area and flows through valley bottom agricultural lands into Nevada Reservoir (**Appendix A, Figure A-37**). Relatively cool water temperatures measured at Nevada Creek above Shingle Mill Creek and Mitchell Creek reflect cold inflows from the headwater areas of Nevada Creek (**Figure 8-1**). Nevada Creek temperatures increase below the confluence of Halfway Creek (**Figure 8-2**), indicating a contribution of relatively warm water from that tributary. Air photos and base parameter assessment data (DTM and AGI, 2005) depict a lack of riparian shading on much of Halfway Creek, as well as on Nevada Creek above Halfway Creek. Both of these reaches likely experience large thermal gains during hot summer days, which results in warm stream temperatures in Nevada Creek below Halfway Creek. Farther downstream, Washington Creek is slightly warm at the Highway 141 crossing, approximately 2 miles upstream of its confluence with Nevada Creek (**Appendix A, Figure A-37**). Between this location and the confluence with Nevada Creek, the stream temperatures on Washington Creek likely experience substantial gains due to a lack of riparian vegetation in this reach. Jefferson Creek contributes water slightly cooler than Washington Creek, in part due to groundwater inputs. Between the Halfway Creek confluence and Nevada Reservoir, Nevada Creek is also sparsely vegetated and significant solar warming of water is likely in the reach, as indicated by warm temperatures measured just above the reservoir (**Figure 8-3**).

Diversion of water for irrigation occurs in the early summer in upper Nevada Creek since water rights in this area only allow diversion until late June. Note that the water temperatures at the start of the monitoring period (**Figure 8-3**) are relatively warm and may reflect warm return flows (overland flow) from the early summer flood irrigation.

Temperature Data Analysis

The Montana FWP temperature database includes data from 2001 for three sites on upper Nevada Creek and four sites on important tributary streams to upper Nevada Creek. **Figure 8-1 through Figure 8-3** (upstream to downstream) display continuous water temperature readings collected at three monitoring sites on Nevada Creek during the summer of 2001. These figures illustrate that the daily range in water temperatures (diurnal fluctuation) is around 10-15°F. The drop in temperature around July 30 at all sites corresponds with a cool and rainy period.

Figure 8-5 shows the distribution of summer temperatures during 2001 at the seven monitoring sites and allows comparison of temperatures between sites. The data shows significant warming from above Shingle Mill Creek to below Halfway Creek. Nevada Creek temperatures increase significantly between the site above Shingle Mill Creek and the site below Halfway Creek; with Halfway Creek having the highest temperatures of all the sites.

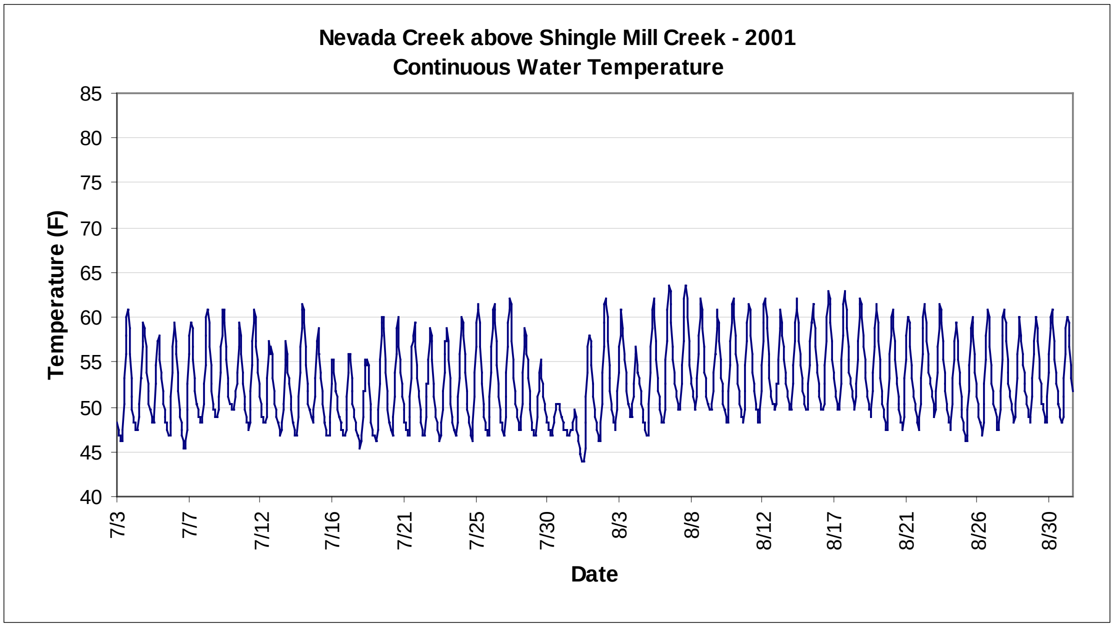


Figure 8-1. Continuous Water Temperature, Nevada Creek above Shingle Mill Creek, 2001

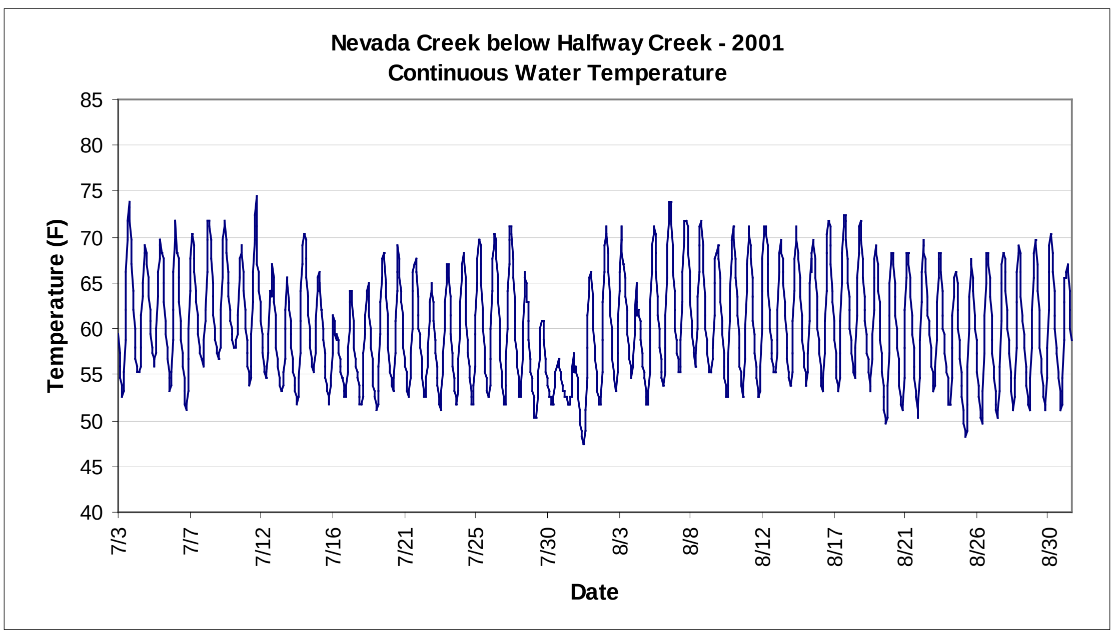


Figure 8-2. Continuous Water Temperature, Nevada Creek below Halfway Creek, 2001

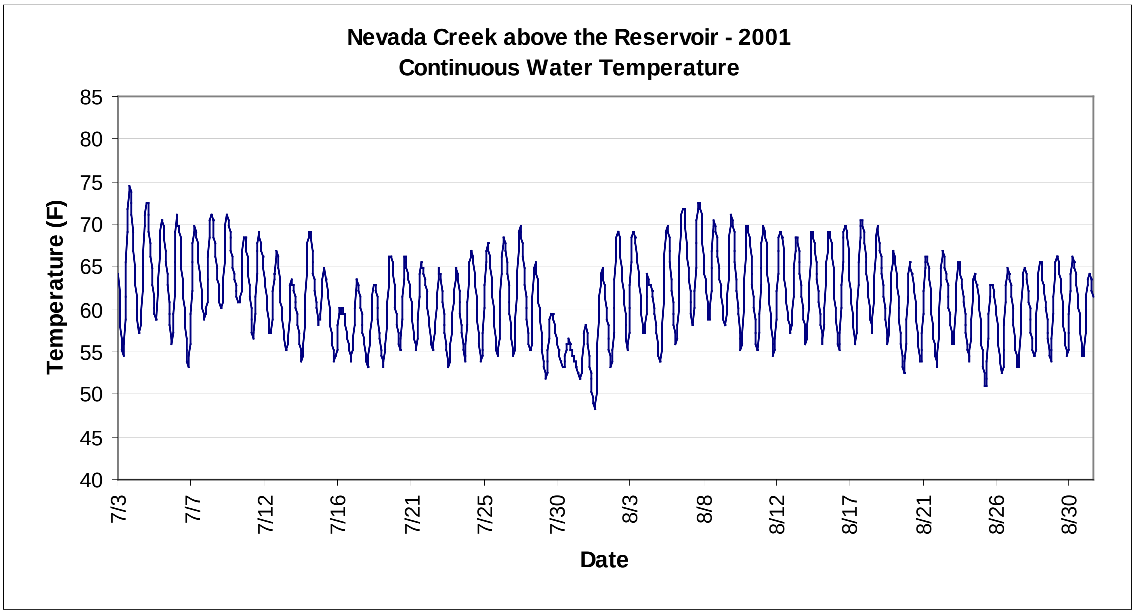


Figure 8-3. Continuous Water Temperature, Nevada Creek above The Reservoir, 2001

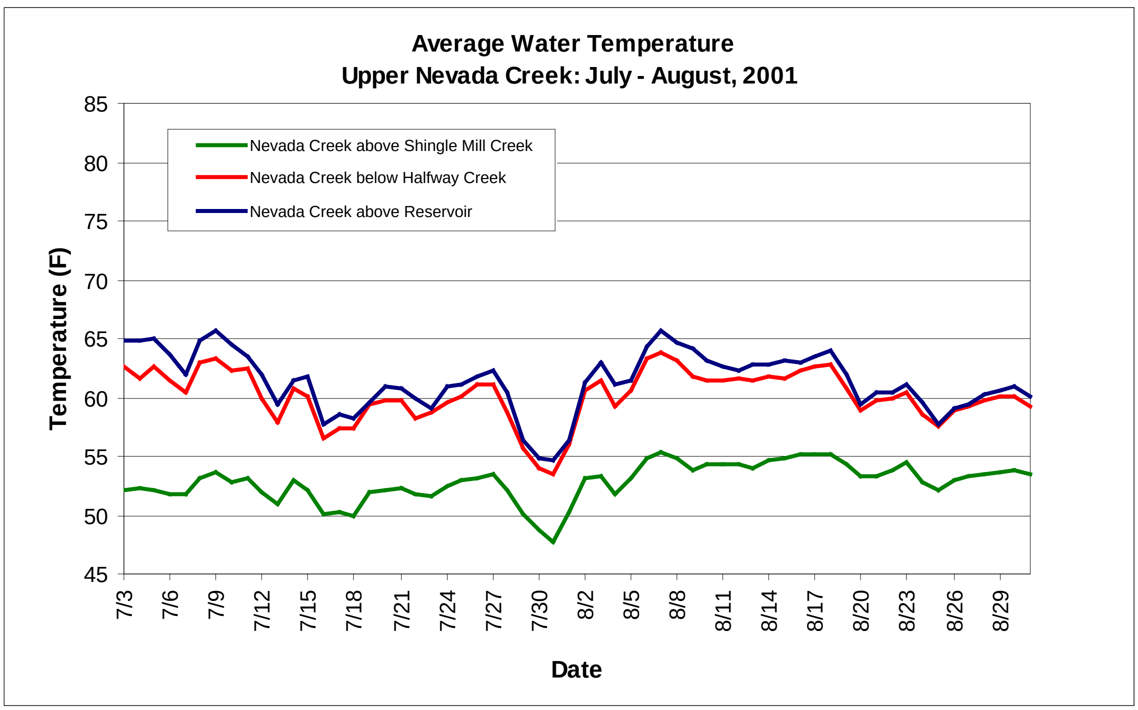


Figure 8-4. Average Daily Water Temperature, Upper Nevada Creek, 2001

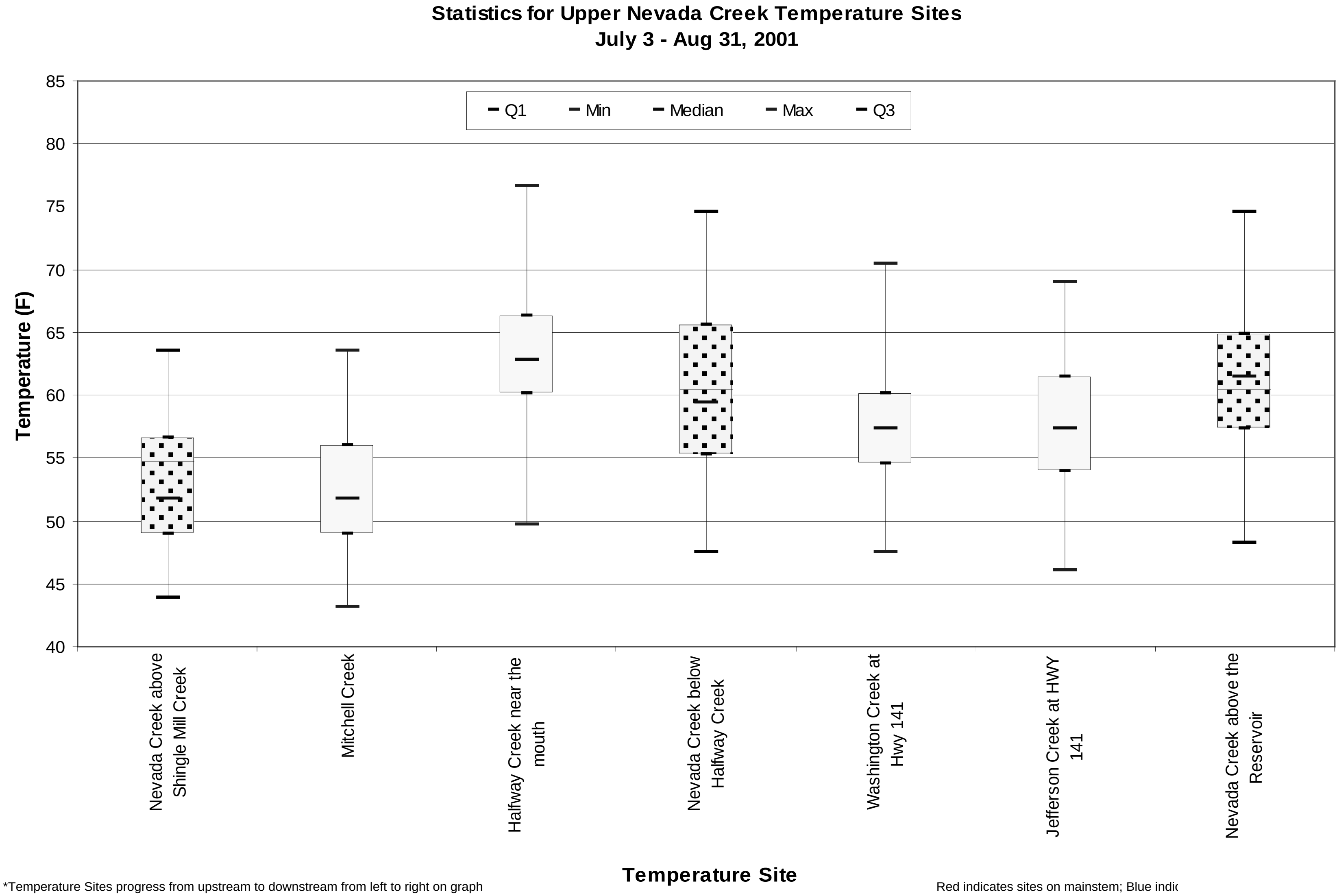


Figure 8-5. Upstream To Downstream Temperature Variation, Upper Nevada Creek, 2001

Upper Nevada Creek Temperature Modeling Results

Five SNTEMP simulations assessed the effect of riparian shade on stream temperatures. Riparian shade is presented as percent of woody bankline vegetation. One simulation was the calibrated model with current woody bankline vegetation conditions (19%). A second simulation modeled naturally occurring conditions. Montana DEQ defined naturally occurring conditions as 95% woody bankline vegetation for this project. Two additional simulations modeled woody bankline vegetation at levels between current and natural conditions. A final simulation assessed the amount of vegetation required to keep temperatures within 1°F Fahrenheit of the natural condition scenario. The 1ºF allowable increase is the temperature target established by Montana DEQ (ARM, 2006).

For naturally occurring conditions, the model simulated a mean daily temperature of 60.66°F above Nevada Creek Reservoir (**Table 8-3, Figure 8-6**). This value is 3.49°F lower than temperature simulated under current conditions. A simulation that increases woody bankline vegetation to 20% reduced mean temperature by 0.14°F; simulating 60% woody bankline vegetation reduced mean temperature by 1.94°F. The target value for this stream segment is 73% woody bankline vegetation. Using this value, the model simulated a mean daily temperature of 61.61°F. This is 2.54°F less than the mean daily temperature with current conditions, and 0.95°F greater than the temperature for naturally occurring conditions. This falls within the 1°F allowable increase from naturally occurring conditions for the mean daily temperatures.

Review of the maximum temperatures, although not as reliable as the mean temperatures, shows that the naturally occurring maximum temperatures also fall within the range where a one degree allowable increase is acceptable. Actual naturally occurring temperatures would be lower since naturally occurring conditions in the tributaries have not yet been achieved and temperature reductions in the tributaries would further reduce the naturally occurring mean and maximum temperatures in Nevada Creek.

These results indicate that meeting temperature targets in Nevada Creek above the reservoir requires increasing woody bankline vegetation to 73% along Nevada Creek modeled stream banks.

Table 8-3. Simulation Results for Upper Nevada Creek

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	63.82	71.31	NA	NA	NA
Calibrated Temperature (Current Conditions)	64.15	71.35	NA	NA	Simulated temperature above the reservoir with current stream conditions
Simulation 1	64.00	70.59	-0.14	-0.76	20% of bank with woody vegetation cover
Simulation 2	62.24	67.60	-1.91	-3.75	60% of bank with woody vegetation cover
Target Conditions	61.66	66.74	-2.51	-4.61	73% of bank with woody vegetation cover
Natural Conditions	60.66	64.98	-3.49	-6.37	95% of bank with woody vegetation cover

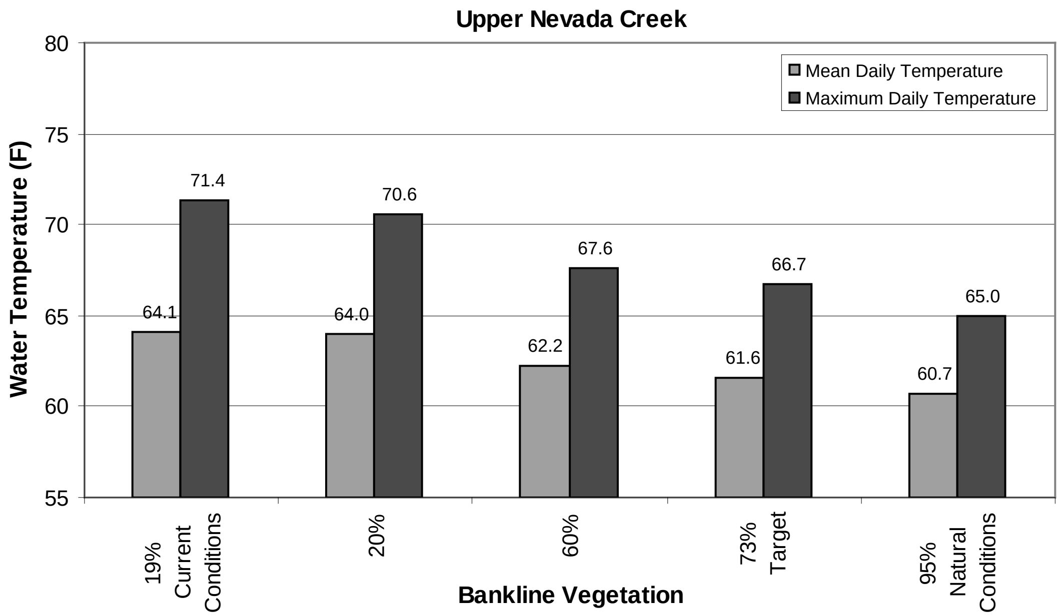


Figure 8-6. Simulated Mean and Maximum Temperature with Change in Bankline Vegetation for Upper Nevada Creek

Upper Nevada Creek Impairment Status Summary

SNTEMP modeling provided simulated naturally occurring conditions temperatures at 95% woody bankline vegetation. The target temperature is 1°F above the naturally occurring temperatures. Comparison with the current conditions temperature indicates that upper Nevada Creek does not meet temperature targets (**Table 8-4**).

Table 8-4. Summary of Temperatures (°F) for Upper Nevada Creek

Parameter	**Temperature Mean Daily Mean Daily Max.**	**Comments**
Current Conditions Temperature	64.15 71.35	Temperature is above the 1° F allowable increase from natural conditions temperature. August 5-7, 2001 temperature data
Target Conditions Temperature	61.66 66.74	1° F allowable increase above natural conditions temperature, requires 73% stream bank woody vegetation
Natural Conditions Temperature	60.66 64.98	Simulated temperature with 95% stream bank vegetation

8.2.1.2 Lower Nevada Creek

Lower Nevada Creek begins at the outlet of Nevada Reservoir (**Appendix A, Figure A-36**). Here, cool water from the bottom of Nevada Reservoir is released (**Figure 8-7**). Between July 4 and July 15, temperatures gradually increase below the reservoir. This reflects reduced water releases from Nevada Reservoir (**Figure 8-8**), as well as increasing air temperature and solar inputs. Downstream, measured temperatures above Nevada Spring Creek reflect a significant temperature increase in Nevada Creek between the reservoir and Nevada Spring Creek (**Figure 8-9**). This reach of lower Nevada Creek notably lacks riparian shading and contains two major irrigation diversions (**Appendix A, Figure A-36**). These conditions all contribute to the large thermal gains during hot summer days on this reach.

Nevada Spring Creek in 2000 contributed relatively warm water to Nevada Creek (**Figure 8-10**). In 2001, restoration projects significantly narrowed Nevada Spring Creek, greatly reducing its surface area and thermal gains. Water temperature data from 2004 show the dramatic decrease in temperatures in Nevada Spring Creek (**Figure 8-11)**.

Downstream, at the mouth of Nevada Creek, temperature readings indicate that Nevada Creek experiences thermal gains from Nevada Spring Creek to its confluence with the Blackfoot River (**Figure 8-12**). Several factors contributed to significant warming of water in this reach in 2000 including warm water from Nevada Spring Creek prior to restoration, warm water from Douglas Creek, and a lack of shade and large channel width between Nevada Spring Creek and the mouth.

Temperature Data Analysis
The temperature database has substantial temperature data for 2000 covering lower Nevada Creek and temperature data for Nevada Spring Creek collected in 2004.

Figure 8-13 displays temperature statistics for lower Nevada Creek and tributary sites. Dam releases drop significantly around the July 4th first cutting of hay, corresponding to an increase in diurnal fluctuation in water temperature seen in the temperature graphs (**Figure 8-8**). The temperature data from Douglas and Cottonwood creeks is from locations upstream of their confluence with Nevada Creek. Therefore, the water reaching Nevada Creek is likely warmer since water from these tributaries undergoes additional thermal loading downstream of the modeling site.

The range in diurnal temperature is low immediately below Nevada Reservoir, but increases downstream above Nevada Spring Creek and more so at the mouth of Nevada Creek.

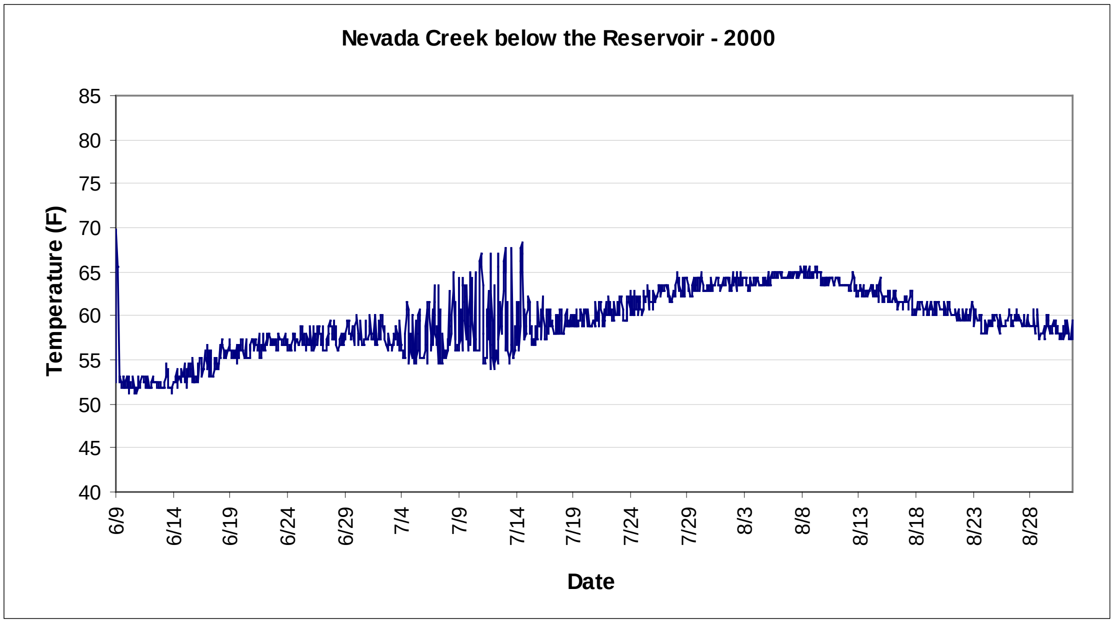


Figure 8-7. Continuous Water Temperature, Nevada Creek below the Reservoir, 2000

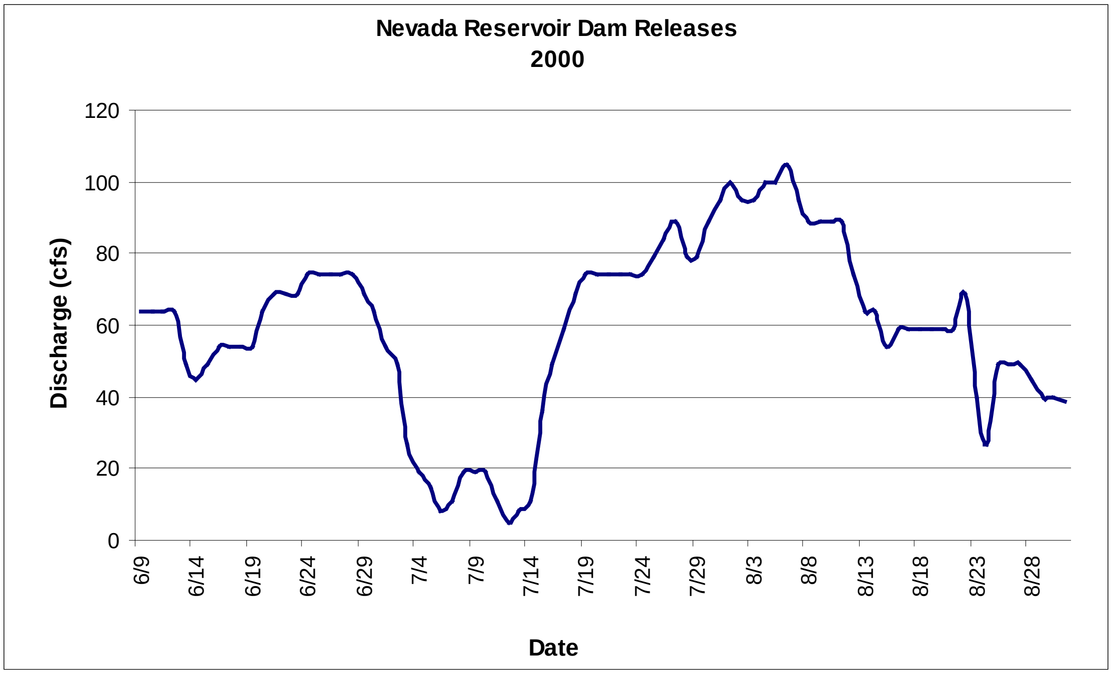


Figure 8-8. Stream Flow below Nevada Reservoir, 2000

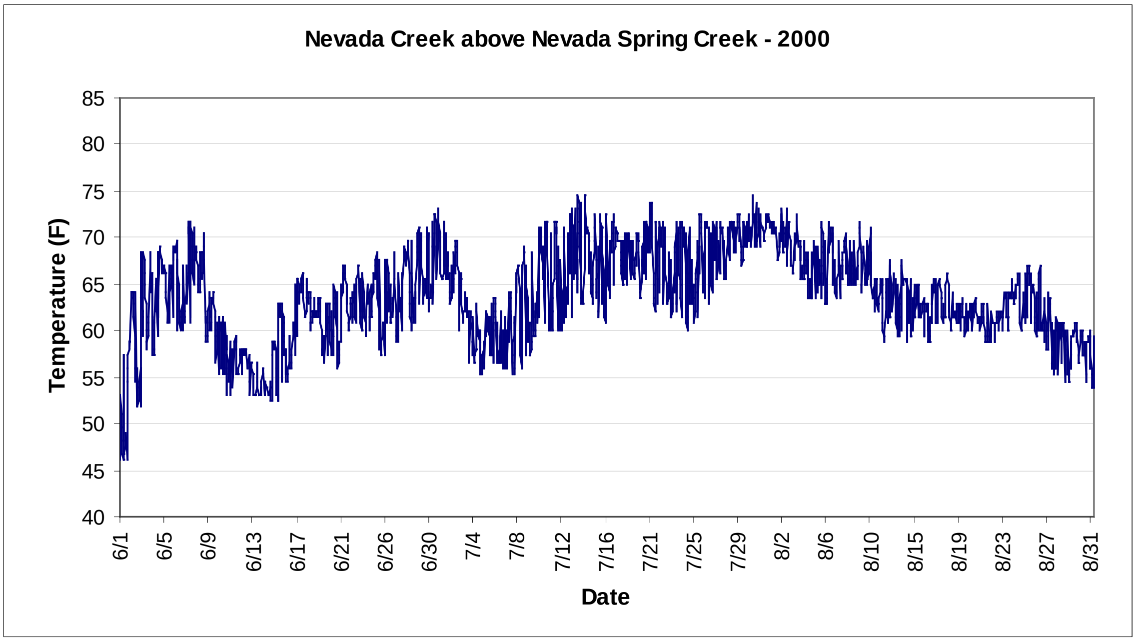


Figure 8-9. Continuous Water Temperature, Nevada Creek above Nevada Spring Creek, 2000

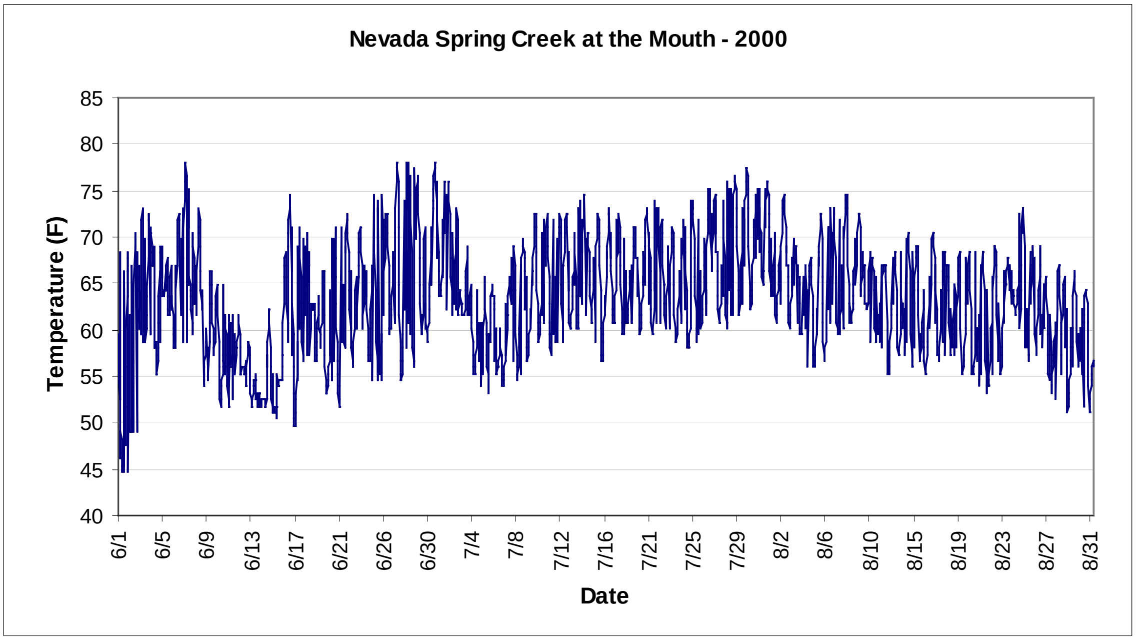


Figure 8-10. Continuous Water Temperature, Nevada Spring Creek, 2000

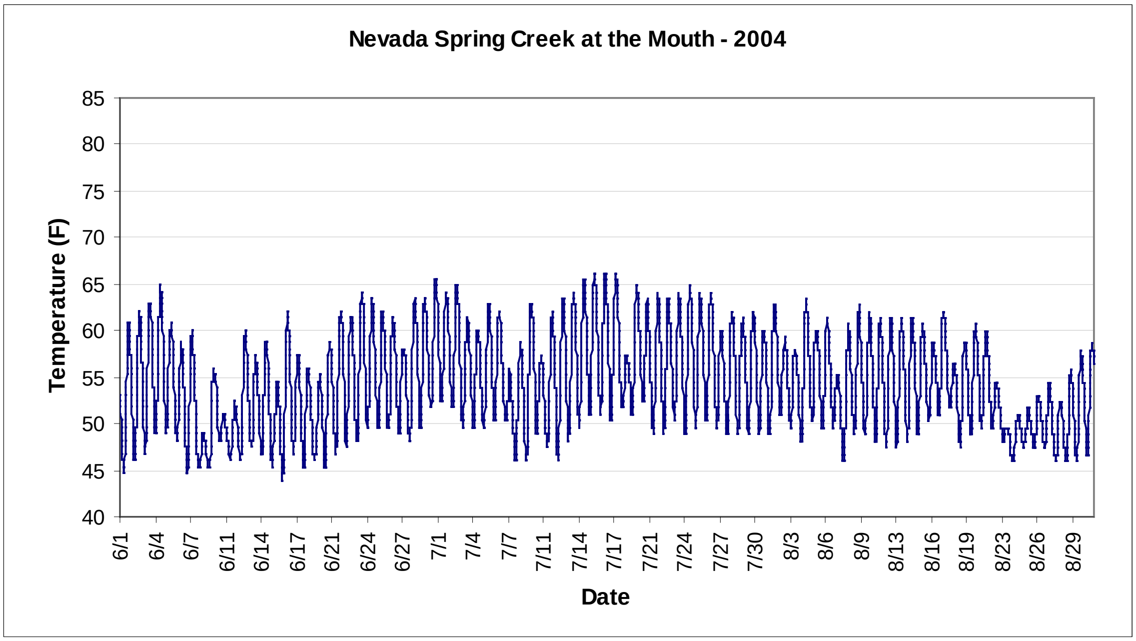


Figure 8-11. Continuous Water Temperature, Nevada Spring Creek at the Mouth, 2004

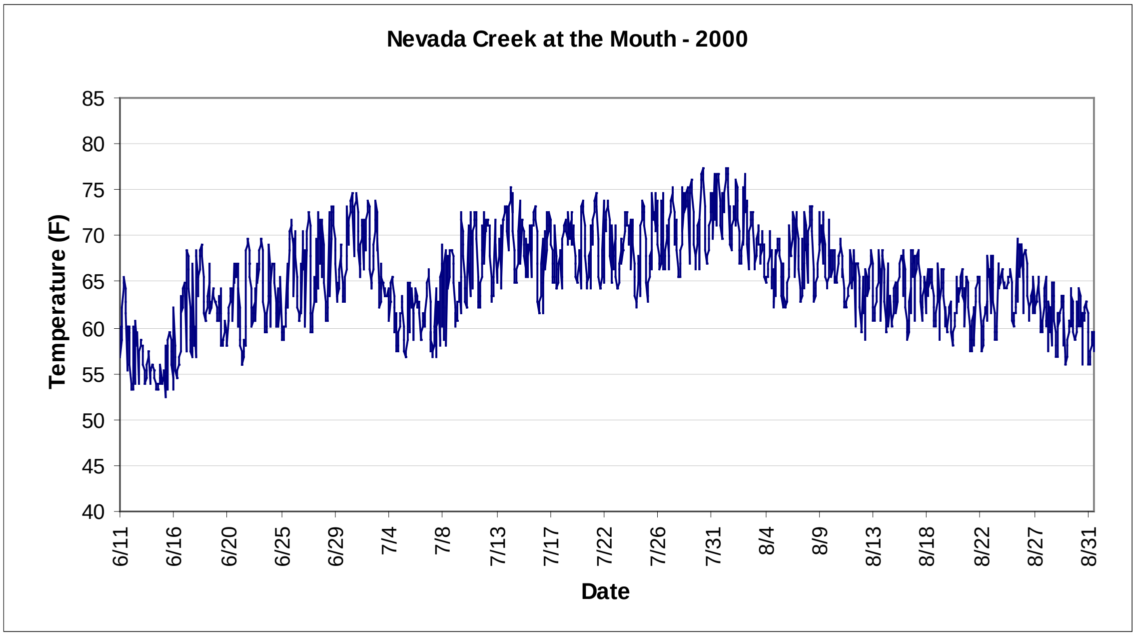


Figure 8-12. Continuous Water Temperature, Nevada Creek at the Mouth, 2000

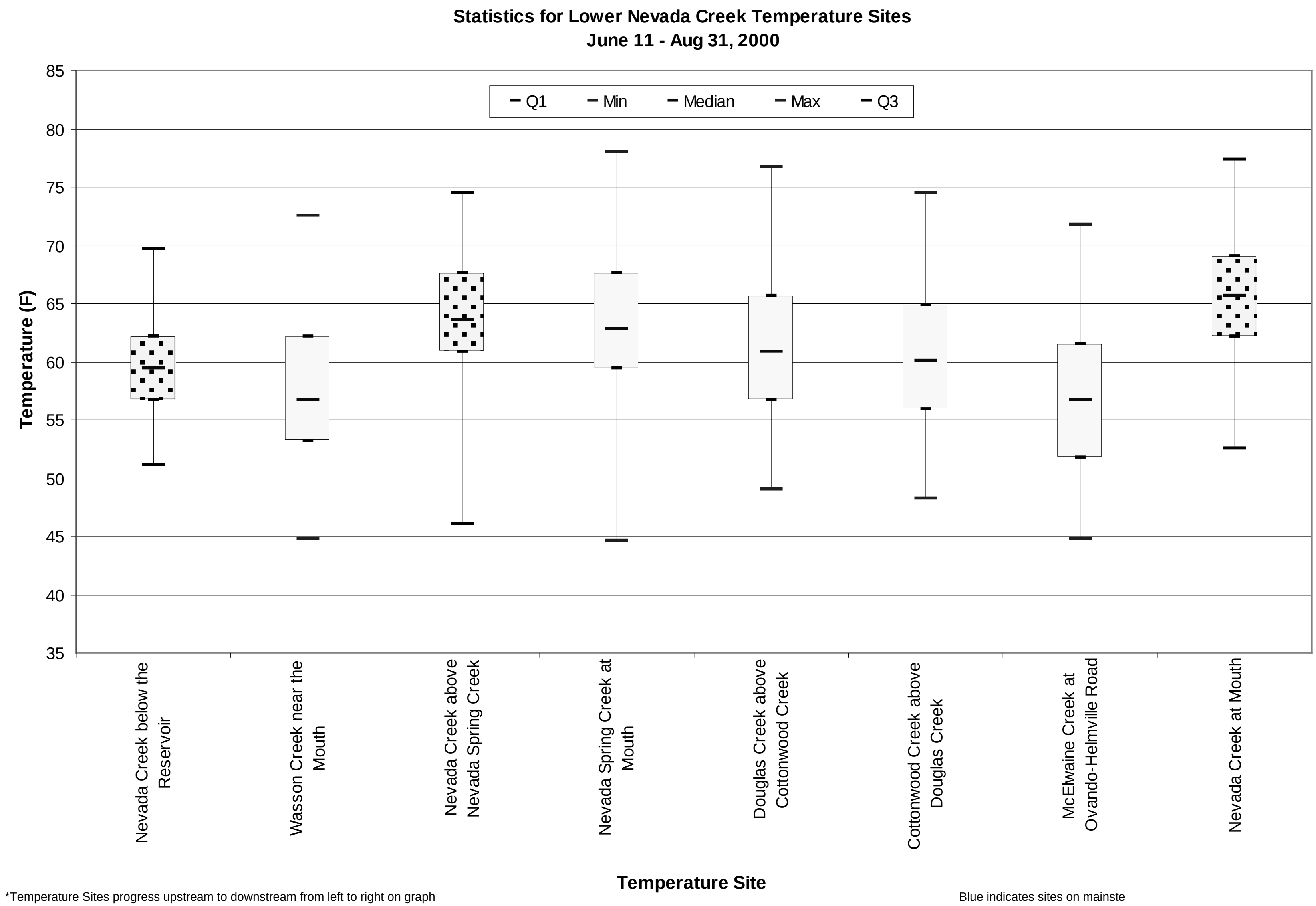


Figure 8-13. Upstream to Downstream Temperature Variation, Lower Nevada Creek, 2000

The average daily temperature graph (**Figure 8-14**) shows that temperatures increase from upstream to downstream, with the highest temperatures occurring from mid July through early August before dropping off steadily in late August.

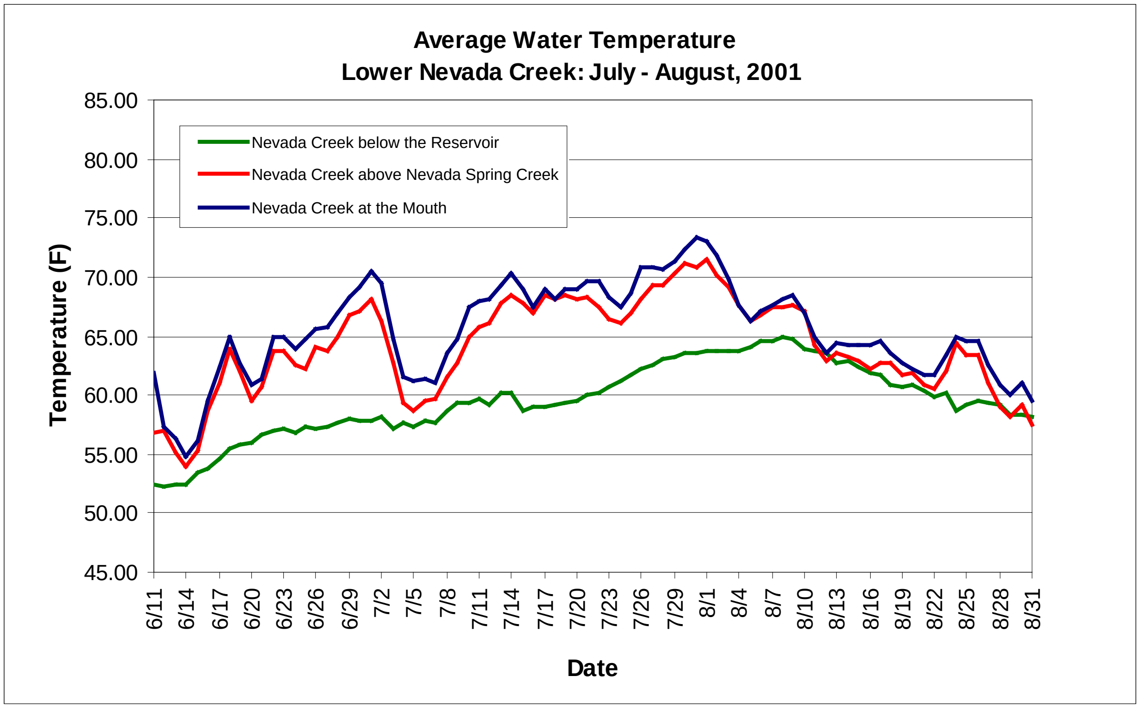


Figure 8-14. Average Daily Water Temperature, Lower Nevada Creek, 2000

Lower Nevada Creek Temperature Modeling Results

Six SNTEMP simulations (**Table 8-5, Figure 8-15**) assessed the effect of riparian shade on stream temperatures. The first calibration utilized data from 2000 for all sites. Model calibration also used 2000 data. The second calibration, referred to as the updated calibration, utilized 2004 (post restoration) data for Nevada Spring Creek. This accounts for the improvement in water temperature (1.3°F mean daily) already realized from 2001 restoration of Nevada Spring Creek. The remaining simulations assessed effects of 20%, 60%, 80%, and 95% woody bankline vegetation conditions.

Simulating 80% woody bankline vegetation along lower Nevada Creek (as well as target vegetation conditions for Cottonwood Creek and Douglas Creek) yields the 0.5°F allowable increase in mean daily water temperature from natural conditions.

Table 8-5. Simulation Results for Lower Nevada Creek at the Mouth

Model Run	Temperature (°F)		Difference from Updated Calibration		Comments
	Mean	Max	Mean	Max	
Observed Temperature	71.91	76.40	NA	NA	Observed Temperature in 2000 above the confluence with Blackfoot River
Calibrated Temperature	71.71	77.18	1.30	1.13	Simulated temperature with current stream conditions
Updated Calibration (Current Conditons)	70.41	76.05	NA	NA	Simulated temperature with current stream conditions and 2004 Nevada Spring Creek temperature data
Simulation 1	70.66	76.44	0.25	0.40	20% of bank with woody vegetation cover; Cottonwood and Douglas Creek with target bankline vegetation
Simulation 2	69.44	74.89	-0.97	-1.15	60% of bank with woody vegetation cover; Cottonwood and Douglas Creek with target bankline vegetation
Target Conditions	68.79	74.1	-1.62	-1.97	80% of bank with woody vegetation cover; Cottonwood and Douglas Creek with target bankline vegetation
Natural Conditions	68.29	73.47	-2.12	-2.57	95% of bank with vegetation cover

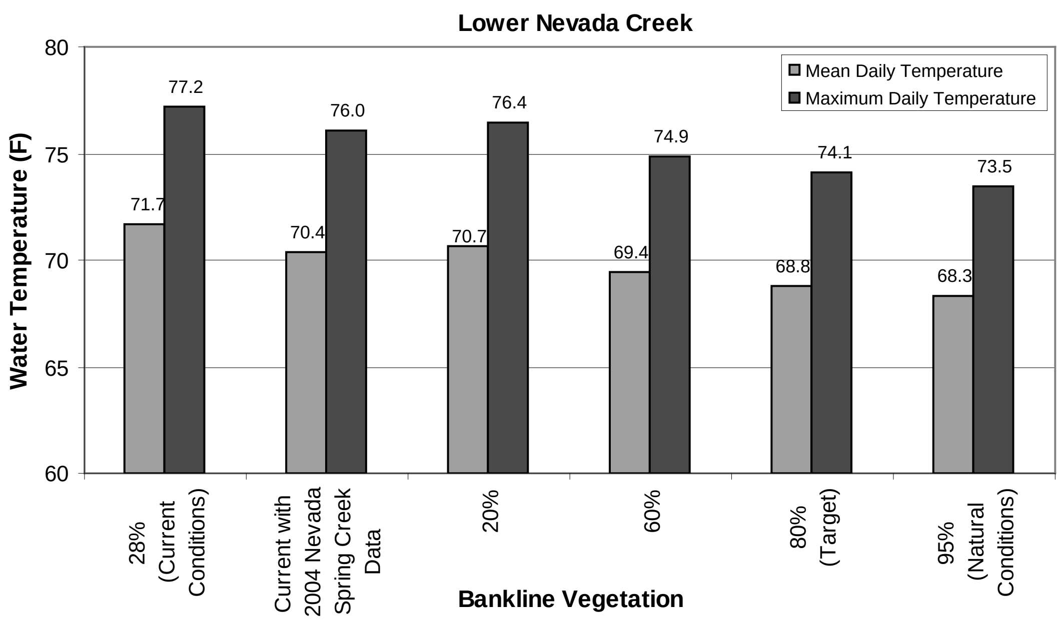


Figure 8-15. Simulated Mean and Maximum Temperature with Change in Bankline Vegetation for Lower Nevada Creek

Lower Nevada Creek Impairment Status Summary

SNTEMP modeling provided simulated natural conditions temperatures at 95% woody bank vegetation. Based on the analysis with shade as the sole source of warming along Lower Nevada Creek, the temperature target would be 0.5°F above the naturally occurring conditions temperature. Comparison with the current conditions temperature indicates that lower Nevada Creek does not meet temperature targets (**Table 8-6**).

Table 8-6. Summary of Temperatures for Lower Nevada Creek

Parameter	Temperature (°F)	Comments
Current Conditions Temperature	70.4	Temperature is above the 1°F allowable increase from natural conditions temperature. July 27 – August 2, 2000, temperature data with 2004 data for Nevada Spring Creek
Target Conditions Temperature	68.8	0.5°F allowable increase above natural conditions temperature, 80% stream bank woody vegetation
Natural Conditions Temperature	68.3	Simulated temperature with 95% stream bank vegetation

8.2.1.3 Murray Creek

Very little information is available for Murray Creek due to land access limitations. Three instantaneous temperature measurements from Murray Creek in May 1983 (near the mouth) and September 2003 (upstream and near the mouth) did not address the hot summer period when stream temperatures are high. Flow measurements taken with the September 2003 temperature measurements show a decrease from 4 cfs to 0.2 cfs from the upstream to downstream sites typical of irrigation withdrawal (DEQ, 2006). In addition, a macroinvertebrate sample collected in September 2003 from the downstream site had a very high biotic index, indicative of thermal alterations that create warm water conditions. Montana DEQ habitat surveys conducted with this sampling also indicated the potential for thermal modifications.

Assessment of vegetation from air photos indicates a decrease in streambank woody vegetation from upstream to downstream along Murray Creek. Shade percentages calculated for reaches Murr1 through Murr3 are 58%, 29%, and 28% respectively (DTM and AGI, 2006). Cottonwood Creek (described below) has similar drainage area, stream morphology, and land uses as Murray Creek. Temperature targets for Murray Creek will therefore be the same stream bank woody vegetation targets as those for Cottonwood Creek (91%) This extrapolation from Cottonwood Creek to Murray Creek has a lower level of certainty in comparison to the other streams having actual temperature records. However, actual data obtained with improved future access can be used to provide temperature targets with a higher level of certainty in the context of adaptive management.

8.2.1.4 Cottonwood Creek

Cottonwood Creek in its upper reaches above Pole Creek has cool water throughout the summer. However, temperatures increase significantly by the time the stream crosses the Ovando-Helmville Road, suggesting large thermal gains in the reach between these two sites. Air photos and water rights data show that below the South Fork of Cottonwood Creek, irrigation diversions significantly reduce flow. About halfway between the South Fork Cottonwood Creek and the Ovando-Helmville Road, riparian vegetation is sparse. Much of the thermal gain realized on hot summer days in Cottonwood Creek is attributable to these factors.

Temperature Data Analysis

The temperature database has data for Cottonwood Creek collected in 2000. **Figure 8-16 and Figure 8-17** (upstream and downstream) display continuous water temperature readings collected at the two monitoring sites during the summer of 2000.

Figure 8-18 shows the statistical distribution of summer temperatures at the two monitoring sites. The continuous temperature graphs show that temperatures fluctuate around 10°F -15°F each day. The drop in temperatures around July 3rd indicates a cooler weather period and coincides with the drop in temperatures on lower Nevada Creek during the same period (**Figure 8-14**). This may also be partly due to reduced irrigation withdrawals during hay harvest. The plots show that temperatures are much higher downstream, although the range between maximum and minimum temperatures is similar.

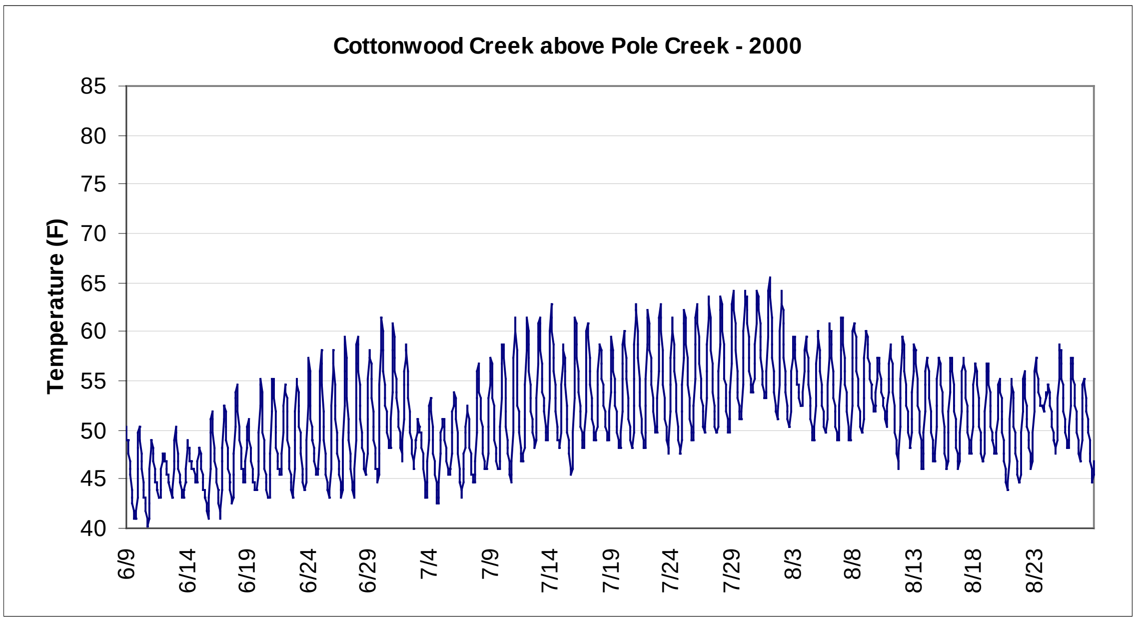


Figure 8-16. Continuous Water Temperature, Cottonwood Creek above Pole Creek, 2000

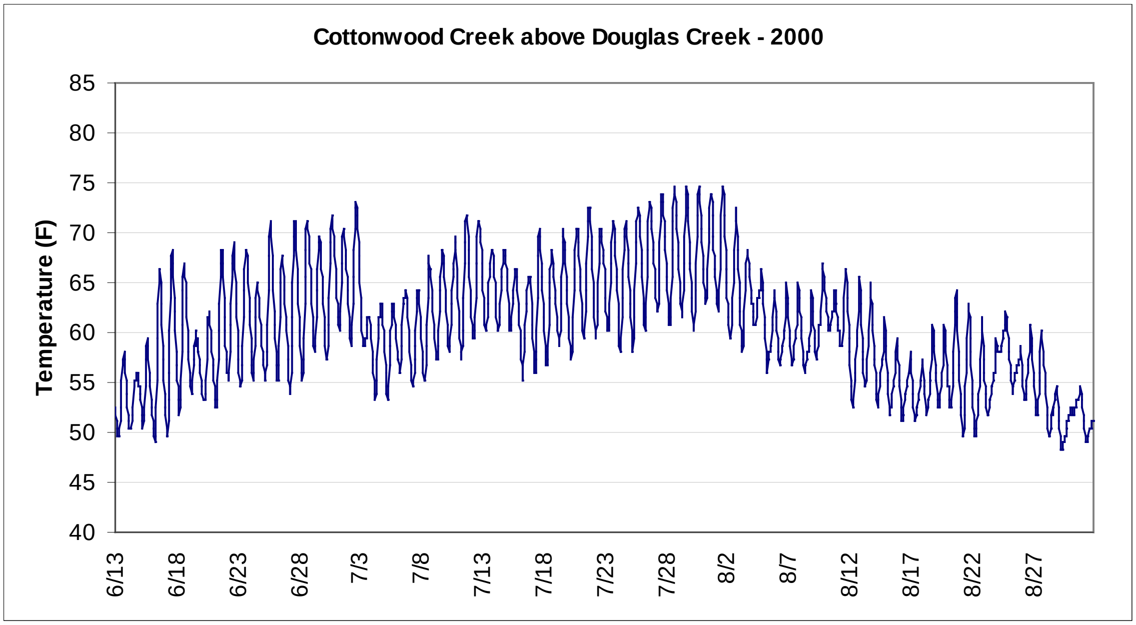


Figure 8-17. Continuous Water Temperature, Cottonwood Creek above Douglas Creek (Ovando-Helmville Road), 2000

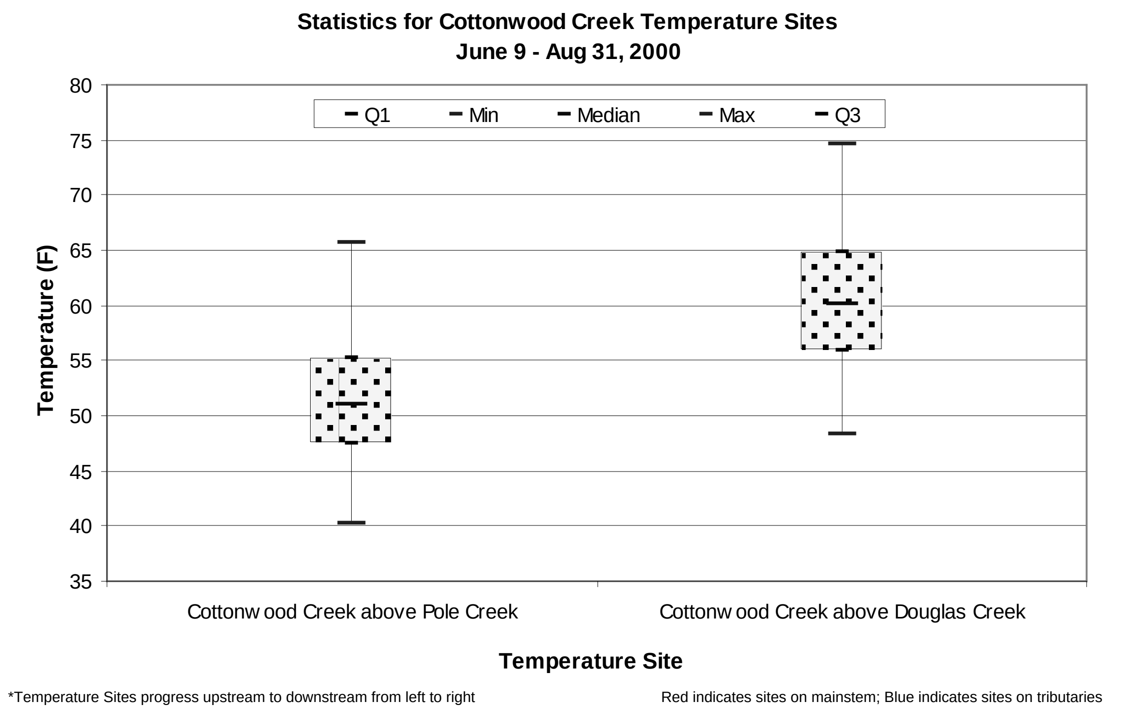


Figure 8-18. Upstream to Downstream Temperature Variation, Cottonwood Creek, 2000

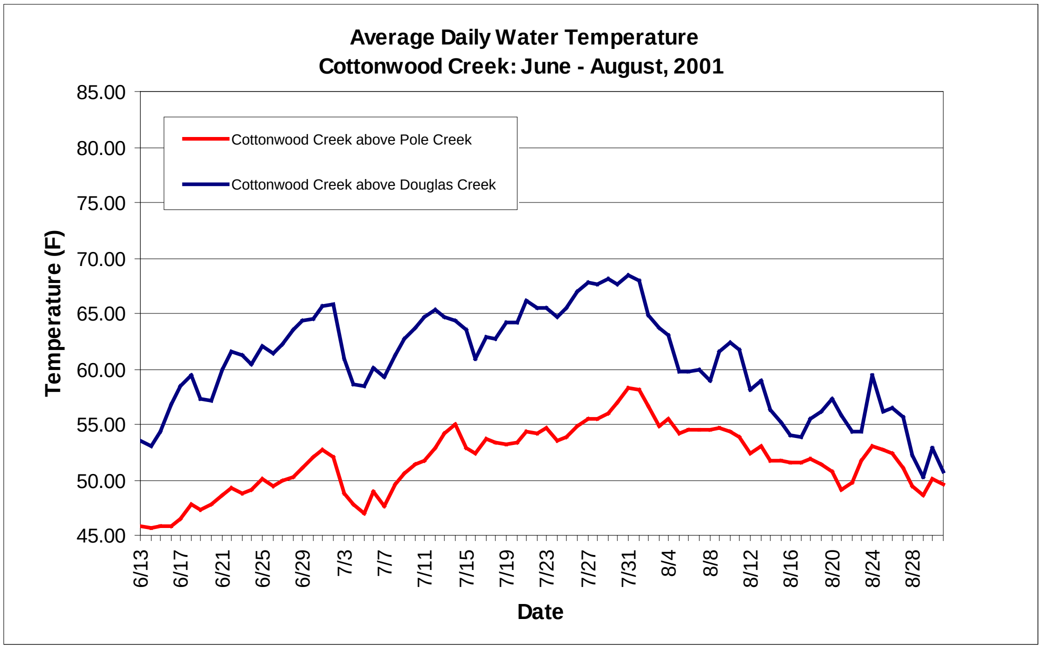


Figure 8-19. Average Daily Water Temperature, Cottonwood Creek, 2000

The average daily temperature graph (**Figure 8-19**) shows that temperatures increase from upstream to downstream, and the highest temperatures occur in late July before dropping off through August.

Cottonwood Creek Temperature Modeling Results

For natural shade conditions (95% woody bankline vegetation), the model simulated a mean temperature of 62.67°F at the mouth of Cottonwood Creek (**Table 8-7 and Figure 8-20**). This value is lower than temperatures simulated with current stream conditions (33% woody bankline vegetation) by 6.88°F. A simulation of 20% woody bankline vegetation increases water temperatures above current conditions. A simulation that increases woody bankline vegetation to 60% reduces mean temperature by 2.84°F. Simulating 91% woody bankline vegetation is within the 0.5°F allowable increase from natural conditions (based on the naturally occurring maximum temperature) and represents the target condition. At this target condition, the mean water temperature is 6.38°F lower than current conditions.

Table 8-7. Simulation Results for Cottonwood Creek at the Confluence with Douglas Creek

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Calibrated Model (Current Conditions)	69.55	79.05	NA	NA	Simulated temperature at output of creek with current stream conditions (33% streambank vegetation)
Simulation 1	70.97	81.03	1.42	1.98	20% of bank with vegetation cover
Simulation 2	66.70	74.62	-2.84	-4.43	60% of bank with vegetation cover
Target Conditions	63.2	69.19	-6.38	-9.86	91% of bank with vegetation cover
Natural Conditions	62.7	68.40	-6.88	-10.66	95% of bank with vegetation cover

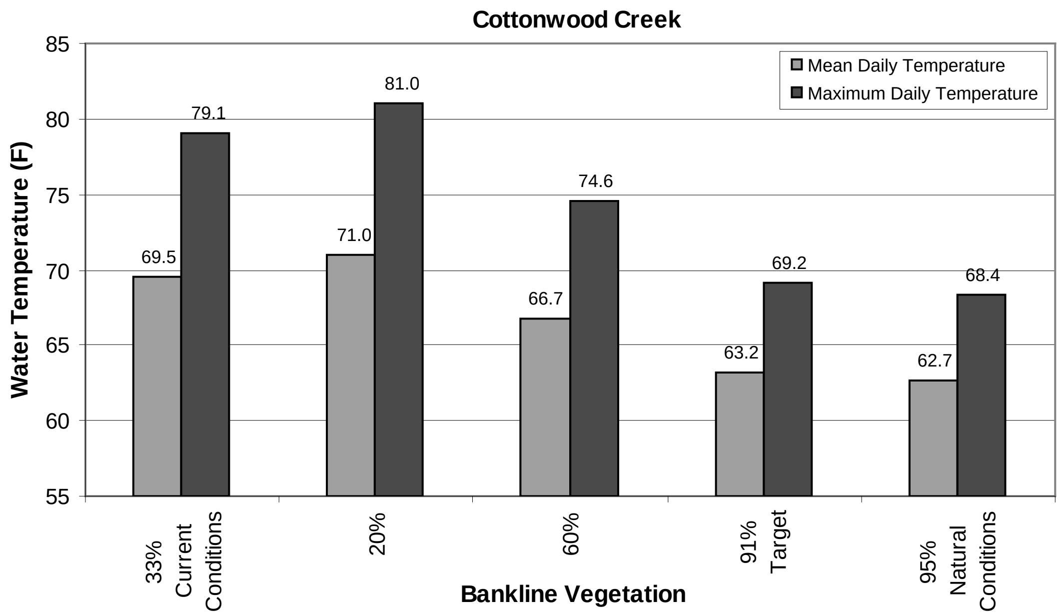


Figure 8-20. Simulated Mean and Maximum Temperature with Change in Bankline Vegetation for Cottonwood Creek

Cottonwood Creek Impairment Status Summary

SNTEMP modeling provided simulated natural conditions temperatures at 95% woody bankline vegetation. The target temperature is 0.5°F above the natural conditions temperature. Comparison with the current conditions temperature indicates that Cottonwood Creek does not meet temperature targets (**Table 8-8**).

Table 8-8. Summary of Temperatures for Cottonwood Creek

Parameter	Temperature (°F)	Comments
Current Conditions Temperature	69.55	Temperature is above the 0.5°F allowable increase from natural conditions temperature. July 27 – August 2, 2000, temperature data
Target Conditions Temperature	63.2	0.5°F allowable increase above natural conditions temperature, 91% stream bank woody vegetation
Natural Conditions Temperature	62.67	Simulated temperature with 95% stream bank vegetation

8.2.1.5 Upper Douglas Creek

The temperature database contains data collected at two sites on upper Douglas Creek in 1998 (**Appendix A, Figure A-39**). Upper Douglas Creek above the reservoirs has cold headwaters emanating from springs in Madison limestone. The mean summer temperature of 46°F is the coldest water measured in the Nevada Creek watershed. Measured Douglas Creek temperatures increase by as much as 25°F through the reservoirs, indicating that the reservoirs heat the water significantly. Field observations from the base parameter assessment (DTM and AGI, 2005) suggest that the reservoirs are relatively shallow, resulting in rapid solar heating of reservoir water.

Temperature Data Analysis

Figure 8-21 and Figure 8-22 display continuous water temperature readings from above and below the Douglas Creek reservoirs respectively (**Appendix A, Figure A-39**). The lower temperatures in Douglas Creek above the reservoirs is due to much of this water sourcing from springs in Madison limestone in the Douglas Creek headwaters. The wide range in daily temperatures at the sites below the reservoirs indicates large thermal gain from both the reservoirs and stream segments separating the reservoirs.

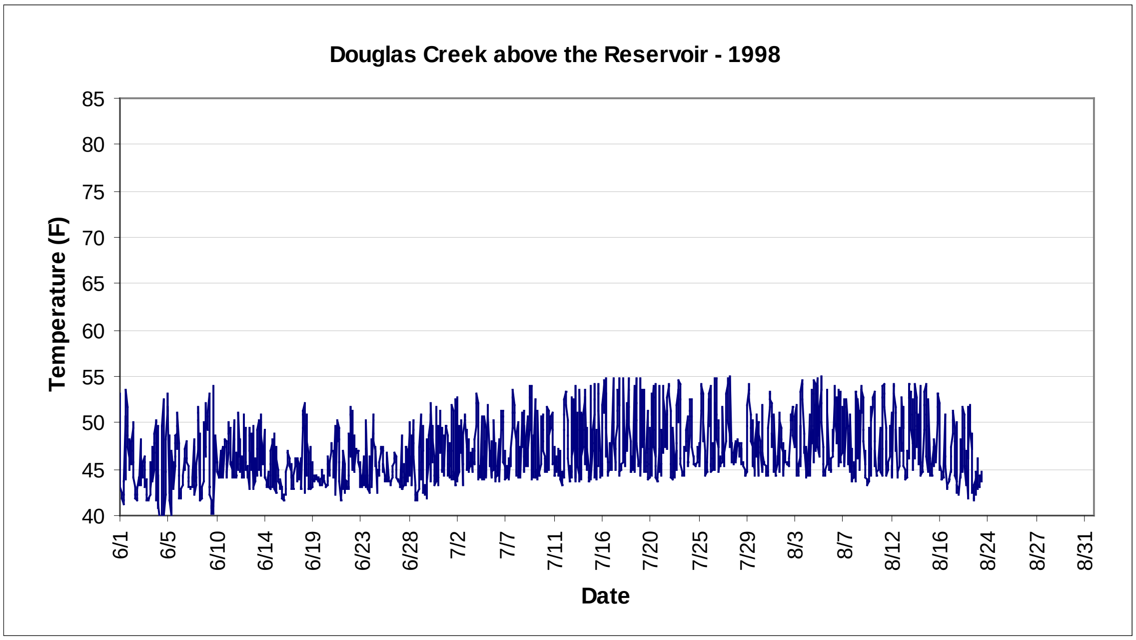


Figure 8-21. Continuous Water Temperature, Douglas Creek above the Reservoirs, 1998

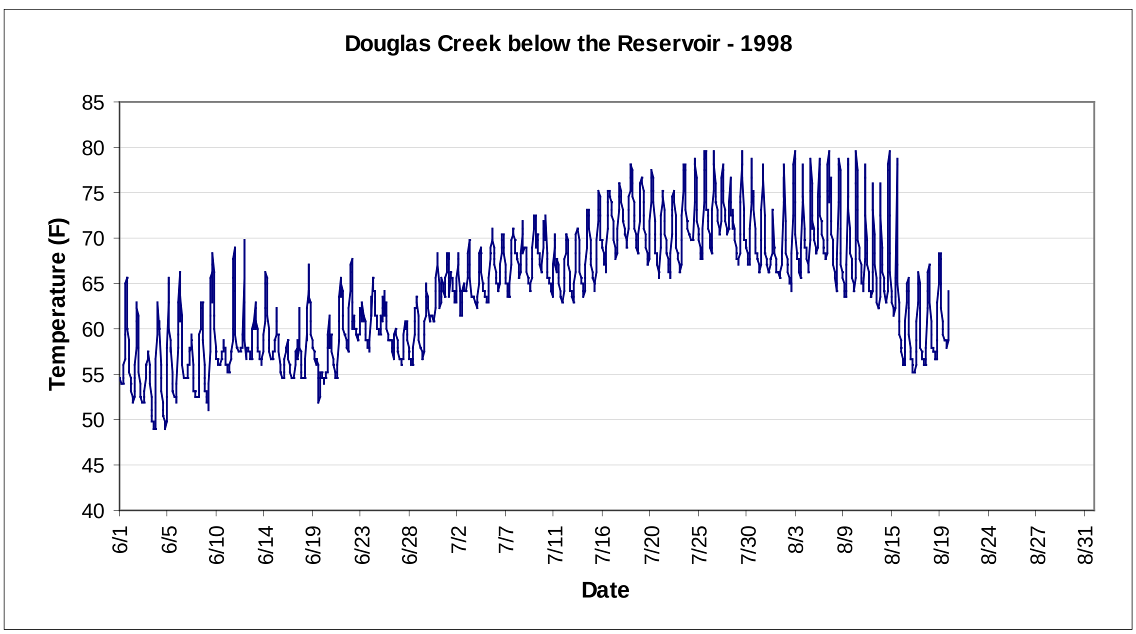


Figure 8-22. Continuous Water Temperature, Douglas Creek below the Reservoirs, 1998

The average daily temperature graph (**Figure 8-23**) shows that the highest maximum temperatures occur at the site below the reservoirs. The highest temperatures occur in late July before dropping off steadily through August. The increase in temperatures of 20°F to 25°F between the sites above and below the reservoirs is a substantial increase in temperature over a very short distance.

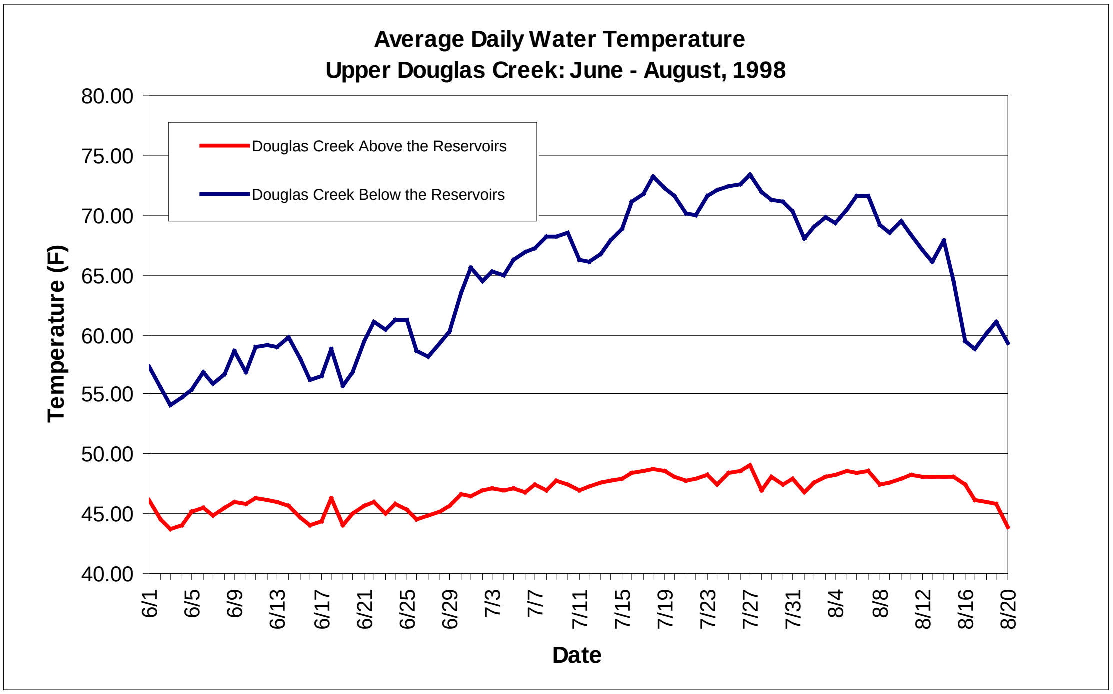


Figure 8-23. Average Daily Water Temperature, Upper Douglas Creek, 1998

Upper Douglas Creek Temperature Modeling Results

Three SSTEMP simulations evaluated the effect that varying shade has on stream temperatures. These bracketed simulations only address the stream segment portion of the listed segment, not the reservoirs. The first simulation modeled current streambank vegetation conditions, (40% woody bankline vegetation). A second simulation modeled natural conditions, defined by Montana DEQ as 95% of the stream banks with woody vegetation. A final simulation determined the target for woody bankline vegetation with the 0.5°F allowable temperature increase. Applying the standard of 0.5°F allowable increase assumes that the combined stream segment and reservoir effects on stream temperature under naturally occurring conditions would results in temperatures of 66.5°F or greater.

SSTEMP modeling simulated an increase in Douglas Creek mean water temperature of 1.51°F between current conditions and natural conditions (**Table 8-9**). Simulating 82% streambank vegetation yields the 0.5°F allowable increase from natural conditions. This requires an increase from 40% to 82% of woody vegetation along streambanks.

Table 8-9. Simulation Results for the Upper Douglas Creek Temperature Model

Model Run	Temperature (°F)		Difference from Calibration		Comments
	Mean	Max	Mean	Max	
Observed Temperature	NA	NA	NA	NA	No applicable observed temperature data due to the presence of reservoirs.
Calibrated Temperature	53.38	64.18	NA	NA	Bracketed calibration (described above)
Simulation 1 (Current Conditions)	53.38	64.18	0.00	0.00	Current conditions, 40% streambank woody vegetation (same as bracketed calibration)
Target Conditions	52.37	59.10	-1.01	-5.10	82% streambank woody vegetation
Natural Conditions	51.87	57.45	-1.51	-6.73	95% streambank woody vegetation

*SSTEMP simulation results are for the stream segments only. The reservoirs are discussed below.

Reservoirs

The reservoirs on upper Douglas Creek cause much of the observed temperature gain between the FWP temperature monitoring sites above and below the reservoirs. Temperature data indicate that the increase in stream temperature between these sites is approximately 20°F. SSTEMP modeling indicates that the stream segments between the reservoirs contribute approximately 1.5°F (6%) of this increase. Therefore, the reservoirs are responsible for approximately 18.5°F (92.5%) of the increase in temperature.

Reasonable agricultural practices fall within the natural conditions defined by Montana DEQ. However, in upper Douglas Creek, the temperature gains are larger than that allowed by the standard. Modifications to the water storage and delivery system that would improve stream temperatures are possible based on field observations and air photo assessment of the irrigation system. These data suggest that the lowermost reservoir has the smallest surface area and is the shallowest (**Table 8-10**). Locations of the reservoirs and the conveyance to irrigated areas suggest that if the lowermost reservoir were consolidated with the upper and middle reservoirs, overall water availability would still be adequate to meet agricultural requirements. This would effectively reduce the total reservoir surface area by approximately 20% and temperature gain from the reservoirs by a similar amount. This results in a further 3.5°F reduction in temperature (18.5°F x 20%) of water below the reservoirs. The lowermost reservoir is shallower than the upper and middle reservoirs and may heat faster as a result. Therefore, the temperature improvements realized from consolidating the reservoirs may be larger than 3.5°F. Consolidation of the reservoirs was chosen as a modeling exercise to demonstrate potential temperature decreases as a result of alternative reservoir management. Other management approaches for reducing temperature gains from these reservoirs are discussed in **Section 10.0** of this document.

Table 8-10. Reservoir Sizes, Upper Douglas Creek

Reservoir	Area (acres)	Percent of Reservoir Area
Upper	11.10	27.8%
Middle	20.88	52.3%
Lower	7.91	19.8%

Upper Douglas Creek Impairment Status Summary
SNTEMP modeling provided simulated natural conditions temperatures at 95% woody bankline vegetation for the stream segment portions and a reduction of 3.7°F from reservoir impacts (20% reduction in reservoir surface area). The target temperature is 0.5°F above the natural conditions temperature. Comparison with the current conditions temperature indicates that upper Douglas Creek does not meet temperature targets (**Table 8-11**).

Table 8-11. Summary of Temperatures (°F) for Upper Douglas Creek

Parameter	Temperature Mean Daily Mean Daily Max.	Comments
Current Conditions Temperature	68.4 80.2	Temperature is above the 0.5°F allowable increase from natural conditions temperature. July 27 – August 2, 2000 temperature data
Target Conditions Temperature	64.0 70.5	0.5°F allowable increase above natural conditions temperature. Requires 82% stream bank woody vegetation in stream segment portion.
Natural Conditions Temperature	63.4 69.0	Simulated temperature with 95% stream bank vegetation and a 3.5°F reduction in temperature from reservoir heating (reduce surface area by 20%).

8.2.1.6 Lower Douglas Creek

Lower Douglas Creek begins at the confluence of Murray Creek and Douglas Creek. Data from two Montana FWP temperature monitoring sites describe the temperature conditions in this segment. The first site is just below Chimney Creek, about 0.5 mile downstream from Murray Creek. Water temperatures at this site are slightly lower than below the Douglas Creek reservoirs, indicative of cooler water contributed by Chimney Creek. Temperatures then slightly decrease downstream to the site above Cottonwood Creek at Ovando-Helmville Road. In this reach, Douglas Creek and the Douglas Creek Canal are coincident for 0.25 mile. In this section, Douglas Creek mixes with cooler canal water, resulting in the observed temperature reduction and dampening of diurnal variation. No temperature data is available below Ovando-Helmville Road. However, a diversion that removes a large proportion of Douglas Creek's flow and the contribution of warm water from Cottonwood Creek suggest that temperatures likely increase in the reach downstream from the Ovando-Helmville road to the confluence with Nevada Creek. Results of SNTEMP modeling described below quantify the temperature increase to the confluence of Douglas Creek with Nevada Creek.

Temperature Data Analysis
Figure 8-24 and Figure 8-25 display continuous temperature data for the two temperature monitoring sites on lower Douglas Creek. In between these two sites, the Douglas Creek Canal and Douglas Creek use the same channel for approximately 0.25 mile and mix. This lowers the temperature of the downstream water and dampens the diurnal variation downstream. **Figure 8-26** also shows a slight decrease from upstream to downstream in average daily temperatures due to the mixing of Douglas Creek and the Douglas Creek Canal.

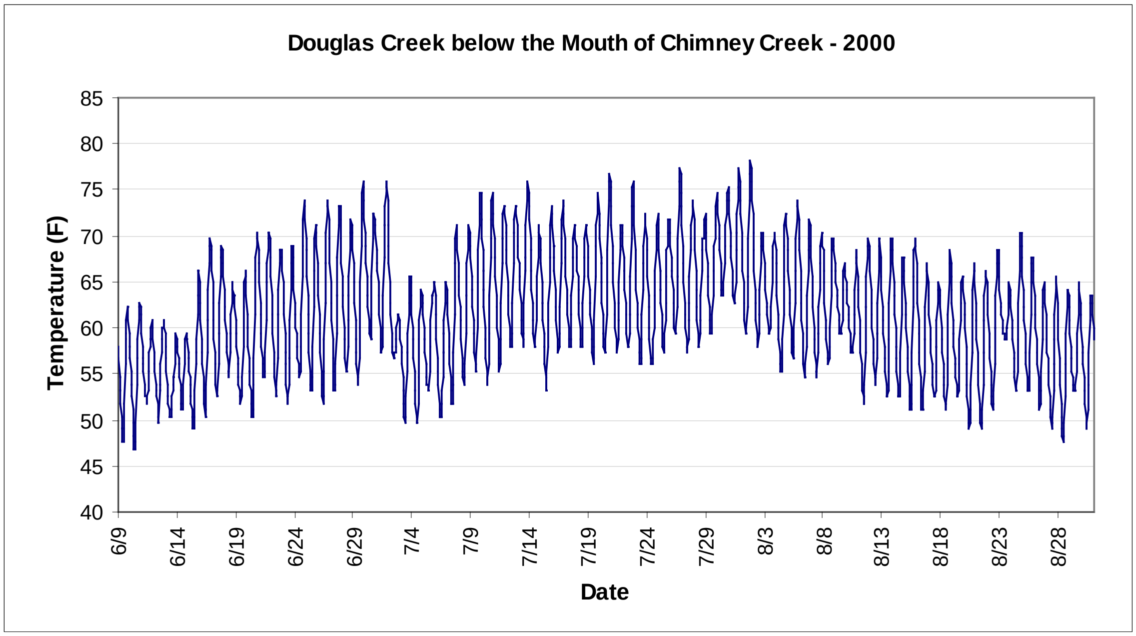


Figure 8-24.Continuous Water Temperature, Douglas Creek below Chimney Creek, 2000

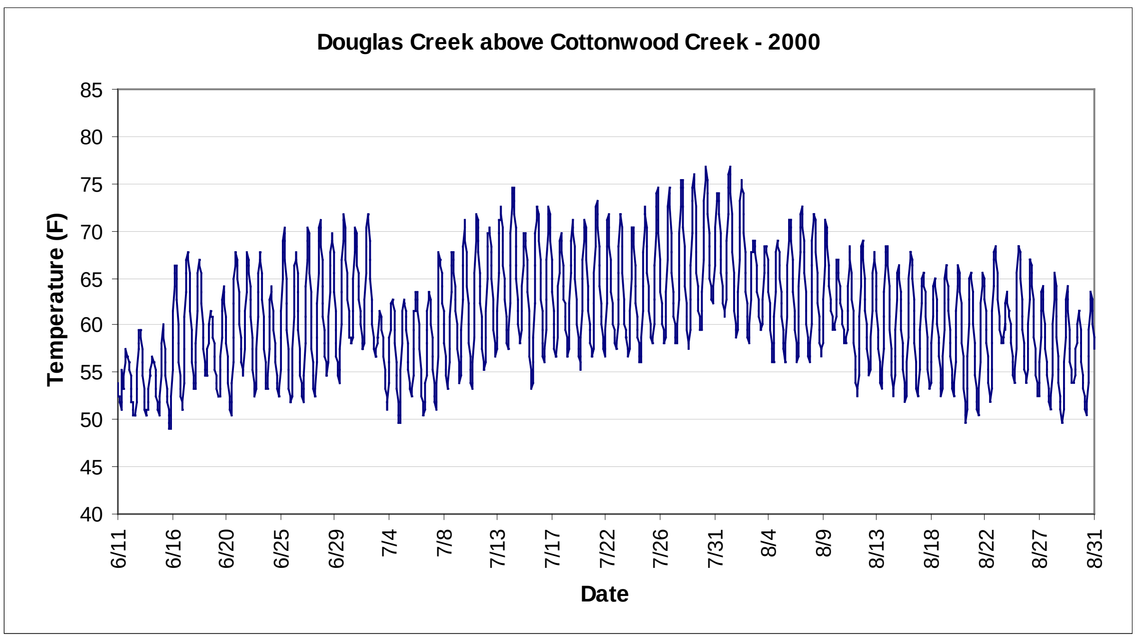


Figure 8-25. Continuous Water Temperature, Douglas Creek above Cottonwood Creek (Ovando-Helmville Road), 2000

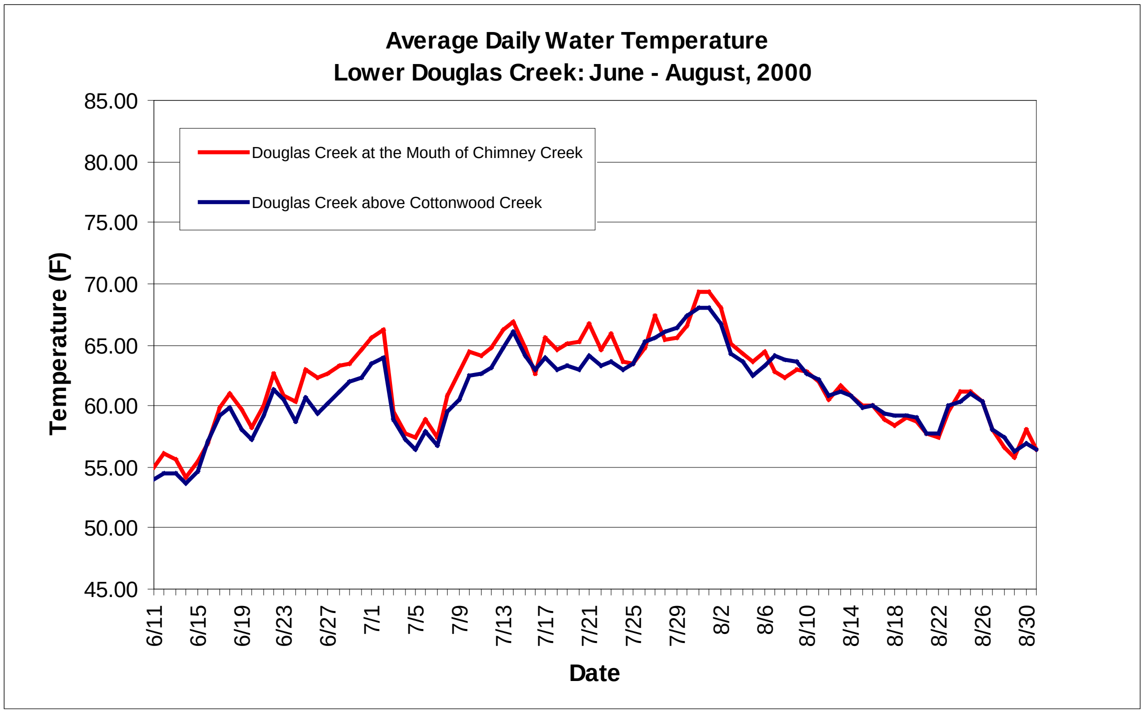


Figure 8-26. Average Daily Temperatures, Lower Douglas Creek, 2000

Lower Douglas Creek Temperature Modeling Results

Five SNTEMP simulations assessed the effect of riparian shade on stream temperatures (**Table 8-12, Figure 8-27**). Riparian shade is presented as percent of streambank with woody vegetation. One simulation was the calibrated model with current streambank woody vegetation conditions (23%). A second simulation modeled natural conditions (95% woody bankline vegetation). Two additional simulations modeled woody bankline vegetation at 20% and 60%. A final simulation assessed the amount of vegetation required to keep temperatures within 0.5°F of the natural condition scenario (Target Conditions Model Run). The 0.5°F allowable increase is the temperature target established by Montana DEQ (ARM 17.30.623(2) (e). Simulation results indicate that lower Douglas Creek current conditions exceed the target temperature by approximately 5.4°F.

Table 8-12. Simulation Results for Lower Douglas Creek at the Confluence with Nevada Creek

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Calibrated Model (Current Conditions)	69.30	78.22	NA	NA	Simulated temperature at output of creek with current stream conditions (23% bankline woody vegetation)
Simulation 1	69.55	79.23	0.25	1.01	20% of bank with vegetation cover Cottonwood Creek target vegetation
Simulation 2	66.38	74.03	-2.92	-4.19	60% of bank with vegetation cover Cottonwood Creek target vegetation
Target Conditions	63.9	69.93	-5.40	-8.29	89% of bank with vegetation cover Cottonwood Creek target vegetation
Natural Conditions	63.4	69.12	-5.92	-9.11	95% of bank with vegetation cover

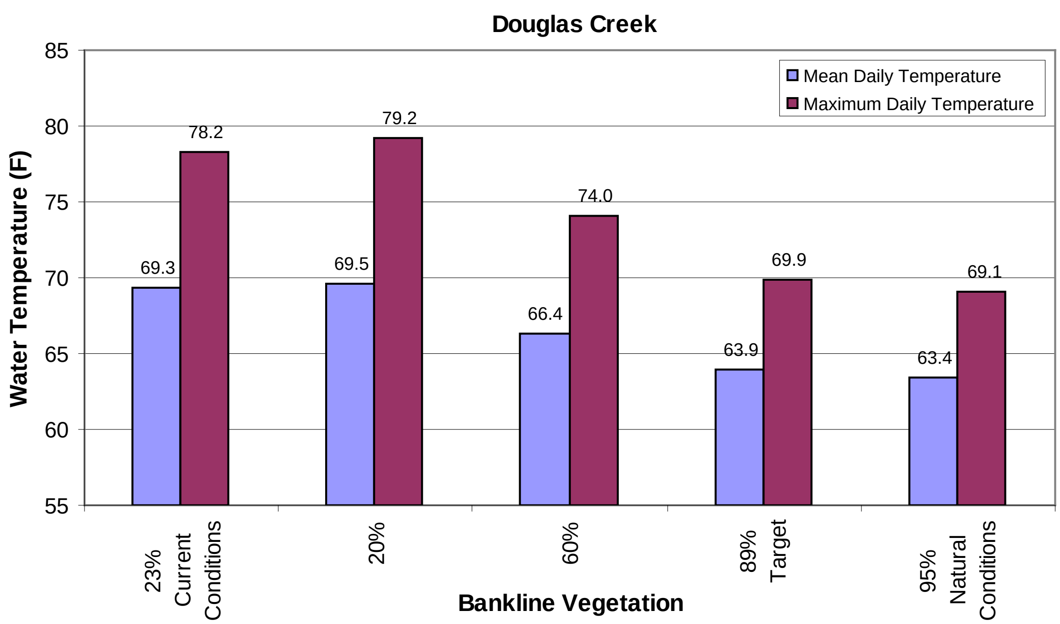


Figure 8-27. Simulated Mean and Maximum Temperature with Change in Bankline Vegetation for Lower Douglas Creek

Lower Douglas Creek Impairment Status Summary

SNTEMP modeling provided simulated natural conditions temperatures at 95% woody bankline vegetation. The target temperature is 0.5°F above the natural conditions temperature. Comparison with the current conditions temperature indicates that lower Douglas Creek does not meet temperature targets (**Table 8-13**).

Table 8-13. Summary of Temperatures for Lower Douglas Creek

Parameter	Temperature (°F)	Comments
Current Conditions Temperature	69.30	Temperature is above the 1°F allowable increase from natural conditions temperature. July 27 – August 2, 2000, temperature data
Target Conditions Temperature	63.9	0.5°F allowable increase above natural conditions temperature, 89% stream bank woody vegetation
Natural Conditions Temperature	63.4	Simulated temperature with 95% stream bank vegetation

8.2.2 Middle Blackfoot Planning Area

Three stream segments in the Middle Blackfoot planning area are on the 303(d) List for temperature impairment: Kleinschmidt Creek, the Blackfoot River from Nevada Creek to Monture Creek, and the Blackfoot River from Monture Creek to Belmont Creek (**Appendix A, Figure A-40**). The lattermost segment, Blackfoot River from Monture Creek to Belmont Creek, is partially in the lower Blackfoot planning area. Therefore, this document presents results for the Blackfoot River downstream to the boundary of the Middle Blackfoot planning area, below the confluence of the Clearwater River and the Blackfoot River. Historic stream temperature data collected by Montana Fish, Wildlife, and Parks (FWP) provides information on high summer water temperatures for the listed segments (DTM and AGI, 2006). Temperature modeling using the Stream Network Temperature Model (SNTEMP) facilitated development of a series of simulations of water temperatures under improved shade, flow, or channel morphology conditions. The SNTEMP models also allowed simulation of the conditions necessary to meet temperature targets.

8.2.2.1 Kleinschmidt Creek

The temperature database has temperature measurements for one site on Kleinschmidt Creek above its confluence with Rock Creek (**Appendix A, Figure A-42**). The data are from 1998, 2001, 2002, 2003, and 2004. Analysis of these data focused on 2001 and 2004. In addition to temperature data, the Big Blackfoot Chapter of Trout Unlimited (BBCTU) collected flow data in 2004 at three locations on Kleinschmidt Creek (Blackfoot Challenge, 2004). These data served as input to the SNTEMP temperature model for Kleinschmidt Creek.

Kleinschmidt Creek originates in a riparian meadow where Ward Creek splits into Kleinschmidt Creek and the continuation of Ward Creek towards Browns Lake (**Appendix A, Figure A-42**). Kleinschmidt Creek then continues through a conifer riparian zone for approximately 0.5 mile before it enters a valley bottom area where it crosses Highway 200 three times. Thermal gains are likely in this valley bottom area due to degradation of riparian vegetation. Below Highway 200, abundant cold groundwater inputs reduce stream temperature. Flow data from 2004 shows an increase in flow due to groundwater inputs from 2.5 cfs at the third Highway 200 crossing to 11.9 cfs less than 1 mile downstream (**Appendix A, Figure A-42**). This reach is located at the toe of the large deposit of glacial outwash that makes up Kleinschmidt Flat and thus gains water from groundwater traveling through the outwash.

Kleinschmidt Creek underwent significant restoration downstream of Highway 200 from 1990 through 2001, resulting in significantly reduced channel width and surface area, and increased channel sinuosity (Hydrometrics, 2005). The majority of restoration took place in 2001. Temperature data from 2001 and 2004 illustrate the resultant temperatures.

Temperature Data Analysis

A comparison of 2001 with 2004 continuous temperature graphs for Kleinschmidt Creek indicates significant improvement in stream temperatures after 2001 restoration (**Figure 8-28 and Figure 8-29**). Minimum temperatures are similar; however, maximum temperatures and the amount of diurnal fluctuation are much lower in 2004.

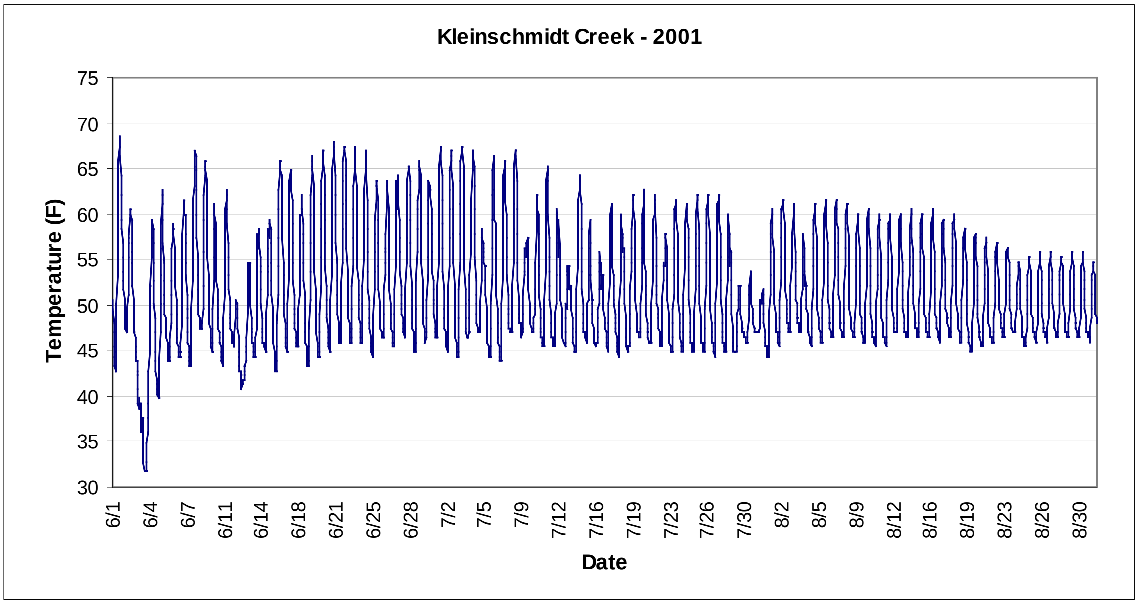


Figure 8-28. Continuous Water Temperature, Kleinschmidt Creek, 2001

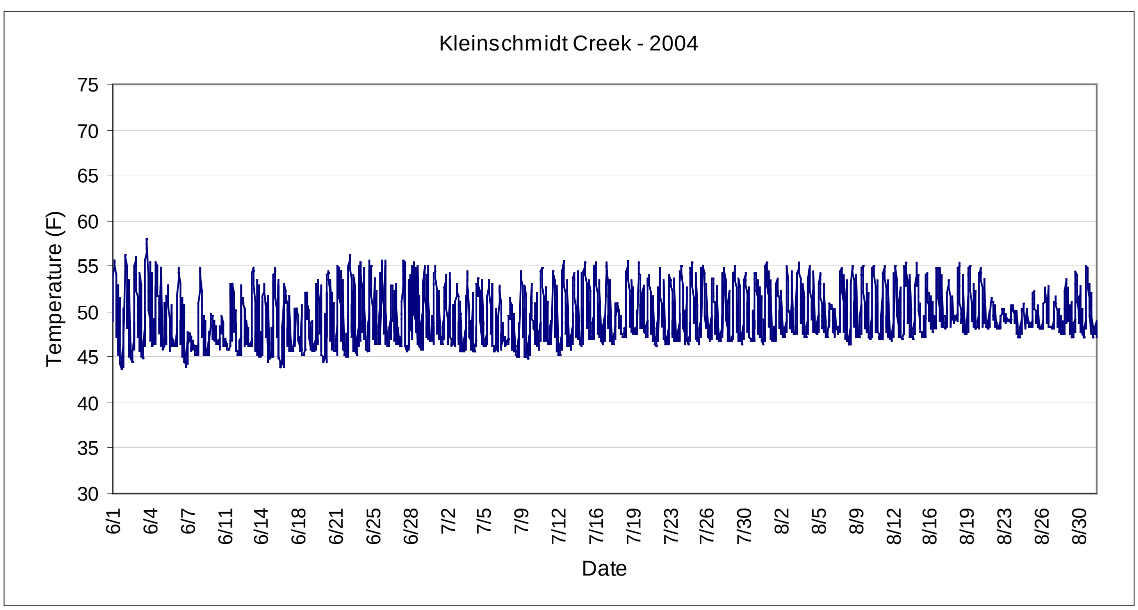


Figure 8-29. Continuous Water Temperature, Kleinschmidt Creek, 2004

Figure 8-30 and Figure 8-31 show the difference in summer temperatures between 2001 and 2004 at the monitoring site above Rock Creek. **Figure 8-31** also illustrates that the range in summer temperatures decrease dramatically post-restoration. Of the temperature readings over the summer of 2004, 50% fall within a 5°F range, centered on 50°F.

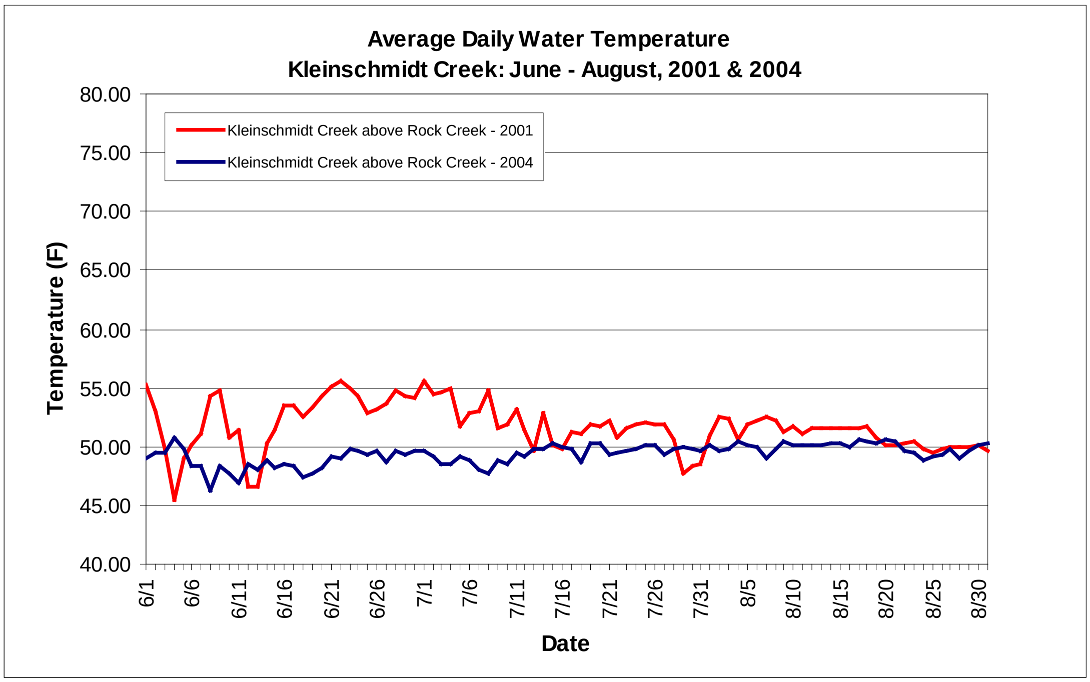


Figure 8-30. Average Daily Water Temperature, Kleinschmidt Creek near Rock Creek, 2001 and 2004

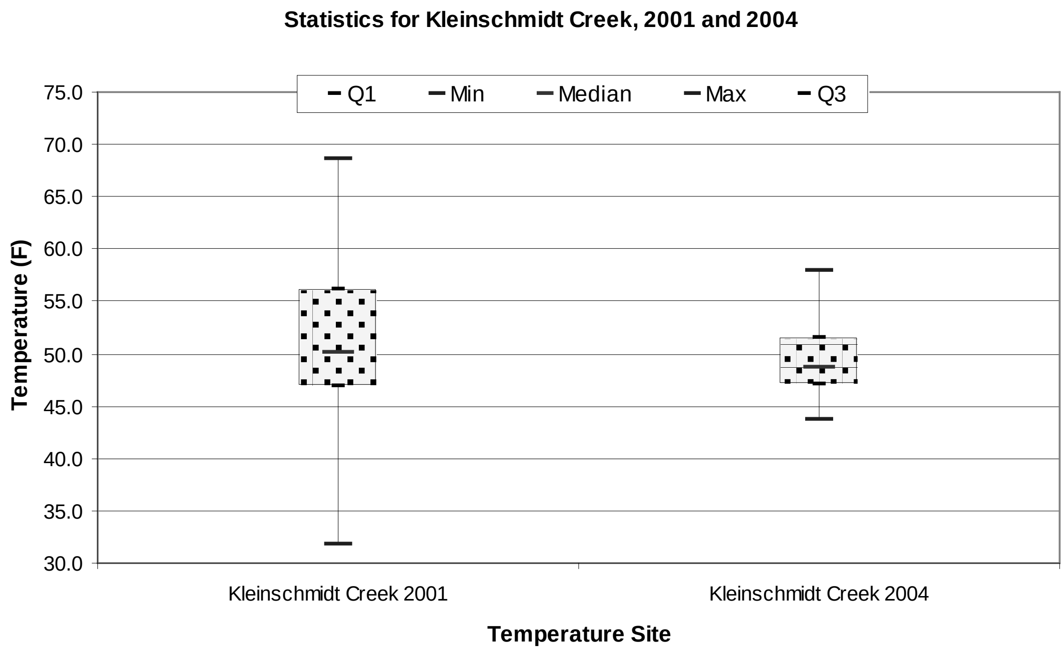


Figure 8-31. Temperature Variation between Years 2001 and 2004, Kleinschmidt Creek

A comparison of 2001 and 2004 data shows that maximum water temperatures frequently are in the low to upper 60s Fahrenheit in 2001, while temperatures rarely exceed 55°F in 2004. Maximum water temperatures also fluctuate more in 2001 than in 2004. Results indicate that the influence of precipitation and air temperature on maximum daily water temperature is smaller in 2004 than 2001.

Kleinschmidt Creek Temperature Modeling Results
Five SNTEMP simulations evaluated the effect of shade on stream temperatures in the upper and lower sections of Kleinschmidt Creek using 2004 FWP temperature data and BBCTU flow data. Shade is expressed as percent of streambanks with woody vegetation. One simulation was the calibrated model that used current streambank vegetation conditions. A second simulation modeled natural conditions defined as 95% woody bankline vegetation. Two additional simulations modeled woody bankline vegetation at levels between current and natural condition. A final target simulation assessed the amount of vegetation required to keep temperatures within the one degree Fahrenheit allowable increase from natural conditions. The following two sections summarize the results of temperature modeling. The first section includes Kleinschmidt Creek above the lowest Highway 200 crossing, and the second is below this crossing.

Kleinschmidt Creek above Highway 200
Kleinschmidt Creek from Ward Creek downstream to Highway 200 had measured flow of 2.5 cfs during the July 15, 2004, modeling period. The SNTEMP model simulated a mean temperature of 62.53°F under natural conditions (**Table 8-14 and Figure 8-32**) at the Highway 200 crossing. This value is lower than the temperature simulated with current stream conditions by 2.52°F. Simulating 69% woody bankline vegetation resulted in a simulated mean temperature

of 63.52°F. This is the 1ºF allowable increase from natural conditions, and is the target for Kleinschmidt Creek above Highway 200.

Table 8-14. Simulation Results for Kleinschmidt Creek at Highway 200

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Calibrated Model (Current Conditions)	65.05	72.99	NA	NA	Simulated temperature with current stream conditions
Simulation 1	65.41	72.43	0.36	-0.56	20% of bank with vegetation cover
Simulation 2	63.88	68.88	-1.17	-4.11	60% of bank with vegetation cover
Target Conditions	63.52	68.09	-1.53	-4.90	69% of bank with vegetation cover
Natural Conditions	62.53	65.84	-2.52	-7.15	95% of bank with vegetation cover

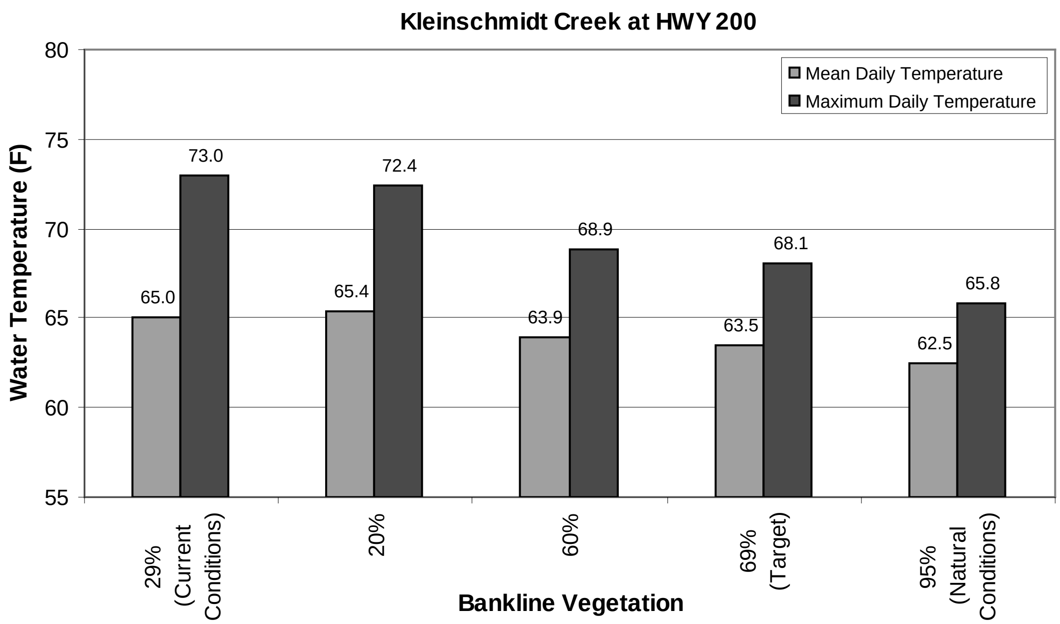


Figure 8-32. Simulated Mean and Maximum Temperature with Change in Stream Bank Vegetation, Kleinschmidt Creek above Highway 200

Kleinschmidt Creek below Highway 200

Below Highway 200, Kleinschmidt Creek steam flow increases through very large groundwater contributions. Flow increased from 2.5 cfs at the lower Highway 200 crossing to 11.9 cfs approximately 1 mile downstream. Under natural conditions (95% woody bankline vegetation), the model simulated a mean temperature of 50.04°F on Kleinschmidt Creek at Rock Creek (**Table 8-14 and Figure 8-33**). This value is lower than temperatures simulated with current stream conditions by 0.84°F, indicating that current temperatures fall within the 1ºF allowable increase from natural conditions.

Table 8-15. Simulation Results for Kleinschmidt Creek above Rock Creek

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Calibrated Model	50.88	55.78	NA	NA	Simulated temperature with current stream conditions
Simulation 1	50.83	55.26	-0.05	-0.52	20% of bank with vegetation cover
Simulation 2	50.40	53.65	-0.48	-2.13	60% of bank with vegetation cover
Natural Conditions	50.04	52.34	-0.84	-3.44	95% of bank with vegetation cover

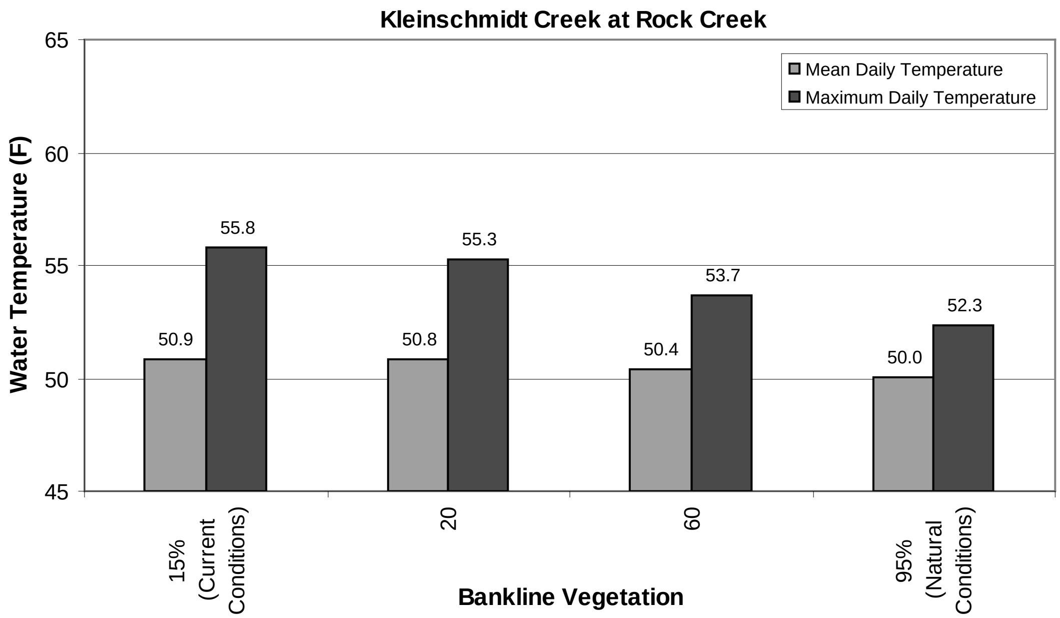


Figure 8-33. Simulated Mean and Maximum Temperature with Change in Bankline Vegetation for Kleinschmidt Creek above Rock Creek

These results indicate that reaches of Kleinschmidt Creek from Highway 200 downstream to Rock Creek currently meet the TMDL temperature impairment criteria. Restoration efforts on Kleinschmidt Creek downstream from Highway 200 reduced stream surface area and improved temperatures over prior conditions. Above Highway 200, establishment of woody vegetation on 69% of Kleinschmidt Creek reduces temperature in the SNTEMP simulations by 1.53°F, highlighting the difference between the two reaches.

Kleinschmidt Creek Impairment Status Summary

SNTEMP modeling provided simulated natural conditions temperatures at 95% woody bankline vegetation. The target temperature is 1°F above the natural conditions temperature. Comparison with the current conditions temperature indicates that the upper portion of Kleinschmidt Creek above Highway 200 does not meet temperature targets and a TMDL is required (**Table 8-16).** Downstream of Highway 200, temperature targets are met (**Table 8-17**). Although temperature TMDLs are required for only one segment of Kleinschmidt Creek (above Highway 200), listed impairments for temperature will remain for the entire stream until targets are met in the segment which requires a TMDL.

Table 8-16. Summary of Temperatures for Upper Kleinschmidt Creek (above the lower Highway 200 crossing)

Parameter	Temperature (°F)	Comments
Current Conditions Temperature	65.05	Temperature is above the 1°F allowable increase from natural conditions temperature. July 15, 2004, temperature data
Target Conditions Temperature	63.53	1°F allowable increase above natural conditions temperature, requires 69% stream bank woody vegetation
Natural Conditions Temperature	62.53	Simulated temperature with 95% stream bank vegetation

Table 8-17. Summary of Temperatures for Lower Kleinschmidt Creek (below the lower Highway 200 crossing)

Parameter	Temperature (°F)	Comments
Current Conditions Temperature	50.88	Temperature is below the 1°F allowable increase from natural conditions temperature. July 15, 2004, temperature data
Target Conditions Temperature	51.04	1°F allowable increase above natural conditions temperature
Natural Conditions Temperature	50.04	Simulated temperature with 95% stream bank vegetation

8.2.2.2 Blackfoot River (Nevada Creek to Monture Creek)

Water temperatures measured at Cutoff Bridge, located on the Blackfoot River above the confluence with Nevada Creek in the upper Blackfoot planning area, are relatively cool for much of the summer (**Appendix A, Figure A-40**). Flow was 180 cfs during the late July 2000 modeling period. Water temperatures increased moderately at this site from late July through early August. Irrigation diversions near this site reduce flow in this reach, increasing thermal gains during hot summer periods. The Blackfoot then meets Nevada Creek, which contributes approximately 22 cfs of relatively warm water. Since 22 cfs is only 12% of the Blackfoot River flow of 180 cfs, the increase in Blackfoot River temperature is relatively small. However, the Blackfoot then travels through a wide, un-shaded reach with additional irrigation withdrawals where thermal gains are significant. By the time water reaches the Raymond Bridge, it has warmed significantly. The monitoring site at Raymond Bridge recorded the warmest water temperatures of any of the monitoring sites on the Blackfoot River.

Farther downstream, cooler Blackfoot River water temperatures measured at Scotty Brown Bridge are indicative of cold-water contribution from the North Fork of the Blackfoot River.

Temperature Data Analysis
The temperature database contains data collected in 2000 for a total of four sites on the Blackfoot River and eight sites on tributary streams in the Middle and Lower Blackfoot TMDL planning areas (**Appendix A, Figure A-40**). Two of the mainstem sites are in the listed segment from

Nevada Creek to Monture Creek, with a third immediately downstream of the Monture Creek confluence. The fourth site is in the lower Blackfoot planning area at Belmont Creek.

The temperature database also contains data collected in other years for three key tributaries, the North Fork Blackfoot River (2000), Monture Creek (1999) and the Clearwater River (2003). **Figure 8-34 through Figure 8-39** (upstream to downstream) display continuous water temperature readings collected at select monitoring sites during the summer of 2000, and for Monture Creek in 1999 and the Clearwater River in 2003. These figures illustrate that for all sites in 2000, temperatures peak around July 30. The drop in water temperature around July 5, 2000, corresponds to a cool and rainy storm cycle.

Figure 8-40 displays the average daily temperatures at the four monitoring sites on the Blackfoot River during the summer of 2000. The site at Cutoff Bridge had the coolest temperatures throughout the summer, while the site at Raymond Bridge had the warmest temperatures. Temperatures are slightly cooler at the other two sites at Scotty Brown Bridge and at Corrick River Bend. Thus, the largest increase in water temperatures on the Blackfoot River occurs between Cutoff Bridge and Raymond Bridge.

Figure 8-41 shows the statistical distribution of summer temperatures during 2000 for the four sites on the Blackfoot River and tributaries. From the plot, it is apparent that temperatures are coolest on the Blackfoot River at the Cutoff Bridge site and increase dramatically at Raymond Bridge, site of the warmest temperatures on the Blackfoot River. Nevada Creek and the Clearwater River both contributed warm water to the Blackfoot River during the summer of 2000, with water temperatures reaching greater than 75°F during that summer. However, the volumes of warm water are small compared to the Blackfoot River discharges. The North Fork of the Blackfoot River and Monture Creek are cold-water streams, and contributed significant volumes of cold water to the Blackfoot River with maximum temperatures in the mid-60s Fahrenheit for both streams. Yourname, Wales, Frazier, and Warren Creeks all contribute relatively small amounts of water and do not significantly affect temperatures in the Blackfoot River.

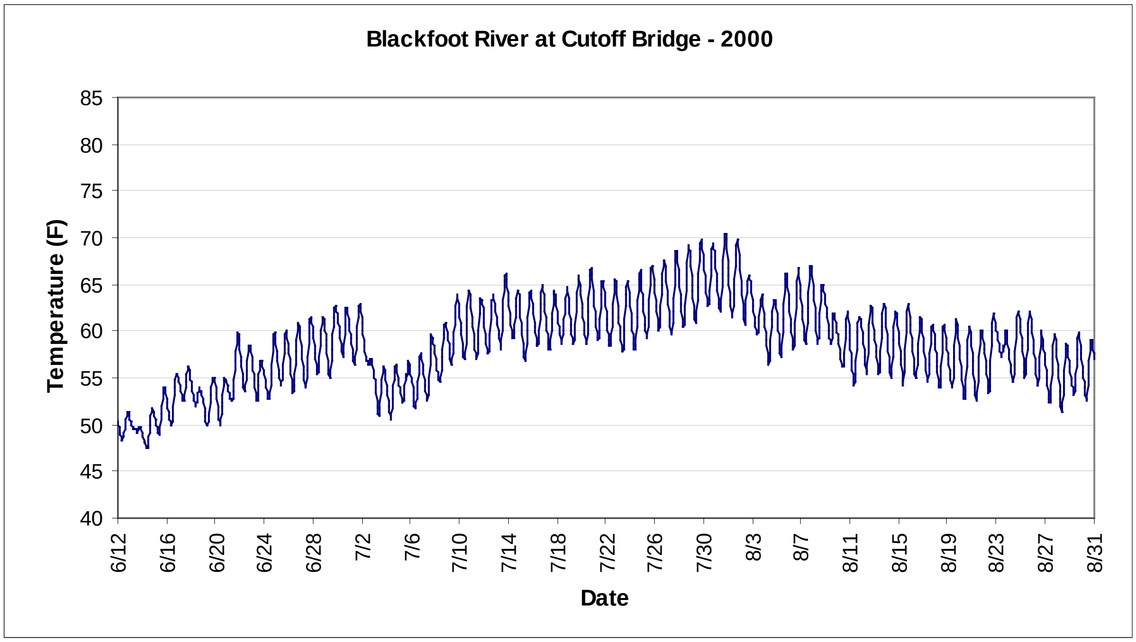


Figure 8-34. Continuous Water Temperature, Blackfoot River at Cutoff Bridge, 2000

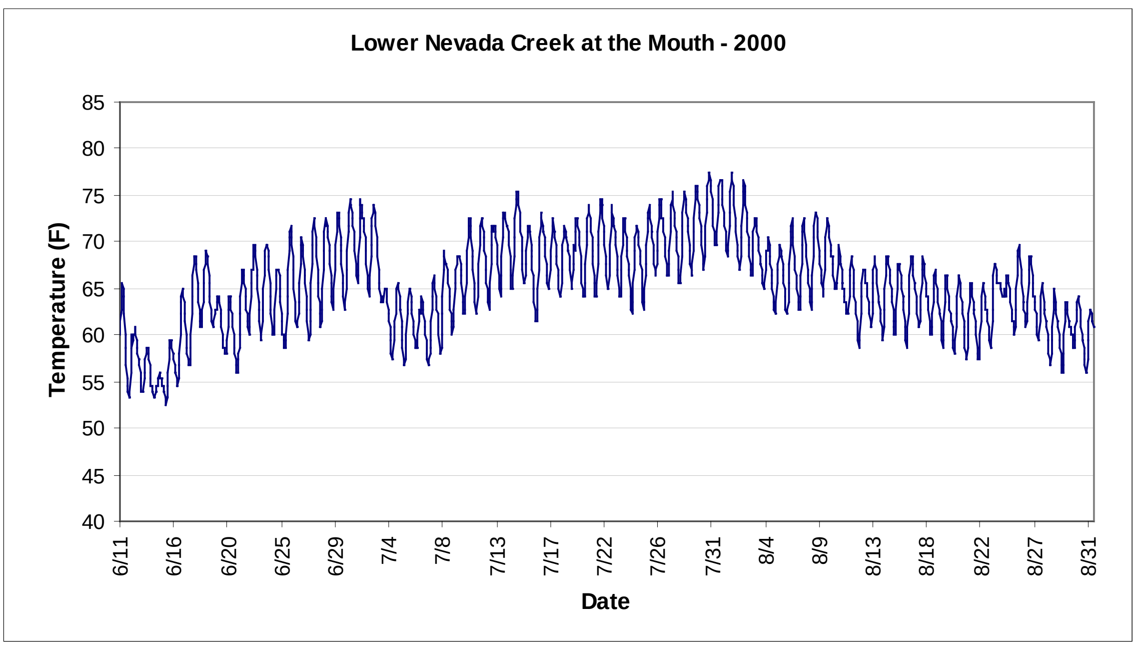


Figure 8-35. Continuous Water Temperature, Lower Nevada Creek at the Mouth, 2000

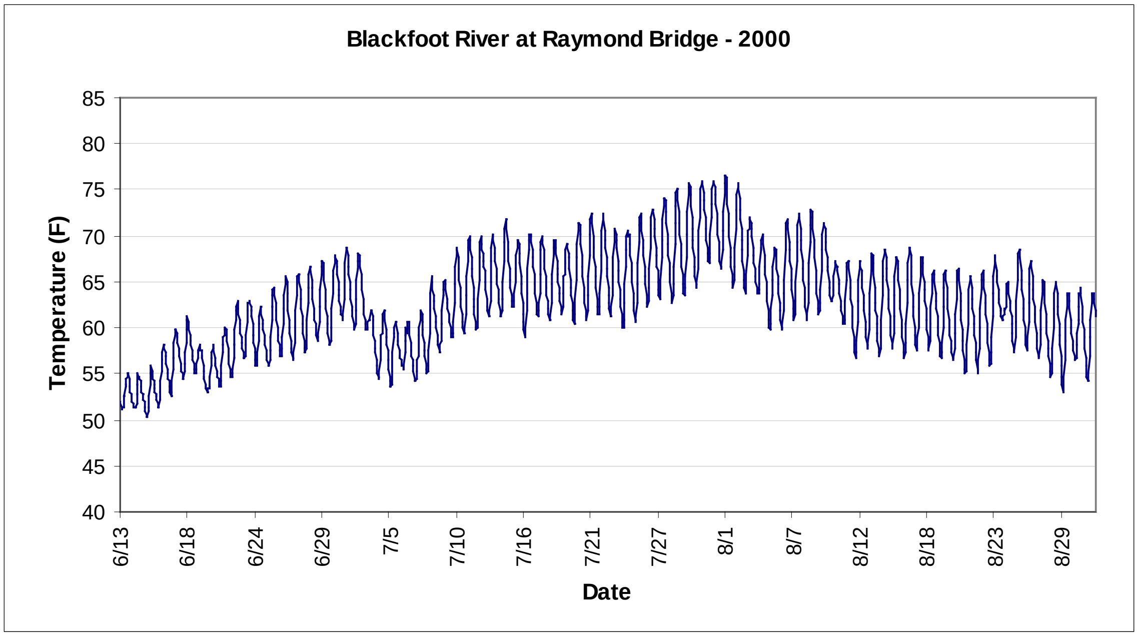


Figure 8-36. Continuous Water Temperature, Blackfoot River at Raymond Bridge, 2000

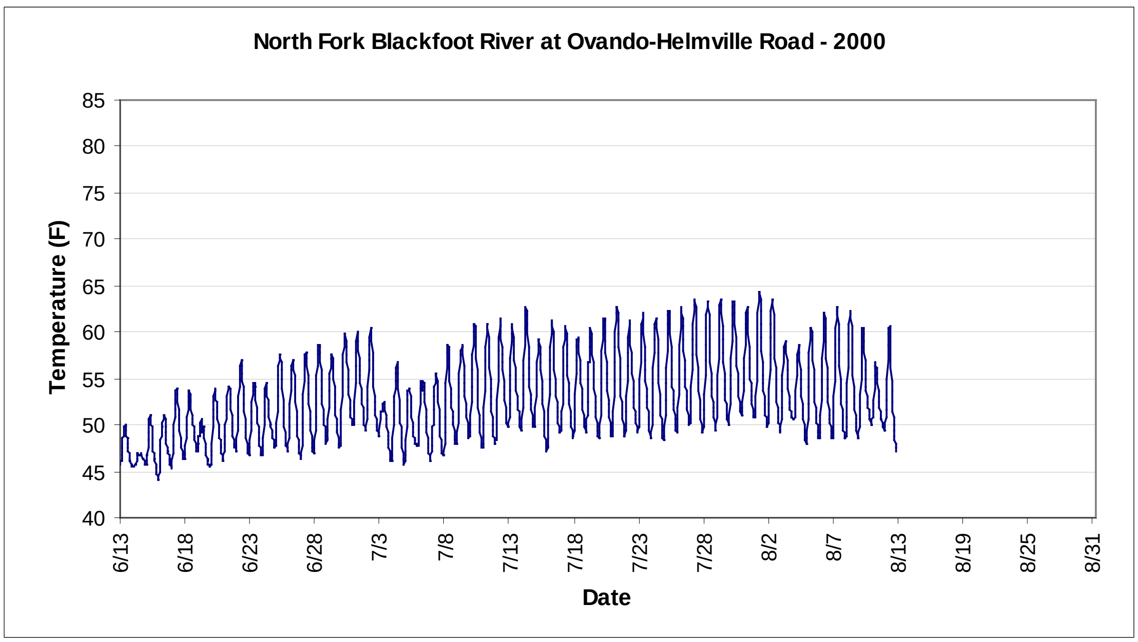


Figure 8-37. Continuous Water Temperature, North Fork Blackfoot River, 2000

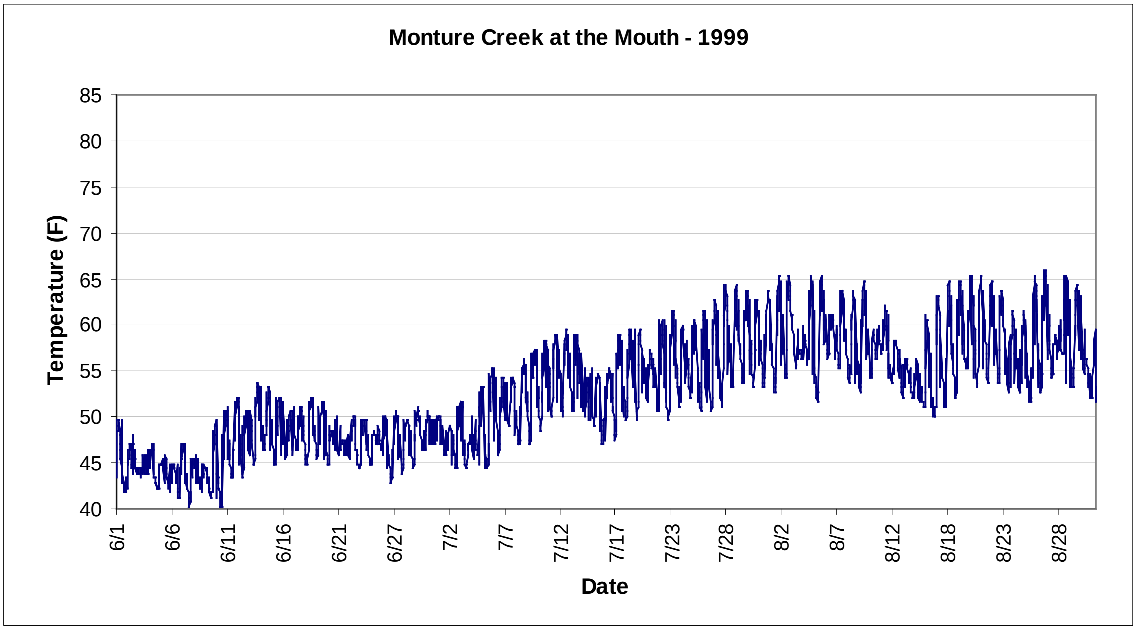


Figure 8-38. Continuous Water Temperature, Monture Creek, 1999

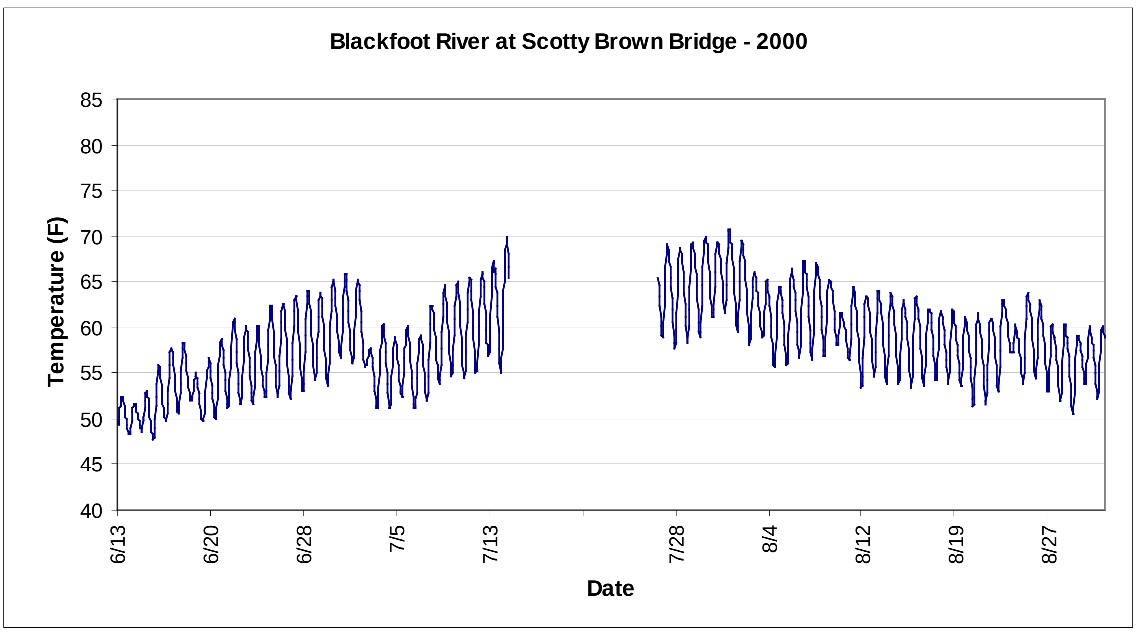


Figure 8-39. Continuous Water Temperature, Blackfoot River at Scotty Brown Bridge, 2000

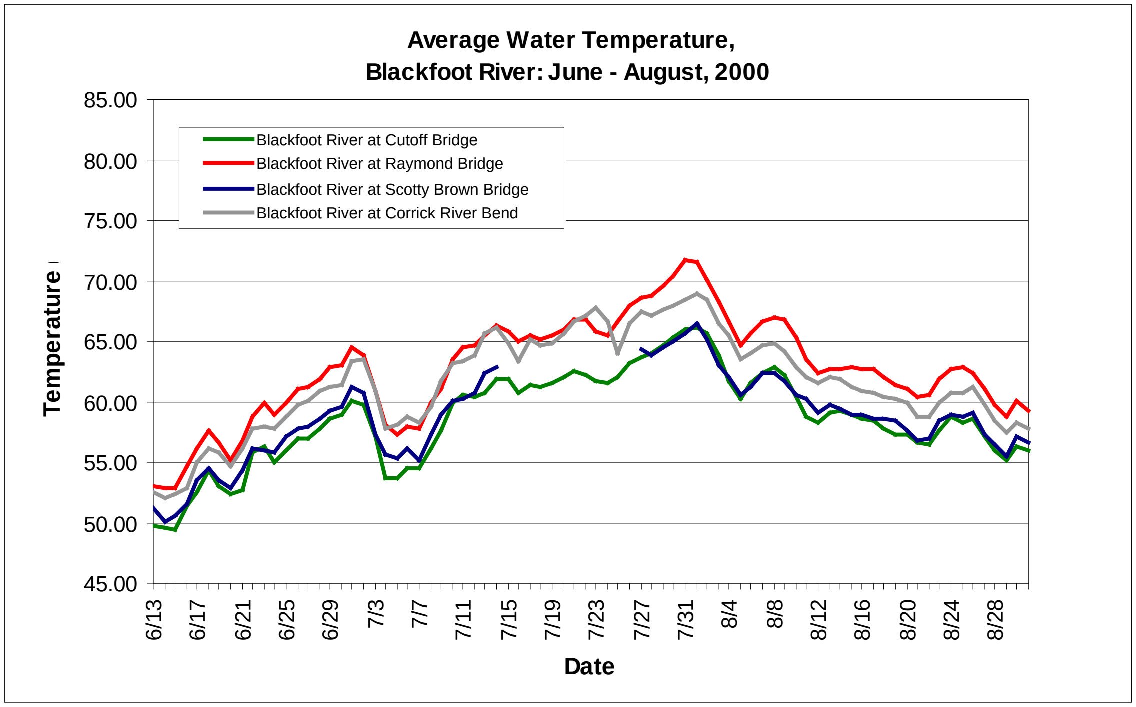


Figure 8-40. Average Daily Water Temperature, Blackfoot River from Nevada Creek to Monture Creek

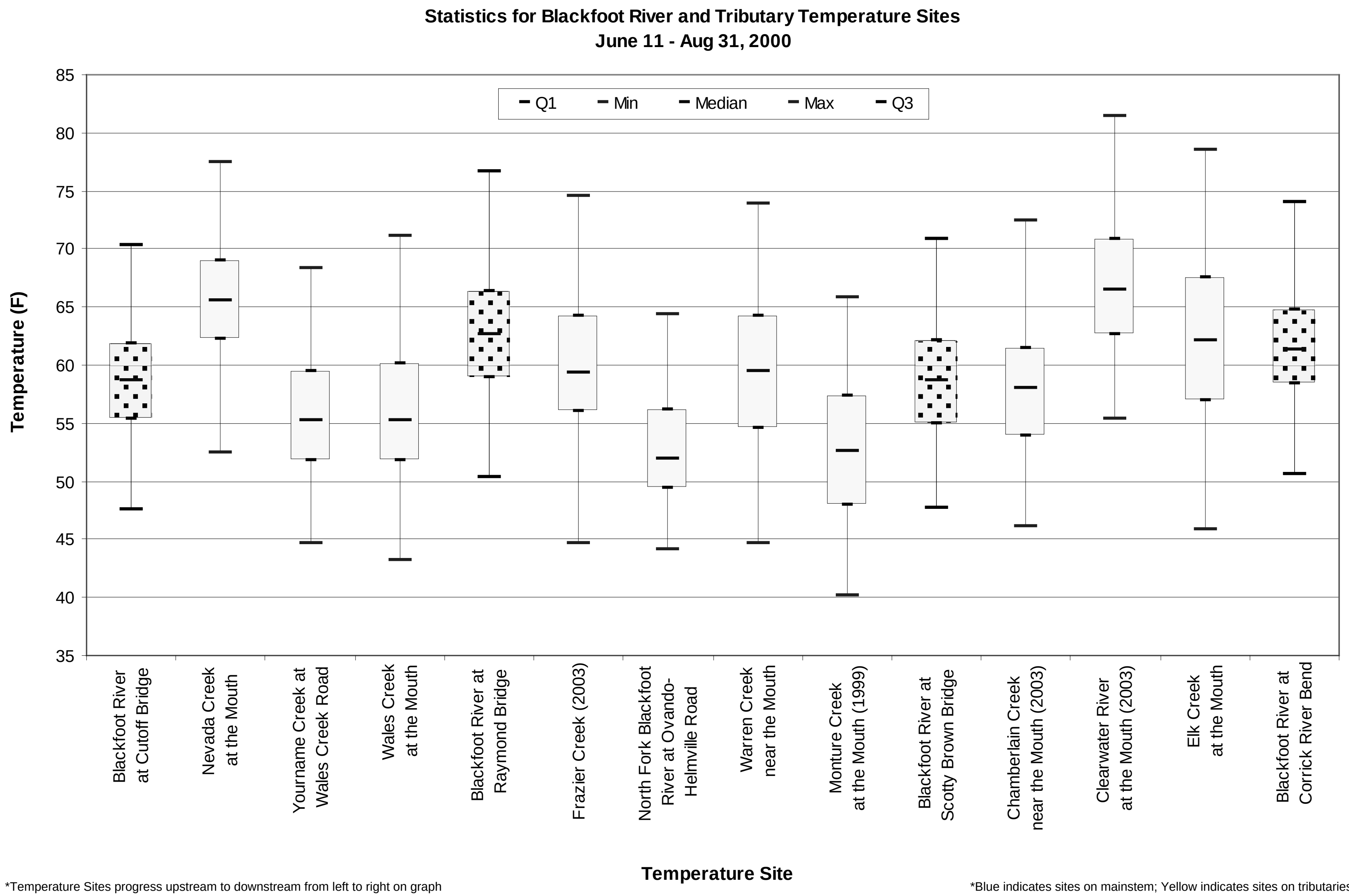


Figure 8-41. Upstream To Downstream Temperature Variation, Blackfoot River and Tributaries, 2000 and Other Years as Noted

Blackfoot River Temperature Modeling Results

The Blackfoot River model simulated temperatures for the Blackfoot River within the Middle Blackfoot planning area by from Cutoff Bridge to Corrick River Bend. This section of the Blackfoot River extends for 49.8 miles, and ends beyond the boundary of the Middle Blackfoot planning area (**Appendix A, Figure A-41**). Therefore, to simulate temperature at the planning area boundary, the SNTEMP model for the Blackfoot River included an output node below the confluence of the Clearwater River.

Stream bank vegetation along the Blackfoot River from Nevada Creek to Monture Creek ranged from approximately 9% to 80%. However, since the Blackfoot River is very wide in this section (average width of 130 feet), this vegetation provides very little shade. Total shade for this segment ranges from one to nine percent and averages 3.9% (DTM and AGI, 2006). Shade calculations indicate that an increase to 95% stream bank woody vegetation increases shade to an average of 8.3%. No appreciable decrease in simulated temperature resulted from this change. Therefore, for TMDL development, the source of increased temperature is warm water from Nevada Creek. Natural conditions for the Blackfoot River are simply reducing Nevada Creek input temperatures to their target values (69.2°F).

Simulations of current temperature conditions and natural conditions at the first monitoring site downstream from Nevada Creek (Raymond Bridge) differed by only 0.23°F (**Table 8-18**). Therefore current conditions for both mean daily and mean daily maximum temperatures fall within the 0.5°F allowable temperature increase from natural conditions. Additional simulations were not warranted.

Table 8-18. Simulation Results for the Blackfoot River at Raymond Bridge

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	69.04	74.96	NA	NA	NA
Calibrated Temperature (Current Conditons)	68.66	74.19	NA	NA	Simulated temperature with current stream conditions
Naturally Occurring Condtions	68.43	73.99	-0.23	-0.20	Natural Conditions: Reduce Nevada Creek temperature to 69.2°F

Blackfoot River Impairment Status Summary

SNTEMP modeling provided simulated natural conditions temperatures with Nevada Creek input meeting Nevada Creek target temperatures (**Table 8-19**). The target temperature is 0.5°F above the natural conditions temperature. Comparison with the current conditions temperature indicates that the Blackfoot River from Nevada Creek to Monture Creek meets temperature targets and a TMDL is not required.

Table 8-19. Summary of Temperatures, Blackfoot River from Nevada Creek to Monture Creek

Parameter	Temperature (°F)	Comments
Current Conditions	68.66	Temperature is below the 0.5°F allowable increase from natural conditions temperature. July 27-29, 2000 temperature data
Target Conditions	68.93	0.5°F allowable increase above natural conditions temperature
Natural Conditions	68.43	Simulated temperature with Nevada Creek meeting temperature targets

8.2.2.3 Blackfoot River (Monture Creek to Belmont Creek)

Between Scotty Brown Bridge (below the confluence of Monture Creek and the Blackfoot River) and downstream at Corrick River Bend, the Clearwater River has the highest water temperatures of any Blackfoot River tributary and contributes a substantial amount of water (**Appendix A, Figure A-15**).

Temperature Data Analysis

Figure 8-42 through Figure 8-45 display continuous summer water temperature data for sites on the Blackfoot River and tributaries from Monture Creek to Belmont Creek. **Figure 8-46** illustrates average daily temperature for the Blackfoot sites in this segment. These data indicate gradually increasing temperatures downstream, with cool inputs from Cottonwood Creek and warm inputs from the Clearwater River.

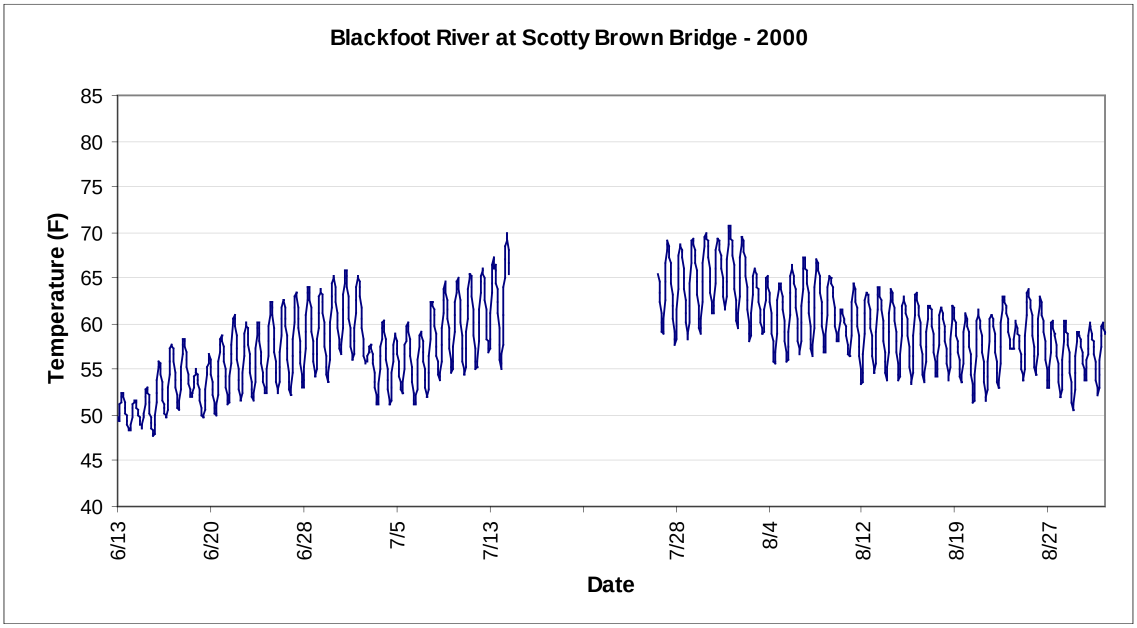


Figure 8-42. Continuous Water Temperature, Blackfoot River at Scotty Brown Bridge, 2000

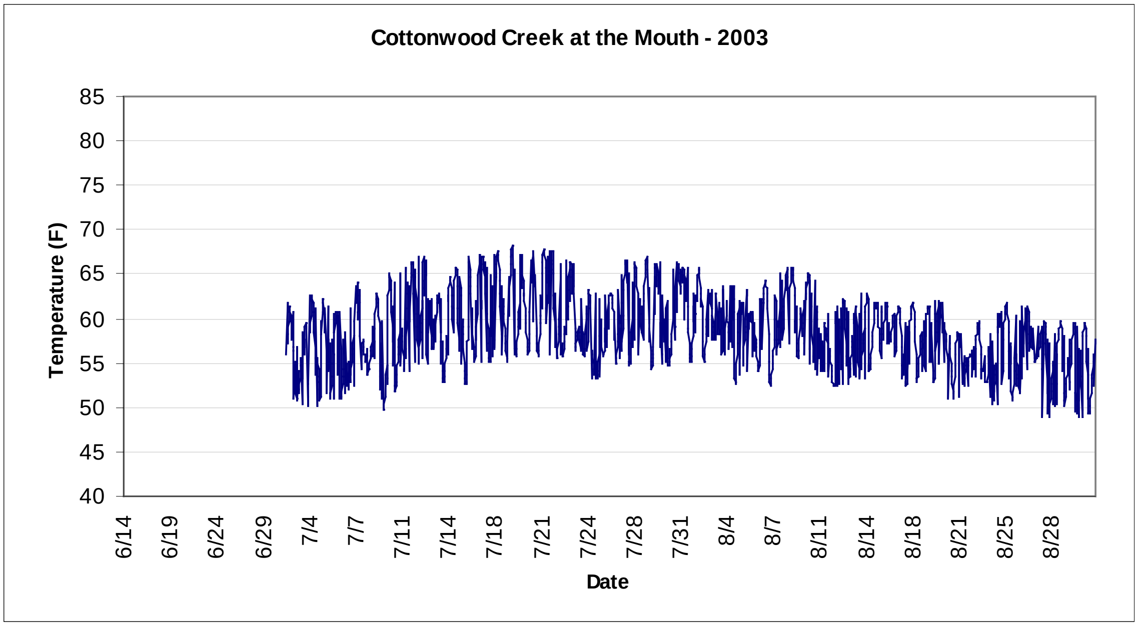


Figure 8-43. Continuous Water Temperature, Cottonwood Creek at the Mouth, 2003

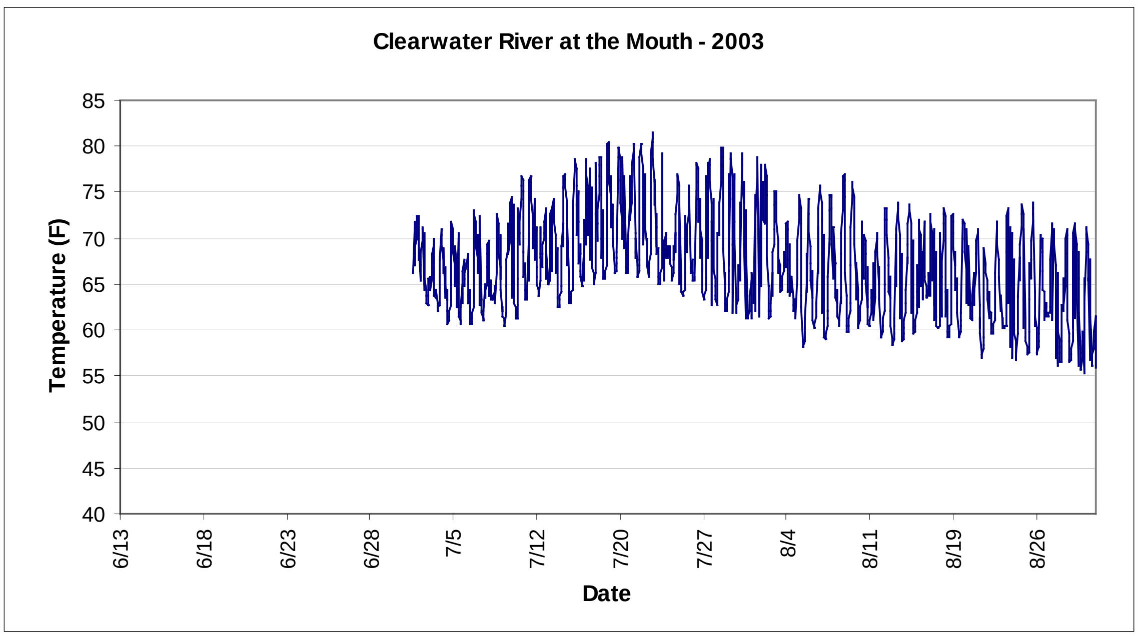


Figure 8-44. Continuous Water Temperature, Clearwater River at the Mouth, 2003

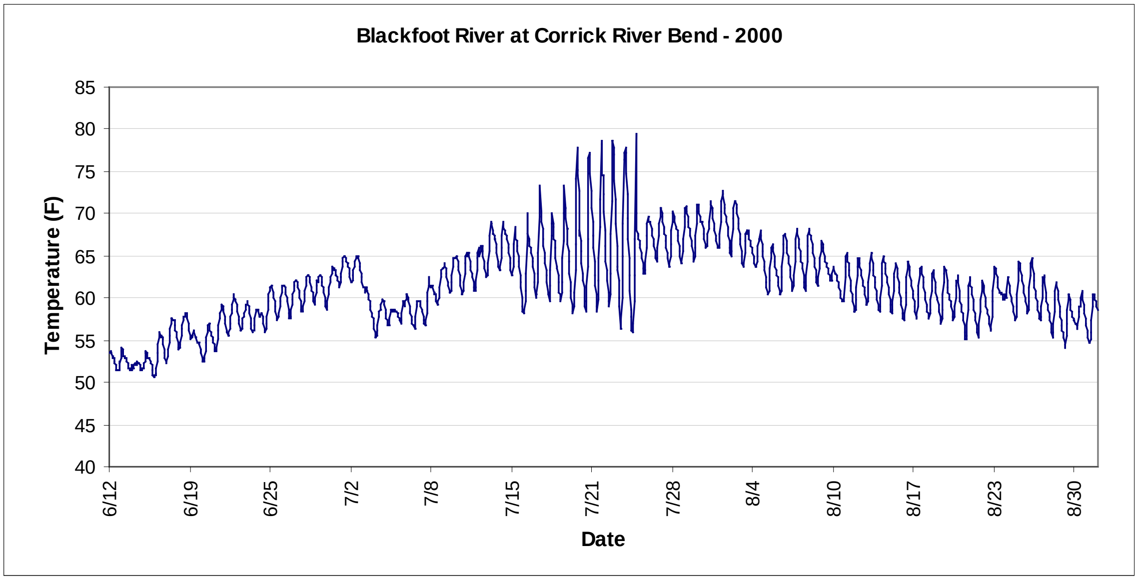


Figure 8-45. Continuous Water Temperature, Blackfoot River at Corrick River Bend, 2000

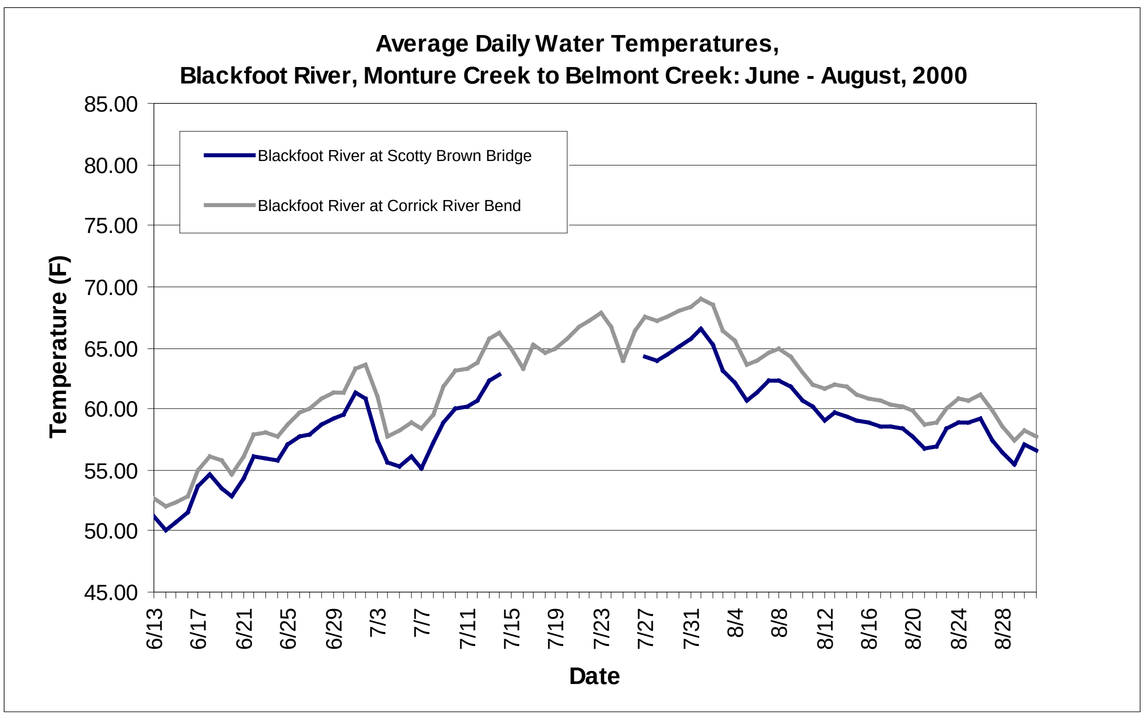


Figure 8-46. Average Daily Water Temperature, Blackfoot River, Monture Creek to Belmont Creek, June 2000

Blackfoot River Temperature Modeling Results

The downstream boundary of the Middle Blackfoot planning area is below the confluence of the Clearwater River and the Blackfoot River. Therefore, the SNTEMP model for the Blackfoot River was constructed with an output point allowing simulation of temperatures at this location. Stream bank vegetation and shade is similar to the upstream segment of the Blackfoot River. The average width is 145 feet; woody vegetation covers 63% of stream banks, and shade averages

6.2%. Increasing stream bank woody vegetation to 95% increases shade to 6.9%. No appreciable decrease in simulated temperature resulted from this change. Therefore, natural conditions for the Blackfoot River are simply reducing Nevada Creek input temperatures to their target values (69.2°F).

Simulations of current temperature conditions and natural conditions below the confluence with the Clearwater River, for both mean daily and mean daily maximum temperatures, differed by only 0.02°F (**Table 8-20**). Therefore current conditions fall within the 0.5°F allowable temperature increase. Additional simulations were not warranted.

Table 8-20. Temperature Modeling Simulations of Current Temperature Conditions and Natural Conditions below the Confluence with the Clearwater River

Model Run	Temperature (°F)		Difference from Calibration (°F)		Comments
	Mean	Max	Mean	Max	
Calibrated Model (Current Conditions)	66.60	70.14	NA	NA	Simulated temperature below the Clearwater River with current stream conditions
Natural Conditions	66.58	70.12	-0.02	-0.02	Current stream conditions; Nevada Creek input under natural conditions

Blackfoot River Impairment Status Summary

SNTEMP modeling provided simulated natural conditions temperatures with Nevada Creek input meeting Nevada Creek target temperatures (**Table 8-21**). The target temperature is 0.5°F above the natural conditions temperature. Comparison with the current conditions temperature indicates that the Blackfoot River from Monture Creek to the Clearwater River meets temperature targets and a TMDL is not required.

Table 8-21. Summary of Temperatures, Blackfoot River from Monture Creek to the Clearwater River

Parameter	Temperature (°F)	Comments
Current Conditions	66.60	Temperature is below the 0.5°F allowable increase from natural conditions temperature. July 27-29, 2000, temperature data
Target Conditions	67.05	0.5°F allowable increase above natural conditions temperature
Natural Conditions	66.58	Simulated temperature with Nevada Creek meeting temperature targets

While temperature TMDLs are not required for the Blackfoot River, elevated water temperatures in these reaches remains a concern for fisheries restoration efforts and water quality. Approaches to reducing temperatures in the mainstem of the Blackfoot River through tributary restoration and BMP implementation are discussed in **Section 10.0**.

SECTION 9.0
POLLUTANT LOADS AND ALLOCATIONS

This section specifies the loads and allocations for each major pollutant category listed as causing impairment of waters in the Middle Blackfoot-Nevada Creek TMDL planning area. The pollutant categories are sediment, metals, nutrients and temperature. The discussion of each major category includes the following basic components:

- Summary of the existing data or description of the computer modeling effort used to estimate loading.
- Pollutant loading quantified by either contributing process or according to a general daily loading equation.
- Allocations of allowable loads to either general land cover categories or land use sources.

Due to both the size of the planning area and the complexities of load estimation, the details of loading analyses are often described in appendices or referenced report documents. Discussions of analytical uncertainty, margin of safety, seasonality and adaptive management approaches for future adjustment to loading estimates are discussed at the end of each pollutant category section.

9.1 Sediment Loading

This section summarizes the current sediment load estimates from the three broad source categories of hillslope erosion, stream bank erosion and road erosion. The details for estimating sediment loading from these sources and deriving TMDLs are described in **Appendix J** and summarized in the sections below. The sediment loads are coarse numeric estimates that may be adjusted, if necessary, through adaptive management. Until better information is available and the linkage between loading and sediment targets and use support becomes clearer, the loading estimates presented here are initial points of departure.

9.1.1 Hillslope Erosion Loading Estimates and Adjustments

Sediment loading from hillslope erosion was estimated through the use of the SWAT model applied across the planning area. A description of the SWAT application is in **Appendix I**. The resulting SWAT hillslope erosion estimates required modifications primarily to account for the coarse slope scale inherent in the model. The model's assignment of a single slope value in each subbasin over-simplified the actual slope variability that would reduce delivery of detached sediment to stream channels. A portion of the modeled hillslope erosion would not be delivered to the channel because of hillslope deposition and vegetation filtering.

The approach used to develop hillslope loading values, starting with SWAT estimates, is described in detail in **Appendix J**. This was accomplished in three ways:

- Based on literature references, the area of potential sediment delivery to a stream was limited to a 350 foot buffer along each stream and included only those areas where the slope was greater than 3 percent. This is referred to as the Adjusted Sheetflow Area Load within **Table J-1, Appendix J**.

- Based on literature references, it was assumed that healthy vegetation buffers along each stream have the potential to reduce the sediment loading from this 350 foot buffer by 75% under naturally occurring conditions. This includes loading from developed land where all reasonable land soil and water conservation practices are applied. This potential load reduction is referred to as the Cumulative Controllable Load in **Table J-1**. The remaining 25% of the Adjusted Sheetflow Area Load is defined as the Cumulative Naturally Occurring Load in **Table J-1**, and it is assumed that this amount of loading will always reach the stream.
- The health of vegetative buffers was evaluated along each of the streams to determine the extent to which the Cumulative Controllable Load was actually being controlled. In areas with no or minimal human influence, it was assumed that the whole load was being controlled and no sediment was reaching the stream above and beyond the Cumulative Naturally Occurring Load discussed above. In areas where human activities were limiting the health and vigor of the vegetative buffer, it was determined that a percentage of the controllable load was actually reaching the stream. These values are given by listed stream segment in **Appendix J, Table J-2**. The amount of controllable load reaching the stream provides a basis for developing sediment loading allocations that can be applied to hillslope processes, as discussed in **Section 9.1.6**.

Table 9-1 provides a summary of the results of the hillslope erosion assessment for the Blackfoot headwaters, Nevada Creek and Middle Blackfoot sub-planning areas. The results by listed stream segment are given in **Table J-1**.

Table 9-1. Summary of Estimated Controllable, Naturally Occurring, and Needed Reductions to Hillslope Erosion Loading in the Middle Blackfoot-Nevada Creek Planning Area

Watershed Source Area	Controllable Load (tons/yr)	Naturally Occurring Load (tons/yr)	Needed Reduction (tons/yr)	Percent Reduction Needed in Controllable Load
Blackfoot Headwaters	4,533	1,511	1,587	35
Nevada Creek	11,584	3,861	4,308	37
Middle Blackfoot,	18,219	6,074	4878	27
Total	**34,336**	**11,446**	**10,773**	**31**

9.1.2 Stream bank Erosion Loading

The base parameter and stream bank erosion inventory project undertaken in 2004 (DTM and AGI, 2005) included direct measurement of sediment from eroding banks on representative reaches of 303(d) Listed streams. **Appendix C** of this document describes the assessment methodology and **Appendix J, Tables J-4 and J-5** give the estimates of total stream bank erosion by assessment reach and listed segment. Maps summarizing calculated bank erosion rates are shown in **Appendix A, Figures A-29 and A-30**. **Table 9-2** below gives values for current segment loads, controllable segment loads, and naturally occurring segment load for each listed stream segment. The table concludes with totals for each of these categories in the Nevada Creek, Middle Blackfoot River, and Blackfoot headwaters planning areas. The headwaters bank erosion estimate is from the headwaters sediment TMDL (DEQ et al., 2004).

Table 9-2. Stream Bank Erosion Inventory Results for Nevada Creek, Middle Blackfoot River, and Blackfoot Headwaters TMDL Planning Areas

Stream Name	Current Segment Load (tons/yr)	Controllable Segment Load (tons/yr)	Naturally Occurring Segment Load (tons/yr)
Nevada Creek Planning Area			
Upper Washington Creek	296	119	177
Lower Washington Creek	1050	353	697
Upper Jefferson Creek	535	220	315
Lower Jefferson Creek	537	220	317
Gallagher Creek	100	27	73
Buffalo Gulch	158	50	109
Nevada Creek (upper)	3,480	1,178	2,302
Braziel Creek	262	70	192
Black Bear Creek	113	30	83
Murray Creek	615	224	391
Upper Douglas Creek	996	356	641
Cottonwood Creek	309	95	214
Lower Douglas Creek	4,224	1,448	2,777
Nevada Spring Creek	25	8	17
McElwain Creek	333	120	213
Nevada Creek (lower)	10,687	3,502	7,185
Middle Blackfoot River Planning Area			
Yourname Creek	274	95	179
Wales Creek	267	96	171
Frazier Creek	0.3	0.1	0.2
Ward Creek	77	23	54
Kleinschmidt Creek	80	24	56
Rock Creek	227	62	163
North Fork Blackfoot River	6,561	2,026	4,535
Warren Creek	85	26	59
Monture Creek	770	209	561
Blackfoot River (Nevada Creek to Monture Creek)	23,605	9,902	20,263
Chamberlain Creek	240	74	166
Cottonwood Creek	296	106	190
Richmond Creek	3	1	2
West Fork Clearwater River	371	115	256
Deer Creek	124	38	86
Buck Creek	5	1.5	3.3
Blanchard Creek	59	15	44
Lower Clearwater River	2,871	890	1981
Blackfoot River (Monture Creek to Clearwater River)	4,002	1,377	2,625
Middle Blackfoot Totals	27,221	8,955	18,266
Middle Blackfoot-Nevada Creek Totals	37,908	12,456	25,451
Blackfoot Headwaters Totals	34,492	5,250	29,242

9.1.3 Road Crossing Sediment Loading

The road sediment loading values in **Table 5-54** for the Nevada Creek planning area are brought forward in the second column of **Table 9-3** below as the estimated current sediment load from 718 road crossings. The amount of controllable sediment loading from road crossings was determined by assuming an achievable 30% reduction in loading with implementation of best management practices that minimize road erosion. The 30% reduction is based on Forest Service and Plum Creek Timber Company (PCTC) analyses on roads under their control after full BMP implementation (DEQ et al., 2004). Other road managers are assumed to have similar capabilities for sediment reductions via BMP applications. As indicated by the last row of **Table 9-3**, this equates to 237 fewer tons/year from the Nevada Creek road system. These results indicate that the Douglas Creek watershed is the largest source of road sediment.

Table 9-3. Road Crossing Sediment Loading and Controllable Reductions by Listed Stream Segment in the Nevada Creek Planning Area

Stream Name	Current Road Sediment Load (tons/yr)	Controllable Road Sediment Load (tons/yr)	Segment Loading with BMP Application (tons/yr)
Upper Washington Creek	8	2.4	5.6
Lower Washington Creek	7	2.1	4.9
Upper Jefferson Creek	8	2.4	5.6
Lower Jefferson Creek	1	0.3	0.7
Gallagher Creek	12	3.6	8.4
Buffalo	23	6.9	16.1
Upper Nevada Creek	29	8.7	20.3
Braziel Creek	31	9.3	21.7
Black Bear Creek	60	18	42
Murray Creek	100	30	70
Upper Douglas Creek	153	45.9	107.1
Cottonwood Creek	32	9.6	22.4
Lower Douglas Creek	167	50.1	116.9
Nevada Spring Creek	8	2.4	5.6
McElwain Creek	35	10.5	24.5
Nevada Creek TPA Non-Listed Streams	104	31.2	72.8
Lower Nevada Creek	12	3.6	8.4
Totals	790	237	553

The second column of **Table 9-4** below brings the road sediment loading figures forward from **Table 5-55** for the Middle Blackfoot and applies the 30% reduction described above. Per the last row of the table, the 30% reduction equates to 505 fewer tons per year from the Middle Blackfoot planning area. The most significant road sediment sources among the listed streams in the Middle Blackfoot include Warren, Cottonwood and Monture creeks. The figures in the table for unlisted streams result from the large number of road crossing in unlisted Clearwater River tributaries.

Table 9-4. Road Crossing Sediment Loading and Controllable Reductions by Listed Stream Segment in the Middle Blackfoot Planning Area

Stream Name	Total Road Sediment Load (tons/yr)	Controllable Road Sediment Loading (tons/yr)	Segment Loading with BMP Application (tons/yr)
Yourname Creek	69	20.7	48.4
Wales Creek	6	1.7	3.9
Frazier Creek	10	3.0	7.1
Ward Creek	14	4.3	10.1
Kleinschmidt Creek	13	4.0	9.2
Rock Creek	20	6.0	13.9
North Fork Blackfoot River	117	35.1	81.9
Warren Creek	238	71.3	166.3
Monture Creek	172	51.6	120.3
Blackfoot River (Nevada Creek to Monture Creek)	62	18.6	43.4
Chamberlain Creek	140	42.0	98.0
Cottonwood Creek	183	54.9	128.1
Richmond Creek	5	1.5	3.5
West Fork Clearwater River	42	12.6	29.4
Deer Creek	39	13	29
Buck Creek	15	4.5	10.5
Blanchard Creek	111	33.4	77.8
Middle Blackfoot TPA Non-303(d) Listed Streams	338	101.4	236.6
Blackfoot River (Monture Creek to Clearwater River)	90	27.0	63.0
Totals	1,684	505	1,179

9.1.4 Sediment from Culvert Failure

The estimation of sediment from roadways includes an analysis of sediment from culvert failure. Sediment at risk due to culvert failure is that saturated by ponded water at the upstream inlet of undersized culverts or from overflow of ponded water onto the road surface with subsequent erosion of the fill. Seventy-three culverts were surveyed in the Middle Blackfoot-Nevada Creek planning area during the 2005 road sediment source assessment. The analysis associated risk of failure with a ratio of culvert width to bankfull channel width (constriction ratio) of less than one. Of the 73 survey sites, 55 had constriction ratios less than 1.

A survey of 17 sites in the Nevada Creek planning area estimated that 1,060 tons of road fill is susceptible to failure. In the Middle Blackfoot, a survey of 38 sites estimated that 4,393 tons were at risk from culvert failure. The mean value of 62.4 tons per site in Nevada Creek and 115.6 tons per site in the Middle Blackfoot were extrapolated to the total number of crossings in each planning area. The amount of fill at risk in Nevada Creek was 44,803 tons (62.4 tons/site times 718 sites); 210,165 tons of fill (115.6 tons/site times 1818 sites) were estimated at risk in the Middle Blackfoot (RDG, 2006). Annual loading was estimated assuming a one percent failure rate in each planning area. Thus, annual loading equals 450 tons per year in the Nevada Creek and 2,100 tons per year in the Middle Blackfoot. Current loading, controllable loading and naturally occurring loading by listed segment is described in **Appendix J**. Subtotals by sub-planning area are given in **Table 9-5**. Lacking detailed analysis of failure rates, the one percent failure per year is an estimated point of departure for the purpose of calculating the at risk loads. Adjustments to this failure rate and the resulting loads are warranted when the results of more detailed culvert failure analysis are available for the planning area.

Table 9-5. Annual Loading from Culvert Failure for Nevada Creek and Middle Blackfoot Planning Areas

Stream Name	Crossings	At Risk Mass (tons)	Annual Loading (tons/yr)	Controllable Load (tons/year)	Naturally Occurring Load (tons/yr)
Nevada Creek Planning Area					
Nevada Creek	718	44,803	448	345	103
Middle Blackfoot	1,818	210,161	2,102	1,618	483
Totals	2,536	254,964	2,550	1,963	586

The naturally occurring loading is that assumed with the replacement of failed culverts with culverts passing the 100 year discharge (Q100). This long-term strategy for culvert replacement follows the guidance from the U.S. Forest Service, Inland Native Fish Strategy (INFISH) recommendations that call for all culverts on USFS land to be able to pass the Q100 flow event. The Q100 replacement scenario resulted in annual loading reductions ranging from 70 to 80 percent less than loading when failed culverts were replaced with ones of similar size.

9.1.5 Sediment Loading Summary

Figure 9-1 summarizes the existing sediment loading in the Nevada Creek and Middle Blackfoot planning areas from hillslope erosion, stream bank erosion, road surface erosion and culvert failure. Total loading to listed streams from the combined processes is estimated at 27,370 tons per year in Nevada Creek and 55,296 tons per year in the Middle Blackfoot.

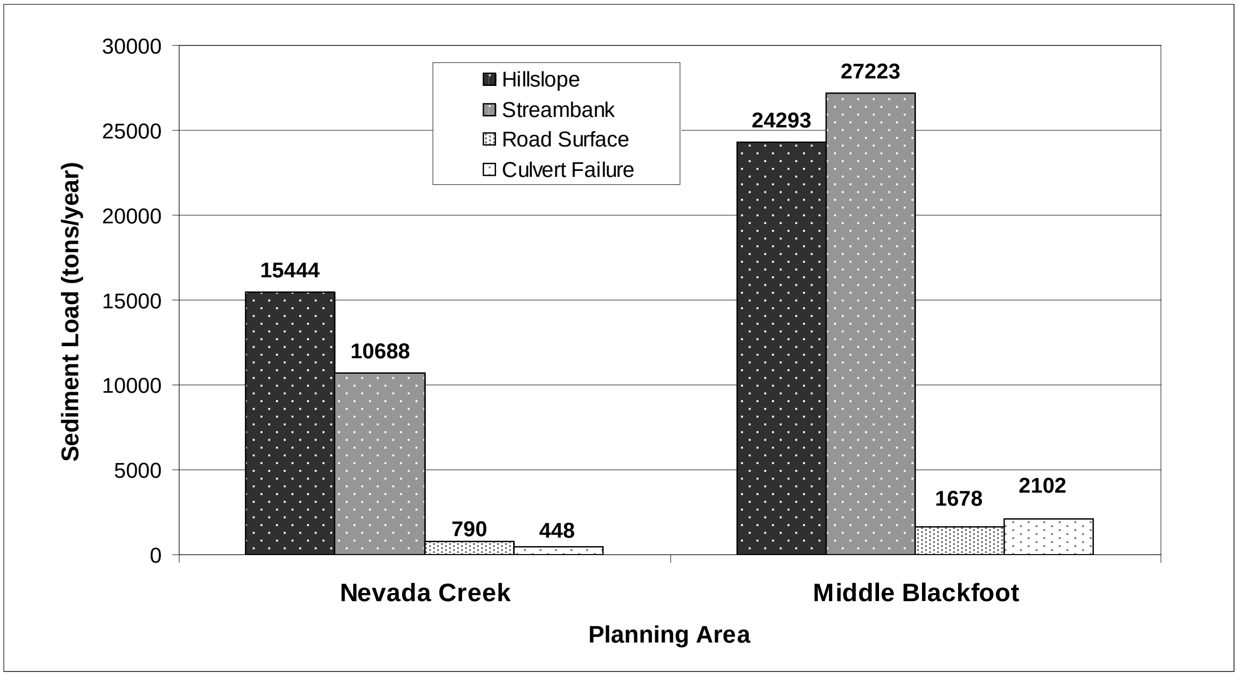


Figure 9-1. Annual Sediment Loading From Principal Sources in the Nevada Creek and Middle Blackfoot Planning Areas

9.1.6 Sediment TMDLs

Based on the source assessment results, TMDLs and allocations were developed for the stream segments listed as impaired by sediment. A TMDL is defined as the sum of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, plus a margin of safety (MOS). The MOS compensates for uncertainty in the load estimates and linkage between pollutant loads and use support. The following equation expresses the TMDL:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

Since there are no point sources in the planning area, the TMDLs do not include WLAs. The TMDLs are expressed as needed reductions in current sediment loading from controllable and naturally occurring nonpoint sources. This approach acknowledges the uncertainty in the numeric estimates while providing useful direction for restoration efforts. The reductions are developed from literature, agency and industry documentation of BMP effectiveness, field evaluation and interpretation of aerial imagery and other geographic information. The sediment TMDLs include an implicit margin of safety described in **Section 9.1.8**.

The TMDLs are given by listed stream in **Table 9-6** both as annual percentages and estimates in tons per year. The current loading and reductions for the Nevada Creek and Middle Blackfoot planning areas are illustrated in **Figures 9-2 and 9-3** respectively. The estimated annual reductions integrate those calculated for each sediment-generating process as described in **Appendix J**.

Table 9-6. Current Sediment Loading, and Sediment TMDLs Expressed as Annual Reductions to Current Loading to Sediment Impaired Streams in the Middle Blackfoot-Nevada Creek Planning Areas

Stream Name	Current Load (tons/yr)	Needed Load Reduction (tons/yr)	Percent Reduction in Total Annual Load
Nevada Creek Planning Area			
Upper Washington Creek	371	88	24%
Lower Washington Creek	771	183	24%
Upper Jefferson Creek	872	295	34%
Lower Jefferson Creek	11	3	30%
Gallagher Creek	364	110	30%
Buffalo Gulch	571	181	32%
Upper Nevada Creek	3,501	909	26%
Braziel Creek	372	86	23%
Black Bear Creek	431	112	26%
Murray Creek	5,743	1,528	27%
Upper Douglas Creek	1,399	414	30%
Cottonwood Creek	4,372	1,166	27%
Lower Douglas Creek	5,012	1,129	23%
Nevada Spring Creek	36	10	28%
McElwain Creek	616	192	31%
Lower Nevada Creek	2,703	621	23%
Middle Blackfoot Planning Area			
YournameCreek	627	181	29%
Wales Creek	308	87	28%
Frazier Creek	39	17	43%
Ward Creek	156	48	31%
Kleinschmidt Creek	27	12	46%
Rock Creek	2,508	754	30%
Warren Creek	397	128	32%
Monture Creek	1,560	342	22%
Blackfoot River (Nevada Cr. to Monture Cr.)	11,421	2,560	22%
Cottonwood Creek	2,009	583	29%
Richmond Creek	23	13	58%
West Fork Clearwater River	693	175	25%
Deer Creek	1,399	271	19%
Blanchard Creek	335	146	44%
Blackfoot River (Monture Cr. To Clearwater River)	4,891	948	19%

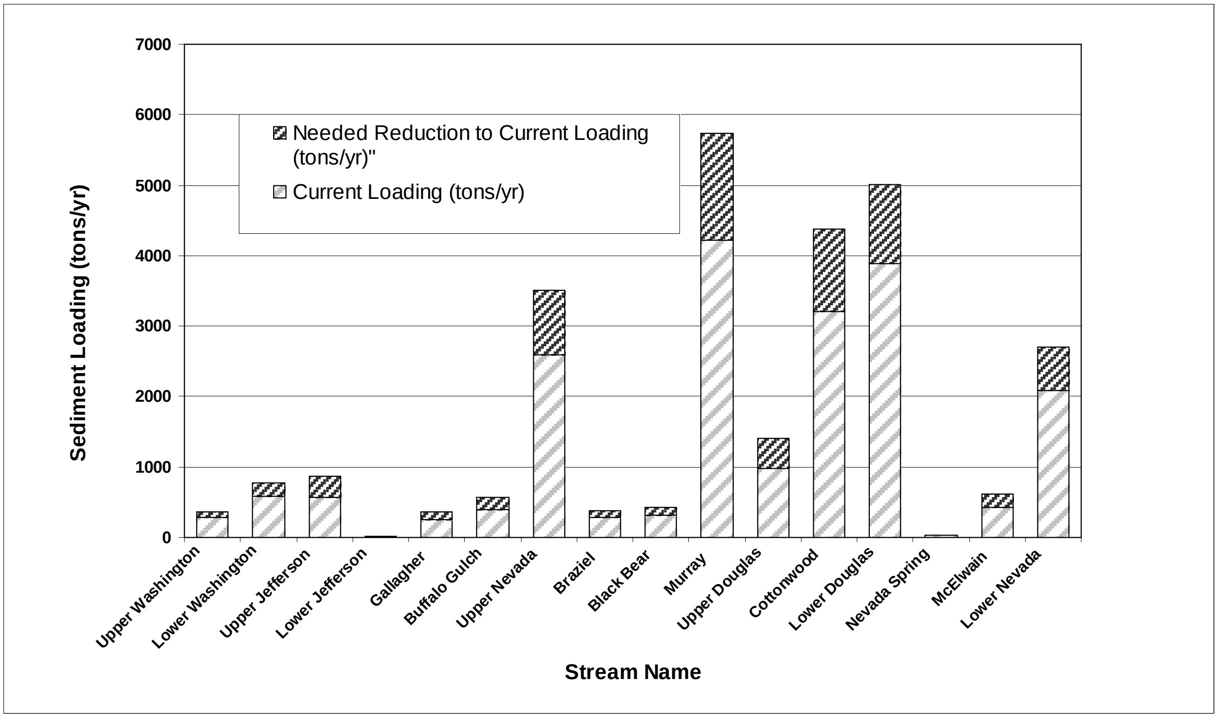


Figure 9-2. Current Sediment Loading and Needed Reductions in Nevada Creek by Listed Stream Segment

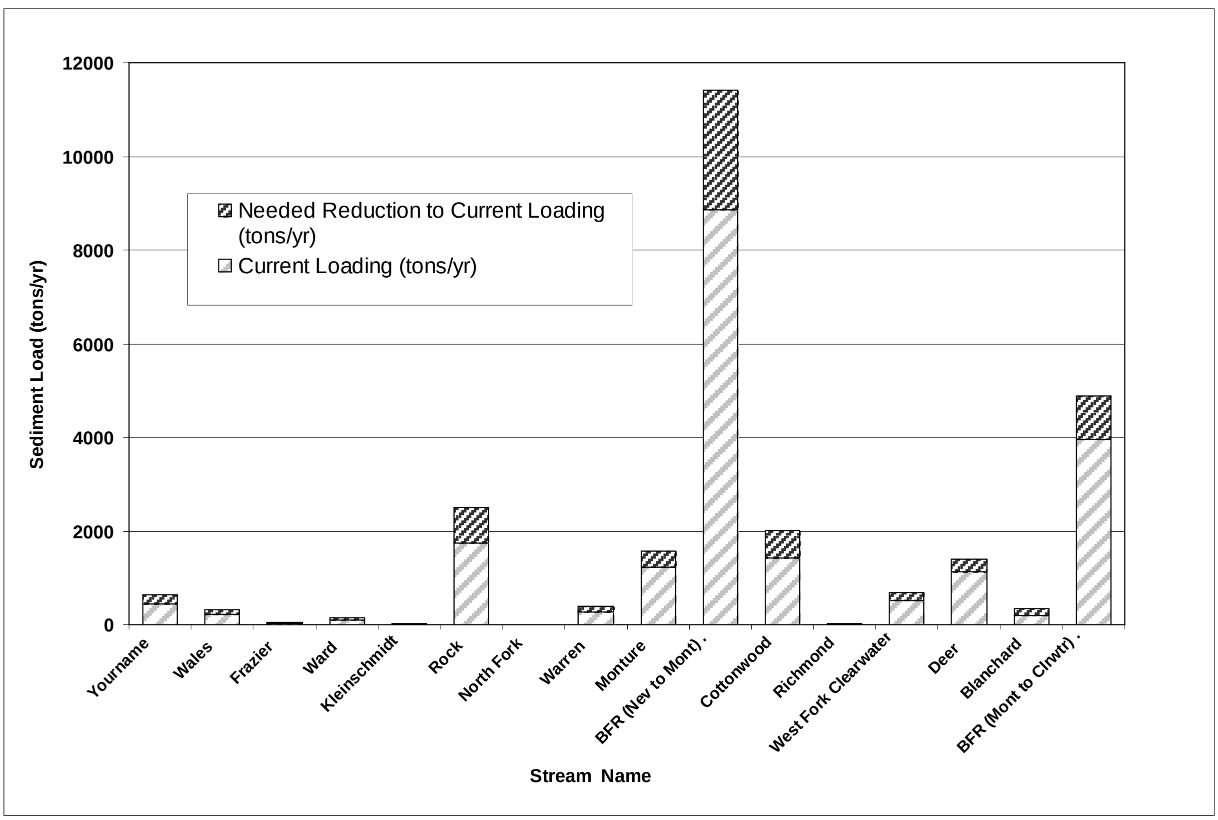


Figure 9-3. Current Sediment Loading and Needed Reductions in the Middle Blackfoot by Listed Stream Segment

Load reductions in the Nevada Creek planning area range from 23% to 34% of current sediment loading. Douglas Creek and its Murray Creek and Cottonwood Creek tributaries appear to be the most significant sediment sources followed by both segments of Nevada Creek. Low loading values for lower Jefferson Creek and Nevada Spring Creek (**Table 9-6**) prevent clear registration of loading and reductions in the figures.

In the Middle Blackfoot, the large bank height to bankfull height ratios measured along the main stem segments strongly influence bank erosion loading estimates and are likely responsible for main stem reaches having the largest loading estimates. The other notable high yielding streams in the Middle Blackfoot include Rock Creek and Cottonwood Creek.

9.1.7 Sediment Allocations

The annual loading reductions are allocated to land uses within the watersheds of impaired streams. They are expressed as a percentage of the needed annual reduction for the listed water body and converted to annual reductions in tons per year by land use source category in **Table 9-7** for Neveda Creek Planning area and **Table 9-8** for Middle Blackfoot Planning Area. Details on how sediment allocations were developed are discussed in **Appendix J**.

Annual hillslope allocations are based upon the proportional loading from SWAT landcover categories that are linked to specific land uses. The size of the allocation reflects the magnitude of modeled annual loading from landcover types that are assumed to support specific land uses. Allocations to livestock grazing, for example, are proportional to modeled loading from rangeland cover types. Broad allocations based on SWAT loading estimates by landcover type were refined by considering the extent of cover types, and corresponding land uses, within the sheetflow area defined by the 350-foot buffer extending from each stream bank. Interpretation of aerial imagery and, in some cases, ground photographs specified allocations to land uses that were not linked to the USGS landcover categories that served to define hydrologic response units (HRUs) recognized by SWAT. The placer mining land use is such a case.

Interpretation of aerial imagery also supported allocations where there was a significant difference between the USGS landcover type and actual ground conditions. Shrub dominated vegetation cover that is characteristic of regrowth following timber harvest is commonly assigned to a rangeland cover type. Unless the forest context of this cover is considered, a strict linkage between rangeland cover types and livestock grazing, the most common land use on rangelands, loading and load reductions from such areas would mistakenly be allocated to grazing rather that silviculture.

Table 9-7. Nevada Creek and Middle Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Crossings	Rural Residential
Nevada Creek Planning Area							
Upper Washington Creek	88	41	2	15	38	7	0
Lower Washington Creek	183	72	105	0	0	6	0
Upper Jefferson Creek	295	113	0	57	113	12	0
Lower Jefferson Creek	3	0	0	0	0	3	0
Gallagher Creek	110	72	26	4	0	7	0
Buffalo Gulch	181	50	10	93	3	25	0
Upper Nevada Creek	909	388	491	7	7	17	0
Braziel Creek	86	45	0	26	0	15	0
Black Bear Creek	112	88	0	1	0	23	0
Murray Creek	1,528	470	71	933	0	54	0
Upper Douglas Creek	414	181	134	0	0	99	0
Cottonwood Creek (Douglas)	1,166	569	554	0	0	43	0
Lower Douglas Creek	1,129	765	272	0	0	92	0
Nevada Spring Creek	10	5	1	0	0	4	0
McElwain Creek	192	92	77	0	0	23	0
Lower Nevada Creek	621	543	56	0	0	22	0
Totals	**7,027**	**3,494**	**1,798**	**1,121**	**161**	**452**	**0**

Table 9-8. Nevada Creek and Middle Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Crossings	Rural Residential
Middle Blackfoot Planning Area							
Yourname Creek	181	130	1	1	1	48	0
Wales Creek	87	52	29	0	0	6	0
Frazier Creek	17	7	0	0	0	10	0
Ward Creek	48	22	0	8	0	18	0
Kleinschmidt Creek	12	1	0	0	0	11	0
Rock Creek	754	503	0	219	0	32	0
Warren Creek	128	13	1	4	0	110	0
Monture Creek	342	36	0	146	0	160	0
Blackfoot River (Nevada Cr. to Monture Cr.)	2560	1127	876	504	0	54	0
Cottonwood Creek (Blackfoot)	583	286	7	77	0	213	0
Richmond Creek	13	0	0	1	0	12	0
West Fork Clearwater River	175	0	0	90	0	85	0
Deer Creek	271	0	0	148	0	124	0
Blanchard Creek	146	21	0	7	0	119	0
Blackfoot River (Monture Cr. To Clearwater River)	948	477	64	0	0	280	127
Totals	**6,265**	**2,675**	**978**	**1,205**	**1**	**1,282**	**127**

Land uses and vegetation conditions were evaluated and photographed within assessed reaches during the bank erosion assessment. The interpretation of ground and aerial imagery and field observations identified the principal land uses affecting stream bank conditions. The relative influence of land uses on loading is based on extent in the watershed and level of effect on sediment filtering vegetation. The percent reduction allocations of stream bank erosion affecting land uses are provided in **Appendix J**, **Table J-10**.

The reductions in road surface erosion and culvert failure are those possible with BMP implementation. **Figure 9-4** summarizes the total sediment load reduction allocations by contributing land use category for the Nevada Creek and Middle Blackfoot planning areas.

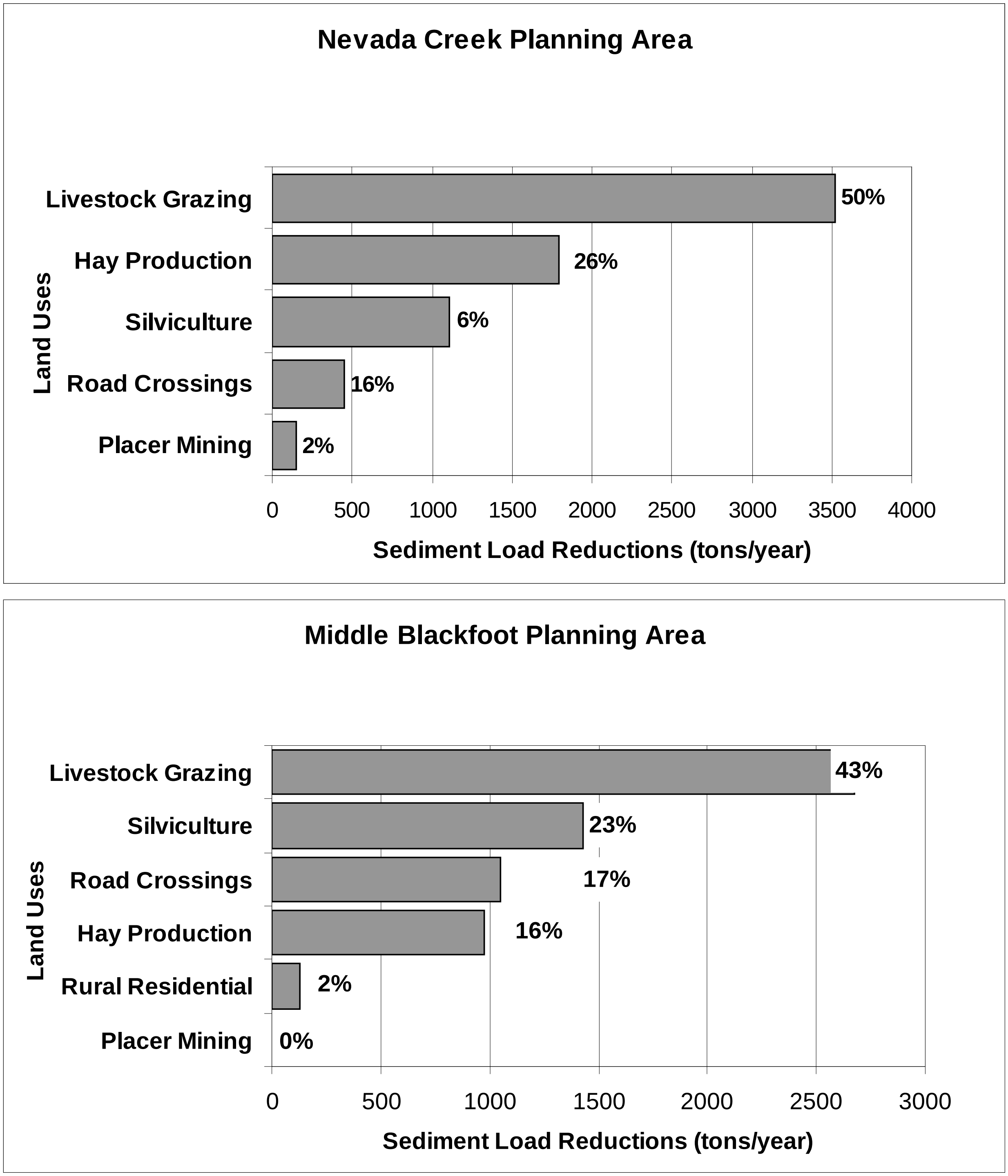


Figure 9-4. Sediment Reduction Allocations (Tons/Yr) by Contributing Land Use Category for the Nevada Creek and Middle Blackfoot Planning Areas

The figure shows the predominant role of livestock grazing in sediment production for both planning areas. After grazing, hay production, silviculture and road sediment account for the largest reduction allocations in Nevada Creek. Silvicultural and road erosion reductions are more prevalent in the Middle Blackfoot. The minor contribution from placer mining in the Middle Blackfoot (0.67 ton/year in Yourname Creek) prevents its registration on the graph.

9.1.8 Daily Loads and Allocations

To calculate daily loads, the estimated mean annual sediment load and reductions were multiplied by the fraction of the SWAT generated annual sediment yield delivered during each calendar day. A nine-year period from January 1996 through December 2004 was selected for simulating water quantity and quality conditions in the Blackfoot watershed using SWAT (**Appendix I**). The model produced output files containing mean daily values for stream discharge and sediment loading (reach files) calculated for the modeling period. The annual load estimates and reductions are distributed daily according to SWAT simulations of daily loading. This approach assumes that the daily distribution of loading from all sources is equal to that in the stream reach simulations documented in the reach files for hillslope erosion. An example calculation is described below for upper Nevada Creek.

Upper Nevada Creek has a total annual sediment load estimate for of 3,501 tons per year (**Table 9-6**). The upper Nevada Creek reach file contains mean daily sediment loads. A daily loading fraction is calculated by dividing SWAT mean daily load by the total over 365 days (535 tons per the upper Nevada Creek reach file output). Current daily loading in upper Nevada Creek is 3,501 tons times the daily fraction. The allowable annual load of 2,592 tons (3,501 - 909 = 2,592) multiplied by the daily fraction gives an allowable daily load that represents the sediment TMDL. **Figure 9-5** illustrates the current daily loading and the allowable daily sediment loading remaining after a 26% reduction in upper Nevada Creek. Average weekly values were calculated in order to smooth the curve in the figure.

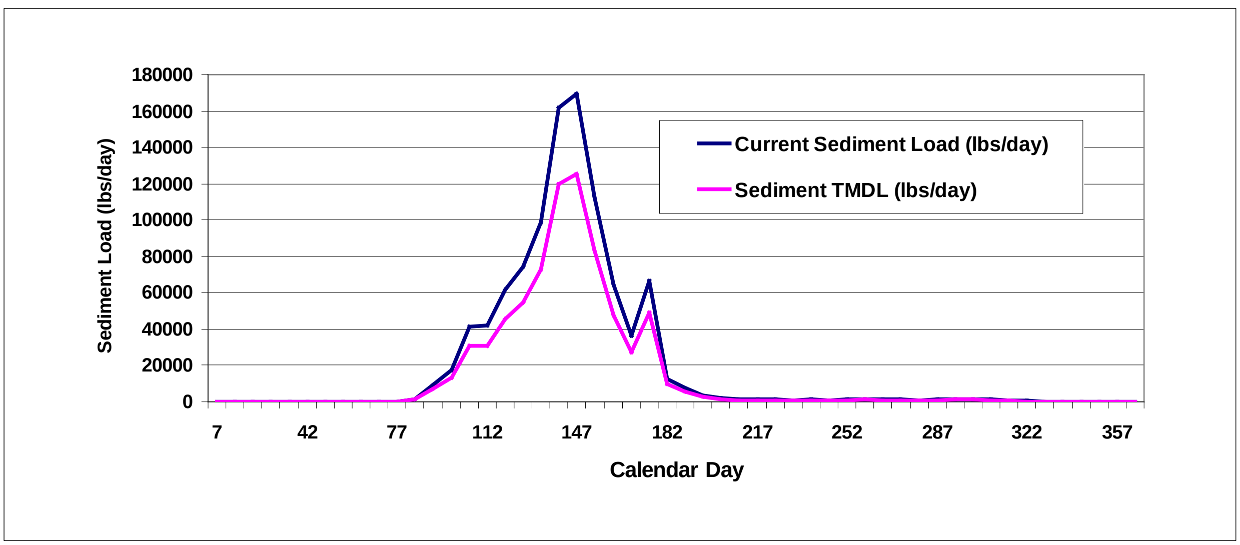


Figure 9-5. Current and Maximum Daily Sediment Loading for Upper Nevada Creek

The large annual variability in loading due to the runoff masks the low flow load reductions. Although a logarithmic scale applied to the Y-axis in the figure would better illustrate low flow reductions, the current scale better characterizes high flow loading when actual load reductions are more achievable and would have the greatest benefit.

The daily load reductions calculated for upper Nevada Creek are allocated to the corresponding land use categories identified for this segment in **Table 9-8**. The daily loads allocated to these land uses are presented in **Table E-1** of **Appendix E** and illustrated in **Figure 9-6.**

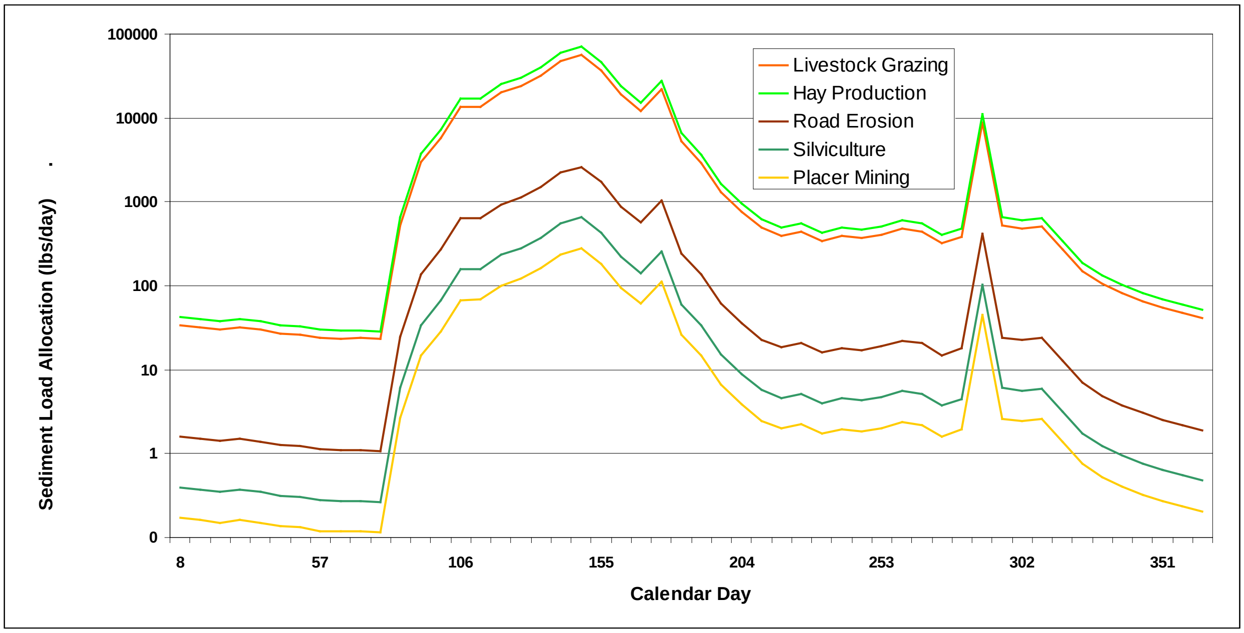


Figure 9-6. Daily Sediment Load Allocations for Upper Nevada Creek

Table E-1 and **Figure 9-6** serve as an example of daily loads allocated to land uses. The use of the table for upper Nevada Creek serves as an example of the daily allocations by the process described above. An example is used in the interest of reducing the cost of tabulating and illustrating all daily data for the remaining 30 sediments of impaired streams. Example TMDLs and allocations for the remaining 30 sediment impaired stream segments are tabulated in **Appendix E, Table E-2** for three separate days: (1) mid-winter base flow loading, (2) peak runoff loading, and (3) mid-summer loading.

9.1.9 Margin of Safety and Seasonality for Sediment TMDLs

The implicit margin of safety for sediment TMDLs has several sources. The first is in the estimated size of the sediment contributing area used in the hillslope analysis for each stream. The slope length across which sheetflow erosion occurs is 350 feet (**Section 9.1.1**) perpendicular to the direction of channel flow. Values in the literature for this distance are quite variable, ranging from 100 feet to 400 feet. A length of 350 is conservatively high in cases where slopes adjacent to channels are nearly level. The uniform use of the 350-foot length made estimates of contributing area larger and its proportion of the entire subbasin area larger. The ratio of contributing area to total subbasin area was used to reduce the gross loading estimates generated by SWAT for hillslope erosion.

The sediment yields calculated by the SWAT model in several subbasins included those from a hydrologic response unit (HRU) labeled as "forest roads." Sediment contributions from this feature were significant in the forested Clearwater River drainage, Murray Creek, Warren Creek, and Buffalo Gulch. Since an estimate of forest road erosion loading was also made using the Washington Forest Practices Board Manual. Measuring road erosion with both SWAT and the Washington manual has the potential for duplicate counting to the extent that sediment from road segments apart from stream crossings is minimal. Loading from SWAT roads HRUs is based on road area and runoff curve number, as described in **Appendix I**, rather than stream proximity and road prism conditions. The degree of double counting for road erosion is an implicit margin of safety in the sediment TMDL. The margin is reduced if one considers that sediment from roads may enter flowing channels at points other than road crossings. An implicit margin of safety exists in the assumed minimum achievable reduction of 25% in human caused stream bank erosion. A minimum 25% reduction was assumed possible on the best condition streams. This is likely an over estimate in the ungrazed portions of headwaters segments like upper Washington Creek (Wash1) and upper Nevada Creek (Nev2) that had stable banks and generally healthy riparian vegetation at the time of the assessments.

Recent research in erosion rates from forest roads in western Montana (Sugden and Woods, 2007) has concluded that base erosion rates may be an order of magnitude less than the 10 tons per acre per year assumed for this road sediment loading analysis. If the research accurately characterizes forest road erosion, an additional implicit margin of safety exists in the calculations based on the base erosion rate of 10 tons per acre.

The modification of the gross hillslope loading estimates from SWAT to reflect conceivable contributing area introduces uncertainty in the hillslope loading estimates. Uncertainty exists in the loading estimates from each of the three principal sediment sources of hillslopes, stream banks and roadwayss. The degree of uncertainty may, in some cases, result in prescribed load reductions that would be difficult to realistically achieve and future adjustments may be warranted. The land cover database and management files describing sediment contributing HRUs in the SWAT model did not reflect the effects of forest fires on sediment delivery. Future revisions to the model will need to incorporate information on fire timing, duration, extent and rate of ground cover recovery to provide more realistic sediment yield estimates for forested areas.

A more generally applicable margin of safety for the sediment TMDL is its further evaluation though the adaptive management process. Several specific goals for adaptive management of sediment loading include:

- Continued refinement or redevelopment of a predictive sediment loading model with improved subbasin slope resolution, improved landcover characterization, and more accurate flow characterization.
- Monitoring of both suspended and bedload sediment transport and their relation to values for fine sediment and channel habitat targets.
- Application of a reservoir response model to simulate the effects of Nevada Lake on the sediment budget for Nevada Creek.
- Further refinement of land use effects on hillslope and bank erosion.

- Refinement of bank retreat rates on which streambank erosion rates are based.

The adaptive management process is an implicit margin of safety that keeps erosion control issues in focus toward finding workable solutions that protect beneficial uses.

Seasonality in the sediment TMDL is applied through the use of daily loading fractions of total annual loading contained in the SWAT generated sediment routing (reach) files for each stream. Use of the daily fractions distributed the total sediment load estimate over 365 days according to sediment transport capacity that varies with daily flow.

9.2 Metals TMDLs and Allocations

As shown in **Table 6-5**, metals TMDLs are required for three water bodies: lower Washington Creek for iron, lower Jefferson Creek for iron and aluminum, and upper Nevada Creek for iron, copper, and lead. Numeric water quality standards are established for these metal impairment causes. Where numeric standards are in place, TMDLs are calculated by multiplying the flow rate by the numeric standard and a unit conversion factor according to Equation 1.

Equation 1. **TMDL = (X mg/L)(Y ft3/sec)(5.4) = (X)(Y)(5.4) lbs/day**

where:
X = the applicable numeric water quality standard in mg/L;
Y = the stream flow in cubic feet per second;
5.4 = the unit conversion factor

The upper bound on daily loading that defines the TMDLs for iron and aluminum is the product of flow times the numeric standard and the appropriate conversion factor. Because the standards for copper and lead are dependent on water hardness, the hardness value, as well as the metal constituent concentration must be determined from sample analysis in order to fully evaluate compliance with the water quality standard at low concentrations and loading conditions that are close to the TMDL.

The relationship between hardness and the standard for a specific hardness dependent metal is a function of two constants. These constants in Equation 2 below for calculating the chronic standard are referred to in Circular DEQ-7 as “mc” and “bc.” To calculate the chronic aquatic life standard for copper, for example, the constant “mc” equals 0.8545 and “bc” equals -1.702 (DEQ, 2006). These constants inserted into Equation 2 to express the relationship between hardness and the chronic aquatic life standard for copper or lead:

Equation 2. **(X µg/L) = exp. {mc[ln(hardness)] + bc**

where:
X = the chronic aquatic life standard for copper or lead
mc = metal specific constant (0.8545 for copper; 1.273 for lead)
bc = metal specific constant (-1.702 for copper; -4.705 for lead)

The standards for iron and aluminum are not hardness dependent and TMDLs are simply calculated from the numeric standard multiplied by daily flow and a unit conversion factor.

9.2.1 Approach to Metals Allocations

The TMDL is comprised of all load allocations from both natural and human caused nonpoint sources, all waste load allocations from point sources plus a margin of safety (MOS). The implicit MOS is discussed below in **Section 9.2.5**. Since no point sources exist in any metals impaired water body, the TMDLs include only natural and human caused nonpoint sources and a MOS.

The strong relationship between metals and sediment loading in this part of the watershed (see **Figure 6-1**) implies that the principal metals loading sources are, to a large degree, the same as those responsible for sediment loading. The principal source categories for metals loading are:

- Naturally occurring sources of metals that are either particulate bound or dissolved
- Controllable human caused sources of metals that are either particulate bound or dissolved

In this section, natural background loading refers to concentrations that have no human influence. Naturally occurring loads include natural background loading in addition to some level of human caused loading under conditions where all reasonable land, soil, and water conservation practices (ARLSWCP) are in place.

There are no known historic or current mining properties in upper Nevada Creek or its tributaries that involve or have involved physical or chemical ore processing that could be discrete sources of dissolved metals causing impairment. As well, these properties are not known to be sources of reactive metal complexes that, when exposed to the atmosphere with excavation, could alter water chemistry enough to cause dissolution of metals from native soils, unconsolidated parent materials, or bedrock. The limited current dataset for metals concentrations precludes quantifying the contribution from each of the two broad sources mentioned above. Therefore, a gross allocation approach is used for the metals TMDL whereby the whole TMDL is allocated to the combination of naturally occurring sources and controllable human sources. This allocation approach is based on the following two critical assumptions:

1. That loads of naturally occurring particulate and dissolved metals concentrations do not exceed water quality standards.
2. That achievable control of human caused sediment loading will prevent standards exceedences due to particulate and dissolved metals fractions.

9.2.2 Lower Washington Creek

Samples from lower Washington Creek were collected during two high flow events, June 2003 and May 2005, and one low flow event in October of 2003. **Table 9-9** lists the analysis results for total recoverable iron, measured flows, current iron loads for each sampling event, and the corresponding iron TMDLs calculated according to Equation 1 above.

Table 9-9. Measured Iron Concentrations, Discharge, Corresponding TMDLs, and Percent Departures for Lower Washington Creek

Sample Date	Analysis Result (mg/L)	Flow (cfs)	Current Iron Load (lbs/day)	TMDL (lbs/day)	Percent Reduction Required Under Sampling Event Conditions
06/12/2003	0.97	3.11	16.30	16.80	None
10/01/2003	1.38	0.024	0.18	0.13	28
05/11/2005	2.45	17.10	226	92.2	59

Note that the TMDL for any specific day is equal to the stream discharge in cubic feet per second multiplied by the numeric standard and the appropriate unit conversion factor. Future TMDLs calculated from flow conditions will necessarily differ from those in **Table 9-9** due to flow variability. **Figure 9-7** illustrates the line graph of the TMDL relative to the three measured loads in lower Washington Creek.

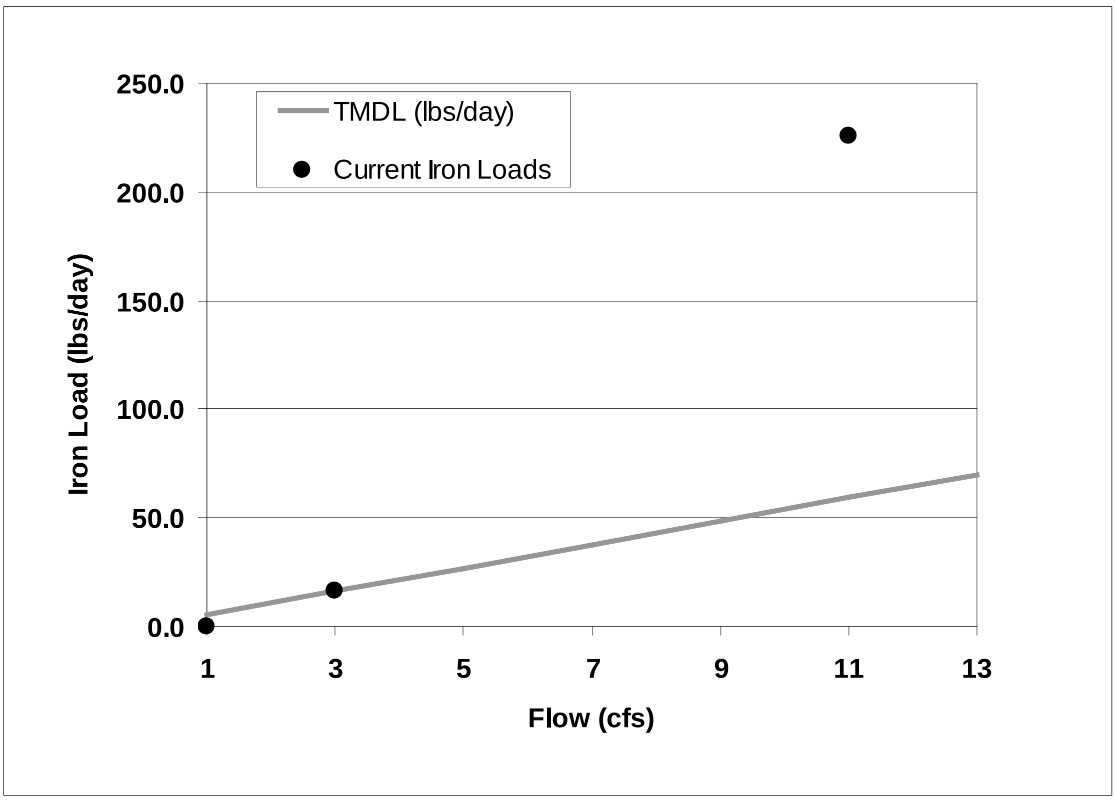


Figure 9-7. The Graph of the Lower Washington Creek Iron TMDL with Current Loads Calculated from Analysis Results for Three Samples

The load allocations in lower Washington Creek are assigned according to the source category approach described above in **Section 9.2.1**. The TMDL for iron in lower Washington Creek is allocated to the combined naturally occurring and human caused particulate bound iron and dissolved iron. This coarse allocation assignment assumes that naturally occurring loading does not cause the water quality standard to be exceeded and that the application of ARLSWCP toward control of human caused sediment loading will bring total recoverable iron levels to within the standard.

Based on the two widely varying results for high flow loading estimates in **Table 9-9**, flow has a marked influence on loading and a reduction of nearly 60% total recoverable iron could be required under the highest flows; a 28% reduction is a more characteristic reduction during base flow conditions. **Table 9-6** specifies that a sediment reduction of about 24% is needed in the combined upper and lower segments of Washington Creek, a reduction of 271 tons per year.

An analysis result of 0.15 mg/L dissolved iron from the May 2005 sampling event accounts for about 14 pounds of the total 226-pound load for that date. The assumption that iron loading is largely a function of sediment loading in Washington Creek suggests that a higher reduction in the total 1142 tons of sediment per year would be needed to reduce loading from particulate iron to levels below the 1.0 mg/L aquatic life standard. Effective control of sediment sources during high flow events could conceivably exceed the 24% reduction (**Table 9-6**). Sediment reductions by the same effective controls may be less than 24% during annual low flow periods. The strength of the sediment-metals loading relationship suggests that adequate control of high flow sediment production will largely control metals loading on an annual basis. The sparse metals data record and the uncertainty in the portion and seasonality of dissolved iron loading suggests that low flow reductions are probably comparable to the 24% sediment reduction and high flow reductions may be more that double this amount. With a better understanding of the effects of sediment loading on instream iron concentrations, adaptive management options could be identified to adjust reductions so that standards for both pollutants are met under most flow conditions.

9.2.3 Lower Jefferson Creek

As in lower Washington Creek, metals monitoring in lower Jefferson Creek occurred during two high flow events in June 2003 and May 2005 and one low flow event during October 2003. **Table 9-10** contains the metals analysis results for iron and aluminum, discharge measurements, the current loads for each sampling event and the corresponding TMDLs calculated according to Equation 1.

Table 9-10. Measured Iron and Aluminum Concentrations, Flows, Current Flow-Based Loads, Corresponding TMDLs, and Percent Departures for Lower Jefferson Creek

Sample Date	Metal	Analysis Result (mg/L)	Flow (cfs)	Current Load (lbs/day)	TMDL (lbs/day)	Percent Reduction Required Under Sampling Event Conditions
6/12/2003	Fe	0.22	2.05	2.43	11.06	None
10/01/2003	Fe	0.51	0.67	1.84	3.61	None
05/11/2005	Fe	2.06	4.15	46.11	22.39	51
6/12/2003	Al	0.27	2.05	3.0	0.96	68
10/01/2003	Al	<0.01	0.67	<0.04	0.31	None
5/11/2005	Al	<0.05	4.15	<1.1	1.95	None

Figure 9-8 illustrates the measured loads for both aluminum and iron in lower Jefferson Creek with their respective TMDL line graphs. Again, the TMDLs in the table are equal to the product

of corresponding flows measured during each specific sampling event multiplied by the chronic aquatic life standards and a unit conversion factor. The standards are 1.0 mg/L for iron and 0.087 mg/L for aluminum. In each case, one exceedence out of three results prompted the impairment listing. The percent reduction column indicates that for both iron and aluminum large reductions are needed during high flows to meet the TMDL.

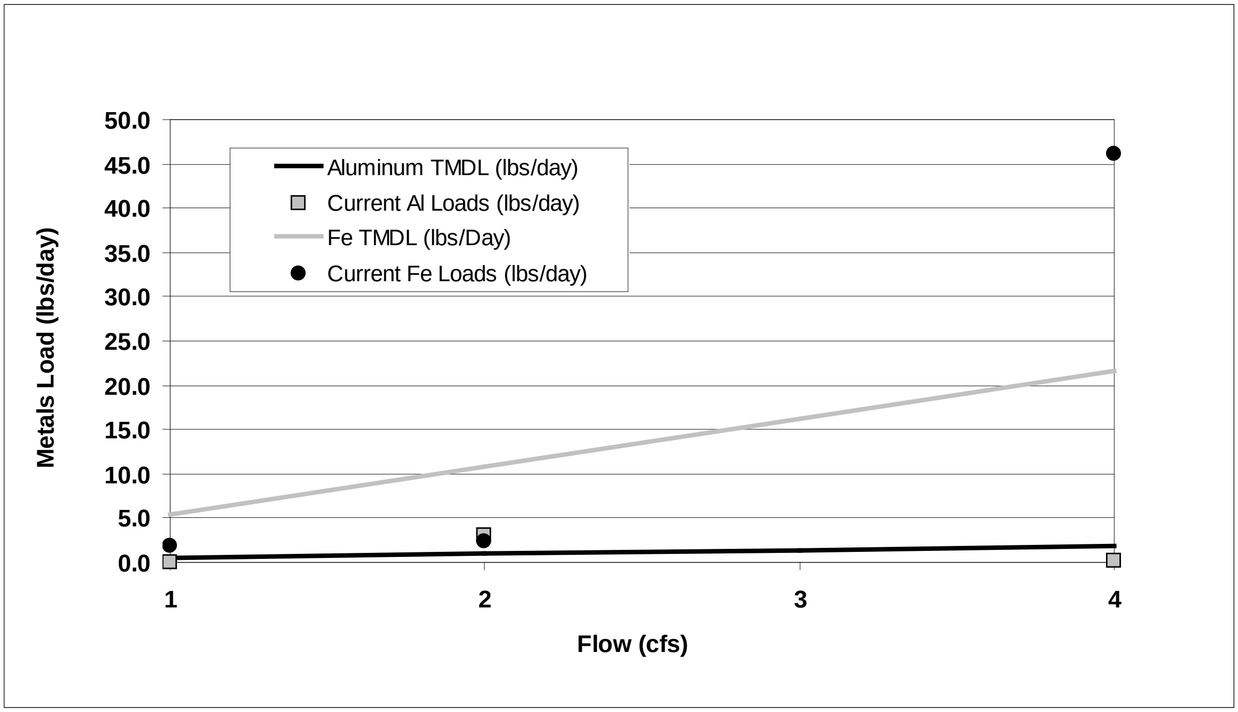


Figure 9-8. The Graphs of the Lower Jefferson Creek Iron and Aluminum TMDLs with the Respective Current Loads Calculated from Analysis Results for Three Samples

As in lower Washington Creek, the allocations for iron in lower Jefferson Creek are equal to the combined naturally occurring and human caused particulate bound iron and dissolved iron associated with both naturally occurring and controllable sources. The allocations for dissolved aluminum are equal to the composite of naturally occurring and controllable human sources. This allocation approach is appropriate due to the evidence linking metals loading to high flow sediment loads.

An analysis for dissolved iron in the sample collected in May 2005 returned a result of 0.03 mg/L, indicating that about 99% of the total recoverable iron load for that sampling event was from particulate sources. The lack of metals loading point sources in the drainage and the lack of quantitative data for specific particulate metals loading sources prompts the use of a composite allocation to source categories. Again, the composite metals allocation is equal to the sum of:

1. Naturally occurring sources of particulate bound and dissolved metals.
2. Controllable Human caused sources of particulate bound and dissolved metals.

The two high flow iron and aluminum results that exceed standards in **Table 9-9** require reductions of 51% and 68% respectively for iron and aluminum. The combined sediment reductions in both upper and lower Jefferson Creek from **Table 9-6** specify a 34% reduction from 883 tons to 585 tons per year, less than that prescribed for iron and aluminum during high flow in **Table 9-9**. In the context of adaptive management and considering the high variability in lower Jefferson Creek metals loading, the restoration strategy seeks to achieve the prescribed sediment reductions in both the upper and lower drainage while monitoring seasonal particulate bound and dissolved metals loading in lower Jefferson Creek. Should monitoring indicate continuing iron and aluminum exceedences in lower Jefferson Creek after sediment goals are achieved, consideration should be given to additional drainage wide sediment controls or additional metals source assessment and control.

9.2.4 Upper Nevada Creek

Upper Nevada Creek was listed as impaired due to cadmium, lead, and mercury in 2006. When compilation of the metals data record was complete it contained no cadmium records, for either dissolved or total recoverable concentrations that exceeded method detection limits. Despite the 2006 cadmium listing, no upper Nevada Creek TMDL for cadmium is developed in this document, and more data is recommended to resolve the cadmium listing. As explained in **Section 6.2**, mercury analysis from May 2005 confirmed that water column concentrations were less than the applicable standard. Therefore, no mercury TMDL is presented here. The metal parameters for which standards exceedances have occurred include iron, copper, and lead. **Table 9-11** contains the upper Nevada Creek data record for these metals. Results in excess of the standard are in bold type in the table. Hardness values are given for copper and lead that are hardness dependent. Note that all exceedences occurred in samples collected during a single high flow event on May 11, 2005.

Table 9-11. Water Quality Analysis Record for Iron, Copper, and Lead in Upper Nevada Creek with Current Loads, TMDLs for Each Sampling Event, and Required Percent Reductions

Sample Site	Metal	Sample Date	Result (mg/L)	Hardness	Flow (cfs)	Load (lbs/Day)	TMDL (lbs/day)	Percent Reduction
NCSW-1	Fe	06/12/2003	0.24		30.6	39.61	165	None
NCSW-1		10/01/2003	0.34		4.75	8.71	26	None
NCSW-1		05/11/2005	**2.62**		103	1455.62	556	62
NCSW-1		08/25/2005	0.29		3.61	5.65	19	None
NCSW-2	Fe	08/25/2005	0.29		8.21	12.84	44	None
12335500	Fe	05/14/2003	0.27		81	75.73	437	None
12335500		05/11/2005	**7.27**		142	5568.44	766	86
12335500		06/06/2003	0.37		81	162	437	None
12335500		08/25/2005	0.27		7.8	11.36	42	None
NCSW-1	Cu	06/12/2003	<0.001	84	30.6	0.08	1.3	None
NCSW-1		10/01/2003	<0.001	120	4.75	0.01	0.28	None
NCSW-1		08/25/2005	<0.001	131	3.61	0.01	0.23	None
NCSW-2	Cu	08/25/2005	0.004	131	8.21	0.18	0.53	None
12335500	Cu	05/11/2005	**0.010**	84	142	7.66	6.13	20
12335500		08/25/2005	<0.001	129	7.8	0.02	0.49	None
NCSW-1	Pb	06/12/2003	<0.001	84	30.6	0.08	0.41	None
NCSW-1		10/01/2003	<0.001	120	4.75	0.01	0.10	None
NCSW-1		08/25/2005	<0.001	131	3.61	0.01	0.09	None
NCSW-2	Pb	08/25/2005	<0.001	131	8.21	0.02	0.20	None
12335500	Pb	05/11/2005	**0.006**	84	124	4.01	0.17	58
12335500		08/25/2005	0.0007	129	7.8	0.03	0.19	None

The TMDL for any sampling event is equal to the stream discharge in cubic feet per second multiplied by the numeric standard and the appropriate unit conversion factor. For future monitoring, TMDLs will differ from the examples in **Table 9-11** because of varying flow and hardness. **Figure 9-9** gives the linear graph of the iron TMDL for characteristic upper Nevada Creek flows at USGS station 12335500 with iron loading data points for the three monitoring sites.

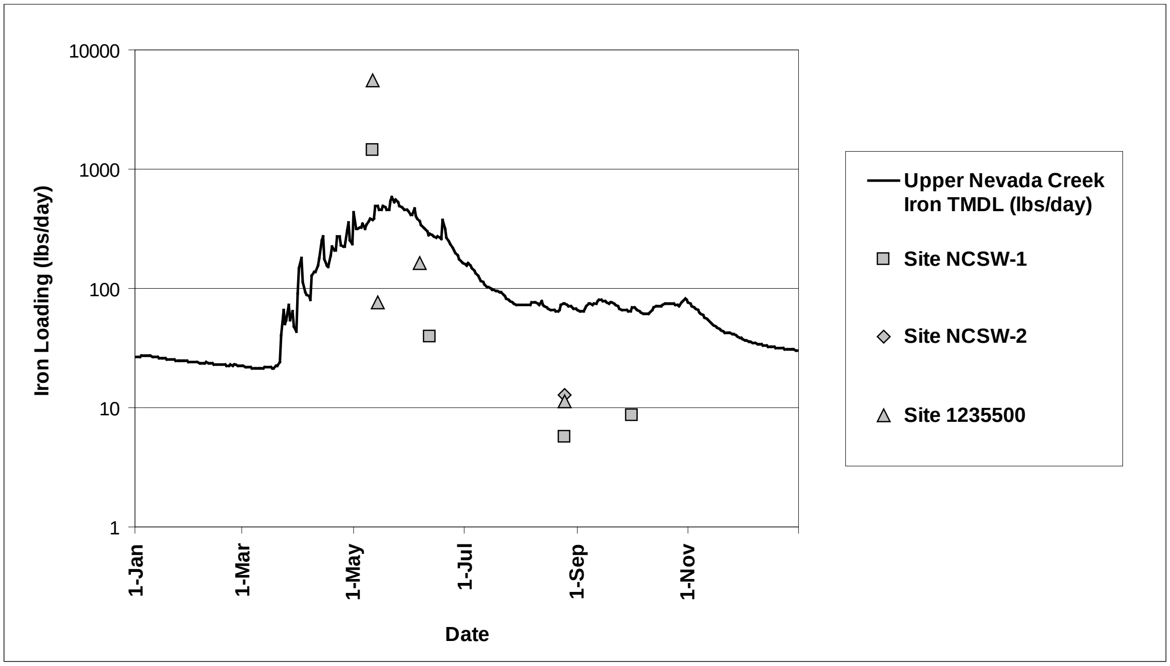


Figure 9-9. Graph of the Annual TMDL for Iron for Upper Nevada Creek at USGS Station 12335500 Compared To Sample Based Iron Loading Values from Three Monitoring Points

As with the iron allocations for Washington and Jefferson creeks, those for upper Nevada Creek are assigned to the composite of the two source categories described above in **Section 9.2.1**. There are no metals point sources in upper Nevada Creek. Therefore the allowable load or TMDL for iron in upper Nevada Creek is allocated to the following composite sources:

- Natural background sources of metals that are either particulate bound or dissolved.
- Human caused sources of metals that are either particulate bound or dissolved.

Due to a lack of detailed iron loading budget, a more detailed accounting of iron allocation among sources is substituted by categorical allocations to known sources. It is assumed that natural background sources will not cause the standard to be exceeded. The composite metals allocation also assumes that the application of ARLSWCP to sediment sources will adequately protect water quality for metals. Should source control and monitoring disprove these assumptions, adjustments to further reduce metals sources will be pursued through the process of adaptive management.

As in the tributaries, there is strong linkage between iron standard exceedences and total suspended solids concentrations in Nevada Creek. This relationship is illustrated in **Figure 9-11.**

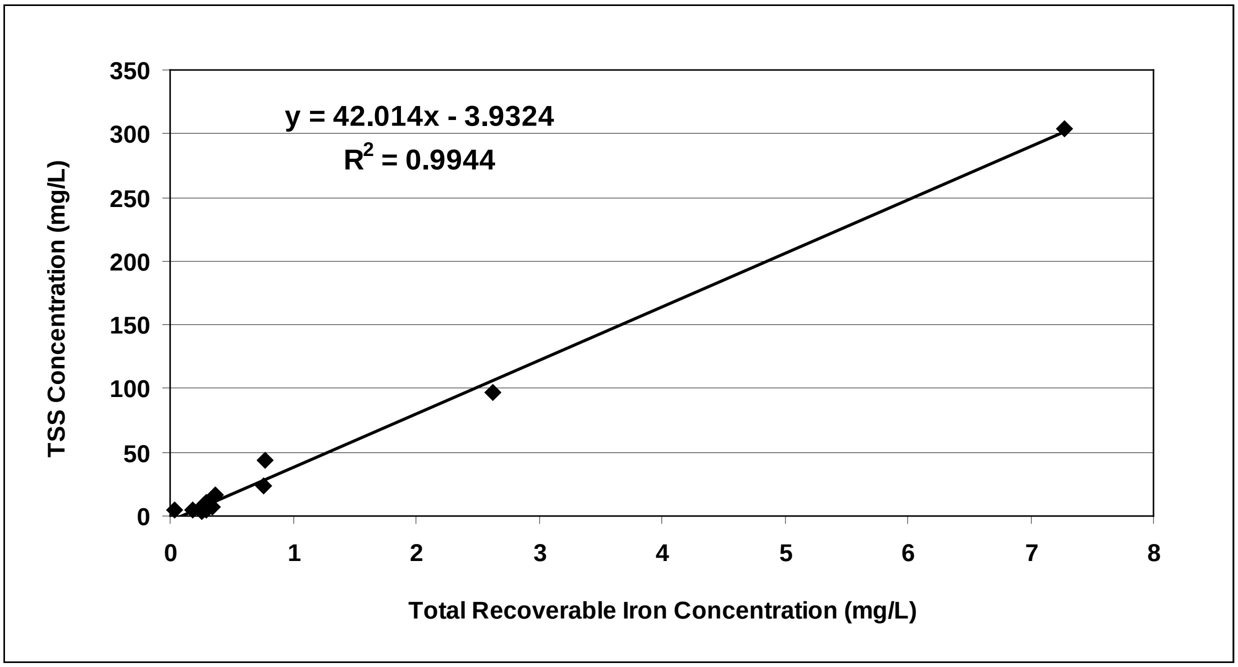


Figure 9-10. Graph of the Relationship between Total Recoverable Iron Concentration and TSS for Analysis Results from Upper Nevada Creek

The sediment TMDL for upper Nevada Creek calls for an annual reduction of 909 tons (26%). A median reduction of about 74% is required to bring the two iron loads that exceed standards to a level below the TMDL. Considering that the two iron standard exceedences in upper Nevada Creek occurred during a single high flow event (05/11/2005), the adequacy of the prescribed 26% sediment reduction and its effects on iron loading should be assessed rather than establishing an initial requirement for a much larger reduction based on data from a single event.

Similar to that for iron, the TMDLs for copper and lead in upper Nevada Creek are equal to the daily flow times the applicable standard and a unit conversion factor. The standards for copper and lead vary with water hardness according to the relationships in Equation 2. **Table 9-11** contains examples of the high and low flow TMDLs for copper and lead at three monitoring sites in upper Nevada Creek. The high flow TMDLs are represented by those calculated for the May and June sampling dates; the low flow TMDLs are represented by those for the August and October dates. These TMDLs were calculated according to Equation 1 after the applicable standards were calculated from the hardness values. Because hardness typically changes with flow during the course of the year, the TMDL cannot be expressed by a line graph.

The allocations for copper and lead in upper Nevada Creek follow the approach described above for iron. The single standards exceedence for each metal was coincident with sediment loading during high flow on May 11, 2005, at USGS gaging station 12335500. Suspended sediment, with its attached metals load, is assumed to be the principal source. Due to the lack of data on dissolved concentrations for these metals some loading from dissolved concentrations cannot be ruled out. Therefore, the allocations for copper and lead in upper Nevada Creek are equal to:

- Naturally occurring sources of sediment bound and dissolved copper and lead.

- Controllable human caused sources of sediment bound and dissolved concentrations of copper and lead.

A composite allocation to these source categories is appropriate since the precise contribution form each source in the composite is not provided by the limited dataset. There are no known point sources of copper or lead in upper Nevada Creek and, therefore, no copper or lead wasteload allocations. It is assumed that control of sources of suspended solids through application of ARLSWPC would be sufficient to prevent standards exceedences, and that dissolved concentrations of copper and lead would not lead to standards exceedences.

9.2.5 Seasonality and Margin of Safety for Metals TMDLs

TMDLs and allocations are required to address seasonal variability in loading conditions and provide for a margin of safety to account for the inherent uncertainty in loading estimates. Seasonality is considered through metals loading assessments that were conducted during high flow and low flow periods. In the case of upper Nevada Creek, the presence of a USGS stream gaging station allows a fairly accurate calculation of daily loads for iron and aluminum that are not hardness dependent. Regardless of the hardness influence on the standard, the use of instantaneous flows in the TMDL equation allows for year round application of TMDLs and allocations. Seasonality is considered in the metals TMDLs in that typical examples were provided for both low flow and high flow conditions. Monitoring recommendations are for seasonal sampling to determine the validity of the assumptions regarding compliance with standards from naturally occurring concentrations of sediment bound and dissolved sources of metals.

A margin of safety is implicit in the use of the chronic aquatic life standard as a basis for the maximum daily loads in that maximum allowable loads are defined at the point where chronic damage to aquatic life would start to occur. Compliance with the TMDL based on the chronic metals standards should prevent the possibility of acute aquatic life damage.

Compliance with the metals TMDLs and allocations will require monitoring of water quality trends on metals impaired streams. The interpretation of monitoring results is the first feedback loop toward adjusting pollutant source control strategies with the goal of preventing standards exceedences. Once approved, the water quality restoration plan becomes a cyclic process of adapting to natural and human land management impacts on water quality by finding and implementing strategies that protect all beneficial uses. The good faith engagement in this adaptive process by significant stakeholders provides a margin of safety against continuing or worsening damage to water quality.

Should future assessment of the sources of metals loading determine that concentration targets are not being met, restoration activities will be reviewed to determine whether they constitute all reasonable land, soil, and water conservation practices (ARLSWCP) for the control of particulate and dissolved sources. Should sustained application ARLSWCP fail to achieve restoration targets, the targets and TMDLs may need to be adjusted to reflect loading and water quality conditions under a land and water management regime that reflects the application of ARLSWCP. Under circumstances where water quality targets and TMDLs are not met and

ARLSWCP are not being implemented, the water body would remain impaired pending the restoration effort needed to meet water quality standards.

9.3 Nutrient TMDLs, Allocations, and Margin of Safety

As described in **Section 7.0**, there are 16 stream segments and one lake in the Middle Blackfoot-Nevada Creek TPA listed as impaired on the 2006 303(d) List due to nutrient related parameters. These include the following:

Nevada Creek TPA	**Middle Blackfoot TPA**
Upper Nevada Creek	Blackfoot River (Nevada Creek to Monture Creek)
Lower Nevada Creek	Blackfoot River (Monture Creek to Belmont Creek)
Lower Jefferson Creek	Frazier Creek
Gallagher Creek	Wales Creek
Braziel Creek	West Fork Clearwater River
Upper Douglas Creek	Yourname Creek
Lower Douglas Creek	
Murray Creek	
Blackbear Creek	
McElwain Creek	
Nevada Creek Reservoir	

Application of the Interim Targets in the TMDLs

As described in **Section 7.1**, the interim TP and TN targets are summer values intended to address nutrient related "conditions which produce undesirable aquatic life." These conditions typically occur during the summer growing season. Since data are limited, it's not possible at this time to develop a thorough understanding of the seasonality of nutrient loading or the relationship between stream discharge and nutrient concentrations/loading. Nevertheless, existing source inventory information (**Section 7.3**) coupled with growing season algae data suggest the nutrient loading during low flow conditions are of greatest concern. To simplify the TMDLs, the interim "summer" TP and TN targets presented in **Section 7.1** are applied as annual values in the TMDLs.

This is a conservative approach. From a practical standpoint, however, since all of the identified nutrient sources are nonpoint sources, the majority of best management practices that could be employed to reduce nutrient loading will result in load reductions any time of the year nonpoint source loading occurs. Thus, seasonally varying TMDLs are not practical in nonpoint source dominated watersheds.

The adaptive management strategy presented in Section 9.3.5 will be employed to modify this approach in the future if additional monitoring or modeling results suggest that it is not appropriate or if a new point source discharge is proposed where it may be possible to control loading on a seasonal basis.

Framework TMDLs intended to provide a starting point for the initiation of future restoration activities for total phosphorus (TP) and total nitrogen (TN) are presented in the following sections. An adaptive management strategy to refine these TMDLs in the future based on additional data and analysis is presented in **Section 9.3.5**.

9.3.1 Total Phosphorus

TMDLs for Nevada Creek and the Blackfoot River are based on available USGS or DNRC stream discharge data and the interim targets described in **Section 7.1**. The interim total phosphorus target for upper Nevada Creek and all tributary streams in both the Nevada Creek and middle Blackfoot River planning areas is 0.01 mg/L. The interim target for lower Nevada Creek and the Blackfoot River is 0.02 mg/L. Although these interim targets are "summer" values, given the limited available data, they are applied as annual values to simplify development of the framework TMDLs (**Section 9.3**). The interim targets and TMDLs can be revised in the future, if necessary, following the adaptive management strategy (**Section 9.3.5**).

9.3.1.1 Upper Nevada, Jefferson, and Gallagher Creeks

The TMDL for Nevada Creek upstream of Nevada Creek Reservoir is shown graphically in **Figure 9-11**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 0.54, 0.81, and 1.67 pounds per day, respectively. Based on the available observed data, the necessary load reductions range from 35% to 96% with an average reduction of 75% (**Table 9-12)**. As shown in **Figure 9-11,** reductions are required at all flow ranges. Data for the two 303(d) Listed tributaries in the upper Nevada Creek watershed are limited to a single sample, which is considered insufficient for characterizing the needed load reductions. Based on these single samples, the total phosphorus TMDLs for lower Jefferson Creek and Gallagher Creek would be 0.11 and 0.02 pounds per day, respectively. Given the uncertainty associated with the limited data, the watershed scale load reductions presented in Table 9-1 are proposed as a framework starting point for these tributaries. The TMDLs for these tributaries will be modified in the future following the adaptive management strategy presented in **Section 9.3.5**.

Table 9-12. Example Total Phosphorus TMDLs for Three Flow Groups, Nevada Creek Upstream of Nevada Creek Reservoir

USGS Station 12335500					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	2	0.11 – 0.54	0.44 – 2.67	35% – 81%
25-75	Average Flows	6	0.54 – 1.67	2.77 – 5.43	56% – 82%
75-100	High Flows	4	1.67 – 66.84	15.39 – 236.08	80% – 96%

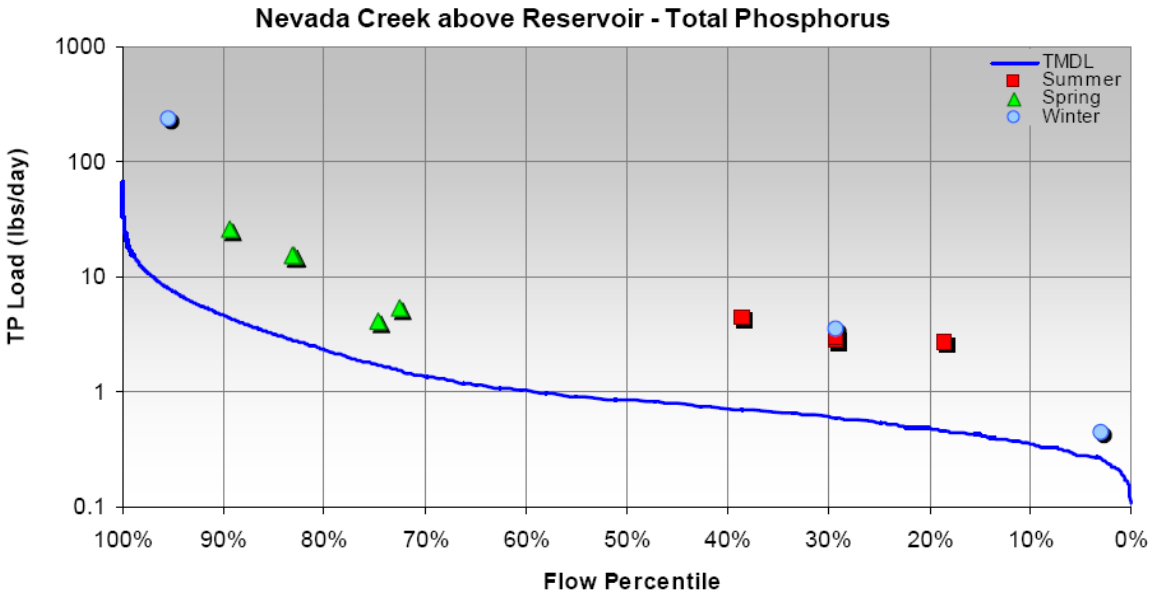


Figure 9-11. Comparison of the Allowable to the Observed Total Phosphorus Load for Nevada Creek Upstream of Nevada Creek Reservoir
USGS Station 12335500

9.3.1.2 Nevada Creek Reservoir

Insufficient data are available to characterize the potential nutrient related problems in Nevada Creek Reservoir and/or to define the water quality potential of the reservoir (i.e., given the characteristics of the watershed, the morphology of the reservoir, and dam operations, what is the potential of the reservoir relative to trophic status?) As described in the adaptive management strategy (**Section 9.3.5**), additional monitoring and modeling will be conducted to better define the water quality potential of the reservoir. In the interim, a total phosphorus TMDL for the Nevada Creek Reservoir has been developed based on the available discharge and water quality data immediately downstream of the Reservoir in Nevada Creek (USGS Station 12336600). The interim TP target of 0.02 mg/L for Lower Nevada Creek will be applied.

The TMDL for Nevada Creek downstream of Nevada Creek Reservoir is shown graphically in **Figure 9-12**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 2.26, 5.93, and 9.70 pounds per day, respectively. Based on the available observed data, the necessary load reductions range from 58% to 91% with an average reduction of 79% (**Table 9-13).** As shown in **Figure 9-12**, reductions are required at all flow ranges. For the purposes of this TMDL, it is assumed that the dissolved oxygen impairment described in **Section 7.4.3.1** is linked to excessive nutrient loading and will be addressed by reducing TP loading. Further, the TP load reductions will be necessary at this point in the Nevada Creek watershed to address the nutrient problem in Lower Nevada Creek.

Table 9-13. Example Total Phosphorus TMDLs for Three Flow Groups, Nevada Creek Downstream of Nevada Creek Reservoir

USGS Station 12336600					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	5	0.03 – 2.26	1.13 – 4.10	58%– 83%
25-75	Average Flows	6	2.26 – 9.70	17.35 – 89.26	77%– 91%
75-100	High Flows	1	9.70 – 175.71	72.57	70%

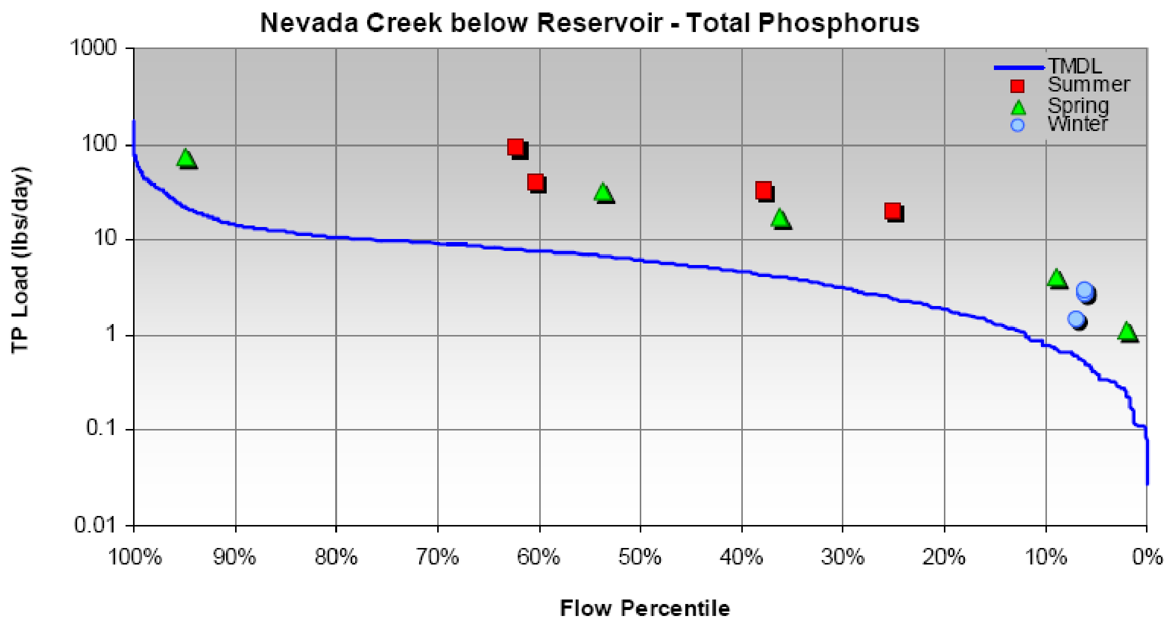


Figure 9-12. Comparison of the Allowable to the Observed Total Phosphorus Load for Nevada Creek Downstream of Nevada Creek Reservoir
USGS Station 12336600

9.3.1.3 Lower Nevada, Upper and Lower Douglas, Murray, McElwain, Braziel, and Black Bear Creeks

The TMDL for Lower Nevada Creek is shown graphically in **Figure 9-13**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 2.37, 2.80, and 4.42 pounds per day, respectively. Based on the available observed data, the necessary load reductions range from 76% to 98% with an average reduction of 77% **(Table 9-14).** As shown in **Figure 9-13**, reductions are required at all flow ranges.

Data for the four 303(d) Listed tributaries in the Lower Nevada Creek watershed are limited to a single sample, which is considered insufficient for characterizing the needed load reductions. Based on these single samples, the respective total phosphorus TMDLs for upper and lower Douglas, Murray, McElwain, Braziel, and Black Bear creeks would be 0.49, 0.04, 0.22, 0.03, 0.07, 0.03 pounds per day, respectively. Given the uncertainty associated with the limited data, the watershed scale load reductions presented in **Table 9-14** is proposed as a framework starting point for these tributaries. The TMDLs for these tributaries will be modified in the future following the adaptive management strategy presented in Section 9.3.5.

Table 9-14. Example Total Phosphorus TMDLs for Three Flow Groups, Nevada Creek at the Mouth

USGS Station 12337800					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	2	0.65 – 2.37	11.64 – 13.83	85% – 86%
25-75	Average Flows	11	2.37 – 4.42	12.66 – 40.15	76% – 90%
75-100	High Flows	9	4.42 – 53.90	66.57 – 1,631.23	84% – 98%

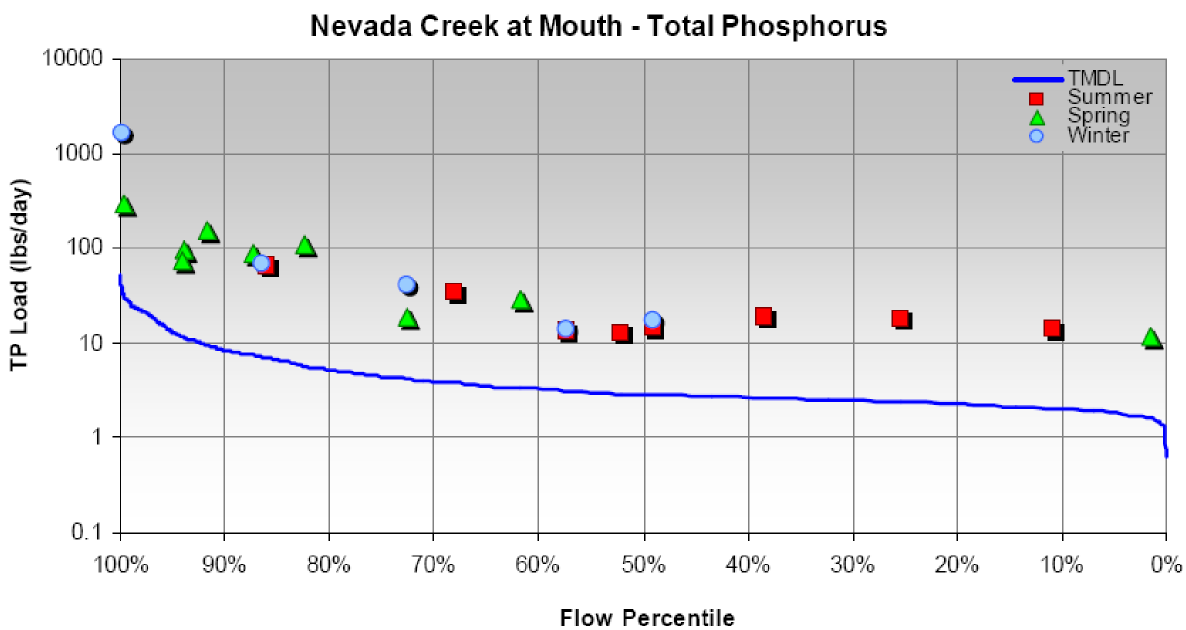


Figure 9-13. Comparison of the Allowable to the Observed Total Phosphorus Load for Nevada Creek at the Mouth

9.3.1.4 Blackfoot River, Frazier Creek, Wales Creek, West Fork Clearwater River, and Yourname Creek

There are two segments of the Blackfoot River main stem in the Middle Blackfoot Planning Area. One segment (MT76F001_31) begins at the confluence with Nevada Creek and ends at Monture Creek. The other (MT76F001_32) begins at the confluence of Monture Creek and ends at Belmont Creek. The downstream point of the Blackfoot River within the Middle Blackfoot – Nevada Creek TPA is at the confluence with the Clearwater River. The available discharge and water quality data at USGS Station 12335100 (upstream of Nevada Creek near Helmville) and station 12340000 (Blackfoot River at Bonner) are used for the purposes of this framework TMDL.

The total phosphorus TMDL for the Blackfoot River at Helmville is shown graphically in **Figure 9-14.** The respective TMDLs at the 25th, 50th, and 75th flow percentiles are 15.20, 17.57, and

31.37 pounds per day. Based on the available total phosphorus data, the necessary load reductions range from 0% to 80% with an average reduction of 17% (**Table 9-15**).

Figure 9-14 suggests that load reductions are only necessary at higher flows, but, as noted above, this data is from a segment of the Blackfoot River above the impaired portion of Nevada Creek. The pooled total phosphorus data for the Blackfoot River main stem shown in **Figure 7-1** includes values for samples collected at Scotty Brown Bridge and Raymond Bridge, both located within the impaired upper main stem reach below Nevada Creek. Given that low flow chlorophyll-*a* levels within this reach are elevated above growing season targets (**Table 7-5**), it would be misleading to conclude that no phosphorous load reductions are necessary in the impaired upper main stem segment of the Blackfoot River during the low flow growing season as implied by **Figure 9-14**. During lower flow conditions, phosphorous uptake by algae is a likely factor contributing to phosphorous concentrations being below target levels.

The total phosphorus TMDL for the Blackfoot River at Bonner is shown graphically in **Figure 9-15**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 58.97, 79.13, 171.40 pounds per day, respectively. Based on the available data, the necessary load reductions range from 0% to 88% with an average reduction of 26% (**Table 9-16**).

Data for the four 303(d) Listed tributaries in the Middle Blackfoot River watershed are limited to one or two samples, which are considered insufficient for characterizing the needed load reductions. **Figure 7-3** shows that phosphorous concentrations in Frazier and Yourname creeks are similar to those for Nevada Creek tributaries. The measured Wales Creek phosphorus concentration of 0.76 mg/L is also comparable to those for the Nevada Creek tributaries. Due to this degree of similarity and because the data is limited, the load reductions presented in **Table 9.3** that are applied to Lower Nevada Creek and the Lower Nevada Creek tributaries are also applied as the TMDL load reductions for Yourname, Wales and Frazier creeks. Based on the results from single samples, the respective low flow total phosphorus TMDLs for Yourname, Wales and Frazier creeks would be 0.22, 0.08, 0.08 pounds per day.

The West Fork Clearwater River phosphorous concentrations measured at two assessment sites were less than the method detection limit of 0.001 mg/L (**Figure 7.3**). However, due to the uncertainty with small datasets, the 21% load reduction applied to the Blackfoot River as described above is applied as the phosphorous TMDL for the West Fork Clearwater River. Based on the results from limited sample results, the total phosphorus TMDL West Fork Clearwater River would be 0.01 pounds per day.

Table 9-15. Example Total Phosphorus TMDLs for Three Flow Groups, Blackfoot River Upstream of Nevada Creek

USGS Station 12335100					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	0	6.47 – 15.20	NA	NA
25-75	Average Flows	11	15.20 – 31.37	5.37 – 37.01	0% – 35%
75-100	High Flows	9	31.37 – 196.20	9.67 – 790.39	0% – 80%

Table 9-16. Example Total Phosphorus TMDLs for Three Flow Groups, Blackfoot River at Bonner

USGS Station 12340000					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	7	19.40 – 58.97	11.15 – 23.28	0%
25-75	Average Flows	9	58.97 – 171.40	9.33 – 135.40	0%
75-100	High Flows	33	171.40 – 1,940.40	129.36 – 8,092.17	0% – 88%

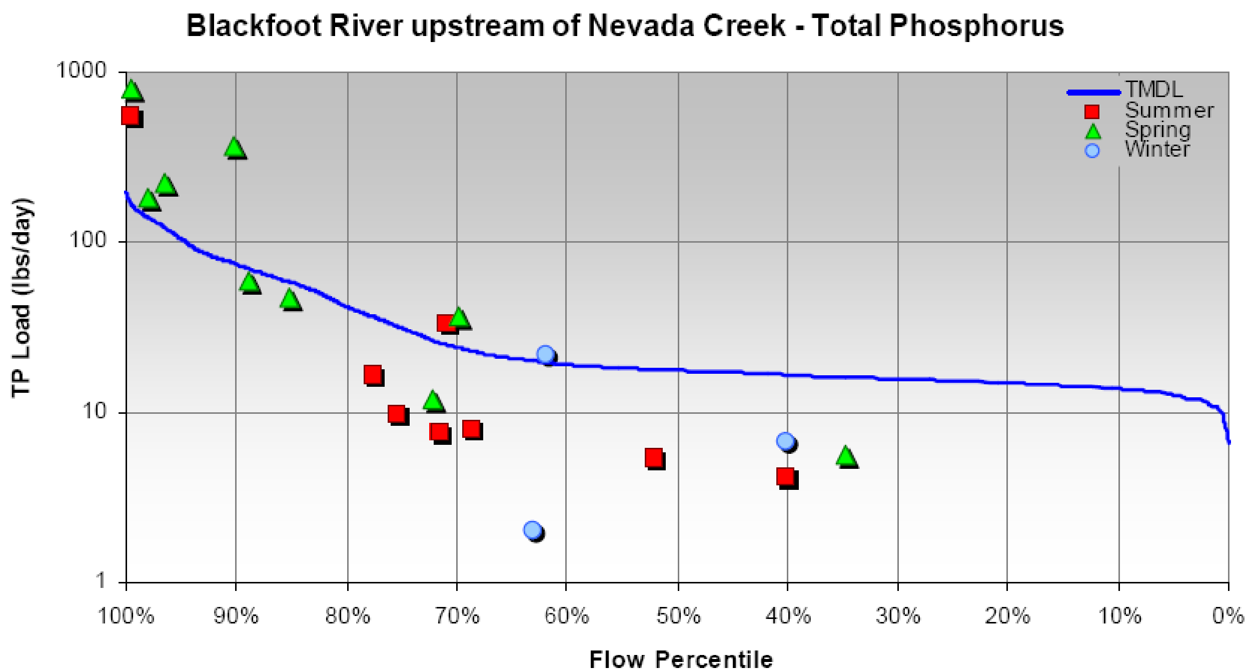


Figure 9-14. Comparison of the Allowable to the Observed Total Phosphorus Load for Blackfoot River Upstream of Nevada Creek (USGS Station 12335100).

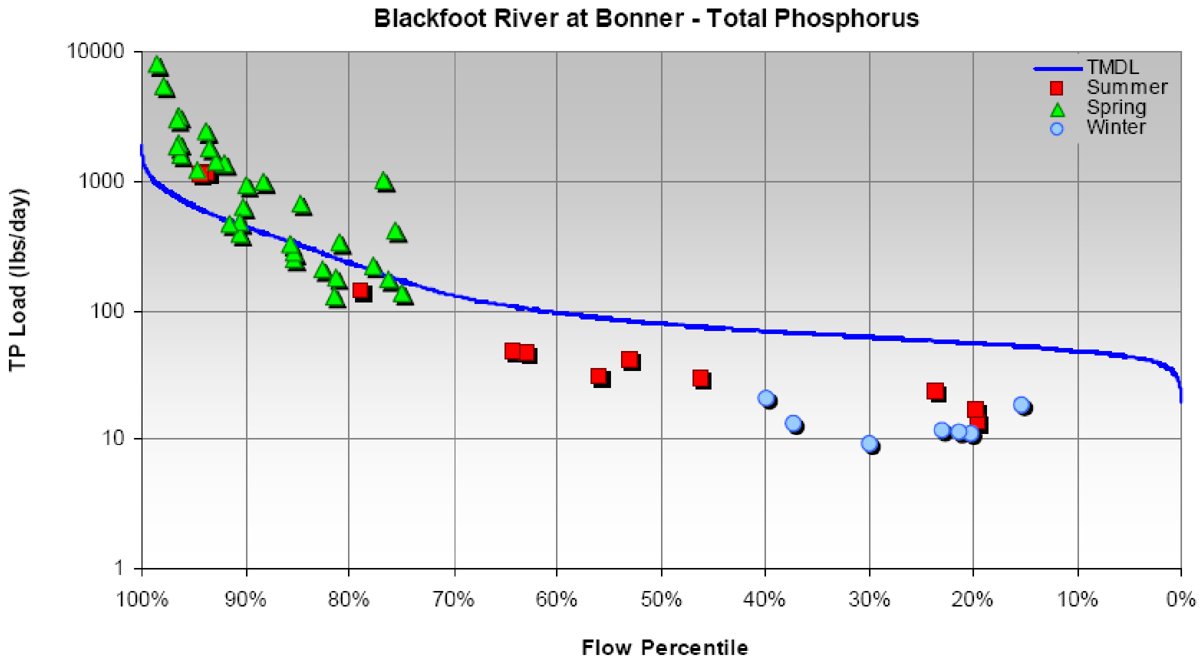


Figure 9-15. Comparison of the Allowable to the Observed Total Phosphorus Load for Blackfoot River at Bonner, MT (USGS Station 12340000).

9.3.2 Total Nitrogen

TMDLs for Nevada Creek and the Blackfoot River are based on available USGS and/or DNRC stream discharge data and the interim targets described in **Section 7.1**. The interim TN target for Upper Nevada Creek and all of the tributaries is 0.33 mg/L. This target is also applicable to the Blackfoot River tributaries. The interim target for Lower Nevada Creek and the Blackfoot River is 0.30 mg/L. Although these interim targets are "summer" values, given the limited available data, they are applied as annual values to simplify development of the framework TMDLs (see the Text Box in **Section 9.3**). The interim targets and TMDLs can be revised in the future, if necessary, following the adaptive management strategy (**Section 9.3.5**).

9.3.2.1 Upper Nevada, Jefferson, and Gallagher Creeks

The total nitrogen TMDL for Nevada Creek upstream of Nevada Creek Reservoir is shown graphically in **Figure 9-16**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 17.79, 28.46, and 56.92 pounds per day, respectively. Based on the available data, the necessary load reductions range from 0% to 76% with an average reduction of 10% (**Table 9-17)**. As shown in **Figure 9-16**, reductions are required at all flow ranges.

Data for the two 303(d) Listed tributaries in the Upper Nevada Creek watershed are limited to a single sample each, which is considered insufficient for characterizing the load reductions. Based on these single low flow samples, the total nitrogen TMDLs for Lower Jefferson Creek and Gallagher Creek would be 1.08 and 0.71 pounds per day, respectively. Given the uncertainty associated with the limited data, the watershed scale load reductions presented in **Table 9-17** is proposed as a framework starting point for these tributaries. The TMDLs for these tributaries will be modified in the future following the adaptive management strategy presented in Section 9.3.5.

Table 9-17. Example Total Nitrogen TMDLs for Three Flow Groups, Nevada Creek Upstream of Nevada Creek Reservoir

USGS Station 12335500					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	2	3.56 – 17.79	6.74 – 9.92	0%
25-75	Average Flows	6	17.79 – 56.92	11.86 – 33.42	0% – 8%
75-100	High Flows	4	56.92 – 2,205.59	104.46 – 1,093.85	8% – 76%

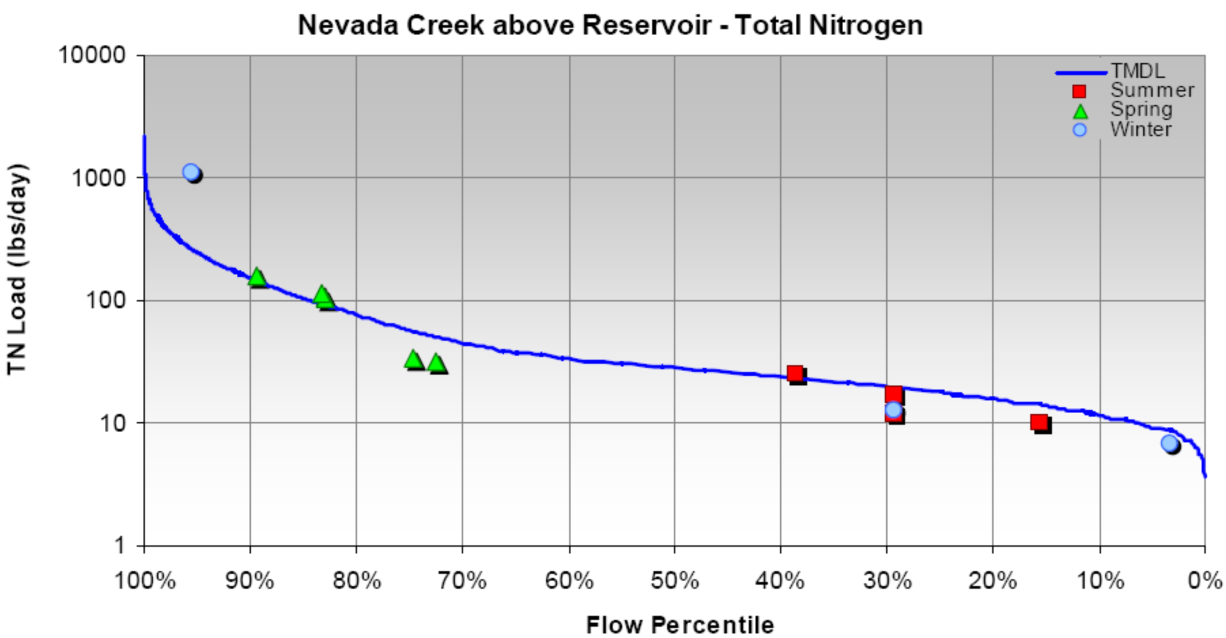


Figure 9-16. Comparison of the Allowable to the Observed Total Nitrogen Load for Nevada Creek Upstream of Nevada Creek Reservoir

9.3.2.2 Nevada Creek Reservoir

Insufficient data are available to characterize the potential nutrient related problems in Nevada Creek Reservoir and/or to define the water quality potential of the reservoir (i.e., given the characteristics of the watershed, the morphology of the reservoir, and dam operations, what is the potential of the reservoir relative to trophic status?). As described in the adaptive management strategy **(Section 9.3.5)**, additional monitoring and modeling will be conducted to better define the water quality potential of the reservoir. In the interim, a total nitrogen TMDL for the Nevada Creek Reservoir has been developed based on the available discharge and water quality data immediately downstream of the Reservoir in Nevada Creek (USGS Station 12336600). The interim TN target of 0.30 mg/L for Lower Nevada Creek will be applied.

The total nitrogen TMDL for Nevada Creek downstream of Nevada Creek Reservoir is shown graphically in **Figure 9-17**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 35.57, 90.55, and 147.15 pounds per day, respectively. Based on the available data, the necessary load reductions range from 0% to 72% with an average reduction of 43% (**Table 9-18).** As shown in **Figure 9-17**, reductions are required at all flow ranges. For the purposes of this TMDL, it is assumed that the dissolved oxygen impairment described in **Section 7.4.3.1** is linked to excessive nutrient loading and will be addressed by reducing TN loading. Further, the TN load reductions will be necessary at this point in the Nevada Creek watershed to address the nutrient problem in Lower Nevada Creek.

Table 9-18. Example Total Nitrogen TMDLs for Three Flow Groups, Nevada Creek Downstream of Nevada Creek Reservoir

USGS Station 12336600					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	5	0.40 – 35.57	4.96 – 24.17	19% – 57%
25-75	Average Flows	6	35.57 – 147.15	90.12 – 279.42	0% – 72%
75-100	High Flows	1	147.15 – 2,635.71	549.78	40%

Flows were obtained at DNRC gage 76F-2000 – Nevada Creek below Nevada Creek Reservoir.

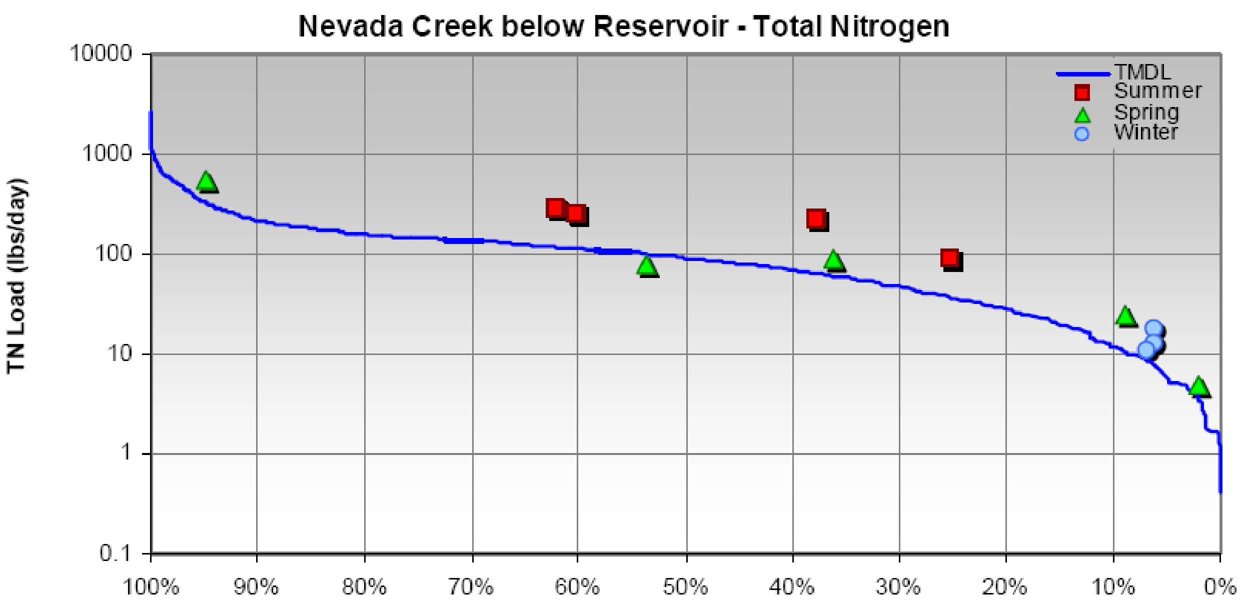


Figure 9-17. Comparison of the Allowable to the Observed Total Nitrogen Load for Nevada Creek Downstream of Nevada Creek Reservoir

9.3.2.3 Lower Nevada, Upper and Lower Douglas, Murray, McElwain, Braziel, and Black Bear Creeks

The total nitrogen TMDL for Lower Nevada Creek is shown graphically in **Figure 9-18.** The TMDLs at the 25th, 50th, and 75th flow percentiles are 35.57, 42.04, and 66.30 pounds per day, respectively. Based on the available data, the necessary load reductions range from 0% to 92% with an average reduction of 47% (**Table 9-19).** As shown in **Figure 9-18**, reductions are required at all flow ranges.

Data for the four 303(d) Listed tributaries in the Lower Nevada Creek watershed are limited to a single sample, which is not sufficient for characterizing the needed load reductions. Based on these single low flow samples, the respective total nitrogen TMDLs for Upper and Lower Douglas, Murray, McElwain, Braziel, and Black Bear Creeks would be 16.02, 6.28, 7.12, 0.89, 0.41, and 0.89 pounds per day. Given the uncertainty associated with the limited data, the watershed scale load reductions presented in Error! Reference source not found. are proposed as a framework starting point for these tributaries. These TMDLs will be modified in the future following the adaptive management strategy presented in Section 9.3.5.

Table 9-19. Example Total Nitrogen TMDLs for Three Flow Groups, Nevada Creek at the Mouth

USGS Station 12337800					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	2	9.70 – 35.57	26.68 – 43.01	9% – 29%
25-75	Average Flows	11	35.57 – 66.30	55.73 – 145.04	0% – 57%
75-100	High Flows	9	66.30 – 808.50	248.75 – 6,121.32	47% – 92%

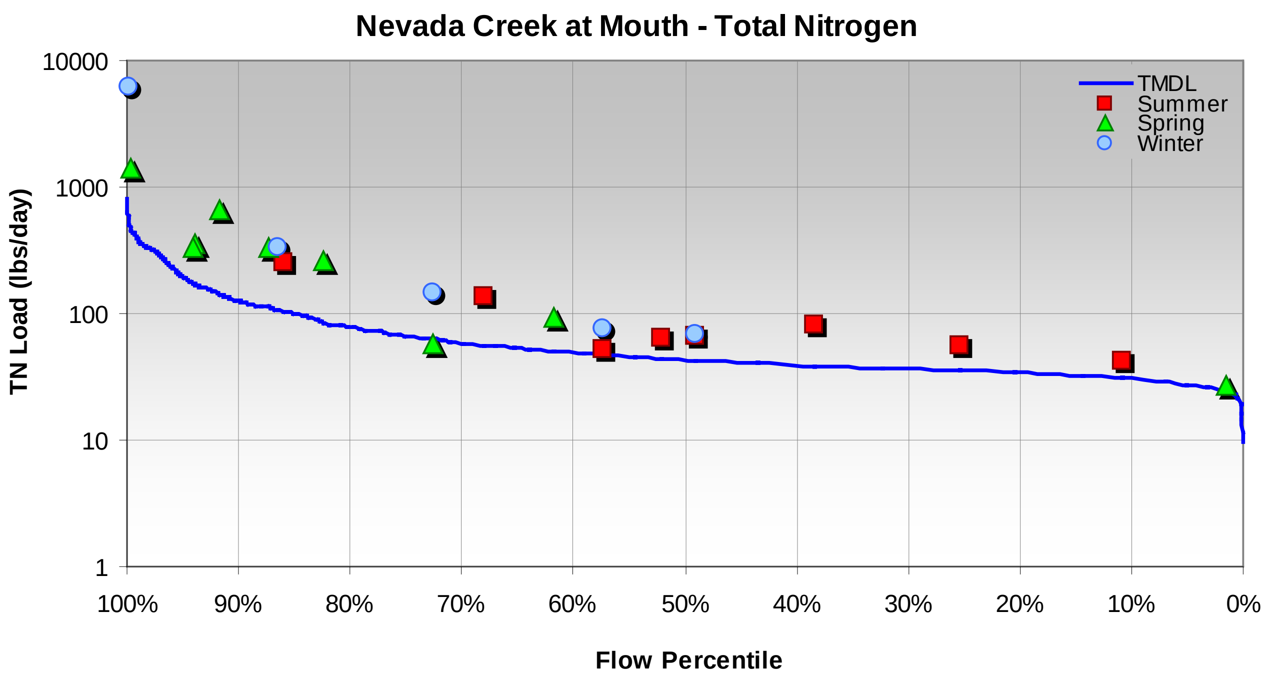


Figure 9-18. Comparison of the Allowable to the Observed Total Nitrogen Load for Nevada Creek at the Mouth

9.3.2.4 Blackfoot River, Frazier Creek, Wales Creek, West Fork Clearwater River, and Yourname Creek

As explained above in **Section 9.3.1.4**, the Mower Blackfoot River main stem is divided into two segments: that from Nevada Creek to Monture Creek (MT76F001_31) and that from Monture Creek to Belmont Creek (MT76F001_32). The targets defined in **Section 7.1.1** apply to both segments. The available discharge and water quality data at USGS Stations upstream (Blackfoot River above Nevada Creek near Helmville – 12335100) and downstream (Blackfoot River at Bonner – 12340000) of the TPA are used for the purposes of this framework TMDL.

The total nitrogen TMDL for the Blackfoot River at Helmville is shown graphically in **Figure 9-19.** The TMDLs at the 25th, 50th, and 75th flow percentiles are 228.00, 263.57, and 468.93 pounds per day, respectively. Based on the available observed data, the necessary load reductions range from 0% to 14% with an average reduction of 1% (**Table 9-20**).

The TMDL for the Blackfoot River at Bonner is shown graphically in **Figure 9-20**. The TMDLs at the 25th, 50th, and 75th flow percentiles are 882.88, 1186.88, and 2554.86 pounds per day, respectively. The available observed data suggests that no load reductions are needed (**Table 9-21)**. To conclude that no growing season nitrogen load reductions are needed for the impaired segments of the Blackfoot River ignores the potential effects of instream consumption of nitrogen by growing algae. The total nitrogen dataset for the main stem reaches (**Figure 7.2**) includes results for samples collected near the Scotty Brown and Raymond bridges, where chlorophyll a target values are elevated during the growing season. Therefore nutrient consumption by algae may be masking the effects of controllable nitrogen sources during low flow conditions. The elevated chlorophyll a results (**Table 7-5**) support this uptake scenario. Based on the difference between upstream data presented in **Figure 9-19**, and results for Lower Nevada Creek (**Figure 9-18**), it is likely that the Nevada Creek drainage provides the majority of excess controllable nitrogen loading throughout the year, particularly during the growing season. Meeting the lower Nevada Creek percent reductions as defined in **Table 9-9** would likely result in acceptable high and low flow nitrogen loading conditions downstream in the Blackfoot River main stem. Given a 12 % mixing ratio between the Blackfoot River and Nevada Creek (**Section 8.2.2.2**), the resulting required percent nitrogen loading reduction in the Blackfoot River would be 1 to 3% during low flow conditions, and 6 to 11 % during high flow conditions.

Data for the four 303(d) Listed tributaries in the Middle Blackfoot River watershed are limited to one or two samples, which are insufficient for characterizing the needed load reductions. Based on individual low flow samples, the total nitrogen TMDLs for West Fork Clearwater River, Yourname Creek, Wales Creek, and Frazier Creek would be 0.72, 7.12, 0.16, and 2.67 pounds per day, respectively. **Figure 7-4** shows that nitrogen concentrations for Frazier and Yourname creeks are similar to nitrogen concentrations in the Nevada Creek tributaries. The nitrogen monitoring record for Wales Creek is a TKN result of 0.20 mg/L and an elevated $NO_3 + NO_2$-nitrogen result of 0.04 mg/L. Because of the limited data, the load reductions presented in Table 9.8 that are applied to Lower Nevada Creek and the Lower Nevada Creek tributaries are also applied as the TMDL load reductions for Yourname, Wales and Frazier creeks.

West Fork Clearwater River nitrogen concentrations are relatively low (0.23 mg TKN/L) or below method detection limits. The 1 to 11% load reduction range applied to the Blackfoot River segments, depending on flow conditions, is also applied as the nitrogen TMDL load reduction for the West Fork Clearwater River. The data for West Fork Clearwater River suggests potential non-impairment for nitrogen. Chlorophyll a concentrations of 24.2 and 85.3 mg/m^2 were measured at two assessment sites (DEQ 2003).

The TMDLs for these Middle Blackfoot River tributaries will be modified in the future following the adaptive management strategy presented in Section 9.3.5.

Table 9-20. Example Total Nitrogen TMDLs for Three Flow Groups, Blackfoot River Upstream of Nevada Creek

USGS Station 12335100					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	0	97.02 – 228.00	NA	NA
25-75	Average Flows	11	228.00 – 468.93	24.26 – 322.35	0%
75-100	High Flows	9	468.93 – 2,942.94	73.30 – 2690.69	0% – 14%

Table 9-21. Example Total Nitrogen TMDLs for Three Flow Groups, Blackfoot River at Bonner

USGS Station 12340000					
Flow Percentile	**Flow Description**	**# of Samples**	**TMDL Range (lbs/day)**	**Range of Observed Loads (lbs/day)**	**Range of Required Reductions (%)**
0-25	Low Flows	7	291.06 – 882.88	11.15 – 23.28	0%
25-75	Average Flows	9	882.88 – 2,554.86	9.33 – 135.40	0%
75-100	High Flows	33	2,554.86 – 29,106.00	129.36 – 8,092.17	0%

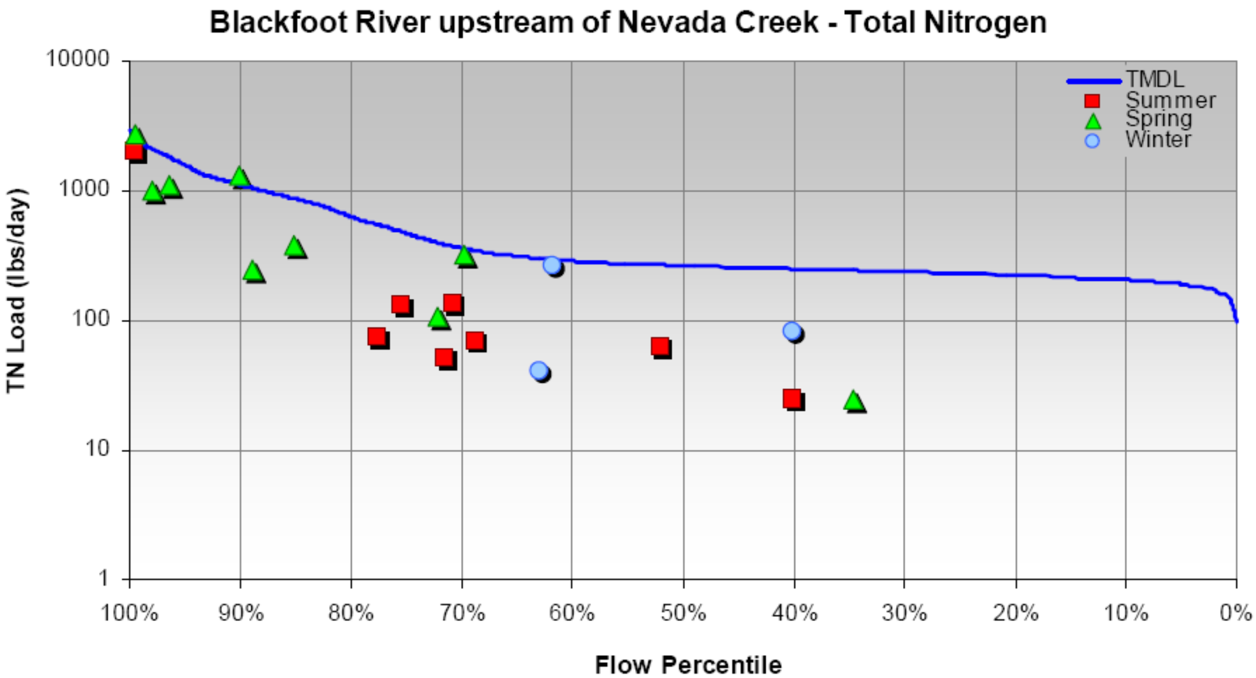


Figure 9-19. Comparison of the Allowable to the Observed Total Nitrogen Load for Blackfoot River Upstream of Nevada Creek

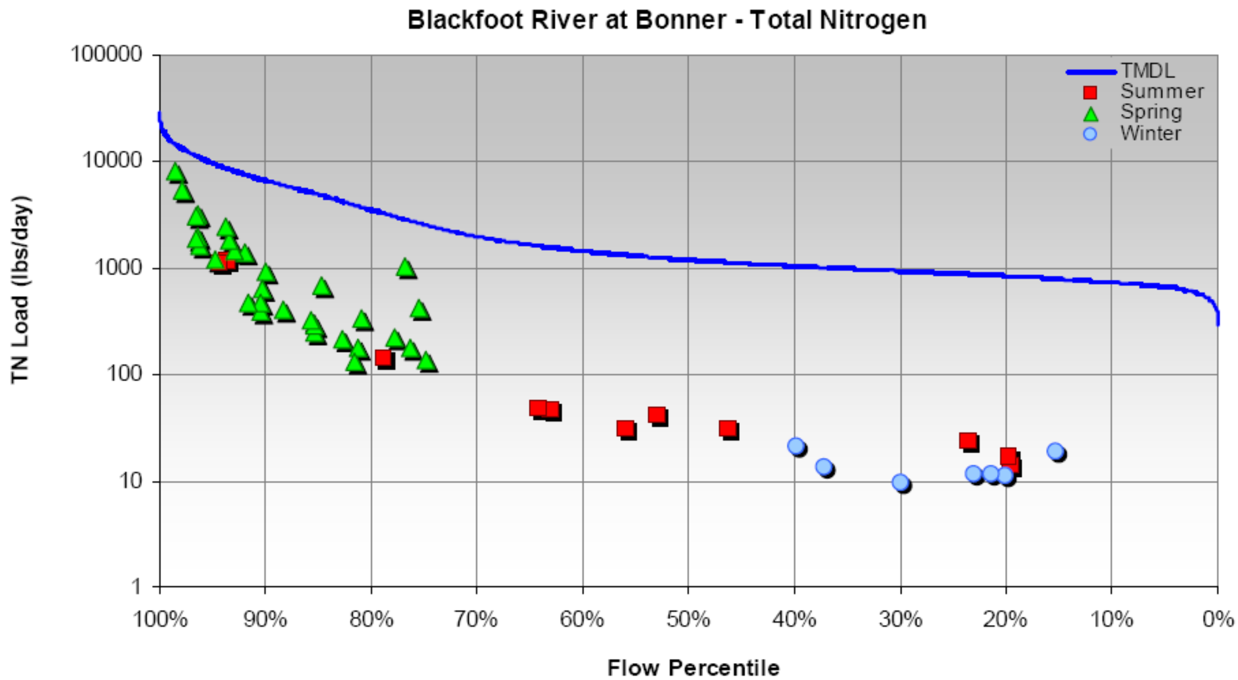


Figure 9-20. Comparison of the Allowable to the Observed Total Nitrogen Load for Blackfoot River at Bonner, MT

9.3.3 Nutrient Allocations

Based on the preliminary source assessment (**Section 7.3**), the potentially significant anthropogenic sources of nutrients within the Middle Blackfoot-Nevada TPA include:

- Dissolved loads of TP and TN from subsurface irrigation return flows.
- Naturally occurring particulate and dissolved loads of TP and TN in both streams and groundwater.
- TP and TN loading from agricultural sources, principally livestock grazing, irrigated hay production, irrigation return flows, and livestock feeding.
- Particulate bound TP and TN from road erosion.
- Particulate bound TP and TN from timber harvest.
- Particulate bound TP and TN from placer mining.

These are all nonpoint sources. There are no known point sources of nutrients in the Middle Blackfoot – Nevada TPA.

Insufficient data are available at this time to determine the relative importance of these sources and/or to quantify existing loads and necessary load reductions. As a result, it is not possible to specifically allocate load reductions to individual sources or source categories. A gross allocation to the above listed nonpoint sources is therefore proposed. Further study is necessary (see the Adaptive Management Strategy in **Section 9.3.5**) to equitably apportion the load reductions to specific sources.

9.3.4 Uncertainty and Margin of Safety

The nutrient TMDLs presented in this document are intended to provide a framework starting point from which watershed stakeholders can begin to address potential nutrient related problems in the waters within the Middle Blackfoot-Nevada Creek TPA. It is acknowledged that the impairment decisions are likely conservative and all components of the nutrient TMDLs are based on limited data. An adaptive management strategy (**Section 9.3.5**) has been developed to address any uncertainties and to facilitate revision of all aspects of the nutrient TMDLs (i.e., impairment decisions, TMDLs, and allocations) in the future as necessary or appropriate. The margin of safety is provided implicitly through the adaptive management strategy.

9.3.5 Adaptive Management Strategy for the Nutrient Targets, TMDLs, and Allocations

An adaptive management strategy is proposed to facilitate revision of the interim nutrient targets, TMDLs, and allocations for the lakes and streams in the Middle Blackfoot – Nevada Creek TPA. This strategy combines and coordinates supplemental study elements with regulatory elements.

9.3.5.1 Supplemental Study Elements

The supplemental study elements include both additional monitoring and modeling. Development and implementation of a detailed monitoring strategy is proposed to:

- Better characterize current water quality and discharge conditions in the tributaries, Nevada Creek, Nevada Creek Reservoir, and the Blackfoot River.
- Develop a better understanding of the connection between groundwater and surface waters, especially downstream of Nevada Creek Reservoir.
- Develop a water balance for the entire Nevada Creek watershed so that actual flow conditions are known and possible flow management options can be considered for all tributaries.
- Compile sufficient data such that a watershed loading and stream/lake response model can be set-up and calibrated.
- Better define nutrient source loadings.

A SWAT model (i.e., a watershed loading model) has been set up for the Middle Blackfoot – Nevada Creek TPA. However, at this point, insufficient data were available for adequate calibration/validation of the model, which, therefore, has limited its use at this time. Ultimately, it is envisioned that the entire Blackfoot River watershed will be simulated by DEQ with a loading model (SWAT, LSPC, or other suitable model). The current SWAT model will be updated in an attempt to derive a more satisfactory and complete calibration/validation for this TPA as well as the entire Blackfoot River watershed, or another watershed loading model will be set up and calibrated.

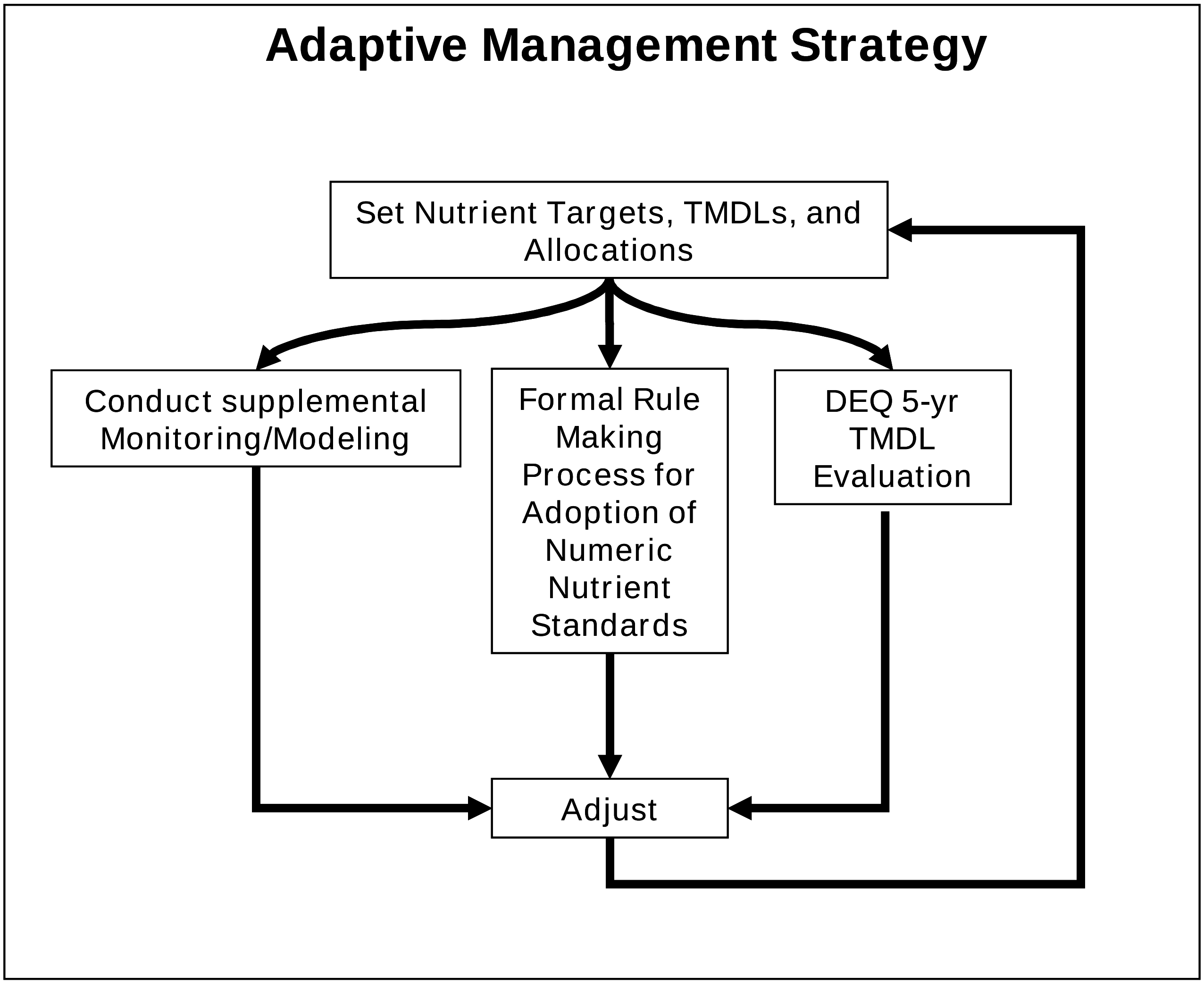
Additionally, a reservoir response model will be set-up and calibrated for Nevada Creek Reservoir. Combined with the watershed loading model, this will be used to develop a better understanding of the response of the reservoir to nutrient loading and also will be used to define the potential of the reservoir. Specifically, the modeling tools will be used to answer the following questions:

1. Given the characteristics of the watershed, the morphology of the Nevada Creek Reservoir, and dam operations, what is the potential of the Nevada Creek Reservoir?
    a. What trophic state can be achieved given the current reservoir management goals and objectives?
2. What are the current nutrient loads from the potentially significant sources?
3. How will in-stream and in-reservoir nutrient loads/concentrations be affected by alternative restoration measures?

9.3.5.2 Regulatory Elements of Adaptive Management

There are two primary regulatory mechanisms through which water quality targets and TMDLs may be modified in the future, as follows: (1) Montana Code Annotated 75-5-703(9)(c) provides a provision for revising the TMDL based on an evaluation conducted by DEQ five years after the TMDL is completed and approved and (2) DEQ has begun the initial steps of numeric standards development for nutrients. DEQ expects to start the formal rule making process for adoption of numeric standards within the next two years. Prior to the start of formal rulemaking, DEQ will provide opportunity for informal public comment, as well as for the formal public comment prescribed under statute.

It is envisioned that the above supplemental study and regulatory elements together will provide the needed data and information to revise the proposed interim nutrient targets, TMDLs and allocations if necessary, and to provide a regulatory and public involvement framework through which the revisions could be made.



9.4 Temperature TMDLs and Allocations

Temperature TMDLs seek to quantify the level of thermal loading that is protective of aquatic life. Loading estimates consider the actual water temperature, flow rates, existing heat sources, and the capacity of the water body to buffer heating effects. Although a loading capacity for heat (e.g. kilocal/per day and per second) is estimated in **Appendix G**, the loading capacity units cannot be readily translated into land and water management options for solving temperature problems. Therefore, surrogate measures are used in this document to focus on controllable variables that directly affect nonpoint sources of elevated stream temperature. There are no known point sources of temperature loading in the planning area.

The temperature modeling procedure described in **Section 8.0** provided the technical framework for developing a surrogate-based temperature TMDL and allocation approach by identifying the major factors influencing water temperatures and estimating their relative effects. The modeling effort identified the relative importance of channel shading, channel geometry, and flow on temperature during the mid-July to mid-August period. For all temperature impaired streams, the dominant influence on temperature loading is lack of shade.

There are nine temperature impaired stream segments in the planning area. They are listed in **Table 8-1**. The applicable standards for temperature in waters classified as B-1 are:

1. A 1ºF increase above naturally occurring temperatures when naturally occurring temperatures are 66ºF or less.
2. Within the naturally occurring range of 66 to 66.5°F, no increase can cause the temperature to exceed 67°F.
3. A 0.5°F increase above naturally occurring temperatures when naturally occurring temperatures are greater than 66.5.

Thermal loading allocations in this document are expressed in terms of prescribed conditions for the dominant factors that control stream temperature because they more clearly translate to restoration options. An example of daily temperature TMDLs, in terms of instantaneous thermal loads (ITLs), are provided numerically (kilocal/day or kilocal/sec) in **Appendix G** for a location on Kleinschmidt Creek. The temperature variables serving as surrogates for thermal loading are listed below and described in the following paragraphs.

- Alteration of flow by diversion or reservoir storage.
- Stream channel shade reduction through woody riparian vegetation removal.
- Solar heating of impounded water surfaces and.
- Alteration of channel geometry that increases water surface exposure to air and sunlight.

Mid-summer irrigation withdrawals decrease the volume of water in streams. High summer air temperature combined with decreased water volume and warmed surface return flows from flood irrigated areas result in large stream temperature increases. Tributary flow and groundwater discharge to channels reduce overall heating. Although naturally occurring low flow conditions and irrigation requirements limit opportunities for increasing stream flows, water storage, and irrigation BMPs have been developed to help increase the amount of diverted water that is actually consumed by the crop. In some cases, such practices can increase the amount of water available for competing beneficial uses during the critical summer period.

The lack of detailed information on water supply in relation to growing season crop demands makes it difficult to judge the current planning area water management regime as representing naturally occurring conditions. Because significant irrigation water delivery and application efficiency improvements for flood systems have been documented (USDA, 1997, Economic Research Station, 1997, Negri et al., 1989), a conservatively low expectation of 15 percent flow augmentation is assumed possible for flood irrigation systems in the Middle Blackfoot-Nevada Creek planning area and is considered as a naturally occurring condition for some water bodies. The exclusive early season timing of irrigation diversions from Nevada Creek above Nevada Lake precludes flow increases for this stream.

For each of several woody riparian vegetation community types, naturally occurring and existing shading characteristics were translated into the percent of the stream bank covered by a particular type (DTM and AGI, 2006). A combination of riparian vegetation mapping, photo evidence of vegetation types and channel offset and literature values for average community height, canopy diameter, and shade density were the basis quantifying shade from vegetation. The extent of bankline vegetation was digitized for each temperature impaired reach. A weighted average vegetation value, based on the relative extent of various vegetation types was calculated for each reach. Shade from vegetation was combined with channel width and topographic shade measurements to give a single shade value for each reach.

Impounded water in storage reservoirs of can sometimes increase temperatures. Surface releasing reservoirs deliver significantly warmer water than reservoirs releasing water from the colder bottom of temperature stratified impoundments. Nevada Lake is a bottom releasing reservoir that adds significantly cooler water to lower Nevada Creek than that entering the reservoir from upper Nevada Creek. The series of three shallower reservoirs on upper Douglas Creek release warmer water from nearer the surface. The downstream most reservoir that is the shallowest causes significant temperature loading. The allocation to a reduction in thermal loading from the reservoirs is applied in upper Douglas Creek.

Channel morphology can greatly influence stream temperatures. Stream bank riparian vegetation that overhangs a narrow stream provides a higher percentage of shade than does equivalent vegetation along a wider stream. The effects of this are two-fold. First, wide streams are inherently more susceptible to thermal heating simply due to their width. Second, increasing stream bank vegetation has a smaller mitigating effect on thermal gain on wider streams. As a result, the temperature target for a wide stream, based on a 1ºF allowable increase from a 95% stream bank vegetation natural condition, may be close to the current condition.

Over-widened streams expose more water surface to temperature loading. Restoring the characteristic width to depth ratio of C and E channel types improves temperature conditions. The characteristic width to depth ratios defined for sediment impaired channels (**Section 5.0**) are achievable geomorphic conditions assumed as naturally occurring conditions. The appropriate width to depth ratios are currently met in some areas. Where improvements are possible, this parameter is included among the temperature allocations, and specific assessment reaches needing channel morphology improvements are given in parentheses in the allocation tables.

9.4.1 Temperature Allocation and TMDL for Upper Nevada Creek

Vegetative shade removal and alteration of channel morphology are the main influences on thermal loading in upper Nevada Creek. **Table 9-22** gives modeled temperature and vegetation conditions. Reference willow community shade conditions were identified at the transition point between the coniferous forested dominated reaches and the wider, more open grassland valley bottom.

Table 9-22. Temperature Allocations for Upper Nevada Creek

Parameter	Condition Category			Allocation	Controllable Source/s
	Current	Naturally Occurring	Restoration Goal		
Modeled Mean Daily Temp. (°F)	64.2	60.7	61.7	NA	Irrigated Hay Production Livestock Confinement Livestock Grazing
Modeled Maximum Daily Temp. (°F)	71.4	65	66.7	NA	
Bankline Vegetation Extent (%)	19	95	73	Increase by 57% of Reference	
Width:Depth Ratio C Types (Nev3)	22	12-20	16	27%Decrease	

Channel encroachment by irrigated hayland and impacts from grazing livestock are limiting shade replacement. The median width to depth ratio is the highest within assessment reach Nev3, but improvements within reach Nev6 are also possible.

9.4.2 Temperature Allocation and TMDL for Lower Nevada Creek

Lower Nevada Creek receives cool water from bottom releases from Nevada Lake. Late July temperatures gradually increase downstream to the mouth of Nevada Spring Creek. Riparian shade removal, irrigation diversions, and reservoir operations that severely reduce mid-July flows all contribute to the large thermal gains between Nevada Lake and Nevada Spring Creek. Thermal gains between Nevada Spring Creek and the mouth of Nevada Creek on the Blackfoot River are caused by warm water discharging Douglas Creek, lack of shade, and large channel width. Lower Nevada Creek allocations are provided in **Table 9-23**. Restoration goals are specified in the table for both C and E channel types, and applicable assessment reaches are identified for each in the table. The width to depth restoration goal is the median value (16) of the target range of 12 to 20 assumed achievable in lower Nevada Creek. The corresponding restoration goal for E channel types is the high end of the range in consideration of period large flows in lower Nevada Creek.

Table 9-23. Temperature Allocations for Lower Nevada Creek

Parameter	Condition Category			Allocation	Controllable Source/s
	Current	Naturally Occurring	Restoration Goal		
Modeled Mean Daily Temp. (°F)	70.4	68.3	68.8	NA	Reservoir Operations Irrigated Hay Production Livestock Grazing
Modeled Maximum Daily Temp. (°F)	76.1	73.5	74.1	NA	
Bankline Vegetation Extent (%)	28	95	80	Increase by 55% of Reference	
Width:Depth Ratio C Types (Nev7, 8, 14)	29	12-20	16	45%Decrease	
Width:Depth Ratio E Types (Nev9)	14	6-11	11	21%Decrease	
Flow Augmentation	Unknown	≥ 15 percent flow increase July 15th to August 15th			

As with upper Nevada Creek, vegetative shade removal and alteration of channel morphology are the main influences on thermal loading in lower Nevada Creek. Reference willow community shade conditions were identified at several locations within the reach including along the north half of Section 6, T12 N R10 W, in the southeast quarter of Section 31, T13N R11W and within the western half of Section 24 and northwest quarter of Section 25, T13N R11W.

9.4.3 Temperature Allocation and TMDL for Cottonwood and Murray Creeks

Temperature loading to Cottonwood Creek occurs within reaches between the mouth of Pole Creek and the Ovando-Helmville road crossing. Air photos interpretation and water rights data show irrigation diversions and sparse vegetation for this reach. Little information is available for Murray Creek. Flow measurements in September 2003 show a decrease from four cfs to 0.2 cfs between two assessment sites. Air photos show a downstream decrease in woody riparian vegetation. Temperature TMDLs and allocations developed for Cottonwood Creek in **Table 9-24** are extrapolated to Murray Creek that has a drainage area, stream morphology, and land uses similar to Cottonwood. The level of certainty in allocations for the Murray Creek is lower than for Cottonwood Creek, but future adjustments in the context of adaptive management can improve this situation.

Table 9-24. Temperature Allocations for Cottonwood and Murray Creeks

Parameter	Condition Category			Allocation	Controllable Source/s
	Current	Naturally Occurring	Restoration Goal		
Modeled Mean Daily Temp. (°F)	69.6	62.7	63.2	NA	Irrigated Hay Production Livestock Grazing
Modeled Maximum Daily Temp. (°F)	79.1	68.4	69.2	NA	
Bankline Vegetation Extent (%)	33	95	91	Increase by 61% of Reference	

9.4.4 Temperature Allocation and TMDL for Upper Douglas Creek

Headwaters flow in upper Douglas Creek emanates from springs in the Madison Limestone. A mean summer water temperature of 46ºF is the coldest measured in the Nevada Creek watershed. Temperatures increase by as much as 25ºF from the headwaters to below three irrigation and stockwater reservoirs. Field observations (DTM and AGI, 2005) describe the reservoirs as shallow relative to Nevada Lake and capable of rapid summer heating. Refer to **Figure 8-23** for an illustration of the temperature increase over a distance of approximately three miles. Modeling of only the stream segments between the reservoirs indicates conditions within the segments accounts for approximately 1.5ºF (6%) of this increase of a 20°F increase, suggesting that the reservoirs are responsible for approximately 18.5°F or 92% of the temperature increase. **Table 9-25** gives the temperature allocations for upper Douglas Creek.

Table 9-25. Temperature Allocations for Upper Douglas Creek Channel Segments and Reservoir Area

Parameter	Condition Category			Allocation	Controllable Source/s
	Current	Naturally Occurring	Restoration Goals		
Modeled Mean Daily Temp. (°F)	68.4	63.4	64.0	NA	Irrigated Hay Production Reservoir Operations Livestock Grazing
Modeled Maximum Daily Temp. (°F)	80.2	69.0	70.5	NA	
Bankline Vegetation Extent (%)	40	95	82	Increase by 44% of Reference	
Reservoir Surface Area (Acres)	40	32	32	20% Reduction in Reservoir Area	

Field observations and air photo assessment of the upper Douglas Creek suggest that achievable modifications to the water storage and delivery system would reduce stream temperatures. The modifications include eliminating the downstream most and shallowest reservoir and consolidating storage in the remaining two. The remaining reservoir locations and existing conveyance system is adequate to meet existing needs. The resulting potential temperature reduction could exceed 3.5°F.

9.4.5 Temperature Allocation and TMDL for Lower Douglas Creek

Lower Douglas extends from the mouth of Murray Creek to lower Nevada Creek. Available data indicate that stream temperatures decrease slightly between the upper Douglas Creek reservoirs and the Ovando-Helmville road crossing. Within his reach, Douglas Creek and the Douglas Creek Canal, containing Nevada Lake bottom releases, are coincident for one quarter mile, resulting in cooler Douglas Creek temperatures through this reach. Farther downstream, a large diversion reduces flow in lower Douglas Creek and warm water from Cottonwood Creek likely increases temperatures between the road crossing and the mouth of Douglas Creek. **Table 9-26** provides the SNTEMP modeling results and allocations for lower Douglas Creek.

Table 9-26. Temperature Allocations for Lower Douglas Creek

Parameter	Condition Category			Allocation	Controllable Source/s
	Current	Naturally Occurring	Restoration Goals		
Modeled Mean Daily Temp. (°F)	69.6	63.4	63.9	NA	Irrigated Hay Production
Modeled Maximum Daily Temp. (°F)	78.2	69.1	69.9	NA	Livestock Grazing
Bankline Vegetation Extent (%)	23	95	89	Increase by 69% of Reference	
Width Depth Ratio C Types (Doug 5, 7)	35	12-20	16	54% Decrease	
Flow Augmentation	Unknown	$\geq$ 15% July 15th to August 15th			

Riparian shade removal is the temperature controlling factor accounted for in the model. Improvement in width to depth ratio is included in the allocations because it affects thermal loading and the sediment source assessment identified significant departures for target values. An allocation for flow augmentation is included because this minimal improvement is thought to be achievable and effective for increasing the assimilative capacity for temperature loading in this critical Nevada Creek tributary.

9.4.6 Temperature Allocation and TMDL for Kleinschmidt Creek.

Kleinschmidt Creek originates as a division of the Ward Creek channel. The portion of Ward Creek not entering Kleinschmidt Creek discharges to Browns Lake. Land uses along the stream are mainly livestock grazing and hay production, with some residential development occurring within the last mile of the stream before its discharge into Rock Creek. Channel restoration to reduce width to depth ratios and increase sinuosity occurred along 1.7 miles of the lower reaches north of US Highway 200. Temperature monitoring data indicate that the projects have reduced instream temperatures. Groundwater discharging to the channel along its lower reaches naturally increases flows and reduces stream temperature. Shade removal is the dominant remaining factor affecting temperature loading.

Temperature modeling was conducted for two reaches of Kleinschmidt Creek, one upstream of the first Highway 200 crossing and a second nearer the mouth on Rock Creek. The upstream reach is the more temperature limited because it receives less groundwater discharge. **Table 9-27** contains modeling results and allocations for the most temperature limited reach.

Table 9-27. Temperature Allocations for Kleinschmidt Creek

Parameter	Condition Category			Allocation	Controllable Source/s
	Current	Naturally Occurring	Restoration Goal		
Modeled Mean Daily Temp. (°F)	65.1	62.5	63.5	NA	Irrigated Hay Production Livestock Confinement Livestock Grazing
Modeled Maximum Daily Temp. (°F)	73.0	65.8	68.1	NA	
Bankline Vegetation Extent (%)	29	95	69	Increase by 42% of Reference	

Model results indicate that lack of channel shade is the cause of Kleinschmidt Creek temperature impairment.

9.4.7 Temperature Impairment to the Blackfoot River Main Stem (Nevada Creek to Monture Creek).

Summer water temperature and flow monitoring of the Blackfoot River main stem at the Cutoff Bridge (4.3 stream miles above the Nevada Creek mouth), indicates cool temperatures and flows of about 180 cfs. Nearby irrigation diversions reduce flows and increase thermal loads. Nevada Creek contributes approximately 22 cfs (12% of main stem flows) of relatively warm water. From the mouth of Nevada Creek, the Blackfoot flows through a wide, un-shaded reach with additional irrigation withdrawals causing significant thermal gains. Monitoring at Raymond Bridge recorded the warmest water temperatures among main stem sites.

Between Raymond Bridge and Scotty Brown Bridge, the Blackfoot receives cold-water from North Fork of the Blackfoot River, Monture Creek and groundwater sources. **Figure 8-41** shows the statistical distributions of 2000 summer temperatures at four sites on the Blackfoot River and several tributaries. Main stem temperatures are coolest at the Cutoff Bridge, increase dramatically at Raymond Bridge, and return to Cutoff Bridge levels below Monture Creek.

Bankline vegetation along the Blackfoot main stem from Nevada Creek to Monture Creek ranges from about nine to 80%. Channel width in this reach averages about 130 feet. Modeled temperature increases reflecting 95% bankline within this reach increases the shade factor from four percent to 8.3%. The wide channel decreases the effect of shade on stream temperature. No appreciable decrease in simulated temperature results from increasing main stem bankline vegetation extent.

Table 9-28 gives simulated current condition and natural condition temperature at Raymond Bridge, where the naturally occurring condition is Nevada Creek flows meeting temperature target conditions. The difference is a temperature reduction of about 0.2°F. This difference is within the 0.5°F allowable temperature increase.

Table 9-28. Modeled Mean Daily and Daily Maximum Blackfoot River Main Stem Temperature Differences at Raymond Bridge with Temperature Target Conditions Met in Nevada Creek

Parameter	Current Condition	Naturally Occurring	Difference from Current Conditions
Modeled Mean Daily Temp. (°F)	68.66	68.43	0.23
Modeled Maximum Daily Temp. (°F)	74.2	74.0	0.20

With temperature target conditions met in Nevada Creek, Blackfoot River main stem temperatures meet water quality standards. Modeling suggests that changes to temperature controlling influences such as bankline vegetation extent, flow, and channel morphology along the main stem between the Nevada Creek mouth and Monture Creek will not have an appreciable effect on water temperatures. Therefore, a temperature TMDL and allocation within this reach are not required. The largest control on main stem temperature between Nevada Creek and Monture Creek is warm water from Nevada Creek.

9.4.8 Temperature Impairment to the Blackfoot River Main Stem (Monture Creek to the Clearwater River).

The downstream boundary of the Middle Blackfoot planning area is on the Blackfoot River below the confluence of the Clearwater River. The SNTEMP model for the Blackfoot River was constructed with an output point allowing simulation of temperatures at this location. Stream bank vegetation and shade is similar to the upstream segment of the Blackfoot River (9% to 80%). The average width is 145 feet; woody vegetation covers 63% of stream banks. Increasing bankline woody vegetation from the current 63% to 95% increased shade from 6.2% to 6.9%. No appreciable decrease in simulated temperature resulted from this change. **Table 9-29** gives simulated current condition and natural condition temperature below the mouth of the Clearwater, where the naturally occurring condition is Nevada Creek flows meeting temperature target conditions.

Table 9-29. Modeled Mean Daily and Daily Maximum Blackfoot River Main Stem Temperature Differences below the Mouth of the Clearwater River

Parameter	Current Condition	Naturally Occurring	Difference from Current Conditions
Modeled Mean Daily Temp. (°F)	66.7	66.6	0.02
Modeled Maximum Daily Temp. (°F)	70.1	70.1	0.02

Simulations of current temperature conditions and natural conditions differed by only 0.02°F. Current conditions fall within the 0.5°F allowable temperature increase. No temperature TMDLs or allocations are required within this reach of the Blackfoot River main stem.

9.5 Seasonality, Uncertainty, and Margin of Safety for Temperature TMDLs

To address seasonality the modeling analyses was focused on conditions during the period July 15th through August 15th, when B-1 temperature standards are most likely exceeded. Targets developed to reduce stream temperatures during the most critical period provide an implicit margin of safety toward meeting temperature standards during less critical seasons.

Other implicit margins of safety are applied by using conservative assumptions in the TMDL development process (U.S. EPA, 1999). The major components are described below:

- The temperature modeling analysis and resulting TMDLs and allocations are based on flow and instream temperature data compiled from a host of studies conducted between 1998 and 2004 for specific restoration projects. Their scope and purpose were limited geographically and did not constitute a comprehensive, synoptic assessment of the factors controlling the temperature of impaired streams. The lack of a focused data collection and analysis effort describing current temperature loading is a significant source of uncertainty in the temperature TMDLs. Therefore, they are presented here as a framework point of departure for future refinements made possible through the process of adaptive management. The application of adaptive management toward refining temperature TMDLs provides an implicit margin of safety in that the process considers adjustments that ensure support for beneficial uses.

- The assumed naturally occurring percentage of bankline woody vegetation (95%) was developed from examples of optimal woody riparian vegetation within several listed segments (**Appendix G**). The examples depict abrupt woody vegetation density changes across property or land use boundaries that do not impose environmental limitations to woody vegetation growth. It is inferred from such examples that the potential for shade from woody vegetation is widespread in the planning area, but uncertainty in its extent remains. Because of natural variability in soil, climate and hydrologic conditions, the actual potential for woody vegetation may be less than 95% in some areas. An assumed potential of 95% bankline extent provides an initial margin of safety, and adaptive management allows for a future assessment and target adjustment if needed.

- Healthy streamside riparian vegetation creates a local microclimate with lower air temperatures and higher humidity. This has an additional cooling effect on stream temperatures not accounted for in the SNTEMP model. Therefore, additional woody riparian vegetation will not only provide additional shade, but will provide additional cooling through this microclimate effect.

The following elements are proposed as an adaptive management approach to future temperature assessment:

1. Accurate characterization of current annual stream discharge and temperature conditions in the listed tributaries, main stem of Nevada Creek and the Blackfoot River.
2. Quantify the seasonal effects of groundwater discharge and its effect on stream temperature during mid to late summer.

3. Evaluate shade restoration potential and refine woody vegetation shade estimates.
4. Develop and execute model scenarios as needed to improve the understanding of current temperature loading and the potential effects of flow volume and channel configuration.
5. Continue monitoring the temperature effects of stream restoration projects.

SECTION 10.0
WATER QUALITY RESTORATION IMPLEMENTATION AND MONITORING PLAN

10.1 Introduction

The preceding chapters of this document describe water quality impairments, water quality impairment sources, water quality restoration targets, and necessary pollutant reductions. The purpose of this chapter is to outline strategies for achieving water quality targets and support of beneficial uses for impaired water bodies in the Middle Blackfoot and Nevada Creek planning areas. This restoration implementation and monitoring plan was written so that water quality restoration management objectives for these planning areas can be integrated with ongoing watershed management efforts in the Blackfoot as well as state-wide water quality management efforts described in Montana's Non Point Source Management Plan. It is intended to serve as a guide to individual landowners and collective partnerships concerned with the maintenance, improvement, and/or restoration of water quality.

This restoration plan is divided into three major sections – Management Recommendations, Implementation, and Evaluating Success. The Management Recommendations section is organized first by planning area then by impaired streams or stream reach. Each impaired stream is discussed individually with a general narrative of current conditions, factors that limit beneficial use support, sources and causes of impairment, and management actions for achieving water quality targets. In cases where impairment causes and sources are not well defined, recommendations for future monitoring are given.

The Implementation section is derived primarily from the "Basin-Wide Restoration Action Plan for the Blackfoot Watershed" (Blackfoot Challenge, 2005). It describes some of the key elements of successful implementation and how water quality restoration objectives can be integrated with existing restoration plans. It also describes the utilization of partnerships for implementation, current management objectives of various stakeholders, a list of planned and potential projects, landowner issues, and potential funding sources for implementation.

The Evaluating Success and Adaptive Management section describes how progress towards meeting water quality restoration targets will be measured, how success or failure will be evaluated, monitoring activities needed to gain a better understanding of water quality in these planning areas, and monitoring activities needed to determine where adjustments to water quality restoration targets and/or management are warranted.

Appendix H contains a list and description of conservation practices or Best Management Practices (BMPs) that can be utilized in water quality restoration efforts. These conservation practices are separated into 8 different categories including Stream BMPs, Riparian Area BMPs, Upland BMPs, Grazing BMPs, Water Conservation BMPs, Forestry BMPs, Road BMPs, and Other Land Uses and BMPs. The conservation practice categories directly correlate to management actions and water quality concerns described in the Management Recommendations section. The conservation practices under each category offers land managers with several implementation options for addressing water quality issues.

10.2 Management Recommendations

This section describes sources, causes, and potential solutions to water quality impairments for each 303(d) Listed stream in the Middle Blackfoot and Nevada Creek planning areas. Water quality issues and solutions are described in the text and summarized in table form.

For TMDL planning purposes, each listed stream has been divided into several reaches. Specific stream reaches are often referenced to describe overall water quality conditions of a listed stream. A map with stream reach delineations can be found in **Appendix A** and further information on individual stream reaches can be found in **Appendix B**.

Pollutant "load" values contained in the tables refer to the "controllable pollutant load". The controllable pollutant load is the portion of the total pollutant load that is assumed to be controllable through the implementation of reasonable land, soil, and water conservation practices.

Source assessment activities for sediment and nutrient impairments determined that hill slopes or upland areas can be a significant source of these pollutants. The terms hill slopes, hill slope, uplands, and upland areas are used interchangeably and refer to the area within 350 feet of the stream channel.

Land uses and human activities can and do negatively impact water quality. It is important to note that while certain land uses and human activities are identified as sources and causes of water quality impairment, the management of these activities is of more concern than the activities themselves. This plan does not advocate for the removal of land uses or human activities to achieve water quality restoration objectives. It does however advocate for improving water quality and preventing degradation of water quality as a result of current or future land use management practices and human activities.

10.2.1 Middle Blackfoot Planning Area

10.2.1.1 Blackfoot River (Nevada Creek to Clearwater River)

Between the mouth of Nevada Creek and Belmont Creek, the Blackfoot River consists of two 303(d) Listed stream segments. The first reach extends from Nevada Creek to Monture Creek and is approximately 22 miles long. The second reach, which is approximately 24 miles long, extends from Monture Creek to Belmont Creek. Only the upper 11 miles of this lower segment, extending from Monture Creek to the Clearwater River, are in the Middle Blackfoot Planning Area.

From the Nevada Creek confluence to the Cedar Meadow fishing access site at the Rd 104 bridge crossing, the Blackfoot River is sinuous and shows evidence of active migration and bendway cutoff. Approximately 20% of the bankline supports woody vegetation, and locally this vegetation is dense (**Appendix B**). The floodplain adjacent to the Blackfoot River is relatively wide, and vegetated with woody species. There is an abrupt reduction in woody riparian vegetation extent downstream of the bridge, as the Blackfoot River is increasingly confined by terraces and high bluffs. The meanders of the river are larger than upstream, and show little evidence of active migration. The river has a narrow riparian thread as it flows along high bluffs of glacial deposits. These high bluffs are gullied, and in places the heads of the gullies encroach into irrigated lands. As the Blackfoot River flows towards the North Fork confluence, it becomes increasingly entrenched, flowing through sinuous meanders with erosion–resistant margins that are commonly forested. The south valley wall has been timber harvested. A large landslide on the south valley wall has encroached on the channel approximately 3 miles upstream of the North Fork confluence. This landslide occurred on March 28, 1998, and consisted of the catastrophic failure of a 1,000 ft long section of a 300 ft high terrace composed of glacial deposits on the southern valley wall of the Blackfoot River. This landslide delivered an estimated 100,000 cubic yards of sediment to the river corridor (University of Montana at Missoula, Geology News, Fall, 1998). The slide evidently blocked the river for a relatively short period of time as it impounded streamflow that ultimately was rerouted around the toe of the slide.

For a few miles below the North Fork confluence the Blackfoot River flows through a meandering channel with open bar areas, good trends in riparian succession, and active channel migration. It then flows through several miles of canyon before emerging into an area of irrigated low terraces that extend beyond the Monture Creek confluence. From Monture Creek to the Russell Gates fishing access, the Blackfoot River is a fairly sinuous channel that exhibits active lateral migration, sediment storage, and riparian succession. The channel becomes more confined below the Russell Gates access site, and is locally confined by both the valley wall and Highway 200. The channel is relatively steep as it flows through canyon to the Clearwater confluence.

Indicators of Habitat and Water Quality Limitations
The Blackfoot River (from Nevada Creek to the Clearwater River) was included on the 1996 303(d) List as impaired due to nutrients and siltation. Nutrient impairment listings remained for the Blackfoot River in 2006. Temperature was added as a cause of impairment in 2006 while the siltation impairment was removed. Data collected in support of TMDL development suggest that the original impairment listings for nutrients and sediment are justified. While temperatures in the Blackfoot River appear to be elevated in certain reaches, modeled and observed water temperatures were within “naturally occurring” ranges (**Section 8.0**) and TMDLs were deemed unnecessary.

Data collection on the mainstem Blackfoot River has identified some level of excess fine sediment primarily in riffle substrate. Excess fine sediment in the Blackfoot River was most evident in reaches immediately below Nevada Creek. Sediment targets in the lower section of the Blackfoot River (Monture Creek to the Clearwater River) were largely met. However, mixed biological results and high levels of bank erosion throughout this lower reach indicate potential sediment issues (**Section 5.0**).

Elevated nutrients in the form of Total Nitrogen and Total Phosphorous have also been identified in the Blackfoot River. Nutrient sampling in the Blackfoot River showed exceedences for Total Phosphorous and Chlorophyll-a. Total Nitrogen exceedences were minimal. It is believed that algae in the Blackfoot River had taken up most excess nitrogen during the time of sampling. This led to the conclusion that while nitrogen targets where not exceeded most of the time due to uptake by algae, excess nitrogen was still being delivered to the Blackfoot River **(Section 7.0 and Section 9.0)**.

Suspected Sources

The primary suspected source of fine sediment on the mainstem Blackfoot River between Nevada Creek and the Clearwater River is accelerated bank erosion (**Table 10-1**). Bank erosion in the Blackfoot River is attributed primarily to grazing practices in the riparian corridor. Residential development and hay production near the River are also noted as causes of bank erosion. Hill slope erosion caused by road extent and grazing practices also contribute to fine sediment accumulations in the Blackfoot River. Road crossings contribute approximately 152 tons of sediment per year to the River and an analysis of culvert failure (**Section 5.0**) estimates 141 tons of sediment could be delivered to the River as a result of culvert failure in a given year.

The accumulation of these sediments and associated habitat impacts may be exacerbated by reductions in minimum streamflow during the irrigation season. Flow alterations may also result in increased water temperatures on the river, although the measured increases in temperature in this stream segment did not warrant a TMDL.

Suspected sources for elevated nutrient levels in the mainstem Blackfoot River include tributary inputs, bank erosion, hillslope sediment, road sediment, agricultural inputs, as well as direct inputs where livestock access or are concentrated adjacent to the stream corridor. Grazing locally extends into the steam corridor, and several concentrated animal feeding areas abut the river system upstream of Raymond Bridge. Upstream of the Nevada Creek confluence, two livestock corrals/feeding pens are located off of the main channel but adjacent to abandoned channel swales. Additional areas of livestock concentration are located in the vicinity of the Helmville Road Bridge. Irrigated agriculture abuts the stream corridor in numerous places upstream of Raymond Bridge.

Table 10-1. Summary of Identified Problems and Applicable Treatments, Blackfoot River (Nevada Cr to Clearwater River)

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (3,855 tons/yr)**	Riparian Area BMPs
			Grazing BMPs
			Water Conservation BMPs
		Road Crossings (46 tons/yr)	Roads BMPs
		Hill slope sediment (541 tons/yr)	Upland BMPs
			Riparian Area BMPs
			Road BMPs
			Grazing BMPs
		Tributary inputs	Tributary treatments
		Low flow alterations	Water Conservation BMPs
Habitat	**Riffle, pool tailout fine sediment concentrations**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Nitrogen Total Phosphorous**	**Grazing practices**	Grazing BMPs
			Riparian Area BMPs
		Tributary inputs	Tributary treatments
		Low flow alterations	Water Conservation BMPs
Temperature	**Elevated**	**Tributary inputs**	Tributary treatments
		Low flow alterations	In-stream flow maintenance
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Historically, the approach to restoration of the Blackfoot River has been to restore its tributaries. Given the certain influence of tributaries on sediment, nutrients, and temperature in the Blackfoot River, this will remain as the primary restoration approach. There are however specific activities that can be applied to the River itself to improve water quality. These activities are described below.

The sediment source assessment for the mainstem Blackfoot River between Nevada Creek and the Clearwater River indicates that the bank erosion contributes 87% of the controllable sediment load. As such, recommended conservation practices should prioritize the treatment of this sediment source. Grazing BMPs and Riparian Area BMPs (**Appendix H**) would enhance filtering of surface runoff for sediment and nutrients, and increase shading on the river. Sections of the mainstem Blackfoot River display evidence of bank degradation from grazing. Some Grazing BMPs, such as water gaps, are locally in place along the river. However, where the channel is not entrenched such that banks are relatively low and susceptible to bank instability due to trampling or removal of vegetation, additional Grazing BMPs would be appropriate conservation measures. These activities have the potential to significantly help address issues related to nutrients and sediment on the river, while also providing some benefit to temperature conditions. Because the Blackfoot River is so wide in this reach, bankline vegetation is limited in its ability to provide shade to the river and thereby affect temperatures in mid-summer time frames when temperatures are highest.

The treatment of upland sediment and nutrient sources through Upland BMPs have the potential to further reduce sediment and nutrient delivery to the stream. Where the high bluffs of glacial deposits are gullied, the sites should be evaluated in terms of the feasibility of reducing erosion rates by site-specific revegetation efforts. Additionally, as the gully headwalls between the Cedar Meadow fishing access and Raymond Bridge encroach into irrigated lands, special care should be given to irrigation practices in these areas to minimize surface runoff into the gullies that will cause accelerated erosion and increased sediment delivery to the Blackfoot River.

Much of the southern valley wall of the mainstem Blackfoot River through the Middle Blackfoot Planning Area has been logged. The continued implementation of Montana's forestry management practices should be applied in any existing or proposed silviculture activities.

Although road crossings are a relatively minor contributor of sediment to the reach, Roads BMPs should be applied to existing and future road crossings to reduce sediment delivery and prevent culvert failure. Road BMPs can also be applied in areas where road extent and road proximity to the River are of concern.

Although "flow alterations" are not listed as a cause of impairment on 303(d) List for the mainstem Blackfoot River, the 2006 list includes "Flow alterations from water diversions" as a source of nutrient impairments. The 303(d) List thereby supports the consideration of low flow management as a conservation measure on the river that will support achieving nutrient TMDLs. Opportunities to increase flows may include Water Banking, Water Rights Leasing, and Water Rights Conversions to In-Stream Flows (**Appendix H**). Irrigation System Management, including efficiency improvements and application management may also be designed to reduce low flow depletions on the river.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment and nutrient conditions or creating additional water quality concerns related to habitat, low flows, temperature, or metals in the Blackfoot River.

Monitoring Needs

Nutrient causes and sources are not well defined in the Blackfoot River or its tributaries. Further monitoring should be conducted to better define and understand causes, sources, and mitigation of nutrient related water quality issues.

10.2.1.2 Blanchard Creek

Blanchard Creek is a tributary to the lower Clearwater River, flowing approximately 13 miles through industrial forest land, state, and private agricultural lands. Blanchard Creek consists of two reaches (**Appendix A; Appendix B**). The upper portion of the listed stream segment, referred to as Blan1, flows through a confined valley. As the creek flows towards the Clearwater River, it emerges on to an alluvial fan in Blan2, and the riparian corridor is locally degraded (**Appendix B**). Blanchard Creek supports WSCT, rainbow trout, and brown trout (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Blanchard Creek was first included on the 1996 303(d) List as impaired due to habitat alterations and siltation. The 2006 listings for Blanchard Creek include alterations in streamside or littoral vegetative cover, low flow alteration, and sediment/siltation. The 303(d) Listed extent of Blanchard Creek is the lower 2.3 miles, from the North Fork confluence to the mouth at the Clearwater River. Data collected in support of TMDL development verify impairments from the 1996 and 2006 303(d) List.

Field data collection in association with the TMDL assessment on Blanchard Creek did not identify high fines concentrations in riffles. McNeil core data also met target values, although by a small margin. Concerns regarding fine sediment on Blanchard Creek are indirectly indicated by poor pool condition and width to depth ratios. Pool frequency, residual pool depths, and pool extent targets were not met indicating that sediment in excess of the channel transport capacity may be causing pool filling. In all cases, measured values were less than half of target values (**Section 5.0**). Width to depth ratios measured in Blanchard Creek were above target values which also indicate reduced sediment transport capacity and increased fine sediment deposition.

The target for woody vegetation extent was not met in Blanchard Creek. Currently, woody vegetation is about 50% of desired levels. The lack of woody riparian vegetation is also evident in the stream as woody debris aggregates were only 25% of target values (**Section 5.0**).

Although flow was not measured, dewatering was evident on the lower reaches of Blanchard Creek and observed during field assessments and reconnaissance (**Appendix B**; DTM and AGI, 2005).

Suspected Sources and Causes
Results of the sediment source assessment indicate that roads and hill slopes constitute the primary controllable sources of sediment in the drainage (**Table 10-2**). Through GIS analysis, 97 possible road crossings have been identified in the Blanchard Creek basin. These road crossings contribute an estimated 111 tons of sediment to the stream channel (**Section 5.0**). Of that, 33 tons per year is considered controllable (**Section 9.0**). Road density in Blanchard Creek is considered extremely high at 5.6 miles per square mile (USDA Forest Service, 1996), and the road prism abuts the narrow floodplain of Blanchard Creek at several locations in Blan1. Although not quantified, additional sediment delivery from this high density of road surfaces is likely.

Another source of fine sediment is hill slope erosion which accounts for approximately 40 tons of controllable sediment. Vegetation removal and soil disturbances in upland areas from livestock grazing practices are suspected as the primary cause of hill slope erosion in Blanchard Creek (**Section 9.0**).

Streambank erosion accounts for approximately 15 tons of controllable sediment in Blanchard Creek (**Section 9.0**). The volume of sediment derived from streambank erosion is twice as high in Blan1 as in Blan2. The primary land use in upper Blanchard Creek has been timber harvesting, and disturbances associated with this harvesting activity are believed to be the primary cause of streambank erosion on upper reaches of Blanchard Creek. On lowermost Blanchard Creek, a low density of bankline riparian vegetation is likely due to residential development, stream corridor grazing, and dewatering. A series of corrals impinge into the stream corridor. The reduction in riparian vigor through the reach has likely compromised bank integrity and resulted in some increased level of bank erosion.

These sediment sources are suspected as the cause of siltation and at least partially responsible for habitat degradation in Blanchard Creek. Other causes of habitat degradation include removal of woody riparian vegetation and over-widening of the stream channel. A reduction in natural levels of bankline woody riparian vegetation can destabilize streambanks, causing erosion and over-widening of the channel cross section. Removal of woody vegetation has also limited recruitment of woody debris which helps create habitat features such as pools. Timber harvesting and livestock grazing are two land uses in Blanchard Creek that can be linked to these causes of habitat degradation (**Section 9.0**).

Siltation and habitat impairments are also exacerbated by a lack of flows in Blanchard Creek. There are at least two major diversions from the stream and the loss of flows has reduced the ability of the stream to flush fine sediments and support desired riparian vegetation conditions.

Table 10-2. Summary of Identified Problems and Applicable Treatments, Blanchard Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment (Pool infilling)**	**Stream bank sediment (15 tons/year)**	Riparian Area BMPs
			Grazing BMPs
		Road sediment (33 tons/yr)	Roads BMPs
		Hill slope sediment (40 tons/yr)	Forestry BMPs
			Upland BMPs
			Grazing BMPs
			Riparian Area BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool frequency, residual pool depth, width to depth ratio, woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Stream BMPs
			Riparian Area BMPs
			Grazing BMPs
			Forestry BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**None identified**		Preventative
Temperature	**None identified**		Preventative
Metals	**None identified**		Preventative

Recommended Conservation Practices/BMPs

Ongoing efforts by DNRC on Blanchard Creek include riparian fencing, bank shaping, and willow planting. According to the Fish and Wildlife Service (http://montanapartners.fws.gov/mt5c5.htm), a water lease arrangement has been made on lower Blanchard Creek made in which diversions are stopped when Blanchard Creek reaches 3 cfs. "Fish-friendly" diversion structures were constructed in 1993, and the culvert under Highway 200 was also modified to facilitate fish passage. Improved grazing management in the riparian corridor has been initiated by Plum Creek Timber Company and the Department of Natural Resource Conservation. Additional opportunities for improvement of water quality conditions in Blanchard Creek are described below.

The management of fine sediment on Blanchard Creek can be best achieved by first addressing those sources with the largest portion of controllable sediment by volume on an average annual basis. These sources include roads and upland areas.

Road-derived sediment is a likely contributor to habitat degradation along much of the creek. In 2005, 3 road crossings were assessed in lower Blanchard Creek. BMP status at these sites ranged from full to lacking and the potential for additional BMPs was noted at each crossing (RDG, 2006). None of these sites were identified as fish passage barriers or at risk for fill failure. An analysis of potential culvert fill failure (**Section 5.0**) did however estimate that 112 tons of sediment could be delivered to the stream in a given year as a result of culvert failure. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the Best Management Practices for Forestry in Montana (MT DNRC/BMP Work Group, January 2006) and the Montana Streamside Management Zone (SMZ) Law (**Appendix H**). BMPs described in these documents should be applied to road crossings where reduction of sediment delivery is possible, where culvert failure is of concern, and where the stream is adversely affected by roads. The main access road up Blanchard Creek closely follows the creek on much of its length. Due the extent of roads and the proximity of roads to the stream in the Blanchard Creek basin, vegetation enhancement on cut slopes, fill slopes, and where the road prism impinges on the active floodplain and channel margin would increase sediment trapping capabilities. Road closure or road obliterations could be considered in areas that are least used for vehicles or travel.

Much of the listed segment of Blanchard Creek flows through a confined valley that is bordered by fairly steep hill slopes that have been historically logged. Recommended conservation measures on Blanchard Creek include reducing sediment sourcing from these hill slopes through the application of Upland BMPs to reduce sediment production from historic timber harvesting activities. Any future logging-related land management should include Forestry BMPs such as SMZ practices, as well as the voluntary practices developed by the 2006 BMP working group (**Appendix H**).

On lowermost Blanchard Creek, corrals that abut the stream corridor are another likely sources of upland sediment. The application of Upland and Riparian Area BMPs adjacent to the corrals would help reduce upland sediment delivery to the stream and also reduce the potential for excessive nutrient loading to Blanchard Creek and the Clearwater River. Grazing BMPs in upland areas are also recommended to promote vegetative filtering capacity which will reduce sediment delivery.

Improving the extent of woody bankline vegetation throughout the Blanchard Creek stream corridor will improve habitat conditions and reduce sediment delivery from streambank erosion and other sources. Currently, the extent of woody vegetation on the banks of Blanchard Creek is on the order of 42%, whereas the target value for this parameter is over 84%. The degradation of this woody vegetation in the stream corridor is likely primarily associated with riparian grazing, timber harvesting, dewatering, and road encroachment. Riparian Area BMP treatments (**Appendix H**), Grazing BMPs, and Water Conservation BMPs would improve woody vegetation extent along the stream bank, reduce streambank erosion through bank stabilization, and reduce sediment delivery from uplands through increased filtering capacity. Improvement of woody riparian vegetation conditions will also provide preventative measures with respect to temperature and nutrient loading.

Much of the substrate on Blanchard Creek consists of coarse armor that appears largely immobile under current flow conditions. Because of its armored nature, rates of natural bed scour on Blanchard Creek appear low. Bedform diversity is very limited, and the channel typically consists of a very coarse bed that forms long, relatively straight run environments. In order to create more habitat complexity, active restoration techniques targeting habitat enhancement (pool excavation, bar construction, riparian planting, and low flow sinuosity creation) would greatly improve fish habitat within the reach. However, these improvements should be implemented only in conjunction with the maintenance of sufficient flows to provide habitat for identified target life stages.

"Flow alterations from water diversions" is included as a source of impairment on the 2006 303(d) List. Field observations indicate significant dewatering on the lower reaches of Blanchard Creek. This loss of low flows during the irrigation season likely contributes to fine sediment accumulations as well as loss of riparian vigor. Opportunities to increase minimum flow rates in Blanchard Creek may include Water Banking, Water Rights Leasing, and Water Rights Conversions to In-Stream Flows (**Appendix H**). Irrigation System Management, including efficiency improvements and application management may also be designed to reduce low flow depletions on the river. Any flow management scheme should consider the preservation of channel forming (bank full) flows in the reach to promote local scour and associated pool formation and maintenance.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in Blanchard Creek.

Monitoring Needs
Comments received during the public review period suggest nutrient monitoring may be warranted in Blanchard Creek.

10.2.1.3 Buck Creek

Buck Creek is a small tributary to Placid Creek, which flows into the Clearwater River above Salmon Lake. It flows through industrial forest land as well as Lolo National Forest land. The Buck Creek corridor is dominated by a conifer/willow riparian assemblage, and numerous emergent wetlands are present in the upper reaches of the creek.

Indicators of Habitat and Water Quality Limitations
The entire length, approximately 2.5 miles, of Buck Creek was included on the 1996 303(d) List for siltation. Use support as well as sources and causes of water quality impairment were listed as "not assessed" in 2006. Data collected from the TMDL assessment of Buck Creek indicate

that targets related to pool habitat and substrate are all met. In 2007 a fire in the Clearwater drainage burned a large portion of the Buck Creek watershed. A short-term effect of this fire will likely be an increase in sediment loading and fine sediment accumulations in Buck Creek. This could possibly lead to Buck Creek not meeting sediment targets in the near term but should not lead to the re-listing of Buck Creek as impaired due to siltation.

Woody bankline vegetation targets are not which suggests a habitat alteration listing may be warranted (**Section 5.0**). Field crews noted that the vegetation present along Buck Creek consists of shrubs rather than conifers which are typical for the area. Additionally, the bed of Buck Creek is very coarse such that flow infiltration rates are high and dewatering is common.

Suspected Sources and Causes
The suspected sources of degradation on Buck Creek include logging-related physical disturbance of the valley bottom that has increased natural infiltration rates within the channel, and altered soils conditions on the channel margins (**Table 10-3**). Riparian degradation within the reach can be associated with the active disturbance of the creek bottom, as well as historic logging in the riparian zone.

While excess fine sediment does not appear to be an issue in Buck Creek an estimated 15 tons of sediment per year are delivered to the stream from 12 road crossings, of which approximately 5 tons is considered controllable. Road density in Buck Creek is considered extremely high (USDA Forest Service, 1996) at 5.9 miles per square mile. The density of road surfaces in this drainage suggests that additional sediment may be contributed to the stream at locations other than crossings. Sediment loads from streambank erosion (5 tons/year) and hill slope erosion (6 tons/year) were determined to be background loads and no reductions are required.

Table 10-3. Summary of Identified Problems and Applicable Treatments, Buck Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**None**	**Roads (5 tons/yr)**	Road BMPs
Habitat	**Woody vegetation extent, surface flow expression**	**Valley Bottom Disturbance**	Stream BMPs
		Riparian Degradation	Forestry BMPs
			Riparian Area BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs
No water quality or fisheries restoration related projects have been documented in Buck Creek (Blackfoot Challenge, 2005).

The primary issue with regard to habitat integrity on Buck Creek is the disturbed valley bottom and riparian zone. In 2004, field crews noted a recovering riparian area following logging and in the long-term, these impacts will likely be remedied by this natural process. This recovery will include reestablishment of conifers in the valley bottom and soils development in the riparian corridor. In the short-term, however, habitat will be limited to substrate condition and associated flow infiltration.

If aquatic habitat within Buck Creek is deemed to be of priority, then active restoration of the stream corridor would accelerate the natural recovery process. This restoration would include reconstruction of the channel using a well-graded substrate that reduces the permeability of the channel bed, as well as extensive revegetation along the stream bank. These treatments would fall under the category of Stream BMPs. It should be noted, however, that channel reconstruction in the reach will result in the removal of existing dense woody vegetation, which is dominated by shrubs.

Of the 15 tons of sediment delivered from road crossings each year, 4.5 tons is considered controllable through the implementation of BMPs. Plum Creek has surveyed 11 of the 12 road crossings in the basin. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the Best Management Practices for Forestry in Montana (Logan, 2001) and the Montana Streamside Management Zone (SMZ) Law (**Appendix H**). In 2004, field crews noted the presence of weeds (knapweed and oxeye daisy) on and along road surfaces. Weed Management activities described in **Appendix H** are recommended.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing habitat and low flow conditions or creating additional water quality concerns related to sediment, nutrients, temperature, or metals in Buck Creek.

Monitoring Needs
No sediment related impairments have been identified and it is believed that Buck Creek is capable of supporting all beneficial uses. Due to dry channel conditions, chemical and biological samplings have not been conducted and the stream remains listed as not assessed. Chemical and biological samplings under wet channel conditions are recommended to confirm beneficial use support.

Monitoring the effects of recent fires in the Buck Creek watershed is also recommended.

10.2.1.4 Chamberlain Creek

Chamberlain Creek is a second order tributary to the Blackfoot River, flowing into the Blackfoot from the south approximately 2 miles downstream of the Monture Creek confluence. Chamberlain Creek flows approximately 10 miles through BLM, private timber, and private agricultural lands. Private lands are located in the lower seven miles of the channel course. Within the upper reaches, Chamberlain Creek flows through a confined valley and narrow stream corridor. The stream sinuosity is typically low, and the riparian zone is commonly densely vegetated with willows. Just below River Junction Road, approximately ½ mile from the Blackfoot River, Chamberlain Creek emerges onto an unconfined terrace surface. As it approaches the river, its course follows old swales of the Blackfoot River, which form linear strands of wetlands in the Blackfoot River floodplain. Chamberlain Creek supports bull trout rearing and fluvial WSCT (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
In 1996, Chamberlain Creek was listed as impaired by flow alterations, habitat alterations, and suspended solids. Since 1990, Chamberlain Creek has been the focus of a comprehensive fisheries restoration effort (**Section 2.1.4.3**). As a result of these efforts, Chamberlain Creek was found to be fully supporting of all beneficial uses and has maintained this status since 2000.

Suspected Sources and Causes
Due to its fully supporting beneficial use status, limited source assessments were completed on Chamberlain Creek. In an effort to determine sediment delivery from roads in the Middle Blackfoot, sediment loads from roads in 303(d) Listed and non-303(d) Listed basins were estimated. In the Chamberlain Creek basin, 109 possible road crossings deliver an estimated 140 tons of sediment per year to the system (**Section 5.0**). Sediment loads from bank erosion (240 tons/year) and hill slope erosion (285 tons/year) were determined to be background loads and no reductions are required (**Section 9.0**).

Prior to restoration, sources and causes of fisheries impairments in the mid to lower reaches of Chamberlain Creek were identified by Montana FWP and included elevated stream sediment from road drainage; livestock induced riparian vegetation suppression, lack of complex fish habitat, and dewatering (Blackfoot Challenge, 2005).

Recommended Conservation Practices/BMPs
Restoration efforts in Chamberlain Creek began in 1990. Completed projects include road drainage repairs, riparian livestock management changes, riparian fencing, fish habitat restoration, large woody debris placement, improvements in irrigation efficiency (consolidation of ditches, conversion from flood to sprinkler system), water leases, installation of a fish ladder on an irrigation canal, and the purchase of a conservation easement. These efforts have occurred throughout the basin but focused mostly in the lower mile of the stream (http://montanapartners.fws.gov/mt5c9.htm).

While both water quality and fisheries related impairments are believed to have been largely addressed through these restoration efforts, additional reductions in sediment (42 tons/year) could be achieved through Road BMPs. Of 109 possible road crossings in Chamberlain Creek and its tributary drainages, 6 were assessed. Road BMPs implemented at these locations ranged from full to partial. Four of these crossings were identified as potential fish passage barriers. Two sites were also identified as at risk for fill failure. Road crossings that present potential fish passage barriers or are at risk for fill failure should be considered for removal or replacement. Opportunities for additional implementation of Road BMPs should also be explored to prevent excess sediment delivery from this source. While streambank and hill slope erosion are not considered to cause siltation issues in Chamberlain Creek, implementation of appropriate BMPs where they are currently lacking is recommended.

In addition to potential sediment reductions from roads, recommendations for sustaining water quality conditions in Chamberlain Creek include maintaining implemented BMPs for full effectiveness and taking preventative actions as future land uses are undertaken to minimize effects on water quality.

Monitoring Needs
With the substantial number of completed projects and the overall recovery effort, it is recommended that all existing practices be monitored to assess their performance and possible maintenance needs. This data will also prove valuable in determining the most effective management approaches that might be applied to other streams in the area. Montana FWP has taken a lead role in monitoring of recovery efforts and this plan supports the continuation of these activities.

Recent surveys by Montana FWP have found increasing levels of whirling disease in the lower portions of Chamberlain Creek. This increase could be related to fine sediment, elevated water temperatures, and water chemistry conditions in the stream influenced by both human activities and/or the stream's natural morphology. Continued monitoring of these conditions is recommended

10.2.1.5 Cottonwood Creek

Cottonwood Creek is a major third order tributary to the Blackfoot River. The stream originates in the Lolo National Forest, and flows southward through a mix of private and State lands toward the Blackfoot River. Cottonwood Creek is approximately 16 miles long and consists of six reaches (**Appendix A; Appendix B**). The uppermost reach, CttnBlk0, is characterized by a manipulated, relatively straight channel that flows through a harvested valley bottom. Portions of the creek are intermittent in this area due to high infiltration rates. In CttnBlk1, the channel flows on the eastern margin of a topographic depression that appears to be glacial in origin. CttnBlk2 flows through a densely vegetated willow bottom within a moderately confined valley. Numerous wetland complexes are located within the reach. In this area, beaver activity is evident and strongly impacts channel form. Cottonwood Creek becomes a gaining stream as it flows southward. In CttnBlk3, the valley bottom widens significantly, and willows are discontinuous but locally dense. CttnBlk4 has been channelized. CttnBlk5 extends to Highway 200, and this reach is characterized by multiple channels, and broad wetland areas with dense willow margins. Below Highway 200, CttnBlk6 flows through an entrenched valley as it approaches the base level control of the Blackfoot River. Cottonwood Creek has been identified as a core bull trout area (Pierce, et al, 2002b) and supports moderate densities of WSCT and low numbers of bull trout in the upper reaches as well as rainbow and brown trout in the middle reaches and brown and brook trout in the lower reaches.

Indicators of Habitat and Water Quality Limitations
The lower 10 miles of Cottonwood Creek were listed in 1996 as impaired due to flow alterations, habitat alterations and siltation. In 2006, Cottonwood Creek was listed as fully supporting of all beneficial uses. Although it was considered fully supporting, data collected during TMDL development indicate that the stream's potential as a fishery is not currently met and that the 1996 impairment listings are still warranted.

Data collected for TMDL development on Cottonwood Creek indicate that the uppermost assessed reach (CttnBlk0) meets very few targets related to habitat or substrate. This reach has poor conditions with respect to excess fine sediment accumulation and residual pool depth. CttnBlk0 meets no Type I targets relating to substrate particle size and has only half of the expected residual pool depth. In addition, targets for pool extent, woody vegetation extent, and woody debris aggregate extent were not met in this reach. Further downstream, conditions improve at the next assessment site (CttnBlk2), which is approximately 1 mile south of Woodworth Road. Here, the stream has extensive undercut banks, supported by a stable, fine grained cohesive bank toe. All targets were met in this reach except those relating to woody vegetation extent and woody debris aggregate extent. Within CttnBlk3, all measured McNeil core fractions show substantial departure from target values, indicating excess fine sediment in the channel substrate. Downstream, approximately 2 ½ miles upstream of Highway 200 in CttnBlk4, conditions are again relatively poor. Similar to CttnBlk0, Cottonwood Creek in this reach has high fines concentrations, poor pool quality and extent, and low concentrations woody vegetation extent and in-channel woody debris (**Section 5.0**).

This data supports the original 1996 impairment listings of siltation and habitat alterations. Excess sediment is evident in measured substrate values as well as in the quality and extent of pools in the stream. The lack of woody vegetation in areas indicates degradation of the riparian area and subsequent effects of in-stream habitat complexity. While more difficult to quantify, the flow alteration impairment is also justified. Fine sediment accumulations and low riparian vigor coupled with the presence of numerous irrigation diversions suggest that a lack of flows has reduced the ability of the stream to flush fine sediments and support desired riparian vegetation.

Suspected Sources and Causes

The suspected causes of degradation on Cottonwood Creek include excess sediment production and delivery, removal of bankline vegetation, and low flow alterations (**Table 10-4**). In terms of sediment supply, results of the sediment source assessment indicate that upland areas are the largest contributors of sediment to the stream. Sediment from hill slope erosion accounts for 994 tons of controllable sediment. Grazing accounts for the majority of the controllable hillslope load; therefore, it receives the highest percentage of the allocated load at 90%. The remaining 10% is allocated to the smaller forestry hillslope load (Table J-9).

The second largest producer of sediment and associated controllable load is streambank erosion. Of the 295.7 tons of sediment per year delivered to the stream, 106.4 tons is considered to be controllable. Bank erosion is highest in the uppermost reaches (CttnBlk0 and CttnBlk1). Vegetation removal and other disturbances in the channel margin caused by timber harvesting are suspected as the cause of bank erosion in these reaches. Although bank erosion severity declines in the downstream reaches, sediment delivery rates from streambanks remain somewhat elevated. Livestock grazing practices that result in excessive vegetation removal and bank trampling are suspected as the primary cause of bank erosion in the lower reaches. Hay production and the associated removal of vegetation are also suspected as contributing to bank erosion.

A total of 177 road crossings have been identified in the Cottonwood Creek watershed. These crossings deliver an estimated 183 tons of sediment to the stream each year. Of the total sediment load, 30% or 54.9 tons/year is considered controllable through the implementation of BMPs.

The sediment from these multiple sources is suspected as to contributing to both fine sediment accumulations as well as pool habitat degradation on Cottonwood Creek. Valley bottom disturbances are also suspected as contributing to riparian and in-stream habitat degradation. Valley bottom disturbance is most evident in upper reaches of Cottonwood Creek, below Cottonwood Lakes, where the riparian corridor has been logged and the channel has been straightened. In the lower reaches, the stream corridor is grazed, and invasive weeks including knapweed, leafy spurge, toadflax, Canada thistle and bull thistle were noted by field crews. The removal of streambank vegetation has led to channel destabilization in some reaches and removed the source of habitat forming woody debris.

Natural dewatering as well as channel manipulation and irrigation diversions have reduced flows in Cottonwood Creek which has exacerbated excess sediment and poor habitat conditions. Flow infiltration rates in the upper reaches are likely higher naturally but are also likely more severe due to timber harvesting activities in the riparian corridor and straightening of the channel. Two major diversions used for irrigation of hay and pasture grounds are found in the lower reaches.

Table 10-4. Summary of Identified Problems and Applicable Treatments, Cottonwood Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (106 tons/yr)**	Riparian Area BMPs
			Grazing BMPs
			Water Conservation BMPs
			Forestry BMPs
		Road sediment (55 tons/yr)	Roads BMPs
		Hill slope sediment (994 tons/yr)	Riparian Area BMPs
			Grazing BMPs
			Upland BMPs
			Forestry BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality, woody vegetation extent**	**Excess fine sediment**	See above
		Valley bottom disturbance	Stream BMPs
			Riparian Area BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Past restoration efforts on Cottonwood Creek have focused on improving in-stream flows and addressing fish entrainment in ditches. Projects performed to date on Cottonwood Creek including the installation of fish ladders at diversions and fish screens in canals immediately below points of diversion, as well as the lining of canals to reduce seepage losses. There has also been some water leasing to improve instream flows, and conversion of flood irrigated lands to sprinkler to improve water use efficiency. The conversion of this irrigation system also resulted in the closing of one ditch. Additional measures that have been taken on Cottonwood Creek include riparian grazing improvements (Blackfoot Challenge, 2005). Similar treatments to those that have already been applied are recommended for the continued recovery of Cottonwood Creek.

In the upper reaches of Cottonwood Creek, especially where the creek flows parallel to Cottonwood Lakes Road, historic logging has affected cover conditions on hill slopes and in the valley bottom. In this area, Upland BMPs will help reduce sediment production from hill slopes. Because of the lack of a riparian buffer on portions of upper Cottonwood Creek, Riparian Area BMPs may be appropriate at the break in slope between the stream valley and the hill slopes. Future logging activities should follow established Forestry BMPs such as Streamside Management Zone (SMZ) practices, as well as the voluntary practices developed by the 2006 BMP working group (**Appendix H**).

The historic channel straightening and riparian logging on upper Cottonwood Creek has resulted in a loss of stream habitat complexity and quality. In addition to treating upland sediment sources in this area, it is also appropriate to incorporate active restoration of the stream corridor in restoration planning. Within the straightened reach, restoration should include Stream BMPs which would consist of channel modifications that would improve sinuosity, slope, bedform complexity, and bankline vegetation density. Any channel reconstruction should use a well-graded substrate in the channel bed that may help to reduce infiltration rates in the stream. Stream BMPs that relate directly to in-stream fish habitat improvements would be an appropriate means to help improve the quality of the fishery.

Between its lowermost crossing at Cottonwood Lakes Road and the Blackfoot River, much of the Cottonwood Creek stream corridor shows evidence of riparian grazing and dewatering. In these areas appropriate Grazing BMPs should be applied to improve bank integrity increase in-channel complexity, and provide shade. Where the stream corridor is actively grazed, Riparian Area BMPs would enhance filtering of surface runoff for sediment, increase shade, and improve woody debris recruitment rates. With regard to flow alterations, opportunities to increase flows may be realized through Water Conservation BMPs, including efficiency improvements and application management. Within the gaining reaches of Cottonwood Creek, where springs augment surface flows, the implementation of Riparian Area BMPs should be prioritized to prevent degradation of the springs. Such protection at the springs and along reaches with upwelling will help keep levels of nutrients, suspended sediment, and water temperatures low throughout the lower portions of the creek.

In 2005, fifteen road crossings were assessed in the Cottonwood Creek basin. All of these sites were located on tributaries to Cottonwood Creek. Four of the sites assessed were noted as lacking any BMPs, six noted partial BMPs while full BMPs were observed at the three sites. Two crossings were assessed on roads that had been closed and vegetation was recovering. Ten of the assessed road crossings were identified as being potential fish passage barriers and potentially at risk for fill failure due to constriction ratio. An additional 13 crossings were identified by the Lolo National Forest as being at risk for fill failure. Thirty percent of road crossings assessed found BMPs to be lacking. If this is extrapolated to the total number of road crossings, it would assume that 53 road crossings would be lacking BMPs. Opportunities for reducing sediment delivery from assessed road crossings are described in RDG, 2006. Road BMPs described in Best Management Practices for Forestry in Montana (Logan, 2001) would provide further sediment reduction from un-assessed road crossings where full BMP implementation is not found. In 2007, BBCTU and the Lolo National Forest replaced an undersized culvert on Cottonwood Creek with a bridge. Completion of this project will allow for fish passage and improve sediment and flow conveyance in the stream reach.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat and low flow conditions or creating additional water quality concerns related to sediment, nutrients, temperature, or metals in Cottonwood Creek.

Monitoring Needs

Monitoring of completed projects on Cottonwood Creek is recommended to assess efficacy and potential maintenance needs. Additionally, field crews noted that at least one instream diversion structure may currently hinder fish passage in Cottonwood Creek. Although no passage assessment was performed, habitat connectivity on Cottonwood Creek should be evaluated, and any barrier conditions remedied.

10.2.1.6 Deer Creek

Deer Creek, in the Clearwater Drainage, is a first order stream that drains into the west side of Seeley Lake. Deer Creek flows 10.3 miles through primarily corporate timber lands with public ownership (Lolo National Forest) in the headwaters and other private lands near the mouth. The upper reaches of Deer Creek consist of alternating confined valleys and open meadows. Some of the unconfined valley bottoms contain emergent wetlands. The lowermost few miles of Deer Creek consist of a coarse grained C channel type.

Indicators of Habitat and Water Quality Limitations

Deer Creek was originally included on the 1996 303(d) List as impaired due to siltation and non-priority organics. In 2006 the stream was listed for sedimentation/siltation. Data collected in support of TMDL development indicate that the sedimentation/siltation listing is warranted but do not support any nutrient or non-priority organic listings. The listed segment of Deer Creek extends from the headwaters to the mouth.

Data utilized in TMDL development indicate that approximately ½ mile above its mouth, Deer Creek has elevated concentrations of riffle fine sediment. While fine sediment concentrations in riffles exceed targets, it is by a narrow margin (**Section 5.0**). Overall, the lower few miles of Deer Creek have been noted as having significantly increased sediment storage relative to upstream. Targets for riffle fine sediment were met at an assessment site seven miles above the mouth. Periphyton samples collected at both sites indicate minor impairment and full use support. Previous assessments have indicated that the stream is lacking in woody debris.

Suspected Sources and Causes

The primary suspected source of fine sediment in Deer Creek is hill slope erosion (**Table 10-5**). Hill slope erosion accounts for 868 tons of controllable sediment and is believed to be caused by timber harvesting activities. The removal of vegetation in upland and riparian areas as well as the landscaped disturbances caused by timber harvesting has reduced sediment trapping and storage capabilities and increased sediment delivery to the stream.

Roads built to access timber harvesting areas have also contributed to fine sediment accumulations in the stream. There are approximately 68 road crossings in the Deer Creek watershed that deliver an estimated 176 tons of sediment per year to the stream (**Section 5.0**). Thirty percent of that load (52.8 tons/year) is considered to be controllable (**Section 9.0**).

Some timber harvesting activities extend down into the Deer Creek corridor which has likely led to accelerated bank erosion rates. The removal of bankline vegetation can lead to bank destabilization which in turn results in accelerated erosion and sediment delivery to the channel. In Deer Creek, sediment from streambank erosion accounts for approximately 38 tons of controllable sediment. Low woody debris concentrations in Deer Creek are also linked to bankline vegetation removal as the source of large woody debris has been reduced through timber harvest activities. Diminished pool habitat quality on Deer Creek is suspected based upon the reported lack of woody debris in the channel.

Table 10-5. Summary of Identified Problems and Applicable Treatments, Deer Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (38 tons/yr)**	Riparian Area BMPs
			Forestry BMPs
		Road sediment (53 tons/yr)	Roads BMPs
		Hill slope sediment (868 tons/yr)	Upland BMPs
			Forestry BMPs
Habitat	**Pool quality (suspected)**	**Riparian degradation**	Stream BMPs Riparian Area BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs
No water quality or fisheries restoration related projects have been documented in Deer Creek (Blackfoot Challenge, 2005).

Recommend conservation measures on Deer Creek include reducing sediment sourcing from hill slopes and roads. On timber harvested hill slopes, Upland BMPs will help reduce sediment production, and Riparian Area BMPs will help reduce sediment delivery to the stream. Any future logging-related land management should include Forestry BMPs such as SMZ practices, as well as the voluntary practices developed by the 2006 BMP working group (**Appendix H**).

Road-derived sediment is a likely contributor to habitat degradation along lower Deer Creek. Of the 68 possible crossings in Deer Creek, 48 have been assessed by Plum Creek Timber Company. In 2005, two road crossings were assessed on Deer Creek as part of TMDL efforts. One site was noted as having partial BMPs while the other site was noted as lacking BMPs. The site where BMPs were lacking was also identified as a potential fish passage barrier. Opportunities for reducing sediment delivery from these crossings are described in RDG, 2006. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**).

The lack of woody debris that has been described on Deer Creek by project stakeholders can be addressed by revegetation of the channel margins, as well as by selective placement of LWD in the channel to promote local scour and improve overall habitat complexity. As such, the Stream BMPs that improve in-stream habitat complexity would be applicable on Deer Creek.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment and habitat conditions or creating additional water quality concerns related to low flows, nutrients, temperature, or metals in Deer Creek.

Monitoring Needs
Aquatic habitat conditions have not been documented in Deer Creek. As pool quality is suspected as a limiting factor to water quality based upon the reported lack of woody debris in the channel, aquatic habitat conditions should be assessed to determine if concerns are warranted.

Comments received during the public review period suggest further nutrient sampling in Deer Creek (particularly in the lower portion) may be needed.

10.2.1.7 Frazier Creek

Frazier Creek is a second order tributary to the Blackfoot River, entering the Blackfoot on the south bank just downstream of Raymond Bridge. Frazier Creek is approximately 3.6 miles long and consists of three reaches (**Appendix A; Appendix B**). Fraz1 is located in the headwaters, where the creek flows through BLM lands in a highly confined, densely forested valley bottom. Fraz2 flows through a semi-confined valley. Fraz3 is characterized by two on-line impoundments, and a poorly discernable channel along much of its course in the lowermost 2 miles. Fraz2 and Fraz3 flow primarily through private lands. Frazier Creek supports genetically pure WSCT, and no other fish species (Pierce et al, 2002b).

Indicators of Habitat and Water Quality Limitations
Impairment causes listed in 1996 for Frazier Creek consist only of flow alterations. In 2006, impairments for Frazier Creek cited on the 303(d) List were expanded to include alterations in streamside or littoral vegetation cover (habitat), low flow alterations, sedimentation/siltation, and nutrients (TP and TKN). The data collected in support of TMDL development confirms all impairments included on the 2006 303(d) List. The listed segment of Frazier Creek extends from its headwaters to its mouth.

Data were collected in support of TMDL development on lower Frazier Creek, where the valley is unconfined and land uses are agricultural. With regard to excess sediment impairments, riffles substrate targets were met in the assessed reach (Fraz3). However, pool frequency, residual pool depths, and pool extent targets were not met and these departures were used in determining sediment impairments as they typically are a direct consequence of excess sediment in the stream. Measured pool frequency and pool extent values were less than half of target values while measured residual pool depths were less than one-third of target values. The presence of excess fine sediment is supported by the measured concentrations of fine sediment on the bed surface in pool tailouts, which were twice as high as target values in the assessment reach (**Section 5.0**).

Habitat alteration impairments on Frazier Creek are reflected in the extent of woody bank vegetation. In Fraz1, the aerial assessment did not identify indications of habitat degradation within this reach (**Appendix B**). Downstream, however, measured field values in Fraz3 did indicate some degradation as bankline woody vegetation extents were 80% of desired conditions. The reduced woody bank vegetation is also likely linked to low in-stream woody debris aggregates which were half of target values.

Montana DEQ collected nutrient samples from Frazier Creek in 2003. Measured concentrations of TKN and TP were substantially above eco-regional nutrient targets for the growing season. $NO_{3/2}$ concentrations were also above targets (**Section 7.0**). While the nutrient impairments for Frazier Creek are based on only one sampling event, the departures from target values are cause for concern and prompted the final impairment determination.

While optimal stream flows were not determined for Frazier Creek, the identified parameters that are indicative of sediment impairments (pool frequency and residual pool depth) area also indicative of low flow impairments. Low flow impacts are exacerbated by the lack of bedform diversity, and conversely, reduced flows limit pool formation and maintenance.

Suspected Sources and Causes

The total sediment load contributed to Frazier Creek from bank erosion, hill slope erosion and road surface erosion is relatively small compared to other basins in the Middle Blackfoot and Nevada Creek planning areas. Results of the sediment source assessment indicate that upland areas and road crossings are the primary contributors of sediment in Frazier Creek. Streambank erosion does not appear to be a significant source of sediment in Frazier Creek.

The estimated controllable sediment load from hill slope sources is 15 tons per year. Current livestock grazing practices are suspected as the primary cause of hill slope erosion. While it is not addressed in the allocations section of this document (**Section 9.0**), historic timber harvesting on the hill slopes of Fraz2 and Fraz3 may also be another cause of hill slope erosion. Furthermore, the trapping of upland sediment has been compromised by the removal of streamside vegetation, resulting in increased delivery of sediment to Frazier Creek.

GIS analysis identified 8 road crossings in the Frazier Creek basin. These crossings contribute an estimated 10 tons of sediment per year to the stream. Thirty percent of that load is considered controllable through the implementation of BMPs. With respect to sediment from roads, a greater concern than road crossings may be the current road network and its proximity to the stream. Road density in Frazier Creek is 1.9 miles/square mile which is considered high (USDA Forest Service, 1996) but not as high as in other basins. Fraz2 and Fraz3 were noted as having extensive forest access road networks. In Fraz2, road encroachment along the channel margin is evident on the aerial photography. Fraz3, has numerous forest access roads in the valley bottom and adjacent hill slopes.

The sediment from these sources is suspected as contributing to both the high percent fines values and the poor pool habitat conditions on Frazier Creek. Additionally, dewatering of lower reaches has likely limited sediment flushing from the pools, and contributed to reduced extent of bankline vegetation. Two storage reservoirs are located in Fraz3 which are likely used to facilitate irrigation of hay and pasture lands. The withdrawal of water for irrigation may partially explain low flow conditions observed in lower reaches of Frazier Creek.

Vegetation removal from riparian areas is suspected as the cause of habitat degradation. Land uses that occur in Frazier Creek (silviculture, livestock grazing, and hay production) typically involve riparian vegetation alteration to either facilitate these activities or result from these activities. The removal of vegetation, specifically woody riparian species on the immediate bankline, is suspected as a contributing factor in the degradation of pool frequency and quality in Frazier Creek. This linkage is based on scour processes that occur adjacent to bank-rooted vegetation as well as around in-stream woody debris. Channel alterations, including construction of the two in-stream reservoirs have also likely affected in-stream habitat conditions by reducing connectivity in the lower reaches. As such, woody debris recruited into the channel in upper reaches is not delivered to the lower portions of Frazier Creek.

Accelerated hill slope sediment production and delivery, stream corridor grazing, and concentration of livestock adjacent to the stream corridor in lower Frazier Creek are the likely primary sources for elevated nutrient levels identified on the 2006 303(d) List. On lowermost Frazier Creek, a corral/feeding pen is located within 250 feet of the stream channel, and there is no woody vegetation buffer evident in the intervening area. The stream corridor is generally grazed as well. In light of the low volumes of hill slope sediment produced in the basin, upland sediment is suspected to be a relatively minor source of nutrients to Frazier Creek.

Table 10-6. Summary of Identified Problems and Applicable Treatments, Frazier Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Road sediment (3 tons/yr)**	Roads BMPs
		Hill slope sediment (15 tons/yr)	Forestry BMPs
			Grazing BMPs
			Riparian Area BMPs
			Upland BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality/extent, woody vegetation extent**	**Excess fine sediment**	Riparian Area BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Nitrogen & Total Phosphorous**	**Hill slope sediment**	See above
		Livestock Grazing	Grazing BMPs
			Riparian Area BMPs
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Frazier Creek (Blackfoot Challenge, 2005).

Only one of eight possible road crossings was assessed in 2005. While the channel was noted as being stable at this location, BMPs were noted as lacking as gullies in the road mitigated road surface drainage. The culvert at this location was perched and identified as a potential fish passage barrier. This culvert was also identified as potentially at risk for fill failure due to constriction ratio. This crossing should be considered for improvement to reduce sediment, allow for fish passage and eliminate fill failure risk. It is also highly recommended that the roads network in the Frazier Creek drainage be evaluated to assess management needed to minimize sediment delivery to the stream corridor as road extent and road proximity to the stream were noted as potential sediment sources. Specific Roads BMPs practices to apply are outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**).

Lower Frazier Creek would likely benefit from improved flow conditions during the irrigation season. Water Conservation BMPs may provide opportunities to increase minimum flow rates.

Riparian Area BMPs and Grazing BMPs are important conservation measures on Frazier Creek. The application of BMPs in the immediate riparian area that improve woody vegetation densities and reduce livestock density will facilitate recovery of habitat parameters identified as not meeting targets. This includes woody vegetation density, pool conditions, and fine sediment accumulations in pool tailouts. Riparian Area BMPs and Grazing BMPs will also help reduce nutrient delivery to the stream channel.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient and low flow conditions or creating additional water quality concerns related to temperature, or metals in Frazier Creek.

Monitoring Needs
Nutrient impairment determinations for Frazier Creek are based on a single sampling event. Further nutrient sampling is recommended to confirm impairments and potential loading sources.

10.2.1.8 Kleinschmidt Creek

Kleinschmidt Creek is a first order spring creek tributary to Rock Creek, draining the southern margin of Kleinschmidt Flat. The creek is approximately 2.6 miles long and flows primarily through private lands. Kleinschmidt Creek consists of three reaches (**Appendix A; Appendix B**). Klein1 originates at the spring-fed headwaters of the creek, and flows through densely vegetated wetlands that provide seepage flows to the stream channel. The valley margins consist of hummocky glacial deposits that are locally forested. Within Klein 2, which begins at the first Highway 200 crossing, the creek is largely barren with respect to woody riparian vegetation. Numerous road crossings are present in the reach as the creek flows through a series of culverts under Highway 200. Klein3 flows from the last road crossing to the mouth and like Klein2, is lacking woody vegetation. Within this reach, seepage from the margin of Kleinschmidt flat is evident in air photos. Kleinschmidt Creek supports very low densities of juvenile brook trout and fluvial WSCT along with higher densities of brook trout and brown trout (Pierce et al, 2002b).

Indicators of Habitat and Water Quality Limitations
Kleinschmidt Creek was not included on the 1996 303(d) List but was listed in 2006 for alterations in streamside or littoral vegetative cover (habitat), temperature, sediment, arsenic, and copper. Data collected in support of TMDL development confirms listings for all impairments except arsenic and copper.

Upstream of the lowermost Hwy 200 crossing, data collected in support of TMDL development indicate that Kleinschmidt creek has excess fine sediment accumulations and a low pool frequency. Field assessments conducted in Klein2 measured 100% fine sediment in riffles. No pool habitat features were identified during the assessment. These parameters indicate excess sediment loading and loss of sediment transport capacity in the stream. Macroinvertebrate data collected in Klein3 indicate a moderate level of impairment partially due to sediment deposition (**Section 5.0**).

Woody vegetation extent is notably low along the streambanks; in Klein 2, only 11% of the total bankline supported woody vegetation. This is well below target values of 69%. The lack of woody riparian vegetation is also evident as in-stream woody debris aggregates values were only 25% of target values (**Section 5.0**).

While temperature targets are met in Klein3, the stream remains listed as impaired for temperature. Mean modeled daily temperatures in upper reaches were nearly 3 degrees higher than modeled naturally occurring temperatures which exceed the allowable increase described in Montana's temperature standard (**Section 8.0**). Downstream, Klein3 has undergone channel restoration and management changes, both of which have helped reduce temperature in the creek through channel narrowing and riparian recovery. Within this restored reach, temperatures are also reduced by groundwater inputs. In the upstream reaches of Klein1 and Klein2, modeled mean daily temperatures are 15 degrees higher than downstream reaches, further indicating significant groundwater inputs into lower Klienschmidt Creek (Klein3) as it flows along the toe of Klienschmidt Flat.

Metals sampling collected in 2003 and 2005 do not support impairment listings for copper and arsenic as results were below standards (**Section 6.0**). Based on this information, TMDLs for these metals were not developed.

Suspected Sources and Causes
The controllable sediment load contributed to Kleinschmidt Creek from roads, hill slopes and streambanks is 7 tons/year (**Section 9.0**); the third lowest sediment load in the Middle Blackfoot planning area. Of these three sources, roads contribute the largest volume of controllable sediment at 4 tons/year or 64% of the total controllable load. GIS analysis identified at least 8 crossings on Kleinschmidt Creek, three of which are Highway 200 crossings. No road crossings were assessed during TMDL development so it is difficult to identify the overall condition of roads in the Kleinschmidt basin. Some of the sediment load from roads may be attributed to sanding of Highway 200 during the winter although this has not been quantified.

Sediment is also contributed to Kleinschmidt Creek from hill slope and streambank erosion. Hill slope erosion accounts for 2 tons of controllable sediment and is believed to be primarily caused by hay production in riparian and upland areas. Hay production in these areas reduces sediment trapping capacity through vegetation removal. Current riparian area grazing practices are suspected as the primary cause of streambank erosion which accounts for 1 ton of controllable sediment. Bank trampling and hoof sheer caused by unrestricted livestock access to the stream increases bank instability and subsequent erosion.

Fine sediment is suspected as being associated with both fine grained channel substrate as well as poor pool quality. With the relatively low sediment volume contributed from identified sources however, factors other than accelerated sediment delivery may be significant. Primarily, flow depletions and a resulting loss of sediment transport capacity are suspected to be a contributing factor in the observed accumulation of fine sediment in the channel bed upstream of the restored reach.

There is a distinct lack of woody bankline vegetation on Kleinschmidt Creek. This condition may be in part natural due to long durations of soil saturation in a system that gains flow along much of its length. Additionally, land use practices, specifically hay production and grazing, are considered to be contributing factors in the observed scarcity of woody riparian species. In the middle reaches of Kleinschmidt Creek (Klein2), the lack of woody riparian vegetation is suspected as contributing to poor pool conditions, due to a lack of scour-generating instream woody debris.

Elevated temperatures in Klein1 and Klein2 are suspected to be caused primarily by a lack of shade. In turn, this lack of shade is attributed to land uses within the stream corridor. Although not quantified, flow alterations above Klein3 may also contribute to elevated temperatures in Kleinschmidt Creek.

Table 10-7. Summary of Identified Problems and Applicable Treatments, Kleinschmidt Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (1 ton/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Road sediment (4 tons/yr)	Roads BMPs
		Hillslope sediment (2 tons/yr)	Grazing BMPs
			Upland BMPs
	Flows	**Low flow alterations**	Water Conservation BMPs
Habitat	**Pool Extent/Quality, Woody Vegetation Extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
Nutrients	**NONE**		Preventative
Temperature	**Temperatures above Natural Range (above Hwy 200)**	**Riparian degradation**	Grazing BMPs Riparian Area BMPs Water Conservation BMPs
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

Kleinschmidt Creek has been the focus of extensive restoration activities since 1991. These restoration activities have focused on the area below the lowermost Highway 200 crossing. Between 1991 and 2001, over 9,000 feet of Kleinschmidt Creek were reconstructed as E4 and C4 stream types. Large woody debris was incorporated in the restoration efforts to improve instream habitat. Livestock fencing and riparian shrubs were also incorporated into restoration efforts. The goals of these projects were to increase channel sinuosity and pool frequency, decrease mean wetted width, and increase the density of woody debris pieces in the channel (Blackfoot Challenge, 2005). More recently, a project involving stream restoration (1,000 feet), the development of an off-site water system, riparian fencing, and prescribed grazing was implemented on Klein2. Similar practices to those that have already been implemented are recommended to gain further improvements to water quality in Kleinschmidt Creek.

Upstream of the final Highway 200 crossing, temperature and siltation problems persist, and there are opportunities to improve stream function and the associated fishery. Recommended conservation practices in this area include Riparian Area BMPs and Grazing BMPs. These practices would improve bank stability, trap sediment produced in valley bottom pastures and thereby reduce upland sediment delivery, improve shade, reduce temperatures, and promote natural channel narrowing. With the saturated condition of the soils on gaining reaches of Kleinschmidt Creek, it is unclear what the potential is for woody riparian vegetation densities. However, it would be appropriate to revegetate several bankline plots that are under Grazing BMPs with riparian shrubs and trees, and monitor their success.

Roads are evidently a significant source of sediment to Kleinschmidt Creek. Since no road crossings were assessed during TMDL development it is not possible to comment on their current BMP status. An assessment of road crossings in Kleinschmidt Creek is recommended to identify opportunities for the application of Roads BMPs outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**). An assessment of the potential contribution of sediment from road sanding activities would also be beneficial.
While low flow alterations are not indicated as a cause of impairment in Kleinschmidt Creek, it is evident that the current flow regime in Klein1 and Klein2 are influencing sediment conditions in the stream. Applicable Water Conservation BMPs in these reaches is recommended to enhance stream flows that will provide flushing flows and to increase sediment transport capacity.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, and temperature conditions or creating additional water quality concerns related to low flows, nutrients, or metals in Kleinschmidt Creek.

Monitoring Needs
Macroinvertebrate sampling results show a moderate level of impairment may be due to nutrient enrichment. Nutrient sampling is recommended to assess potential nutrient related water quality impairments and sources.

Continued monitoring of completed restoration projects to assess effectiveness, maintenance needs, and other opportunities for additional water quality improvements is recommended.

10.2.1.9 Monture Creek

Monture Creek is major tributary to the Blackfoot River flowing southward 24 miles from a high roadless watershed that borders the Bob Marshall Wilderness to the Blackfoot River. The first 12 miles of the creek flows through public lands (Lolo National Forest) with the remaining 12 miles flowing through primarily private lands. Monture Creek consists of 13 stream reaches (**Appendix A; Appendix B**). Mont1 through Mont4 flows through a largely confined, forested valley bottom. Mont5 extends to the USFS Rd 107 bridge, and consists of a moderately sinuous stream that has active bar formation and lateral channel migration. Mont5 also has extensive woody debris jams that contribute to habitat complexity. Mont6 extends from the bridge to the Dunham Creek confluence; this reach consists of a pool-riffle channel with active sediment storage in both point bars and mid-channel bars. Mont7 consists of a sediment-laden channel with active channel migration and bar formation. In Mont8, the stream emerges from the forested valley to flow through wetland complexes. Mont9 continues to flow through wetland complexes, and the channel locally abuts glacial deposits that form the west valley wall. Mont10 extends to Highway 200, and consists of a sinuous channel that intermittently abuts glacial deposits to the east. Abandoned channel segments support emergent wetlands in this reach. Below Highway 200, Mont11 follows a forested hillslope on its eastern valley margin. Mont12 consists of a pool/riffle-dominated channel that is bound by a moderately dense willow corridor, and Mont13 is entrenched into the valley margin of the Blackfoot River. Monture Creek supports populations of bull trout, WSCT, rainbow trout, brown trout, and brook trout (Piece et al, 2002b).

Indicators of Habitat and Water Quality Limitations

Monture Creek was listed as impaired in 1996 due to siltation and habitat alterations. In 2006, water quality impairment listings were limited to alterations in streamside or littoral vegetative cover (riparian habitat). Data collected in support of TMDL development suggests that the 1996 siltation listing is still warranted as is the 2006 habitat associated impairments.

Riffle substrate targets were met in assessed in reaches of Monture Creek (Mont5, Mont7, Mont10, and Mont12). However, McNeil Core substrate samples indicate excess sediment in Mont5. Elevated pool tailout surface fines were also measured in Mont12. Data collected on Monture Creek in support of TMDL development also indicate that several reaches have less than optimal pool frequency, pool extent, and residual pool depths. Pool frequency targets are not met within Mont10 and Mont12 with values less than half of desired conditions. Although departures are not severe, residual pool depth targets are not met within Mont5 and Mont12. Pool extent values measured in Mont7 and Mont 12 were 60% of target values. Mont7 and Mont10 did not meet width to depth ratio targets and measured values were well above typical conditions for C-channel types (**Section 5.0**). The magnitude and extend of the target departures suggest that the stream has a higher potential for fine sediment transport and pool formation than it currently maintains, which thereby supports the 1996 siltation listing.

Woody vegetation extent is below target values in several reaches of Monture Creek (Mont5, Mont10, and Mont12). However, the magnitude of departure for woody vegetation targets is not as severe as other impaired water bodies of the Middle Blackfoot Planning Area. The lowest measured woody vegetation extent on Monture Creek is approximately 93% of target values (**Section 5.0**).

The departure from sediment and habitat related targets vary greatly from reach to reach in Monture Creek making impairment determinations difficult. The findings of the TMDL do however indicate consistent target departures, including excess sediment in reaches Mont5 through Mont12.

Suspected Sources and Causes

The suspected sources of fine sediment in Monture Creek are primarily hill slopes and stream banks, and to a lesser extent, roads (**Table 10-8**) (**Section 9.0**). Hill slope erosion accounts for 359 tons of controllable sediment while streambank erosion accounts for 208 tons.

Two major land uses are likely to be the cause of both hill slope and streambank erosion. Disturbed soil surfaces and vegetation removal in upland areas associated with historic timber harvesting activities are believed to the primary cause of hill slope erosion. Similarly, harvesting of woody vegetation in riparian areas has led to streambank instability, erosion, and sediment loading. Historic timber harvesting activities are most evident in reaches Mont5 through Mont7. With regard to hill slope and streambank erosion, historic timber harvesting activities are attributed to 80% of the sediment load. Current livestock grazing practices also contribute to hill slope and streambank erosion; 20% of the sediment load is estimated to be derived from these sources. Excessive and unrestricted livestock access to the stream has led to streambank instability, erosion and sediment loading.

Roads account for approximately 52 tons of controllable sediment. GIS analysis identified 121 possible road crossings in the Monture Creek watershed. Road density in Monture Creek is 1.4 miles per square mile which is considered moderate (USDA Forest Service, 1996).

The fine sediment delivered to the channel from the various identified sources likely contributes to poor pool quality in Monture Creek. However, riparian degradation is evident throughout Monture Creek, particularly in Mont5 through Mont13. Woody vegetation removal from riparian areas as a result of historic timber harvesting activities and current livestock grazing practices are directly related to riparian degradation in these reaches. As pool conditions are below potential on several of these segments of Monture Creek, the reduction of woody riparian vegetation is suspected as a contributing factor in the degradation of pool habitat and local overwidening of channel cross sections.

Table 10-8. Summary of Identified Problems and Applicable Treatments, Monture Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (208 tons/yr)**	Riparian Area BMPs Grazing BMPs Forestry BMPs
		Road sediment (52 tons/yr)	Roads BMPs
		Hillslope sediment (359 tons/yr)	Forestry BMPs
			Upland BMPs
			Riparian Area BMPs
			Grazing BMPs
Habitat	**Pool frequency, residual pool depth, woody vegetation extent**	**Excess fine sediment; riparian degradation**	Riparian Area BMPs
			Grazing BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Since 1990, as part of fisheries restoration efforts, restoration activities have been implemented on over nine miles of Monture Creek including riparian fencing, development of low-impact grazing systems, removing of two near stream winter livestock feeding areas, riparian revegetation, and instream habitat restoration through large woody debris placement (2 miles). Major restoration efforts have also occurred on Dunham Creek, a significant tributary to Monture Creek which has reduced sediment delivery downstream. Continued implementation of similar conservation practices and BMPs will further improve water quality conditions in Monture Creek. Additional recommendations are described below.

The recommended conservation practices on Monture Creek consist of fundamental Best Management Practices related to logging, grazing, and roads. If logged areas in the watershed above Dunham Creek are contributing excess fine sediment, Forestry BMPs are recommended to reduce sediment sourcing from harvested hill slopes, and delivery of that sediment to the creek.

Hill slope erosion can be reduced through Forestry BMP measures as defined in the Montana Streamside Management Zone Law, and the practices set forth by the DNRC/BMP Work Group regarding Best Management Practices for Forestry in Montana.

Where the primary land use that abuts the Monture Creek stream corridor is livestock grazing, the recommended conservation practices are all Grazing BMPs and Riparian Area BMPs. Adjacent upland areas that are prone to accelerated sediment production while in agricultural uses would benefit from Upland BMPs. These practices will promote the recovery of woody riparian vegetation on Monture Creek, which will in turn improve bank integrity, reduce fine sediment loading, contribute to habitat complexity, and increase shade.

Of a possible 121 crossings in the Monture Creek watershed, 6 were assessed in 2005 during TMDL development. The six crossings assessed were on tributaries to Monture Creek and no assessments were conducted on the main channel. Five of the assessed crossings were noted as having partial BMPs. The remaining site lacked BMPs. If these observations are extrapolated, all crossings in the Monture Creek watershed could require further BMP implementation. Some of the sites were on roads that had been decommissioned or closed. Three crossings were identified as potential fish passage barriers due to perched culverts and at risk for fill failure due to constriction ratio. An additional site was also identified as at risk for fill failure by the Lolo National Forest. These culverts should be evaluated for replacement to allow for fish passage and reduce failure risks. Other specific recommendations for sediment reductions from assessed crossings are described in RDG, 2006. Un-assessed road crossings should be evaluated to determine if additional BMPs described in the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**) could be applied.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment and habitat conditions or creating additional water quality concerns related to low flows, nutrients, temperature, or metals in Monture Creek.

Monitoring Needs

Continued monitoring of completed restoration projects on Monture Creek are recommended to assess effectiveness, identify maintenance needs, and identify additional opportunities for water quality improvements.

10.2.1.10 North Fork Blackfoot River

The North Fork is the largest tributary to the Blackfoot River. It is a fourth-order stream that headwaters at the Continental Divide in the Scapegoat Wilderness. It flows southward through the Helena National Forest before entering the Blackfoot River Valley approximately one mile downstream of the National Forest boundary. The uppermost reaches of the North Fork Blackfoot River, in the Scapegoat Wilderness Area, flow through bedrock canyons that have experienced forest fire in recent years (most notably 1988). Although the channel is confined in its upper reaches, substantial volumes of stored stream sediment are visible on air photos, suggesting excessive sediment loading. High rates of sediment delivery to the uppermost reaches of the North Fork are potentially a consequence of the recent fires. Near the point where the North Fork exits the Wilderness Area, if flows along the toe of a feature mapped as the "Big Slide"; this feature is an unstable hill slope adjacent to the river that has multiple debris flow scars that extend into the North Fork channel. When the North Fork crosses into the Helena Forest land, upland timber harvesting is evident, and numerous roads cross the river. Further south, the North Fork flows out of the forest and onto Kleinschmidt Flat, where it transitions from an entrenched, bedrock controlled river to a meandering C channel type with sediment storage, active channel migration, and bendway cutoffs. As it flows along the margin of Kleinschmidt Flat, segments of the North Fork are braided, reflecting high sediment loads. Below Highway 200, the North Fork flows through an entrenched corridor that is bound by glacial deposits. The reach has large open point bars that support riparian regeneration. Several abandoned channel segments form arcuate depressions/wetland features. The North Fork supports one of the Blackfoot watershed's largest bull trout spawning populations, fluvial WSCT, rainbow trout, brown trout, and low densities of resident brook trout (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations

In 1996, the North Fork Blackfoot River was listed for habitat alterations and siltation; in 2006 it was found to be fully supporting based on strong long-term recovery of bull trout redd numbers and numbers of all sizes of bull trout and WSCT since 1989. Data reviewed in support of TMDL development confirm that the beneficial uses of the North Fork are fully supported.

Because the North Fork was considered fully supporting in 2006, complete assessment data were not collected for TMDL planning purposes. Substrate data collected in 1992 show some elevated values of fine sediment; several of the samples were collected about one mile downstream of the wilderness boundary, suggesting natural causes of these high fines loads. These high fines values may reflect short-term impacts from the 1998 fires in the upper watershed. Periphyton data collected on the stream in August of 2004 shows no or slight impairment with respect to the siltation index, and depict full support of aquatic life (Weber, 2005).

Although the North Fork has been found to be fully supporting for water quality beneficial uses, fisheries related impairments identified by Montana FWP include localized channel alterations that lack instream complexity, suppressed riparian vegetation, and natural and irrigation caused dewatering in critical bull trout migration corridors (Blackfoot Challenge, 2005). These fisheries related impairments are confined to localized areas in middle reaches of the North Fork. Whirling disease is also present in the lower drainage.

Suspected Sources and Causes

Excess sediment and habitat alterations do not appear to be major water quality concerns in the North Fork. The elevated fine sediment levels measured in the North Fork in 1992 are suspected to be related to 1988 fires in the upper watershed (**Table 10-9**). However, activities below the wilderness boundary and the affected fire area could lead to siltation and habitat issues. Like all other sediment listed streams in the Middle Blackfoot planning area, sediment is delivered to the North Fork from three primary sources. The sediment load from hill slope erosion represents the largest portion of the controllable sediment load (**Section 9.0**). The sediment load from hill slope erosion is a very large number primarily due to the size of the watershed and the effects of fire in the headwaters. A small portion of that load, 8,994 tons/year, is considered to be controllable with appropriate management practices. In general, the controllable sediment load from hill slopes is concentrated in the middle and lower reaches of the North Fork. Sediment from streambank erosion is next in terms of the controllable sediment load (**Section 9.0**). Since this number is estimated from extrapolated values, it is difficult to identify where the highest bank erosion sediment loads occur. GIS analysis identified 79 possible road crossings in the North Fork watershed that deliver an estimated 157 tons of sediment per year to the system, of which 35 tons are considered controllable.

Land uses in the North Fork include timber harvesting, livestock grazing, hay production and irrigation. These current and historic land uses can be linked the sediment sources and controllable sediment loads described above and in **Table 10-9**. Dewatering of the stream, both natural and for irrigation, is of particular concern as flow alterations could potential decrease the sediment transport capacity of the North Fork leading to higher fine sediment accumulation and associated habitat problems.

Table 10-9. Summary of Identified Problems and Applicable Treatments, North Fork Blackfoot River

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (1,964 tons/yr)**	Riparian Area BMPs Grazing BMPs
		Road sediment (35 tons/yr)	Roads BMPs
		Hill slope sediment (8,994 tons/yr)	Riparian Area BMPs
			Forestry BMPs
			Upland BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**None**		Preventative
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

The high native fisheries value of the North Fork has prompted several efforts to address identified fisheries impairments. Since 1989, conservation measures on the North Fork Blackfoot River have included the installation of screening devices on five irrigation diversions, implementation of Riparian Area BMPs in lower reaches, securing of 9 miles of riverfront conservation easements, streambank stabilization at two locations, and irrigation efficiency improvements that involved relocation of a diversion point and ditch retirement. These efforts have resulted in a strong long-term recovery of bull trout redd numbers and numbers and sizes of bull trout and WSCT.

Recommended conservation practices for the North Fork are for continued implementation of Riparian Area BMPs, as well as maintenance of instream flows during the irrigation season. As necessary, roads and logged areas on national forest land should be managed with Roads BMPs and Forestry BMPs to prevent accelerated sediment loading due to human impacts in the future.

Six road crossings were assessed in the North Fork drainage in 2005 as part of the sediment source assessment. All of the assessed sites were noted as having partial BMPs in place. Specific recommendations for sediment reduction are described in RDG, 2006. Three of the assessed crossings were identified as potential fish passage barriers as well as at risk for fill failure. These crossings should be considered for replacement to address these issues. Un-assessed crossings should also be evaluated to determine if additional BMPs described in the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**) could be applied.

In addition to BMPs described above recommendations for sustaining water quality conditions in the North Fork Blackfoot River include maintaining implemented BMPs for full effectiveness and taking preventative actions as future land uses are undertaken to minimize effects on water quality.

Monitoring Needs
No immediate monitoring needs are present for the North Fork. This plan supports the continued monitoring of project effectiveness and fisheries recovery efforts by Montana FWP. This plan also supports the continued post-fire sediment monitoring conducted by the Lolo National Forest since 1989.

10.2.1.11 Richmond Creek

Richmond Creek is a small second order tributary to the Clearwater River, flowing into the upper end of Lake Alva. Richmond Creek flows primarily through corporate timber lands. The course of Richmond Creek is fairly steep, and several sections of the creek have a step-pool channel morphology. Woody debris plays a prominent role in bedform formation along Richmond Creek. The channel is typically confined within steeply sloping hillslopes; as such, it has a very narrow floodplain and riparian corridor.

Indicators of Habitat and Water Quality Limitations
Richmond Creek was included on the 1996 303(d) List as "threatened" due to siltation and non-priority organics. In 2006, impairment listings were limited to sedimentation/siltation. Data collected in support of TMDL development confirm the sedimentation/siltation impairment listings for Richmond Creek but do not support the "threatened" status related to nutrients or non-priority organics. The impairment listings apply to the entire length of Richmond Creek.

The primary indication of water quality limitations on Richmond Creek is elevated fine sediment measured in riffles in 2003. Riffle substrate measurements showed fine sediment values nearly two and three times higher than target values (**Section 5.0**). Macroinvertebrate sampling results showed no impairment and indicate full support for aquatic life. However, periphyton data concluded an elevated siltation index for Richmond Creek but only a minor degree of impairment (Bahls 2004).

Suspected Sources and Causes
The total sediment load derived from hill slope, streambank, and road surface erosion is the lowest of all impaired streams in the Middle Blackfoot planning area. Of a total of 10 tons of sediment delivered to the stream per year from these sources, 5 tons is considered controllable.

Timber harvesting activities in the 1970s and 1980s are believed to the primary cause of hill slope and streambank erosion. Upland and riparian areas have been harvested for timber. Vegetation removal and other disturbances in these areas have led to soil instability, erosion, reduced sediment trapping capabilities, and sediment loading.

An extensive road network which included roads in the stream corridor was built to facilitate timber harvesting activities. Road erosion accounts for 5 tons of the total sediment load and 2 tons of controllable sediment (**Section 9.0**). GIS analysis identified 11 road crossings in the Richmond Creek basin. Road density in the Clearwater-Salmon watershed (where Richmond Creek is located) is estimated to be 4.6 miles per square mile. This is considered to be high (USDA Forest Service, 1996) and suggests that total road surfaces may contribute additional sediment to the stream.

Table 10-10. Summary of Identified Problems and Applicable Treatments, Richmond Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (1 ton/yr)**	Riparian Area BMPs Forestry BMPs
		Road sediment (2 tons/yr)	Roads BMPs
		Hillslope sediment (2 tons/yr)	Riparian Area BMPs
			Upland BMPs
			Forestry BMPs
Habitat	**None**		Preventative
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Richmond Creek (Blackfoot Challenge, 2005).

Recommended conservation objectives for Richmond Creek are to reduce sediment sourcing from hill slopes and roads, and to reduce the delivery of that sediment to the creek. Roads currently cross and closely follow the channel in several places. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**). Locally, where access points cross the channel, woody riparian vegetation has been cleared. These areas would benefit from Upland BMPs to restore cover against the valley bottom.

On timber harvested hill slopes, Forestry BMPs identified in the Streamside Management Zone (SMZ) guidelines, as well as the voluntary practices developed by the 2006 BMP working group are recommended as appropriate measures to reduce sediment production and delivery rates (**Appendix H**).

An evaluation of four culverts on Richmond Creek in 2002 indicated that all four are likely barriers to fish passage (Cahoon, 2005). The majority of the barriers are due to the culvert slope, as well as the water depth at low flow. If habitat connectivity is deemed a priority in the watershed, the removal of these barriers is recommended as a primary conservation measure in Richmond Creek.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment conditions or creating additional water quality concerns related to habitat, low flows, nutrients, temperature, or metals in Richmond Creek.

Monitoring Needs
Comments received during the public review period suggest that further nutrient monitoring in Richmond Creek (particularly the lower portion) may be needed.

10.2.1.12 Rock Creek

Rock Creek is the largest valley tributary to the North Fork Blackfoot River and flows 8.2 miles through public (State) and private lands. Rock Creek is made up of seven reaches between its headwaters and the North Fork Blackfoot River confluence (**Appendix A; Appendix B**). Rock1 flows through glacial deposits above Kleinschmidt Flat, and in this area the stream corridor is bound by dense conifer forest. Rock2 consists of a geomorphic transition zone as the creek flows onto Kleinschmidt Flat. Rock3 flows through a narrow riparian corridor along the margin of Kleinschmidt Flat. Rock4 continues to follow the eastern margin of Kleinschmidt Flat, although riparian densities are high relative to upstream. In Rock5, the channel crosses onto Kleinschmidt Flat, and as it flows onto the glacial deposits of the flat, flow infiltration into the coarse sediment is evident on the air photos (**Appendix B**). The channel is relatively straight, and supports minimal woody vegetation on its banks. Rock6 begins at a fenceline in the middle of Kleinschmidt Flat where there is an abrupt reduction in woody riparian corridor extent relative to upstream conditions. Rock7 extends to the North Fork Blackfoot River. The channel gains surface flow in this reach, as evidenced by increased channel dimensions and increased woody riparian corridor extent relative to Rock6 (**Appendix B**). Rock Creek provides rearing of bull trout, WSCT, brown trout, rainbow trout, and resident brook trout (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
The entire length of Rock Creek was listed in 1996 for flow alterations, habitat alterations, and siltation. Despite restoration efforts along the entire length of the creek, these water quality concerns have persisted since Rock Creek was originally listed in 1996 and the listed impairments in 2006 include alterations in streamside or littoral vegetative covers (habitat), low flow alterations, and sedimentation/siltation. Data collected in support of TMDL development confirms the impairment listings.

Data collected in support of TMDL development, which included 3 assessment sites in three reaches on Rock Creek, identified low residual pool depths, low pool frequencies, high width to depth ratios, and limited woody vegetation extent. Measured residual pool depths in the upper reaches were near but below target values. In the upper reaches, percent surface fines pool tailouts were twice target values. Measured pool frequencies in all assessed reaches were below targets with significant departures in the upper reaches. Restoration efforts have likely narrowed the stream channel. However, width to depth ratios remain above targets set for E/F channel types in the upper reaches and C channel types in the lower reaches (**Section 5.0**). Departures from these targets suggest pool infilling and reduced natural pool formation from excess sediment. These targets also indicate reduced sediment transport capacity, increased fine sediment deposition, and reduced sediment sorting and channel complexity which collectively suggests that flow alterations are contributing to siltation issues.

With respect to riparian habitat and streamside vegetative cover, woody riparian vegetation levels are less than optimal. Woody riparian vegetation in upper reaches of Rock Creek is near desired conditions and is 72% of target values. Moving downstream, woody riparian vegetation conditions decline as current conditions are only 44% of target values. The degradation of riparian habitat may also help explain low pool values due to reduced quantities of habitat forming woody debris.

Suspected Sources and Causes
Results of the sediment source assessment indicate that hill slopes are the primary source of sediment to Rock Creek. Hill slope erosion accounts for 1,730 tons of controllable sediment load in Rock Creek (**Section 9.0**). Two land uses are believed to be the primary cause of hill slope erosion. Livestock grazing is common along Rock Creek and surrounding areas. Current grazing practices have resulted in excessive vegetation removal and soil surface disturbance leading to erosion and sediment delivery. Historic timber harvesting activities in the upper reaches of Rock Creek have also contributed to hill slope erosion and account for 30% of the hill slope sediment load. Adding to hill slope erosion is the presence of multiple invasive weed species along Rock Creek. Weeds also contribute to soil instability and subsequent erosion.

Streambank erosion accounts for approximately 38 tons of controllable sediment and is believed to be caused by current and historic livestock grazing practices and timber harvesting activities in the riparian area (**Section 9.0**). These land uses often result in removal of vegetation and bank destabilization leading to erosion and sediment delivery. Sediment loads from bank erosion in the upper reaches of Rock Creek are minimal and considered mostly natural. The middle reaches of Rock Creek have the highest sediment loads from bank erosion and subsequently the largest controllable loads. Moving downstream, bank erosion rates decrease significantly.

GIS analysis identified 29 possible road crossings in the Rock Creek drainage. These crossings contribute an estimated 40 tons of sediment per year to the system. 5.97 tons of sediment from roads is considered to be controllable through improved management. Road density in Rock Creek is considered moderate (USDA Forest Service, 1996) with 1.3 miles per square mile. Roads closely follow portions of Rock Creek, particularly in Rock4.

While it has not been quantified, sediment and residual materials derived from restoration efforts may be another source of sediment in the Rock Creek system. Sediment produced from these disturbances is expected to decline over time as the stream recovers and stabilizes.

Riparian habitat degradation is evident throughout Rock Creek with perhaps the exception of Rock1. Measured woody riparian values were well below target values in all assessed reaches of

Rock Creek. Again, current and historic livestock grazing practices and timber harvesting activities are believed to be the primary cause of riparian area disturbances. In addition to these activities, there is some rural residential development in the area which may also have affected riparian habitats. Hay production was also noted as encroaching in riparian areas in some assessed reaches.

Rock Creek experiences both natural and human-induced dewatering which has exacerbated excess sediment and degraded habitat conditions. Low flow conditions have reduced the ability of the stream to flush and transport excess sediment and support desired woody riparian vegetation.

Table 10-11. Summary of Identified Problems and Applicable Treatments, Rock Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (38 tons/yr)**	Riparian Area BMPs
			Forestry BMPs
			Grazing BMPs
		Road sediment (6 tons/yr)	Roads BMPs
		Hill slope sediment (1,730 tons/yr)	Riparian Area BMPs
			Grazing BMPs
			Forestry BMPs
			Upland BMPs
Habitat	**Pool frequency, residual pool depth, width to depth ratio, woody vegetation extent**	**Excess fine sediment**	See above
		Low Flow Alterations	Water Conservation BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Restoration work started on lower Rock Creek in 1990. To date restoration activities have occurred along the entire stream. Eight fish passage barriers were removed, and headgates were modified to increase their efficiency. Irrigation efficiency was improved by converting lands from flood to sprinkler irrigation. Several miles of Rock Creek were restored from a straight, over-widened channel to a more sinuous channel with a much lower width to depth ratio. These projects incorporated woody debris clusters, revegetation using shrubs and conifers, and improved grazing management practices. Much of Rock3 has been restored as an E-type channel; restoration elements include channel shaping, bank armoring, and woody debris placement. Rock7 has been largely restored as a C channel type with placed boulders, woody debris, and constructed pool/riffle sequences (Blackfoot Challenge, 2005). In the past two years, a water lease on Rock Creek has kept the stream from going dry during the summer.

Conservation practices that would benefit conditions on Rock Creek relate to upland sediment management, riparian corridor management, and maintenance of instream flows. The application of Upland BMPs to improve upland vegetation conditions will serve to reduce the sourcing and delivery of fine sediment to the creek. Areas grazed by livestock within the Rock Creek corridor should apply Grazing BMPs and Riparian Area BMPs. The implementation of Riparian Area BMPs would also improve riparian habitat by increasing woody bankline vegetation.

Although Rock Creek is prone to natural dewatering as it flows across Kleinschmidt Flat, this natural infiltration is exacerbated by withdrawals during the irrigation season. This loss of low flows during the irrigation season likely contributes to fine sediment accumulations as well as loss of riparian vigor. Minimum flow rates could likely be increased in Rock Creek through the application of additional Water Conservation BMPs.

Numerous restoration projects have been implemented on Rock Creek in recent years. These projects appear to have a high level of success; as such, Stream BMPs that focus on additional channel restoration and habitat improvements are recommended as needs are defined.

In 2005, five road crossings were assessed in the Rock Creek drainage. BMP implementation ranged from full to lacking at these five sites. Specific recommendations for sediment reduction at these crossings are described in RDG, 2006. Four of the assessed crossings were identified as potential fish passage barriers and potentially at risk for fill failure. These crossings should be considered for improvement to address these issues. Un-assessed crossings should also be evaluated to determine if additional BMPs described in the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**) could be applied to reduce sediment.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in Rock Creek.

Monitoring Needs
Continued monitoring of completed restoration projects to assess effectiveness, identify maintenance needs, and identify additional opportunities for improvements to water quality are recommended on Rock Creek.

10.2.1.13 Salmon Lake

Salmon Lake is one of several lakes in the Clearwater River drainage. It is located approximately 7 miles above the Clearwater and Blackfoot River confluence and is approximately 660 acres in size. The lake fishery has historically been diverse with high numbers of stocked trout and kokanee as well as wild populations of bull trout, WSCT, mountain whitefish, northern pikeminnow, peamouth, and other native species. Since the 1990’s, illegally introduced northern pike have been the dominant species. Salmon Lake also supports self-sustaining populations of yellow perch, largemouth bass, and brown trout.

Indicators of Habitat and Water Quality Limitations
Salmon Lake was included on the 1996 303(d) List as impaired due to nutrients, organic enrichment (DO), and siltation. The listing was prompted by fisheries surveys conducted from the 1950s to the 1970s (**Section 2.0**). In 2006, Salmon Lake was found to be fully supporting of all beneficial uses. Nutrient concentrations measured since the mid-1980s appear to be within the normal range, excess algae growth has not been documented and interpretation of Chlorophyll-a

samples concluded that the lake is less nutrient-rich than at the start of the record in the late 1970s.

Suspected Sources
As Salmon Lake was found to be fully supporting, an assessment of potential water quality impairment sources was not conducted. Comments received during the public comment period note an increase in residential development in the watershed is raising nutrient concerns in Salmon Lake.

Recommended Conservation Practices/BMPs
At this time, the only recommendations for maintaining water quality in Salmon Lake are to maintain water quality of tributary inputs and to encourage the implementation of applicable BMPs described in Appendix H where they are not already in place to avoid creating water quality concerns in the future.

Monitoring Needs
This plan recommends further monitoring of water quality in Salmon Lake. Further monitoring will allow for adjustments in management if water quality declines in the future. Current available data should be reviewed in detail to determine monitoring parameters and frequency. Comments received during the review period suggest nutrients, chemical contamination, and temperature in Salmon Lake be evaluated.

10.2.1.14 Seeley Lake

Seeley Lake is one of several lakes in the Clearwater River drainage. It is located approximately 16 miles above the Clearwater and Blackfoot River confluence and is approximately 1,047 acres in size. Seeley Lake supports the largest adfluvial bull trout population in the upper Clark Fork region. The lake fishery is also diverse, with regular stocking of WSCT and kokanee, as well as many self-sustaining native and non-native species (mountain whitefish, peamouth, northern pikeminnow, brown trout, and yellow perch). Northern pike have also expanded dramatically since illegally introduced in the 1990s and have caused major changes in relative species composition.

Indicators of Habitat and Water Quality Limitations
In 1996, Seeley Lake was listed as impaired due to organic enrichment (DO). Seeley Lake was classified as mesotrophic (medium level of nutrients) in the 1970s and this classification was confirmed in the 1990s (**Section 2.0**). Constant or lower sampling values for nutrients, oxygen, and Secchi depth between the 1970s and 1990s coupled with no indication of nuisance algae blooms led to the determination that Seeley Lake was fully supporting of beneficial uses in 2006.

Suspected Sources
As Seeley Lake was found to be fully supporting, an assessment of potential water quality impairment sources was not conducted. However, increasing development and recreation at the southern end of Seeley Lake has raised concerns over nutrients. The outlet arm in particular regularly exceeds Montana standards for turbidity and TSS due to high volumes of speed boat and recreation traffic in this shallow lake region near the outlet from June-August (FWP files

2005-2007). As a result, visible increases in turbidity are evident in the Clearwater River from Seeley Lake to the Morrell Creek confluence. Missoula County photo documentation has also confirmed the gradual encroachment of infrastructure around the lakeshore and conversion of native riparian vegetation to manicured lawns along the Seeley Lake Perimeter and Clearwater River at the outlet (Missoula County Office of Planning and Grants, Missoula County Conservation District). The City of Seeley Lake is also experiencing rapid human population growth and is planning for modifications or upgrades to its septic treatment system.

Recommended Conservation Practices/BMPs

At this time, the only recommendations for maintaining water quality in Seeley Lake are to maintain water quality of tributary inputs and to encourage the implementation of applicable BMPs described in Appendix H where they are not already in place to avoid creating water quality concerns in the future. The issue of turbidity increases in the outlet arm should be examined and addressed as they not only affect the lake, but also the Clearwater River downstream.

Monitoring Needs

This plan recommends further monitoring of water quality in Seeley Lake. Further monitoring will allow for adjustments in management if water quality declines in the future. Current available data should be reviewed in detail to determine monitoring parameters and frequency. Comments received during the review period suggest nutrients, chemical contamination, and temperature in Salmon Lake be evaluated.

10.2.1.15 Wales Creek

Wales Creek is a second order tributary to the Blackfoot River. Wales Creek flows approximately 9 miles through public (BLM) lands in the headwaters and private lands in the lower drainage. Its confluence with the Blackfoot River is approximately ¼ mile upstream of Raymond Bridge on the south bank. For the purposes of water quality restoration planning, Wales Creek consists of a single two mile reach which begins at an on-channel reservoir (**Appendix A; Appendix B**). Immediately below the reservoir, Wales Creek flows through a moderately confined valley bottom. Multiple ditches parallel the creek below the reservoir. The channel maintains a narrow riparian fringe as it flows toward the Blackfoot River. Immediately above its confluence with the Blackfoot, Wales Creek is largely devoid of woody riparian vegetation. The fisheries species composition within Wales Creek consists of fluvial westslope cutthroat trout and brown trout below the reservoir and genetically pure, resident westslope cutthroat trout above the reservoir.

Indicators of Habitat and Water Quality Limitations

The listed segment of Wales Creek is just over 2 miles long, extending from the reservoir outlet to the Blackfoot River. Wales Creek was included on the 1996 303(d) List as impaired due to flow alterations and siltation. Wales Creek is listed on the 2006 303(d) List for low flow alterations, alterations in streamside or littoral vegetative covers (habitat), nitrogen, phosphorous, sedimentation/siltation, and chlorophyll-a. Data collected and reviewed in support of TMDL development support all impairment listings for Wales Creek.

Due to access limitations, Wales Creek was not assessed in 2004. The data used to identify sediment related water quality limitations were collected by DEQ in 2003, and consisted of substrate and macroinvertebrate samples. None of the targets developed for these parameters were met in Wales Creek. Measured riffle substrate fines were nearly double target values (**Section 5.0**). The macroinvertebrate scores indicate a moderate level of water quality impairment. Analysis of a periphyton sample collected in September, 2003 from a site about one quarter mile above the mouth also indicated moderate impairment and partial support for aquatic life due mostly to siltation (Bahls 2004). The accumulation of fine sediment in riffles and the siltation findings from periphyton sampling suggest that low flow conditions may add to sediment transport and storage limitations of the stream.

In September 2003, Montana DEQ collected nutrient samples in Wales Creek. The results show significant departures for $NO_{3/2}$ and TP. Measured values included 0.04 mg/L $NO_{3/2}$, compared to the 0.02 mg/L eco-regional growing season target; and 0.076 mg/l TP, compared to the 0.01 mg/L eco-regional seasonal target for TP. Chlorophyll-*a* samples collected during the same sampling event returned a value of 105 mg/m^2, which is slightly above the aquatic life use support guidance value of 100 mg/m^2 (**Section 7.0**).

Results of the aerial assessment indicate that the woody riparian corridor is degraded along the listed stream segment (**Appendix B**). This lack of woody riparian vegetation is most evident in the lowermost portion of Wales Creek near its mouth. This degradation consists of almost a wholesale loss of woody riparian species, which supports the TMDL listing for alterations in streamside vegetative cover (habitat).

Suspected Sources and Causes

The suspected sources of fine sediment on Wales Creek include streambanks, hill slopes, and roads (**Table 10-12**). Streambank erosion is estimated to be the largest contributor of fine sediment and accounts for 80% of the controllable sediment load from these sources. Erosion of streambanks and sediment delivery is believed to be caused by livestock grazing practices (excessive and unrestricted access to the stream) and hay production in the riparian area which have resulted in removal of vegetation and destabilization of streambanks (**Section 9.0**).

Sediment from hill slope erosion also contributes to fine sediment in Wales Creek. Hillslope erosion accounts for approximately 23 tons of controllable sediment (**Section 9.0**). Current livestock grazing practices in upland areas are suspected as the primary cause of hill slope erosion. It should be noted however that timber harvesting has occurred on the hill slopes in Wales Creek and these practices may be contributing to hill slope erosion and sediment loading.

Roads constructed to facilitate land uses such as timber harvesting also contribute to sediment accumulations. GIS analysis identified 4 road crossings in the Wales Creek watershed that contribute an estimated 6 tons of sediment per year to the stream (**Section 5.0**). A small portion of this load, 1.68 tons, is considered to be controllable through improved management. Road density in Wales Creek is 0.7 miles per square mile. At least a portion of an access road closely bounds the stream corridor.

Low flow alterations are also suspected as a source of the fine sediment accumulations in the channel. An aerial photo assessment indicates that a substantial amount of instream flows are diverted into the reservoir. Multiple ditches parallel the creek below the reservoir conveying water for irrigation and significantly dewater the stream. Flow alterations have reduced the ability of the stream to flush fine sediments resulting in excess deposition.

Grazing within the stream corridor is suspected as the primary cause of low woody vegetation density along Wales Creek. Woody riparian vegetation degradation is likely exacerbated by flow alterations that negatively affect riparian health.

The suspected sources of nutrients on Wales Creek include streambank erosion, as well as stream corridor access by livestock. No corrals/feeding pens were identified as affecting the stream corridor, however significant grazing in the stream corridor creek is indicated by vegetation patterns.

Table 10-12. Summary of Identified Problems and Applicable Treatments, Wales Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Road sediment (2 tons/yr)**	Roads BMPs
		Hill slope sediment (23 tons/yr)	Upland BMPs
			Grazing BMPs
			Forestry BMPs
		Stream bank sediment (96 tons/yr)	Grazing BMPs Riparian BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Excess Fine Sediment Low Woody Vegetation Extent**	**Excess fine sediment**	See above
		Riparian degradation	Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Nitrogen Total Phosphorous**	**Stream Bank Sediment**	Riparian BMPs
		Livestock Grazing	Grazing BMPs
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Previous projects implemented on Wales Creek include the development of a riparian pasture upstream of the reservoir in 2004 intended to reduce grazing pressure on the riparian area.

Recommended conservation practices on Wales Creek are intended to address excess fine sediment accumulations, poor woody vegetation extents and elevated nutrient concentrations. These measures include fundamental BMPs related to roads, grazing, uplands, riparian area, and forests, as well as in-stream flow maintenance practices to promote sediment flushing and recovery of impacted riparian vegetation.

Roads currently cross and closely follow the channel in several places. Due to access, none of the identified road crossings were assessed. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**).

Upland BMPs would be appropriate on flood irrigated lands on the south side of the creek below the reservoir. Such practices would help reduce sediment sourcing and delivery from flood irrigated areas. Grazing BMPs and Riparian BMPs are also highly recommended for Wales Creek. These practices may be most beneficial in the lowermost reaches of Wales Creek where the riparian degradation appears most severe. Riparian BMPs and Grazing BMPs are also recommended to reduce nutrients in Wales Creek. These BMPs should focus on reducing grazing pressure within the stream corridor, which would reduce direct inputs from cattle into the creek, facilitate the filtration of surface runoff, and promote vegetative recovery that will in turn reduce the delivery of nutrient-laden bank sediment to the channel.

The diversion of flows out of Wales Creek at the reservoir likely contributes to fine sediment accumulations as well as loss of riparian vigor downstream. Opportunities to increase minimum flow rates may be found in Water Conservation BMPs. Irrigation System Management, which may include converting flood irrigated areas below the reservoir to sprinkler, may be an appropriate consideration in an attempt to increase low flows.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, and low flow conditions or creating additional water quality concerns related to temperature or metals in Wales Creek.

Monitoring Needs
The status of completed projects on Wales Creek is not well documented. Monitoring of the completed project to assess efficiency and maintenance needs is recommended.

Nutrient impairment determinations for Wales Creek are based on one sampling event. Further sampling should be conducted to confirm nutrient impairments, potential sources, and mitigation opportunities.

10.2.1.16 Ward Creek

Ward Creek is a second order tributary that feeds into Browns Lake and Kleinschmidt Lake. Ward Creek originates on Arrastra Mountain and flows approximately 17 miles through mixed ownership with the lower 6 miles exclusively on private land. Ward Creek consists of eight reaches (**Appendix A; Appendix B**). Ward1, in the stream's headwaters, flows through a confined, densely forested valley. In Ward2, the channel emerges into hummocky glacial terrain. Ward Creek then flows through broad, open meadows within Ward3. The channel definition within Ward3 is highly variable (**Appendix B**). Ward4 is bound by numerous access roads, and the channel is relatively confined by valley walls. In Ward5, the channel flows through open meadows in which the channel has been relocated and channelized on the valley margin. Ward6 extends to Highway 200, and consists of a narrow straight channel with a small on-line impoundment. Below Highway 200, Ward7 consists of a small meandering E type channel with locally dense woody riparian vegetation. This section of densely vegetated valley bottom also contains the headwater spring of Kleinschmidt Creek. Ward8, which extends from the Road

#112 crossing to Browns Lake, supports minimal woody vegetation in the riparian zone. Ward Creek supports resident brook trout, but no native salmonids (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations

Ward Creek was listed in 1996 for flow alterations, and is included on the 2006 303(d) List for physical substrate habitat alterations and sedimentation/siltation. TMDL development has confirmed that all of the impairment listings are justified. The listed segment of Ward Creek is above Browns Lake.

The data collected on Ward Creek in support of TMDL development indicate high levels of fine sediment in the creek, poor pool frequency, shallow residual pool depths, excessive width to depth ratios, and low woody vegetation extent. All of these suggest a relatively poor aquatic habitat condition on the creek.

Ward1, in the stream's headwaters, flows through a confined, densely forested valley that displays no indicators of degradation on aerial photography (**Appendix B**). Below this headwaters reach, dirt roads encroach on the channel corridor, and adjacent hill slopes have been clearcut. Both Ward 3 and Ward4 show evidence of riparian degradation on aerial photography; some incision on this section of creek has been described by local observers. Immediately downstream, in the middle reaches of Ward Creek, none of the sediment or habitat related targets were met. Measured percent fines in this reach were three times target values and pool tailout fines were nearly double values set for C-channel types in the Middle Blackfoot planning area. Pool frequency and pool extent were also well below target values. Width to depth ratios in this reach were measured as 27.4 compared to a target range of 12 to 19 (**Section 5.0**). These parameters indicate that the stream has a reduced sediment transport capacity, increased fine sediment deposition and infilling, and reduced sediment sorting and channel complexity.

Channel conditions improve greatly downstream of Highway 200 as Ward Creek approaches Browns Lake, however sediment and habitat related impairments are still evident. Fine sediment in riffles are well below target values but fines in pool tailouts remain elevated. Measured pool frequency in this reach is equal to target values (**Section 5.0**). However, residual pool depth and pool extent targets are not met, indicating that although the number of pools is appropriate for a given length of channel, the volume of water held in these pools is markedly low.

Similar to sediment and in-stream habitat, riparian habitat improves in the downstream direction. Measured woody vegetation extent in the middle section of Ward Creek upstream of Highway 200 (Ward5) is only 30% of desired conditions. Near Browns Lake, woody vegetation in is equal to target values. In both reaches, in-stream woody debris aggregates are well below target values. Even though woody vegetation extent is higher in the lower reach, no in-stream woody debris aggregates were measured in this reach.

While flow changes in Ward Creek have not been quantified, the data suggest that flow alterations (both natural and human caused) may have reduced the ability of the stream to effectively transport sediment and support desired riparian vegetation.

Suspected Sources and Causes
Results of the sediment source assessment indicate that hill slopes are the primary contributor of sediment to Ward Creek (**Table 10-13**). The sediment load from hill slope erosion accounts for 35 tons of controllable sediment in Ward Creek. The cause of hill slope erosion in Ward Creek is believed to be current livestock grazing practices which have resulted in surface soil disturbances, excessive vegetation removal, reduced sediment filtering capacity, and subsequent sediment loading. While it is not noted in the sediment load allocation (**Section 9.0**), extensive historic timber harvesting in the upper reaches of Ward Creek is a likely contributing factor in hill slope sediment production.

Stream bank erosion is another source of fine sediment in Ward Creek and accounts for approximately 23 tons of controllable sediment (**Section 9.0**). Current livestock grazing practices in the riparian area are believed to be the primary cause of streambank erosion. Un-restricted access to the stream by livestock has led to destabilization of the stream banks and subsequent erosion. Woody riparian vegetation removal during historic timber harvesting activities has also led to bank destabilization. This is most evident in Ward3 where timber harvesting was noted as extensive and where bank erosion rates are also the highest.

Of the three major sediment sources, roads contribute the smallest total and controllable sediment load. GIS analysis identified 16 possible road crossings in Ward Creek. These crossings are estimated to deliver 14 tons of sediment per year to the stream (**Section 5.0**). In addition to the road crossings, numerous access roads that bind the stream in Ward4 are also likely to contribute sediment in this reach. Road density in Ward Creek is considered high at 2.6 miles per square mile (USDA Forest Service, 1996).

A significant portion of the total sediment load delivered to Ward Creek is derived from streambanks, whereas roads contribute the lowest portion of the total load (**Table 10-13**). These sources are suspected as contributing to fine sediment loading in the creek, which in turn has resulted in pool degradation. The low extent of woody vegetation between the National Forest Boundary and Highway 200 may be in part due to natural soils/moisture conditions in the localized wet meadow areas, however the grazing that has occurred has likely reduced the natural extent and density of woody species. The over-widened condition measured on this middle section of Ward Creek (Ward5) is also likely due to riparian grazing, although in several areas of the drainage, current grazing pressure is relatively low.

Riparian habitat degradation and low levels of woody vegetation extent are suspected as being caused by the various land uses in the area. Historic timber harvesting was noted as extensive in the upper reaches and harvesting in the riparian area is evident. Agricultural land use practices including grazing and hay production have included the removal of woody streamside vegetation in the middle portions of Ward Creek, as well as portions of the lower reaches downstream of Highway 200. The loss of woody riparian vegetation is also likely linked to poor pool frequency and extent as the source of in-stream woody debris has been reduced.

Flow alterations are suspected as exacerbating issues related to fine sediment accumulations and low extents of woody bank line vegetation. Although a detailed analysis of flow conditions was not conducted, several diversions are present along the lower reaches of the stream suggesting that irrigation could play a role in fine sediment buildup due to a lack of flushing flows.

Table 10-13. Summary of Identified Problems and Applicable Treatments, Ward Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (23 tons/yr)**	Riparian BMPs
			Grazing BMPs
			Forestry BMPs
		Road sediment (4 tons/yr)	Roads BMPs
		Hill slope sediment (35 tons/yr)	Upland BMPs
			Forestry BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality and extent; overwidening; woody vegetation extent**	**Excess fine sediment**	See above
		Channelization	Stream BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Within the Ward Creek watershed, over 4,500 acres of land in three Waterfowl Production Areas are owned by the US Fish and Wildlife Service. The US FWS also holds 3,840 acres of land in the Ward Creek watershed in conservation easements. Between 2005 and 2007, several restoration activities have been implemented in Ward5 in an attempt to address several water quality concerns. These activities include off-stream water development, channel restoration (300 ft), riparian revegetation, irrigation structure improvements, riparian and wetland fencing, water gap installation, and grazing management. Similar practices to those that have been implemented are recommended for further improvement of water quality in Ward Creek.

The conservation practices recommended for Ward Creek are intended to help reduce fine sediment accumulations in the creek, to promote recovery of the channel cross section, and to maximize natural bank line vegetation potential. If the cross section shape is improved, woody vegetation established, sediment loading diminished, and low flows maintained, Ward Creek has the potential to provide significantly better aquatic habitat than current conditions provide.

Hill slopes have been identified as primary contributors of sediment to Ward Creek. Grazing BMPs are recommended as a primary means of reducing hill slope sediment production. Additionally, the extent of logged areas immediately adjacent to the channels suggests that these areas are continuing to produce and deliver sediment to the stream. In these areas, Upland BMPs would reduce sediment production and delivery to the creek. Any ongoing logging in the area should subscribe to the Forestry BMPs outlined in the Montana Streamside Management (SMZ) law, and incorporate the voluntary Best Management for Forestry practices developed by the Montana DNRC/Montana BMP Work Group in January 2006.

In the hayed and grazed valley bottoms of Ward Creek, Riparian and Grazing BMPs are recommended to maximize stream bank stability, growth of woody bank line vegetation, and recovery of the channel cross section from historic impacts. In areas where the channel is notably over-widened, such as in the privately owned valley bottoms upstream of Highway 200, active channel restoration work through Stream BMPs would allow reconstruction of a an appropriate cross section that would promote channel recovery much faster that more passive BMPs associated with land use change. Any channel restoration work on Ward Creek should focus on achieving a channel slope/cross section configuration that ensures effective sediment transport and provides significantly increased habitat complexity. Numerous segments in the middle reaches of Ward Creek are markedly straight and appear to have been relocated onto the valley margin to facilitate hay production. Channel restoration opportunities in these areas include a significant increase in channel sinuosity, coupled with improved floodplain access in reportedly incised reaches.

Only one of a possible 16 road crossings was assessed during TMDL development. Partial implementation of Road BMPs were noted at this site which was also identified as a fish passage barrier due to a perched culvert. Although roads have not been identified as a significant sediment source in the Ward Creek watershed, the road crossings and road surfaces that are present should continue to be managed using the Roads BMPs outlined by the Montana DNRC/BMP Work Group (**Appendix H**).

Opportunities to increase minimum flow rates may be identified through Water Conservation BMPs. The improvement of instream flows on Ward Creek would help flush fine sediment from the channel bed, and help recover woody riparian vegetation stands where soil moisture conditions are appropriate.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in Ward Creek.

Monitoring Needs
A restoration effectiveness monitoring program has been implemented for the recently completed projects on Ward Creek. Continued monitoring of the completed projects is recommended to assess efficiency, maintenance needs, and additional opportunities for improvements to water quality.

10.2.1.17 Warren Creek

Warren Creek is a small 2nd order tributary to the Blackfoot River and flows approximately 14 miles through a mixture of State and private lands. Warren Creek is made up of 12 reaches (**Appendix A; Appendix B**). The uppermost reach, Warr1, flows off the flank of Ovando Mountain, from bedrock onto glacial deposits of the Blackfoot River Valley. Within this reach the stream channel is moderately confined and bound by dense conifer forest (**Appendix B**). In Warr2, the stream flows into a broad valley with open meadows. As Warren Creek approaches Highway 200 in Warr3, there is an abrupt reduction in woody riparian density. Warr4 is a short channelized reach downstream of Highway 200. In this reach, the channel is bordered by berms of excavated material, which has created an entrenched channel cross section with very limited floodplain area. Warr5 has a severely degraded riparian corridor, and loss of channel definition is evident within the reach. In Warr6, the channel has been relocated northward of its historic course, and the current channel course is bordered by a well defined but narrow riparian thread. The channel definition in Warr7 is highly variable, and valley bottom wetlands coupled with increasing channel definition in the downstream direction suggest groundwater seepage inputs into the reach. From Rd 104 downstream, Warr8 is characterized by a marked increase in woody riparian cover relative to upstream. The riparian cover extent is substantially less downstream in Warr9, which consists of a very sinuous channel with a severely degraded riparian corridor. Groundwater seepage is evident in Warr10 in the form of a boggy valley bottom and a multiple active channel threads. Warr11 consists of a sinuous channel that has several channelized segments and a severely degraded riparian corridor. Approaching the Blackfoot River, Warr12 is entrenched within the northern valley wall of the Blackfoot River. Surveyed fish populations in Warren Creek document a mixed species composition of brook trout, brown trout, and low numbers of WSCT (Pierce et al, 2002b).

Indicators of Habitat and Water Quality Limitations

The listed segment of Warren Creek includes its entire length from the headwaters to the confluence with the Blackfoot River. Warren Creek was initially included on the 1996 303(d) List for low flow alterations. Listings for low flow alterations continued in 2000 and habitat alterations were added as well. In 2006, Warren Creek was listed as impaired due to low flow alterations and fish passage barriers. Data collected in support of TMDL development indicate that the low flow alteration listing is warranted and at least one potential fish passage barrier was identified. Additionally this process identified excess sediment as a limiting factor for water quality.

Assessments were conducted along five reaches of Warren Creek. The data collected from these sites led to the development of sediment TMDLs as the stream showed consistent departures from targets for pool frequency, pool extent, and residual pool depth. Although five reaches on Warren Creek were assessed, only two of those assessments recorded any pool habitat features. Where pools were mapped, residual pool depths were less than half of target values and fine sediment accumulations were evident in pool tailouts. Macroinvertebrate sampling in the middle reaches of Warren Creek revealed large percentages of filter feeders and corresponding low metric scores suggesting that fine sediment is affecting aquatic life (**Section 5.0**).

In middle portions of Warren Creek, irrigation withdrawals support livestock and hay production, and result in significant dewatering of the creek. The combination of fine sediment accumulations and agriculturally-related dewatering suggests that low flow alterations have impacted sediment transport conditions in Warren Creek resulting in increased fine sediment deposition and a consequent reduction in habitat quality.

While habitat alterations or alterations in streamside or littoral vegetative covers are not reflected in the impairment listings for Warren Creek, it should be noted that measured woody vegetation extent values were not met in four out five assessed reaches (**Section 5.0**). In some cases, woody vegetation was completely absent. The lack of woody vegetation along Warren Creek may also be linked to reduced habitat complexity as the source of in-stream woody debris, a habitat forming feature, has been reduced. In-stream woody debris aggregates were also absent in some reaches.

Suspected Sources and Causes
Results of the sediment source assessment indicate that roads are a primary of source of sediment on Warren Creek (**Table 10-14**). GIS analysis identified 43 possible road crossings in the Warren Creek watershed. These crossings are estimated to contribute 238 tons of sediment per year to the stream of which approximately 71 tons are considered to be controllable through management (**Section 9.0**). It should be noted however that only one road crossing was assessed in the entire Warren Creek watershed during the source assessment. This particular crossing delivered a high sediment load which was used to estimate total sediment loading from roads through extrapolation and may have skewed the results of this analysis. Road density in Warren Creek is considered high (USDA Forest Service, 1996) at 3.1 miles per square mile. Sediment delivery from these road surfaces also likely contributes to excess fine sediment conditions in Warren Creek.

Streambank and hill slope erosion also contribute sediment to Warren Creek. Streambank erosion accounts for 26 tons of controllable sediment (**Section 9.0**). Current livestock grazing practices which include grazing in the riparian area are believed to be the primary cause of streambank erosion. Excessive vegetation removal and bank trampling as a result of livestock grazing has destabilized banks leading to erosion and sediment loading. Although bank erosion rates are highest in Warr11, Warr12, and Warr3, elevated sediment delivery from streambanks was also identified in Warr5, Warr6, Warr7, Warr8, and Warr10.

Livestock grazing practices are also suspected as the primary cause of hill slope erosion accounting for 18 tons of the controllable sediment load. Hay production practices have also been identified as a potential cause of hill slope erosion (**Section 9.0**). In both cases, reduced sediment filtering capacity from excessive vegetation removal in upland areas as a result of these practices is believed to lead to increased sediment delivery.

Collectively, these sediment sources are suspected as related to the poor pool conditions on Warren Creek. Low flow depletions are also suspected as contributing to degradation of pool habitat, as well as to the absence of substantial woody bankline vegetation. Irrigation diversions are present along several reaches of Warren Creek, primarily in the lower 6 miles. The most significant impact of the irrigation withdrawals appears to be in the middle reaches of Warren Creek; in lower reaches, the problem is less severe as groundwater inputs maintain perennial flow conditions.

Numerous sections of Warren Creek have been channelized, and this channelization has impacted the creek by reducing natural pool frequency and associate habitat complexity. The habitat downstream of Warr2 has been homogenized by channelization to the point where pools or stream channel obstructions that might create pools are minimal. The loss of woody riparian vegetation is also suspected as contributing to in-stream habitat issues as woody debris, a pool forming feature, has been reduced.

Table 10-14. Summary of Identified Problems and Applicable Treatments, Warren Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (26 tons/yr)**	Riparian Area BMPs
			Grazing BMPs
		Road sediment (71 tons/yr)	Roads BMPs
		Hillslope sediment (18 tons/yr)	Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality and extent; woody vegetation extent**	**Excess fine sediment**	See above
		Channelization	Stream BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

Warren Creek has been the focus of extensive restoration efforts beginning in 1991. Projects completed to date include removal of three streamside corrals, improved fish passage at four locations, three miles of channel reconstruction, improved riparian grazing practices (off-stream watering facilities, water gap improvements, riparian fencing, rotational grazing systems), riparian revegetation, conservation easements, and enhanced stream flows in the lower three miles of the stream (Blackfoot Challenge, 2005). Although most of these activities have concentrated on reaches below Highway 200 (Warr4 – Warr12), several projects have been implemented above Highway 200 as well.

As roads have been identified as a primary sediment source in the Warren Creek watershed, all roads and crossings that contribute sediment to the channel should be aggressively managed according to guidelines set forth by the Montana DNRC/BMP Work Group (**Appendix H**). Of the 43 road crossings in Warren Creek, one was assessed. This site was noted as lacking Road BMPs and a potential fish passage barrier and at risk for fill failure due to constriction ratio. Although the culvert was recently reset, these concerns are still present and further actions may be necessary. Sediment delivery issues from this crossing are described in RDG, 2006. Un-assessed road crossings in Warren Creek should be evaluated to determine appropriate sediment reduction measures, removal of fish passage barriers, and fill failure risk reduction.

Although their contributions to sediment in the creek appear somewhat less than roads, the uplands and stream banks should be managed with appropriate BMPs that reduce sediment sourcing and delivery to the channel. These include Upland BMPs for the non-riparian areas adjacent to Warren Creek, Grazing BMPs, and Riparian Area BMPs.

Where Warren Creek has been historically channelized, active stream restoration techniques contained within the suite of Stream BMPs are recommended to improve habitat and water quality conditions. Numerous projects have already been implemented on Warren Creek; it is recommended that these projects be monitored closely such that future projects draw on any lessons learned to date.

Opportunities to increase minimum flow rates may be identified in Water Conservation BMPs. As groundwater inputs improve flow conditions in lower reaches of Warren Creek, Water Conservation BMPs should be most aggressively applied to middle reaches were dewatering is most severe.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in Warren Creek.

Monitoring Needs
Continued monitoring of completed projects on Warren Creek is recommended to assess project efficiency in addressing both water quality and fisheries related issues.

As discussed in Suspected Sources and Causes section for Warren Creek, the sediment load from roads may be overestimated. A more detailed assessment of the sediment contribution from roads may be warranted as part of sediment management efforts in Warren Creek.

10.2.1.18 West Fork Clearwater River

The West Fork Clearwater River is located in the northwest corner of the Clearwater drainage, originating high in the southernmost portion of the Mission Range. The uppermost 3 miles of the West Fork flow through National Forest land; downstream of the National Forest boundary, the river flows for approximately 9 miles through land owned by private timber interests. The West Fork Clearwater River flows into the Clearwater River approximately 3 ½ miles upstream of Seeley Lake. In its upper reaches, the West Fork is closely confined within a narrow stream valley. As it emerges from the confines of the steep terrain into the Clearwater River Valley, its lower reaches develop a more sinuous planform that is characterized by a discreet migration corridor and unvegetated point bars.

Indicators of Habitat and Water Quality Limitations
In 1996, the West Fork Clearwater River was listed as impaired on the 303(d) List for non-priority organics and siltation. The West Fork Clearwater was listed in 2006 as impaired for Chlorophyll-a. The data collected in support of TMDL development confirm the 1996 siltation listing but do not support the Chlorophyll-a or non-priority organic listings.

Limited data was available to determine the impairment status with respect to siltation of the West Fork Clearwater River. Riffle substrate and macroinvertebrate data were collected at two locations on the West Fork Clearwater River by Montana DEQ in 2003. While the macroinvertebrate sampling results were met and full support of aquatic life was determined, measured riffle substrate values for percent fines ≤ 6mm and ≤ 2mm exceeded targets at both locations. In the lower sinuous reaches of the West Fork, the presence of extensive open bar features suggest high sediment loading from upstream (**Section 5.0**). Field reconnaissance into this area revealed local fine sediment buildup in the channel bed. Nutrient and Chlorophyll-a sampling at the same locations did not exceed eco-regional targets (**Section 7.0**).

Suspected Sources and Causes

Streambank, hill slope, and road erosion deliver an estimated 599 tons of sediment per year to the West Fork Clearwater River (**Section 9.0**). Streambank erosion is suspected as the primary contributor of sediment accounting for 62% of the sediment load and 43% of the controllable sediment load from these three sources. While streambank erosion accounts for the largest portion of the total sediment load, hill slope erosion accounts for the largest controllable sediment load (52%) from these sources. Much of the course of the West Fork Clearwater River is in terrain that has been extensively logged. Vegetation removal and soil disturbances in riparian and upland areas as a result of timber harvesting activities is believed to be the primary cause of streambank and hill slope erosion.

Access roads constructed to facilitate timber harvesting activities are another source of sediment in the West Fork Clearwater River. GIS analysis identified 81 road crossings in the drainage which deliver an estimated 42 tons of sediment per year to the stream (**Section 5.0**). While not quantified, it is also likely that additional sediment from the forest access road network is delivered to the stream.

Table 10-15. Summary of Identified Problems and Applicable Treatments, West Fork Clearwater River

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Streambank sediment (115 tons/yr)**	Forestry BMPs
			Riparian Area BMPs
		Road sediment (13 tons/yr)	Roads BMPs
		Hillslope sediment (140 tons/yr)	Riparian Area BMPs
			Forestry BMPs
Habitat	**None**		Preventative
Nutrients	**None**		Preventative
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration projects have been documented in the West Fork Clearwater River. Recommended conservation objectives for the West Fork Clearwater River are to reduce sediment sourcing from hill slopes, streambanks, and roads, and to reduce the delivery of that sediment to the river.

No data was collected on individual road crossings in the West Fork Clearwater River drainage making it difficult to determine the status of Road BMPs or specific sediment reduction measures that are needed. An assessment of road crossings in the West Fork Clearwater drainage is recommended to determine potential sediment reduction activities from this source through the implementation of Roads BMPs developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**).

On timber harvested hill slopes, Forestry BMPs identified in the Streamside Management Zone (SMZ) guidelines, as well as the voluntary practices developed by the 2006 BMP working group are recommended as appropriate measures to reduce sediment production and delivery rates (**Appendix H**). These practices can be augmented with Riparian BMPs to reduce sediment delivery to the channel.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment conditions or creating additional water quality concerns related to habitat, low flows, nutrients, temperature, or metals in the West Fork Clearwater River.

Monitoring Needs
Comments received during the public review period suggest that further nutrient and temperature monitoring in the lower reaches of the West Fork Clearwater River may be needed.

10.2.1.19 Yourname Creek

Yourname Creek is a second order tributary to the Blackfoot River that flows approximately 9 miles through public (BLM) and private lands, entering the Blackfoot approximately ½ mile downstream of the Cedar Meadow Fishing Access. Yourname Creek is located at the southern edge of the Middle Blackfoot planning area boundary and consists of four reaches (**Appendix A; Appendix B**). Reach Your1 is a relatively steep, confined headwaters channel bounded by dense conifers. In reach Your2, the channel lies within a relatively narrow valley bounded by basalts. Reach Your3 supports a continuous narrow riparian fringe in what appears to be a partially cleared alluvial valley bottom (Aerial Assessment: **Appendix B**). In the lowermost reach (Your4), there is a distinct loss in channel definition as the creek approaches the Blackfoot River. Alteration of riparian vegetation is evident in the lowermost two reaches. Yourname Creek supports a genetically pure population of fluvial WSCT with densities increasing substantially in the upstream direction (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Yourname Creek was originally included on the 303(d) List due to flow alterations in 1996. In 2006, impairments in Yourname Creek include low flow alterations, alterations in streamside or littoral vegetative cover (habitat), sedimentation/siltation, and total phosphorous. Data collected in support of TMDL development confirmed all impairments and identified additional impairments for TKN and Chlorophyll-a.

Due to access limitations, available data for determining impairments was limited. Sediment data collected in 2003 by DEQ indicate that Yourname Creek contains high concentrations of fine sediment in riffles. Additionally, macroinvertebrate scores indicate a moderate level of water quality impairment while periphyton sampling results showed a slight impairment due to siltation (**Section 5.0**). Results of the shade assessment associated with the temperature modeling of the area indicates that in lower Yourname Creek, approximately 50% of the bankline supports woody vegetation. Excess fine sediment and low woody vegetation extents also suggest that stream functions are limited by low flows.

Nutrient and Chlorophyll-a impairments are based on sampling conducted by Montana DEQ in 2003. Results from September 12, 2003 returned 0.47 mg/l TKN and 0.14 mg/l TP, above the respective eco-regional growing season targets of 0.32 mg/L and 0.01 mg/L. Chlorophyll-*a* sampling on the same date returned a value of 127 mg/m^2 that exceeds the 100 mg/m^2 guidance level for aquatic life support (**Section 7.0**).

Suspected Sources and Causes
Results of the sediment source assessment indicate that hill slope erosion is a major source of sediment to Yourname Creek (**Table 10-16**) accounting for 189 tons of controllable sediment. Current livestock grazing practices are suspected as the primary cause of hill slope erosion (**Section 9.0**). Soil disturbances and excessive vegetation removal in upland areas from current practices has increased erosion and reduced sediment filtering capacity leading to sediment loading. Hay production practices, historic timber harvesting (Your2), and historic placer mining in upland areas are also believed to contribute to sediment from hillslopes

Sediment from streambank erosion is another significant source of sediment loading in Yourname Creek. Streambank erosion accounts for 95 tons of controllable sediment (**Section 9.0**). Streambank sediment loads are generally low in the upper reaches of Yourname Creek. The highest sediment load from bank erosion is found in lowermost Yourname Creek where 85% of the controllable streambank sediment load is produced. Current livestock grazing practices in this area are believed to be the primary cause of streambank erosion as un-restricted livestock access to the stream has resulted in bank trampling and bank instability.

GIS analysis identified 33 road crossings in the Yourname Creek basin which deliver an estimated 63 tons of sediment per year to the stream (**Section 5.0**). Of the total sediment load from roads, 19 tons is considered controllable through management actions. Road density is considered moderate (USDA Forest Service, 1996) in Yourname Creek at 1.5 miles per square mile. The road network appears to be most extensive in Your2 where access roads were constructed to facilitate timber harvesting activities and closely follow the stream corridor.

Low flow alterations are suspected as related to fine sediment accumulations as well as the low extent of woody bank line vegetation documented in the aerial assessment. Several ditches come off of Yourname Creek as it enters the Blackfoot Valley, and there is a distinct loss of channel definition below these diversions. Natural dewatering has not been identified in Yourname Creek so dewatering from irrigation withdrawals is believed to be the primary cause. Flow conditions in Yourname Creek have likely reduced the ability of the stream to transport fine sediments through the system and support a woody riparian vegetation corridor. Alteration of riparian vegetation is evident in the lowermost two reaches. The lack of bankline vegetation on Yourname Creek is also likely related to agricultural practices in the stream corridor, including grazing and hay production.

The primary suspected sources of nutrients on Yourname Creek are related to stream corridor grazing. One corral was identified as proximal to Yourname Creek, but this corral appears largely unused or abandoned. Remaining potential sources of nutrients include bank sediment, hill slope sediment, and direct inputs from cattle accessing the stream corridor.

Table 10-16. Summary of Identified Problems and Applicable Treatments, Yourname Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (95 tons/yr accelerated)**	Riparian Area BMPs
			Grazing BMPs
		Road sediment (19 tons/yr)	Roads BMPs
		Hill slope sediment (189 tons/yr)	Riparian BMPs
			Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Cpmservatopm BMPs
Habitat	**Woody Vegetation Extent**	**Low Flow Alterations**	Water Conservation BMPs
		Riparian Degradation	Grazing BMPs
			Riparian Area BMPs
Nutrients	**TKN Chlorophyll-*a***	**Streambank Sediment**	Riparian BMPs Grazing BMPs
		Hill slope sediment	
		Livestock Grazing	
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration projects have been documented in Yourname Creek. The treatments recommended for water quality improvements in Yourname Creek are similar to those described for other streams in the planning area.

Reach Your1 is a relatively steep, confined headwaters channel bounded by dense conifers. No evidence of impairment was identified in this reach as part of the aerial assessment so minimal management actions are necessary

The stream banks on Yourname Creek should be managed with appropriate BMPs to reduce sediment sourcing and delivery to the channel. Grazing BMPs in conjunction with Riparian Area BMPs would promote natural recovery of grazing impacted stream segments. These BMPs are also recommended to reduce nutrient loading to the creek. This includes reducing direct access of cattle to the creek, as well as reducing bank and hill slope erosion associated with hoof shear, trampling, and general ground disturbance.

Water Conservation BMPs should be explored in terms of their potential to increase minimum flow rates in Yourname Creek. The most extensive dewatering occurs in the lower reaches of the creek, from just upstream of the Road #121 crossing to the mouth, so BMPs should be focused in this area.

No data was collected on individual road crossings in the Yourname Creek drainage making it difficult to determine the status of Road BMPs or specific sediment reduction measures that are needed. An assessment of road crossings in Yourname Creek is recommended to determine potential sediment reduction activities from this source through the implementation of Roads BMPs developed by the Montana DNRC/BMP Work Group in January 2006 (**Appendix H**).

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient and low flow conditions or creating additional water quality concerns related to temperature or metals in Yourname Creek.

Monitoring Needs
All water quality impairments for Yourname Creek are based on a limited data set. If land access is permitted, a more detailed assessment to determine water quality impairments, causes, sources, and opportunities for water quality improvements is recommended.

10.2.2 Nevada Creek Planning Area

10.2.2.1 Black Bear Creek

Black Bear Creek is a small first order tributary to Bear Creek in the upper Douglas Creek watershed which flows approximately 7.5 miles through both public (BLM) and private lands. Black Bear Creek consists of 4 reaches (**Appendix A; Appendix B**). BlkBr1 and BlkBr2 are in the confined, forested headwaters area of the drainage. At the upstream end of BlkBr3, the channel enters a more open valley that is bound by Tertiary-age sedimentary rocks. Within this reach, the channel definition as visible on aerial photography diminishes, and woody riparian vegetation is notably sparse. Blkbr4 flows through a narrow valley that is bound by benches comprised of Tertiary-age sediments. The reach has a narrow riparian fringe and relatively limited floodplain extent. As of 2002, Black Bear Creek did not support fish (Pierce et al, 2002b).

Indicators of Habitat and Water Quality Limitations
Black Bear Creek was first included on the 1996 303(d) List as impaired due to habitat alterations and siltation. In 2006 listed impairments expanded to include alterations in streamside or littoral vegetative cover (habitat), sedimentation/siltation, solids (suspended/bedload), and nutrients (TP and TN). Data collected in support of TMDL development provides justification for all of the 2006 impairment listings along the entire length of Black Bear Creek.

Black Bear Creek met only one of ten sediment targets (**Section 5.0**) which indicates significant habitat degradation. Sediment and habitat data are derived from lower reaches in the watershed where agricultural uses are most intense. Montana DEQ collected a single water quality sample from a location 250 yards upstream from the mouth of Black Bear Creek on September 26, 2003. The analyses returned values of 0.75 mg/L TKN and 0.293 mg/L TP; both of which exceed corresponding eco-regional growing season targets (**Section 7.0**).

Suspected Sources and Causes
The primary suspected sources of sediment to Black Bear Creek are hill slope and streambank erosion which account for the majority of the total controllable sediment load. The upland and streambank erosion sediment loads are primarily attributed to current grazing management practices in the area. Bank erosion in the lowermost reach of Black Bear Creek (Blkbr4) contributes approximately 84% of the streambank sediment load.

Sediment from roads accounts for 18 tons of controllable sediment, but there is evidence of road encroachment in the upper stream segments and road density is estimated to be 2.9 miles/square mile (RDG, 2006). GIS analysis identified 12 road crossings in the Black Bear Creek basin which contribute an estimated 60 tons of sediment annually to the stream (**Section 5.0**).

Pool habitat within the assessed reach of lower Black Bear Creek is of poor quality, which is likely the result of several factors. Accelerated loads of fine sediment cause pool infilling, and reduced instream flows due irrigation diversions reduces the ability of the channel to flush those fines downstream. This is supported by observations of field crews in 2004 which reported slow moving water and large amounts of fine sediment in Blkbr4 (DTM and AGI, 2005). Additionally, the degradation of woody riparian vegetation is likely linked to poor pool quality, because woody vegetation provides scour elements on the bankline and within the channel.

Degraded bankline vegetation in the lower reaches is likely due to river corridor grazing as well as dewatering. Upper stream segments show evidence of riparian vegetation alteration as a result of historic timber harvest activities. Combined, these activities have reduced woody riparian vegetation conditions to less than optimal levels.

The elevated nutrient concentrations in Black Bear Creek are presumed to be the result of erosion of both streambanks and hill slopes, as well as livestock grazing in the creek corridor and the presence of corrals near the creek.

Table 10-17. Summary of Identified Problems and Applicable Treatments, Black Bear Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (30 tons/yr)**	Riparian Area BMPs
			Grazing BMPs
			Forestry BMPs
			Water Conservation BMPs
			Stream BMPs
		Road sediment (18 tons/yr)	Roads BMPs
		Hill slope sediment (189 tons/yr)	Grazing BMPs
			Forestry BMPs
			Upland BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality and extent; woody vegetation extent**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
		Riparian degradation	Riparian Area Grazing BMPs
Nutrients	**TKN** **Total Phosphorous**	**Streambank Sediment**	Grazing BMPs Riparian BMPs Upland BMPs
		Upland Sediment	
		Livestock Grazing	
Temperature	**NONE**		Preventative
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Black Bear Creek (Blackfoot Challenge, 2005). However, in 2004 field crews noted a riparian fence along a portion of Blkbr4 where recovery is apparent.

The primary recommended conservation practices for Black Bear Creek are tied to BMPs for agricultural land use. This includes Grazing BMPs that control livestock use of streambank environments to improve bank stability and reduce sediment production. The implementation of Grazing BMPs should also address upland erosion sediment sources. Riparian Area BMPs and active revegetation of the channel margins with willows would also help improve bank stability, and provide shade that will help keep water temperatures down. Upland BMPs and Forestry BMPs are also recommended in areas of historic timber harvests. If feasible, the management of irrigation diversions to create an annual spring pulse of water that mimics natural runoff patterns would help to flush fine sediment from the stream bed. Ideally, Grazing, Riparian Area, and Water Conservation BMPs would be implemented together as part of comprehensive management plan to achieve desired results. Stream BMPs present additional options for achieving water quality restoration targets but require a more active approach to restoration and would still require the implementation of other BMPs to ensure success. Weeds appear to be a problem throughout the drainage weed management is recommended.

In 2005, field crews assessed one road crossing and noted partial Road BMPs were in place but that additional sediment reduction measures were possible. At least one culvert in the Black Bear Creek drainage was found to be perched creating a fish passage barrier as well as putting the crossing at risk for fill failure (RDG 2006). Road BMPs should be considered at this crossing to address sediment delivery, fish passage, and fill failure issues. Assessment of other road crossings in the Black Bear Creek watershed is recommended to identify opportunities for implementation of Road BMPs (**Appendix H**).

With regard to nutrients, special attention should be paid to areas where livestock are corralled adjacent to the stream corridor. In these areas, Riparian and Grazing BMPs are critical in preventing the delivery of excess nutrients to Black Bear Creek. Additionally, reducing direct grazing pressure along the creek bottom will reduce direct input of nutrients from livestock, as well as reduce inputs from sediment due to bank trampling.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, low flow, and nutrient conditions or creating additional water quality concerns related to temperature or metals in Black Bear Creek.

Monitoring Needs

The nutrient impairment determinations for Black Bear Creek are based on one sampling event conducted by Montana DEQ in 2003. While the nutrient exceedences are significant, further monitoring should be conducted to verify impairments and identify potential sources.

10.2.2.2 Braziel Creek

Braziel Creek is a tributary to Nevada Creek, flowing into Nevada Creek from the west just below Nevada Reservoir. Braziel Creek consists of three reaches (**Appendix A; Appendix B**). Aerial assessment results indicate that the uppermost reach (Braz1) is a fairly steep, confined channel that flows through densely forested headwaters. Braz2 is less confined, such that the channel is more sinuous, and the creek corridor supports primarily willows. Braz3 is the lower-most reach and reflects the emergence of Braziel Creek onto an alluvial fan. Within this reach, woody riparian vegetation is sparse and altered; the creek is locally channelized as it flows over the fan surface to the Nevada Creek floodplain.

Indicators of Habitat and Water Quality Limitations
A three-mile segment of Braziel Creek upstream of its mouth was originally included on the 1996 303(d) List as impaired due to habitat alterations and siltation. These listings remained in 2006 and a nutrient impairment (TP) was also added. Data collected in support of TMDL development confirms impairments identified in 1996 and 2006.

The poor habitat is most expressed by very shallow pools. Although the bed sediment measured in middle reaches is relatively coarse, excess fine sediment is suspected to contribute to habitat degradation in other areas. In addition, in-stream woody debris and woody riparian vegetation did not meet targets (**Section 5.0**). Total phosphorous samples taken by Montana DEQ in 2003 were an order of magnitude greater than the TP eco-regional growing season target concentration of 0.01 mg/L (**Section 7.0**).

Suspected Sources and Causes
Streambank erosion associated with grazing and silvicultural practices is the primary source of sediment in Braziel Creek making up 70 tons of controllable sediment with the middle reach (Braz2) contributing 89% of the streambank sediment load (**Section 9.0**). In 2004, field crews noted instability in the stream banks (Braz2) with historic placer mining as a potential for the stream channel disturbance. On the lower portion of Braziel Creek, alterations of the channel as it flows over the alluvial fan have likely resulted in some instability and excess sediment delivery.

Logging access roads border the valley bottom and extend up the drainage contributing sediment to the stream (9 tons of controllable sediment). GIS analysis identified 13 road crossings in the Braziel Creek basin which contribute an estimated 31 tons of sediment annually to the stream (**Section 5.0**). Road density is considered extremely high (USDA Forest Service, 1996) at approximately 4.9 miles/square mile suggesting additional sediment may be delivered from these surfaces. The remaining controllable sediment load (53 tons) is attributed to upland erosion associated with grazing activities (**Section 9.0**).

Some riparian clearing has occurred in the upper reaches and in the lower reach and woody riparian vegetation is notably sparse. In some areas of the upper reaches the streamflow was entirely infiltrated during the field assessment of summer 2004. The degradation of woody riparian vegetation on the streambanks, as well as dewatering are also suspected as negatively affecting stream habitat. These impacts reflect agricultural land uses as well as timber harvesting in the upper watershed.

The suspected source of nutrients in Braziel Creek is primarily grazing activities. These activities include grazing along the creek, as well as the placement of livestock corrals less than 100m from the stream in the lower reaches. The grazing pressure in the stream corridor results in both direct delivery of nutrients from cattle, as well as indirect effects of bank trampling and delivery of nutrients that are accumulated in bank sediment.

Table 10-18. Summary of Identified Problems and Applicable Treatments, Braziel Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**None Measured (however excess fine sediment suspected as source of habitat degradation)**	**Stream bank sediment (70 tons/yr)**	Stream BMPs
			Riparian Area BMPs
			Grazing BMPs
			Forestry BMPs
			Water Conservation BMPs
		Road sediment (9 tons/yr)	Roads BMPs
		Hill slope sediment (53 tons/yr total)	Upland BMPs
			Forestry BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs Stream BMPs
Habitat	**Pool quality and extent; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
			Forestry BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Phosphorous**	**Streambank sediment**	Grazing BMPs Riparian BMPs
		Livestock Grazing	
Temperature	**None**		Preventative
Metals	**None**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Braziel Creek (Blackfoot Challenge, 2005). A project involving channel restoration (600 feet), riparian exclusion, and riparian revegetation is under development with a landowner in the lower reach of Braziel Creek.

On Braziel Creek, BMPs should concentrate on the reducing sediment and nutrient delivery to the stream, and improving the integrity of the riparian corridor. This will be most effectively achieved through the application of Grazing BMPs and Riparian Area BMPs. These conservation practices will serve to reduce the amount of nutrients and sediment produced and delivered to the stream, and will promote the recovery of a woody riparian corridor along the stream. Riparian BMPs will facilitate recovery of vegetation where historic logging encroached to the streambanks.

In local areas where the channel has been physically altered such as in the middle and lower reaches, active channel restoration through Stream BMPs would help to maintain surface flows, reduce bank erosion, and recover riparian vegetation. Field crews noted that dewatered sections of the middle portions of Braziel Creek appear to have been historically placer mined. If so, active restoration would be highly beneficial to recreate a natural channel form.

Water Conservation BMPs should be considered with regard to maintaining instream flows in reaches that currently go dry in the summer. The preservation of low flows during the irrigation season will help flush fine sediment, reduce nutrient concentrations, and support riparian recovery.

In upland areas, a combination of Upland BMPs, Grazing BMPs, and Forestry BMPs should help to address sediment from hill slope erosion. While grazing appears to have the greatest impact on hill slope erosion, large amounts of knapweed are present and timber harvesting has occurred in the area. Promoting recovery of native vegetation should help reduce sediment from hill slope sources.

Additional sediment-management practices appropriate for Braziel Creek include BMPs for roads. While partial Road BMPs were noted at sites assessed in 2005, some road segments are very steep and contribute sediment directly to the stream. At least two culverts are undersized and present a potential risk for fill failure. Those same culverts are perched and create fish passage barriers (RDG 2006). These crossings should be considered for improvement to address these issues. Un-assessed road crossings should be evaluated to determine possibilities for further sediment reduction through the implementation of Road BMPs (**Appendix H**).

Grazing BMPs are appropriate measures for the reduction of nutrient levels on all reaches of Braziel Creek. On lower Braziel Creek, where corrals are located on the alluvial fan surface, Riparian BMPs should be implemented to reduce the delivery of nutrients from that facility. For at least on series of corrals, it appears as though the direction of surface runoff is away from Braziel Creek and towards Nevada Creek. As such, the BMPs should be extended onto the Nevada Creek floodplain to reduce nutrient delivery to that receiving stream.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, low flow, and nutrient conditions or creating additional water quality concerns related to temperature or metals in Braziel Creek.

Monitoring Needs
The nutrient impairment determinations are based on one sampling event conducted by Montana DEQ in 2003. While the nutrient exceedences are significant, further monitoring should be conducted to verify impairments and identify potential sources.

10.2.2.3 Buffalo Gulch

Buffalo Gulch is a small 2nd order tributary to the Nevada Creek Reservoir and flows approximately 7 miles through a mix of public (Helena National Forest) and private lands. Private lands are primarily in the lower 4 miles. Buffalo Gulch consists of three reaches (**Appendix A; Appendix B**). The uppermost reach, Buff1, is a relatively steep channel that is closely confined by hill slopes of dense conifer forest. Downstream, Buff2 marks an abrupt reduction in woody vegetative cover relative to upstream. The creek is moderately confined in the lower end of Buff2, and beaver dams are common. Spoil piles derived from placer mining line portions of the channel. Buff3 consists of the lowermost portion of Buffalo Gulch as it approaches the upper end of Nevada Creek Reservoir. Within this approximately one mile long reach, the creek flows through a low-gradient, willow dominated valley bottom. Lower Buffalo Gulch supports moderate densities of resident westslope cutthroat trout and low densities of rainbow trout (Blackfoot Challenge, 2005). The Helena National Forest documented low numbers of brook trout on National Forest lands in 2006 (Laura Burns, Personal Communication).

Indicators of Habitat and Water Quality Limitations
Buffalo Gulch was not included on the 1996 303(d) List. In 2006 however, the stream is listed as impaired due to physical substrate habitat alterations and sedimentation/siltation. Data collected in support of TMDL development confirm the 2006 impairment listings. The entire length of Buffalo Gulch from its headwaters to its mouth is considered impaired.

The primary indicators of limitations to habitat and water quality on Buffalo Gulch include excess fine sediment, a low pool frequency, and a lack of woody riparian vegetation. Although riffle substrate targets were met the middle section of Buffalo Gulch, pool frequencies were less than 30% of target conditions, and the bed surface in pool tailouts averaged 100% fine sediment. McNeil core measurements for sediment finer than sand (2mm) did not meet targets. The measured woody vegetation extent is approximately 50% of desired conditions, and pool habitat extent is markedly low. Three fourths of the macroinvertebrate metrics measured on Buffalo Gulch did not meet targets (**Section 5.0**).

Suspected Sources and Causes
The suspected primary source of controllable sediment to Buffalo Gulch is upland erosion (275 tons), and to a lesser extent, bank erosion (50 tons) and roads (7 tons). Timber harvest in the upper Buffalo Gulch watershed has been extensive and accounts for half of the upland sediment load. Grazing in the lower reaches also contributes to the upland sediment load (**Section 9.0**).

Logging roads occupy the valley bottom throughout the length of Buffalo Gulch. Road surveys in Buffalo Gulch were conducted by the Helena National Forest which estimated an annual sediment load of 23 tons. Road density in Buffalo Gulch is estimated to be 2.6 miles per square mile which is considered high (USDA Forest Service, 1996).

In middle portions of the watershed, placer spoils line the channel margin and likely contribute to bank instability and erosion. Bank trampling as a result of grazing has caused significant channel widening. Bank erosion and instability are also attributed to riparian hay production and removal of woody riparian vegetation.

These sediment sources are considered to be contributing factors in the degradation of pool habitat. A lack of woody bankline vegetation also has contributed to the low pool frequency, as the woody vegetation helps drive the scour processes that create and sustain pools. The lack of woody bankline vegetation is linked to grazing practices as well as timber harvesting. One additional source that is suspected in exacerbating the limiting factors is low flow alterations due to diversions.

Table 10-19. Summary of Identified Problems and Applicable Treatments, Buffalo Gulch

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (50 tons/yr**	Riparian Area BMPs
			Stream BMPs
			Forestry BMPs
			Grazing BMPs
			Water Conservation BMPs
		Road sediment (7 tons/yr)	Roads BMPs
		Hill slope sediment (275 tons/yr total)	Upland BMPs Forestry BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool frequency and extent; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Forestry BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**NONE**		Preventative
Temperature	**NONE**		Preventative
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Buffalo Gulch (Blackfoot Challenge, 2005).

As a major suspected source of sediment to Buffalo Gulch is upland areas, Upland BMPs, Grazing BMPs, and Forestry BMPs are all appropriate measures to address sediment loading. All of these BMPs will help to achieve a significant recovery of native hill slope vegetation which in turn will help reduce sediment sourcing and delivery to the stream. Noxious weeds identified in Buffalo Gulch include Canada thistle, houndstongue, and knapweed; this infestation has likely increased hill slope sediment production and should be addressed.

Grazing, Riparian Area, and Forestry BMPs can be used to promote woody vegetation recovery along the stream banks to enhance habitat and reduce streambank erosion. In 2004, field crews specifically indicated that riparian fencing would provide a means of improving sediment and habitat channel conditions on Buffalo Gulch.

In the middle reaches of Buffalo Gulch, where historic placer mining activities disturbed the cross section, floodplain access is limited due to spoil berms on the channel bank. These areas would benefit from Stream BMPs that include reshaping the channel cross section and placer spoils, and creating in-stream habitat features and a bounding floodplain surface. Any active restoration efforts should include an extensive revegetation effort within the stream corridor. Additionally, enhancement of in-stream flows will help promote sediment flushing and sustain riparian vegetation.

Road BMPs should be considered to reduce sediment from roads. The Helena National Forest has identified a partial culvert barrier downstream of the National Forest Boundary which should be considered for replacement. Additional assessments of existing road crossings are recommended to identify other aquatic passage and sediment reduction opportunities.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in Buffalo Gulch.

Monitoring Needs
No immediate monitoring needs are present in Buffalo Gulch.

10.2.2.4 Cottonwood Creek

Cottonwood Creek is a major tributary of Douglas Creek flowing 18 miles through a mixture of public (BLM) land in the headwaters and private lands in the valley. Cottonwood Creek is comprised of three reaches (**Appendix A; Appendix B**). CttnNev1 is located upstream of County Road 271 and flows through a U-shaped valley bottom that is typically on the order of 500 feet wide. The density of riparian vegetation is variable across the valley floor, ranging from bare ground to thick willow stands. Downstream of the Road 271, CttnNev2 flows through a narrow cottonwood corridor that diminishes in the downstream direction. CttnNev3 flows across an open valley sub-parallel to Douglas Creek. It supports a narrow thread of willows. The upper reaches of Cottonwood Creek support high densities of resident WSCT and brook trout, and the lower reaches support only long nose suckers (Pierce et al, 2002b).

Indicators of Habitat and Water Quality Limitations
Cottonwood Creek from the mouth of the south fork to its confluence with Douglas Creek was included on the 1996 303(d) List as impaired due to flow alterations, nutrients, salinity, TDS, and chlorides. The impairment listings for 2006 only include low flow alterations. Data collected in support of TMDL development confirm the low flow alteration impairment listing. TMDL development also identified sedimentation/siltation and temperature as additional limiting factors. Cottonwood Creek was listed as impaired due to nutrients in 1996. Due to the age of available data, nutrient impairments cannot be confirmed, however a TMDL for total phosphorous (TP) has been developed until additional nutrient sampling and analysis occurs.

High concentrations of fine sediment in the channel bed were measured in lower reaches of Cottonwood Creek during the field investigation of July 2004. The average percent surface fines value for pool tailouts in lower reaches of the creek is 98%. Residual pool depths are approximately one half of target values. Similarly, woody vegetation extent is about half that of habitat target conditions and woody debris aggregates are absent (**Section 5.0**).

Cottonwood Creek in its upper reaches above Pole Creek has cool water throughout the summer. However, Cottonwood Creek temperatures increase significantly by the time Cottonwood Creek reaches Ovando-Helmville Road, suggesting large thermal gains in the reach between these two sites. Modeled mean daily maximum temperatures in Cottonwood Creek below Pole Creek were nearly 7^{o} F above modeled naturally occurring temperatures (**Section 8.0**).

Suspected Sources and Causes
The sediment source assessment for Cottonwood Creek indicates that upland areas are the primary contributors of sediment to the stream channel (2,991 tons of controllable sediment). Upland sediment loads are attributed to grazing practices and hay production in riparian areas (**Section 9.0**).

Approximately 95 tons of total controllable sediment comes from streambank erosion. Of that sediment load, 81% is derived from the two lowermost reaches (**Section 9.0**). Land use along Cottonwood Creek includes grazing within the stream corridor; fine sediment loading in the bed is suspected as caused by bank trampling and erosion. In many areas, block failure of high banks has resulted in development of an inset floodplain surface adjacent to the channel, indicating some natural recovery of the impacted channel. Although there is some evidence of bank healing, active riparian grazing and hoof shear were evident along the creek, and the channel remains locally over-widened at livestock crossings. Weed infestations comprised of Canadian and Musk Thistle also appear to be contributing to bank instability.

Road sediment is a relatively minor contributor to the system (10 tons of controllable sediment). Road density in the Cottonwood Creek drainage is 2.3 miles per square mile. GIS analysis identified 69 road crossings in the Cottonwood Creek basin that deliver an estimated 32 tons of sediment annually to the stream (**Section 5.0**).

Water diversions, irrigation, and dewatering are extensive throughout the Cottonwood Creek drainage as noted by field crews in 2004 and 2005, aerial photographs, and water rights records. Upland sediment, bank erosion, and roads in conjunction with the dewatering effects of irrigation are suspected sources of poor pool habitat quality in Cottonwood Creek. Irrigation diversions are also suspected as being at least partially responsible for high temperatures on Cottonwood Creek.

The primary suspected source of high temperatures on Cottonwood Creek is lack of shade. Riparian vegetation is relatively sparse along the entire listed stream segment which field crews attribute to grazing practices. The lack of woody vegetation that drives up stream temperatures also impacts overall habitat conditions within the corridor. Woody bank vegetation extent along the entire length of Cottonwood Creek is estimated to be 33% (**Section 8.0**).

A nutrient (total phosphorous) TMDL for Cottonwood Creek has been developed, although existing nutrient data on the creek are outdated. There are suspected sources of nutrients on the creek including grazing practices in the stream corridor, and concentration of livestock in corrals that are adjacent to the channel.

Table 10-20. Summary of Identified Problems and Applicable Treatments, Cottonwood Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment (pool tailouts)**	**Stream bank sediment (95 tons/yr)**	Riparian Area BMPs
			Grazing BMPs
			Water Conservation BMPs
		Hill slope sediment (2,991 tons/yr)	Grazing BMPs
			Upland BMPs
		Road sediment (10 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Grazing BMPs Riparian Area BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Unknown**		Monitoring
Temperature	**Water Temperatures above Natural Range**	**Riparian degradation**	Riparian Area Stream BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

Past projects on Cottonwood Creek include channel restoration, riparian revegetation and riparian habitat improvements, irrigation improvements, removal of streamside feedlots, and fish passage improvements (Blackfoot Challenge, 2005). These projects occurred primarily in the lower portion of the watershed. In some areas, erosion rates appear to have declined recently as several banks were observed to be supporting young riparian vegetation which may be a result of completed projects. Field crews noted that the riparian area had been fenced in a portion of CttnNev2. However, the fence was knocked down in several areas and the riparian area appeared to have been grazed as heavily as the surrounding area. For completed projects such as these, maintenance and monitoring will be important to sustain recovery and improvements to water quality.

The recommended conservation practices/BMPs for Cottonwood Creek consist primarily of Grazing BMPs, Riparian Area BMPs, and Water Conservation BMPs. With the application of Grazing BMPs and Riparian Area BMPs in the stream corridor such as riparian exclosures or off-site watering, riparian recovery would be encouraged, which would improve bank integrity, increase shade, increase in-stream habitat complexity, and reduce nutrient delivery to the stream. Several corrals have been noted along Cottonwood Creek and relocation of those corrals further from the stream would be beneficial to water quality. Active revegetation in combination with riparian grazing management would also facilitate this riparian recovery. Weeds were noted in the stream corridor and weed management in these areas would help promote bank stabilization and overall recovery.

The management of diversions and improvement of irrigation systems to secure sufficient flow volumes to flush fine sediment and reduce the rate of warming on the stream would help address temperature loading, degraded habitat conditions on the creek, and riparian vegetation recovery.

Upland sediment is primarily associated with grazing practices and Grazing BMPs that improve the timing, frequency, and intensity of grazing are recommended. Upland BMPs such as filter strips that provide a buffer between hay ground and the stream would also help reduce sediment from upland areas.

While the sediment load from roads is the smallest of all sediment sources, Road BMPs are encouraged wherever possible to reduce sediment, allow desirable fish passage, and maintain channel form and function. Current Road BMPs were noted as ranging from partial to full (RDG, 2006). Un-assessed road crossings should be evaluated to determine possibilities for further sediment reduction through the implementation of Road BMPs (**Appendix H**).

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, temperature, and low flow conditions or creating additional water quality concerns related to nutrients or metals in Cottonwood Creek.

Monitoring Needs

The effectiveness and success of completed projects on Cottonwood Creek have not been well documented. Monitoring and any necessary maintenance of these projects is recommended.

Iron exceedences were captured in metals sampling completed during the TMDL development. However, not enough data was available at the time of this document to determine impairment. Further sampling to determine significance and sources of iron is recommended.

Cottonwood Creek was listed as impaired due to nutrients in 1996; the 2006 303(d) List does not include any listings for nutrients. The stream was sampled once by Montana DEQ on May 23, 1983. Results were 0.23 mg/l for total phosphorous (TP), and 0.02mg/l for NO_{23}. Due to the age of the existing data, there is a high degree of uncertainty in determining the impairment status regarding nutrients in Cottonwood Creek. Without more recent data, the criteria for sufficient credible data are not met.

10.2.2.5 Douglas Creek (Upper)

Douglas Creek is a major tributary to lower Nevada Creek flowing 18 miles through public (BLM) and private lands. Significant tributaries to Douglas Creek include Black Bear Creek, Cottonwood Creek, Chimney Creek, and Murray Creek. For TMDL planning purposes, Douglas Creek is spilt into two segments (upper and lower). Upper Douglas Creek extends from its headwaters downstream approximately 13 miles to the confluence with Murray Creek. This segment consists of four reaches (**Appendix A; Appendix B**). Doug1 and Doug2 are relatively steep channels of the upper watershed that are confined by hillslopes that support moderate to dense conifer forest. Locally, the channel gradient and confinement both decrease, and these unconfined reaches support open meadows and variably dense willow corridors. Downstream of Doug2, the creek flows into a wide valley. Doug3 and Doug4 occupy the open valley portion of upper Douglas Creek, and where the channel is typically sinuous and sparsely vegetated with riparian shrubs. In Doug3, many of the willows are decadent, and beaver dams are present. Doug4 is a sinuous channel that is locally incised (**Appendix B**). Douglas Creek supports a moderate pure population of WSCT in the headwaters and low numbers of native non-game species in the lower and middle reaches (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations

Upper Douglas Creek was included on the 1996 303(d) List as impaired due to flow alterations, habitat alterations, siltation, nutrients, salinity/TDS/chlorides, and temperature. In 2006, impairments listed for upper Douglas Creek included alterations in stream-side or littoral vegetative cover (habitat), arsenic, chlorophyll-a, low flow alterations, nutrients (TN, TKN, TP), sedimentation/siltation, and temperature. With the exception of salinity/TDS/chlorides and arsenic all other impairments have been confirmed through TMDL development.

Excess fine sediment deposition and poor habitat conditions have been documented on upper Douglas Creek. Assessment data from the upstream portion of the stream segment (Doug2) showed fine sediment in riffles to be two times the target (**Section 5.0**). Downstream, lower reaches are characterized by excess fines, pool frequencies of less than 20% of target values, and shallow residual pool depths. These conditions are indicative of impairments caused by excess sediment and habitat degradation. In 2004, field crews specifically noted the poor substrate and lack of in-stream habitat on lower reaches.

The coldest water temperatures measured in the Nevada Creek planning area are in the headwaters of Douglas Creek (46^{o} F). As the creek flows into the open valley, however, temperatures increase by as much as 25^{o} F before reaching Murray Creek. The mean daily temperatures modeled for existing conditions on upper Douglas Creek are 5^{o} F higher than the temperatures modeled for naturally occurring conditions (**Section 8.0**).

Montana DEQ collected water quality samples in September 2003 at two sites on upper Douglas Creek: one about three miles upstream of the Sturgeon Creek confluence and a second about one quarter mile upstream of the Murray Creek confluence. The upper site returned values of 0.093 mg/L TP, 0.01 mg/L $NO_{3/2}$, and 0.61 mg/L TKN. The TP and TKN values exceed the corresponding eco-regional targets and the $NO_{3/2}$ value meets its target. The downstream site above Murray Creek returned values of 0.241 mg/L TP, 0.2 mg/L NO_{23}, and 0.49 mg/L TKN. All of these values exceed their respective eco-regional growing season targets (**Section 7.0**). It should be noted that these samples were taken very close to the cutoff dates which separate the concentrations allowed by water quality standards and that the magnitude of exceedence is somewhat misleading. Two Chlorphyll-*a* samples were collected from upper Douglas Creek by DEQ in 2003 at the same sites from which water quality samples were collected. The Chlorophyll-*a* concentration at the upstream site was 96.8 mg/m^2; the result for the lower site was 106 mg/m^2. The mean of these two results, at 103 mg/m^2, exceeds the 100 mg/m^2 threshold for aquatic life and cold water fisheries use support.

Metals water quality samples in upper Douglas Creek have been collected at several locations, including two samples (from separate locations) obtained by DEQ in 2003 and by Hydrometrics in 2005. Combined data from these sampling events show two water quality standard exceedences, both for arsenic during low flow conditions. Given the geology of the drainage basin and the widespread nature of the low-level concentrations, there is a high probability that the arsenic concentrations are due to natural weathering processes. Therefore, upper Douglas Creek is not considered impaired by arsenic.

Suspected Sources and Causes

Sediment sources that are contributing to the water quality impairments on upper Douglas Creek include a high volume of upland sediment, road sediment, and stream bank sediment. The hill slope sediment load is attributed to grazing practices and riparian hay production in the lower end of the listed segment. Historic timber harvesting in upper reach segments is also suspected as a cause of accelerated hill slope erosion (**Section 9.0**).

Streambank erosion is relatively minor in the uppermost reaches of Douglas Creek, however historic timber harvesting in riparian areas has likely resulted in some excess bank erosion. Downstream, bank erosion rates increase dramatically as the creek meanders through a broad open valley that is irrigated and grazed. The largest measured bank sediment source on upper Douglas Creek is 220 tons per mile per year from an incised reach (Doug4) (**Section 9.0**). Grazing and hay production are considered primary factors in these elevated bank erosion rates. Invasive weeds including knapweed, houndstongue, and Canada thistle were noted in the stream corridor and upland areas during the field investigation of July 2004; these infestations have likely accelerated natural erosion rates in both stream and upland environments.

Logging roads are present throughout the upper reaches of upper Douglas Creek. Road density within upper Douglas Creek is 2.4 miles per square mile with 111 possible road-stream crossings contributing 153 tons of sediment per year to the system (**Section 5.0**).

Irrigation diversions were noted throughout the lower end of upper Douglas Creek and irrigation ditches follow both sides of the valley. Flow depletions due to agricultural diversions are suspected as a source of the fine sediment accumulations and associated habitat degradation. .

Flow depletions are also a suspected contributor of thermal loading. Three reservoirs that facilitate irrigation water storage and conveyance are identified as the primary thermal loading source in upper Douglas Creek (92.5% of the temperature increase). Temperature impairments are also linked to lack of shade and woody bank vegetation. Locally, some areas exhibit high levels of woody bank vegetation (100% in the assessed reach of Doug2). However, when the entire length of upper Douglas Creek is examined, woody bank vegetation extent is only 40%, most of which appeared to be dead or decadent (**Section 8.0**).

The primary suspected source of nutrients on upper Douglas Creek is stream corridor grazing. Grazing in the immediate stream area is linked to accelerated bank erosion which results in contributions of both sediment and nutrients to the stream. Stream corridor grazing is also linked to direct inputs of nutrients in the form of animal waste. Areas where livestock are concentrated adjacent to the stream are also considered a nutrient source. Corrals are present in the lower reaches of upper Douglas Creek that abut the stream corridor.

Table 10-21. Summary of Identified Problems and Applicable Treatments, Upper Douglas Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (102 tons/yr total)**	Riparian Area BMPs
			Grazing BMPs
			Upland BMPs
			Forestry BMPs
			Water Conservation BMPs
		Hill slope sediment (681 tons/yr)	Upland BMPs
			Forestry BMPs
			Grazing BMPs
		Road sediment (46 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality; riparian degradation**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Phosphorous**	**Livestock Grazing** **Streambank Sediment** **Upland Sediment**	Grazing BMPs Riparian Area BMPs
	TKN		
	NO23		
	Chlorophyll-a		
Temperature	**Water Temperatures above Natural Range**	**Riparian degradation**	Riparian Area BMPs
			Forestry BMPs
			Grazing BMPs
		In-stream reservoirs	Water Conservation BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**None**		Preventative/Monitoring

Recommended Conservation Practices/BMPs

Fish ladders have been constructed on two of the instream reservoirs located on upper Douglas Creek. Riparian revegetation, riparian habitat improvements, and range improvements have also been completed in the stream corridor (Blackfoot Challenge, 2005).

In addition to projects that have been completed, there are numerous opportunities to improve habitat and water quality conditions on upper Douglas Creek. In the uppermost portions of the watershed, excess fines and pool habitat degradation have been identified. In these areas, sediment management from upland areas (Grazing, Upland, and Forestry BMPs) and roads would reduce the fine sediment loading within the upper reaches. Woody vegetation density in the uppermost reaches is relatively good and maintenance is recommended.

In 2005, eleven road-stream crossings or road-near-stream sites were assessed. Partial BMPs were noted in assessment sites in lower Douglas Creek while most sites in the upper reaches noted a lack of BMPs. Implementation of Road BMPs where they are presently lacking is recommended to reduce sediment. Where road BMPs exist, maintenance and additional BMPs are recommended as field crews noted opportunities for improvement (RDG, 2006). At least 7 culverts in upper Douglas Creek are undersized and present fish passage barriers. These same culverts are at risk for fill failure due to a constriction ratio of <1.0.

In the section of upper Douglas Creek where the stream emerges from its forested headwaters into the open valley, TMDL data collection efforts identified dewatering as a major limitation with respect to water quality and habitat. It is therefore recommended that any water quality restoration efforts in the area focus on the maintenance of minimum flows using Water Conservation BMPs to promote sediment flushing, temperature reductions, and riparian recovery in the reach.

There are several options for addressing temperature increases created by the reservoirs. As noted in **Section 8.0**, the reservoirs are very shallow and consolidation would increase the depth while reducing the surface area resulting in lower stream temperatures. Another approach would be to reconfigure the reservoir outlets from their current top-releasing design to a bottom-releasing scenario. This would ensure that any stratified, relatively cool water at the bottom of the reservoirs is passed downstream. A third option would be constructing a connecting stream bypass channel around the reservoirs. This would allow water to be diverted to the reservoirs while providing cooler water to the stream below the reservoirs. Any alteration to the existing on-line irrigation structures would require further analysis into the feasibility and anticipated benefit of such actions, while making sure that irrigation needs are met.

When viewed as a whole, the existing riparian vegetation in the area is typically sparse and largely decadent; very little in the way of natural regeneration of riparian vegetation was observed. It is therefore appropriate to consider Grazing BMPs and active replanting of vegetation (and other Riparian Area BMPs) to facilitate stream corridor recovery and temperature reductions. In upper reaches, any future timber harvesting should be implemented using Forestry BMPs to protect the riparian area.

In the lower reaches of upper Douglas Creek, Grazing BMPs and Upland BMPs are recommended to reduce hill slope erosion. The use of filter strips (and other Upland BMPs) would help reduce sediment from hay production which was noted as a significant source of hill slope sediment. Weed management and increasing soil stability is recommended in riparian and upland areas throughout the watershed.

Throughout the upper Douglas Creek watershed, the application of Riparian Area, Grazing, and Upland BMPs is recommended as a means of reducing nutrient delivery to the stream. These BMPs should include reducing all forms of sediment delivery to the stream, reducing grazing pressure in the stream corridor, and ensuring that corrals are located a sufficient distance away from the creek so as to prevent excessive nutrient loading.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, temperature and low flow conditions or creating additional water quality concerns related to metals in upper Douglas Creek.

Monitoring Needs
As noted in the Recommended Conservation Practices/BMPs section, riparian area and range improvement projects have been undertaken in upper Douglas Creek. However, the maintenance and effectiveness of these projects is not well known. Monitoring of completed riparian and range projects for maintenance and effectiveness is recommended.

Arsenic exceedences were noted during sampling events conducted as part of TMDL development. From the limited samples, it is unclear as to whether arsenic exceedences are a result of local geology, human activities, or both. Further monitoring is recommended to confirm possible arsenic sources.

The nutrient impairment determinations are based on one sampling event conducted by Montana DEQ in 2003. While the nutrient exceedences are significant, further monitoring should be conducted to verify impairments and identify potential sources.

10.2.2.6 Douglas Creek (Lower)

Douglas Creek is a major tributary to lower Nevada Creek, flowing 22 miles through public (BLM) and private lands. Significant tributaries that join Douglas Creek between its headwaters and mouth include Black Bear Creek, Cottonwood Creek, Chimney Creek, and Murray Creek. For TMDL planning purposes, Douglas Creek is spilt into two segments (upper and lower). Lower Douglas Creek extends from the mouth of Murray Creek to its confluence with Nevada Creek. Lower Douglas Creek consists of five reaches. Between Murray Creek and its mouth, lower Douglas Creek consists of five reaches (**Appendix A; Appendix B**). Doug5, just below Murray Creek flows through a narrow valley that is naturally confined by volcanic rocks, and further encroached on by Montana Highway 271, which also occupies the narrow valley bottom. In places, Douglas Creek has been straightened and relocated against the valley margin. In Doug6, the creek flows through a wider, less confined stream valley that supports dense riparian shrubs. The Douglas Creek Canal augments flows over a short distance within Doug6. Doug7 has moderately dense vegetation, and the stream valley is bound by alluvial terraces that form broad upland flats. Doug8, which flows to the Cottonwood Creek confluence, is sparsely vegetated and channel definition within the reach is poor relative to that upstream. There is an off-channel storage reservoir on the upstream end of the reach, and aerial assessment results suggest that abandoned secondary channels have been reconfigured within this reach to convey irrigation water to adjacent fields (**Appendix B**). At the lower end of Douglas Creek, Doug9 consists of a highly sinuous channel that supports a narrow swath of woody riparian vegetation. Douglas Creek supports a moderate pure population of WSCT in the headwaters and low numbers of native non-game species in the lower and middle reaches (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Lower Douglas Creek was included on the 1996 303(d) List as impaired due to flow alterations, habitat alterations, siltation, nutrients, salinity/TDS/chlorides, and temperature. In 2006, impairments listed for upper Douglas Creek included alterations in stream-side or littoral vegetative cover (habitat), arsenic, low flow alterations, nutrients (TKN and TP),

sedimentation/siltation, and temperature. With the exception of salinity/TDS/chlorides and arsenic all other impairments have been confirmed through TMDL development.

Of thirteen sediment and habitat water quality target parameters (**Section 5.0**), lower Douglas Creek met only three target parameters. Fine sediment accumulations are evident in riffles and pool tailouts. The channel is over-widened in areas and streambanks lack needed woody vegetation which is likely contributing to loss of in-stream habitat complexity. Macroinvertebrate data collected in this reach shows moderate to severe impairment with respect to aquatic life.

Nutrient samples were collected from lower Douglas Creek just upstream of the Ovando-Helmville Road crossing on June 12 and October 1, 2003. Total phosphorus results for the two sampling events were 0.212 and 0.126 mg/L, both of which exceed the eco-regional target values. TKN result for the June sampling was 0.51 mg/L, exceeding the eco-regional runoff season target of 0.40 mg/L (**Section 7.0**). The method detection limit for analysis of the October sample was 0.50 mg/L, too high to provide information on target departure.

Modeled mean daily temperatures for lower Douglas Creek were 5.9^{o} F above modeled naturally occurring mean daily temperatures. This is above the 1^{o} F temperature increase allowed by the State's temperature standard (**Section 8.0**).

Four metals samples (two high flow and two low flow samples) were collected at the Ovando-Helmville county road crossing west of Helmville. The four samples showed one low flow arsenic exceedence. The single exceedence for arsenic may be related to weathering of arsenic bearing parent materials in the drainage. Thus, lower Douglas Creek at this time is not considered as impaired due to arsenic (**Section 6.0**).

Suspected Sources and Causes
In 2002, Montana FWP identified fisheries-related impairments on lower Douglas Creek as a lack of instream wood, grazing impacts to bank integrity and vegetation, elevated sediment, temperature and nutrient levels, and reduced instream flows (Pierce et al, 2002b). The findings of water quality investigations are consistent with those of Montana FWP and are described below.

Based on the data collected and modeling results, the primary suspected sources of the excess fine sediment in lower Douglas Creek include upland areas and eroding banks. Hill slope erosion is attributed to the primary land uses in the area which are grazing and hay production. Grazing practices and hay production also contribute to bank erosion through vegetation removal and bank destabilization. Field crews noted evidence of riparian grazing in both assessed reaches as well as an overall lack of riparian vegetation with bare banks exposed. Grazing practices and hay production are also likely linked to the lack of woody riparian vegetation, channel widening, and poor habitat conditions in lower Douglas Creek. Woody debris aggregate extent, woody vegetation extent, and channel width to depth ratio targets are not met in lower Douglas Creek. Weeds are present in both upland and riparian areas which create more instability.

Another major factor contributing to bank erosion and bank instability is straightening of the channel and channel confinement. The upper portion of this stream segment consists of an irrigated valley bottom that is semi-confined between volcanic outcrop as well as Highway 271.

In several areas the creek has moved and straightened against the valley wall to facilitate agricultural use of the valley bottom. Some of the straightening may also be related to road construction as the Highway 271 embankment has isolated portions of the historic floodplain of Douglas Creek. This straightening of Douglas Creek downstream of the mouth of Murray Creek has resulted in an over-steepening of the channel, which in turn has caused the channel to incise, or downcut. This incision has resulted in the detachment of Douglas Creek from its historic floodplain. The incised channel has begun to widen out and develop an inset floodplain surface. The resulting nested channel configuration consists of a low floodplain on the channel margin, and locally high (~8 ft) eroding banks comprised of fine grained historic floodplain deposits. Downstream of the Highway 271 bridge, the confinement of Douglas Creek is markedly reduced. The largest volumes of sediment derived from streambanks in lower Douglas Creek are sourced from reaches within and just below this destabilized segment.

Roads contribute the least amount of sediment to the stream but the effects of roads are much greater than just sediment as described above. Eighty eight road crossings in lower Douglas Creek contribute approximately 167 tons of sediment to the stream each year. Highway 271 runs along the stream at several locations. Road density is 2.4 miles per square mile.

Flow depletion due to diversions is also considered to be a causative element with regard to fine sediment accumulations, pool habitat degradation, and low extents of woody bankline vegetation. Numerous irrigation ditches, diversions, and storage structures were observed during the 2004 field assessment and are evident in aerial photos. The Douglas Creek Canal does augment flows over a short distance within Doug6 but a diversion below the confluence with Cottonwood Creek diverts about half of the flows and dewatering is apparent (DTM and AGI, 2006). Flow depletion has reduced the ability of the channel to flush fine sediments from hill slope, stream bank, and road sources downstream and have hindered riparian vegetation regeneration.

Flow depletions likely factor into elevated water temperatures but lack of woody riparian vegetation or shade has been identified as the primary cause of thermal loading. Overall woody bank vegetation extent for the entire length of lower Douglas Creek is estimated to be 23%, which is well below the 84% needed to achieve desired water temperatures. The channel is also over-widened in some areas which further reduces the shading effects of woody vegetation (**Section 8.0**).

The suspected sources of nutrients on lower Douglas Creek include streambank erosion, as well as stream corridor access by livestock. Livestock enclosures are present adjacent to the stream corridor in reaches Doug5 and Doug8. One of these corrals is adjacent to an old stream channel/ditch that could potentially convey nutrients back to the main channel.

Table 10-22. Summary of Identified Problems and Applicable Treatments, Lower Douglas Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (997 tons/yr total)**	Stream BMPs
			Grazing BMPs
			Riparian Area BMPs
		Hill slope sediment (1,403 tons/yr)	Upland BMPs
			Grazing BMPs
		Road sediment (50 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent ant quality; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Phosphorous**	**Streambank Erosion Upland Erosion Livestock Grazing**	Grazing BMPs
	TKN		
Temperature	**Water Temperatures above Natural Range**	**Riparian degradation**	Upland BMPs
			Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**None**		Preventative/Monitoring

Recommended Conservation Practices/BMPs

Riparian revegetation, riparian habitat improvements, and range improvements have been completed in lower Douglas Creek (Blackfoot Challenge, 2005).

The primary recommended conservation measures on lower Douglas Creek are Grazing BMPs to facilitate recovery of degraded streambanks and riparian vegetation. Streambank stabilization and riparian vegetation would also be enhanced by Riparian Area BMPs that increase woody vegetation and protect riparian areas from overuse.

The overall development of a woody vegetation corridor through various conservation measures (Grazing, Riparian, and Upland BMPs) would improve shading and keep water temperatures cooler. The temperature issues on lower Douglas Creek would also be helped by enhancing instream flows that would increase water depth and flow velocity and thereby reduce heating. Increased minimum flows would also have the added benefits of flushing fine sediment from the channel bed, and facilitating the recovery of woody bankline vegetation.

Grazing BMPs are recommended to reduce nutrient delivery to lower Douglas Creek. These BMPs should include a reduction in grazing pressure in the stream corridor. Additional Riparian BMPs will help reduce nutrient delivery to the stream. Relocation of corrals away from the channel or any ditches that reconnect with the mainstem would minimize nutrient loading from those facilities.

Lower Douglas Creek is somewhat unique in the Nevada Creek planning area in that it has channel segments that are deeply incised into fine soils. This has resulted in accelerated bank erosion that is in part attributable to channel straightening upstream of the 271 bridge. Currently, high banks are continuing to erode and contribute fine sediment to the creek. However, field observations indicate that the downcutting is largely complete; and as such, sediment production rates will naturally decay with time as the channel continues to recover. Active stream restoration efforts associated with Stream BMPs could effectively accelerate that process of bankline recovery. Typically, the development of a restoration approach for an incised channel includes an assessment of the cost/benefit relationship of several options. One means of increasing stability is to raise the channel bed to re-access the historic floodplain surface. This approach is most feasible where the incision is ongoing, at a point when channel is only mildly incised. The incision on lower Douglas Creek is likely too deep to make this option cost effective. Another option is to relocate the channel away from its current course, which would consist of designing and constructing a new, more sinuous channel on the historic floodplain surface. This approach can result in excellent results with regard to channel function, however poses challenges with regard to the expansion of flood zones and overall cost.

Commonly, the most cost effective rehabilitation strategy for incised channels like lower Douglas Creek is to foster the natural process of inset floodplain development. That can be achieved by enhancing vegetation on the developing floodplain to increase its stability, as well as by widening it through active excavation. Excavating a wider floodplain would serve to physically remove sediment from the corridor that would otherwise erode into the creek. A less aggressive approach would be to lay back vertical banks to a lower slope, and aggressively revegetate those banks.

During the field investigation of July 2004, it was noted that beaver dams in the incised channel segments effectively reduced bank erosion rates by backwatering the stream. If the presence of beaver is acceptable to stakeholders, their continued activities would help reduce bank erosion rates.

Several diversion structures on lower Douglas Creek have been identified as causing erosion. Conservation measures to be considered on Douglas Creek should include the evaluation and possible reconstruction of diversion structures to minimize local sediment contributions to the creek.

Roads contribute 46 tons of controllable sediment. Roads BMPs are recommended to reduce this sediment source, reduce the impacts of road crossings on channel form and function, and to allow for fish passage.

Field crews noted weeds throughout lower Douglas Creek and weed management should be consider as part of water quality restoration projects.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, low flow, temperature, and nutrient conditions or creating additional water quality concerns related to metals in lower Douglas Creek.

Monitoring Needs
The effectiveness and success of completed projects on lower Douglas Creek have not been well documented. Monitoring and any necessary maintenance of these projects is recommended.

Arsenic exceedences were noted during sampling events conducted as part of TMDL development. From the limited samples, it is unclear as to whether arsenic exceedences are a result of local geology, human activities, or both. Further monitoring is recommended to confirm possible arsenic sources and impairments.

The nutrient impairment determinations for lower Douglas Creek are based on limited sampling events. Further monitoring should be conducted to verify impairments and identify potential sources.

10.2.2.7 Gallagher Creek

Gallagher Creek is a relatively small tributary to upper Nevada Creek. The stream is approximately seven miles long and flows through both public (Helena National Forest) and private lands. Gallagher Creek consists of two reaches (**Appendix A; Appendix B**). The upstream reach is a confined, cobble dominated, moderately entrenched channel that flows through a dense conifer forest. Downstream, the creek emerges from the confined headwaters onto an open terrace/alluvial fan complex. The lowermost 2 ½ miles of Gallagher Creek consists of a meandering channel that flows through an open valley bottom. The channel has a grassy floodplain with a narrow fringe of moderately dense riparian shrubs along the stream banks. Within this lower reach, there is a downstream reduction in woody vegetation density and channel definition. Gallagher Creek supports only resident westslope cutthroat trout. The lower reaches support low densities of WSCT that increase to moderate levels in the middle reaches (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
The 1996 impairment listing for the lowermost 3 miles of Gallagher Creek in 1996 is flow alterations. In 2006, additional listings included alterations in stream-side or littoral vegetative covers (habitat), sedimentation/siltation, and nutrients (TP and TKN). Data collected in support of TMDL development confirm the 1996 and 2006 impairments listings for Gallagher Creek.

Gallagher Creek met only 2 of 10 sediment and habitat related TMDL targets (**Section 5.0**). The lack of pools and fine substrate indicate excess fine sediment as well as lack of overall in-stream habitat complexity. Woody riparian vegetation extent was calculated as 44%. This is approximately 59% of desired woody riparian vegetation extent for this stream type. The lack of woody vegetation may also explain low values for in-stream woody debris aggregates and pools. Macroinvertebrate samples showed moderate to severe impairments with respect to sediment and habitat. Results of nutrient sampling conducted by Montana DEQ in 2003 indicate impairments in Gallagher Creek for TKN and TP (**Section 7.0**). Samples returned results of 0.55 mg/l TKN and 0.154 mg/l TP which are above the eco-regional targets of 0.4 mg/l for TKN and 0.01 mg/l for TP.

Suspected Sources and Causes
With respect to excess fine sediment, the TMDL development for Gallagher Creek indicates that the production of sediment from uplands is the most significant contributor of controllable fine sediment in the creek. Current grazing practices have been identified as the primary cause of hill slope erosion (**Section 9.0**). Hay production practices and silvilcultural practices also contribute to hill slope erosion. All of these land uses reduce the amount of vegetation outside of the riparian area and the ability of the system to trap and store sediment. Invasive weeds including Canada thistle, musk thistle, white top and spotted knapweed were recorded as present during the field investigation of July 2004. The presence of these weeds may also be contributing to soil instability and sediment delivery.

The second largest contributor of sediment to Gallagher Creek is stream banks. The field investigation of July 2004 noted actively eroding banks on Gallagher Creek in areas of historic beaver ponding. Beaver ponding resulted in the deposition of fine sediment in the ponds, and breaching of the dams has resulted in exposure and erosion of that material. Where the stream banks are stable, they are commonly deeply undercut. Active grazing and hay production in riparian areas are suspected as the primary causes of bank erosion on Gallagher Creek. The stream bank erosion load from the headwaters is minor (10 tons/yr) but increases dramatically downstream where these land uses are present (89.5 tons/yr) (**Section 9.0**). Reported elk foraging in the area may also contribute to sediment production from both stream banks and uplands.

The sediment source assessment indicates that roads are a relatively minor contributor of sediment to Gallagher Creek. GIS analysis identified 7 road crossings in Gallagher Creek that deliver an estimated 12 tons of sediment per year to the stream. Road density in Gallagher Creek is considered high at 1.9 miles per square mile (USDA Forest Service, 1996).

The suspected sources of the poor pool habitat on Gallagher Creek include fine sediment loading and flow depletions. These factors can directly impact residual pool depth by causing deposition in pool areas. Additionally, the lack of woody bankline vegetation on Gallagher Creek is suspected as related to the poor pool extent and quality, as wood derived from such vegetation has the capacity to create pools and thereby increase pool frequency, and to cause local scour, which contributes to pool depth. Moving from upstream to downstream there is a reduction in woody vegetation density and channel definition through the listed stream segment. The extent of woody bankline vegetation is approximately 60% of the target value. The lack of vegetation is likely due to impacts of both livestock and wildlife grazing and foraging, as well as flow depletions. It is also possible that the willow corridor was intentionally thinned or removed to facilitate hay production. Streamside vegetation alteration and flow alterations are evident on the aerial photography (**Appendix B**).

Stream corridor grazing is suspected as the primary source of nutrients to Gallagher Creek. Grazing contributes nutrients through the accelerated erosion of nutrient-bearing hill slope and streambank sediments, as well as through direct waste inputs when cattle access the creek.

Table 10-23. Summary of Identified Problems and Applicable Treatments, Gallagher Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (27 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
			Water Conservation BMPs
		Road sediment (4 tons/yr)	Roads BMPs
		Hill slope sediment (186 tons/yr total)	Upland BMPs
			Riparian Area BMPs
			Grazing BMPs
			Forestry BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality and extent; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Grazing BMPs Riparian Area BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**TKN**	**Stream bank sediment** **Upland sediment** **Livestock grazing**	Grazing BMPs Riparian Area BMPs
	Total Phosphorous		
Temperature	**NONE**		Preventative
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Gallagher Creek (Blackfoot Challenge, 2005).

To reduce sediment from hill slope sources, Grazing, Upland, and Forestry BMPs are recommended. Increasing vegetation in upland areas through management will help trap and store sediment instead of delivering it to the stream channel. In addition to restoring upland vegetation levels, Weed Management is recommended to increase soil stability and overall upland health.

Grazing and Riparian Area BMPs are recommended to promote the recovery of vegetation, reduce bank erosion rates and reduce sediment loading in the stream corridor. One assessed reach of Gallagher Creek (Gall2b) was noted to be a heavy use area for both cattle and elk. Developed stream crossings and fencing may be particularly helpful in this area to focus animal use of the stream. Improving upland wildlife habitat is another suggestion for protection of the riparian area in the impaired reach. Improvement of the riparian area through these management practices should increase in-stream habitat complexity through woody debris recruitment as well. Although Gallagher Creek is not listed for temperature, its receiving water body, upper Nevada Creek, is listed. The increased shade provided by woody vegetation will also help reduce temperatures downstream in Nevada Creek, where stream temperatures are elevated and requiring a TMDL.

Grazing BMPs are recommended as a primary means of reducing nutrient delivery to Gallagher Creek. Grazing in the stream corridor is suspected as a primary cause of nutrient loading, and BMPs should therefore concentrate on reducing grazing pressure on the channel margin.

Riparian Area BMPs are recommended as a complementary measure that will facilitate the retention of nutrients in the riparian zone.

Increasing in-stream flows through Water Conservation BMPs are recommended and would compliment other conservation practices on Gallagher Creek. Increased flows would help flush fine sediment and aid in the recovery of woody riparian vegetation. In 2004, field crews noted several irrigation diversions in need of structural improvements; any repairs that would boost efficiencies have the potential to increase in-stream flows during the irrigation season.

While at least seven road crossings have been identified, no road crossings were examined in the Gallagher Creek watershed during TMDL development. The small sediment load may indicate that the roads and road crossings are well maintained with BMPs in place but assessments of road crossings to determine potential sediment reduction is recommended. An undersized culvert has been noted by Montana FWP (Blackfoot Challenge, 2005).

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, and low flow conditions or creating additional water quality concerns related to temperature metals in Gallagher Creek.

Monitoring Needs
The nutrient impairment determinations for Gallagher Creek are based on limited sampling events. Further monitoring should be conducted to verify impairments and identify potential sources.

10.2.2.8 Jefferson Creek (Upper)

Jefferson Creek is a second order tributary to upper Nevada Creek. Upper Jefferson Creek is approximately 5.5 miles long, and extends from the headwaters to one mile above the mouth of Madison Gulch. Upper Jefferson Creek drains the eastern slopes of Dalton Mountain on the Helena National Forest before entering private lands. Upper Jefferson Creek consists of a single reach, referred to as Jeff1 (**Appendix A; Appendix B**) which flows through a narrow valley bottom with evidence of riparian degradation. Jefferson Creek supports a population of resident WSCT and rainbow trout (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Upper Jefferson Creek was first included on the 1996 303(d) List as impaired for flow alterations, habitat alterations, and siltation. The 2006 list impairments included alterations in stream-side or littoral vegetative covers (habitat) and sedimentation/siltation. Data collected in support of TMDL development confirm the sediment and habitat related impairments but do not confirm flow alterations as a limiting factor.

Excess fine sediment has been measured in the channel of upper Jefferson Creek, and this sediment loading is indicative of degraded conditions in the reach (**Table 10-24**). All but one substrate target measurement (<6mm) were not met in upper Jefferson Creek. Additionally, when compared to TMDL targets developed for the reach, the creek has low pool frequencies, shallow pool depths, and limited overall pool extent which verify excess sediment findings (**Section 5.0**). Macroinvertebrate sampling shows moderate sediment/habitat related impairments in the upper mountain region of Jefferson Creek, and severe impairments in the lower valley region.

Additional limitations to habitat and water quality are caused by a low extent of woody bankline vegetation. Woody vegetation extent is approximately 40% of target values (**Section 5.0**). In addition to excess sediment, a lack of woody vegetation and in-stream woody debris recruitment is likely contributing to poor pool habitat and quality.

Suspected Sources and Causes
The suspected primary sources of sediment loading in upper Jefferson Creek are stream bank and hillslope erosion. Combined these two sources account for 456 tons of controllable sediment with about half of the load coming from each source (**Section 9.0**). Causes of bank erosion include placer mining, livestock grazing practices and silviculture. Portions of upper Jefferson Creek have been extensively placer mined which has significantly impacted the physical character of the stream. The disturbance of the stream during mining has left banks less stable which has led to higher erosion rates. In addition to historic mining, the riparian area is actively grazed contributing to further bank instability. Historic timber harvesting of steep hillslopes adjacent to Jefferson Creek is evident on aerial photography.

Similar to bank erosion, causes of hill slope erosion are livestock grazing practices, placer mining and silvicultural practices. All of these practices result in disturbance of the ground surface which causes an increased susceptibility of soil erosion and transport towards the stream channel. Noxious weeds, which commonly infest areas where the ground has been disturbed, were also noted as present in upland areas.

Roads are estimated to contribute a relatively minor fraction of the overall sediment load. Road density in upper Jefferson Creek is considered high (USDA Forest Service, 1996) at 3.0 miles per square mile but roads crossings contribute only 8 tons of sediment per year to the stream.

The riparian corridor on upper Jefferson Creek consists of primarily herbaceous vegetation on the stream banks with moderately dense riparian shrubs in the riparian buffer zone. The limited extent of woody vegetation is clearly linked to disturbances caused by historic placer mining. These disturbances include the mechanical removal of vegetation in order to access the underlying alluvium for processing. Other riparian vegetation was buried by placer spoils. These spoils, which typically form long berms along the channel margin, do not support regenerating vegetation due to poor soil properties. As a result, the placered channel is straight and entrenched with minimal floodplain access. Habitat complexity is minimal. In places, the creek flows through multiple shallow channels that are physically defined by the spoil piles. In addition to the impacts of mining on the riparian zone, active grazing in the area has further suppressed the recovery of riparian vegetation.

While not confirmed, flow alterations are a suspect source of habitat/water quality limitations on upper Jefferson Creek and have been noted by Montana FWP (Blackfoot Challenge, 2005). These depletions are related to fine sediment buildup, as well as low bank line woody vegetation extents. Placer mining may potentially relate to induced flow infiltration into the coarse grained, placered valley bottom. Irrigation diversions may also contribute to low flows.

Table 10-24. Summary of Identified Problems and Applicable Treatments, Upper Jefferson Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (219.6 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Road sediment (2.4 tons/yr)	Roads BMPs
		Upland sediment (236 tons/yr total)	Upland BMPs
			Grazing BMPs
			Forestry BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
			Stream BMPs
Nutrients	**NONE**		Preventative
Temperature	**NONE**		Preventative
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in upper Jefferson Creek (Blackfoot Challenge, 2005).

Addressing the impacts of placer mining in upper Jefferson Creek is a primary consideration as the active restoration of placer mined stream segments has the potential to dramatically improve habitat and water quality conditions in the reach. Currently, placer mined sections are monotonously straight, poorly vegetated, and .prone to flow infiltration into the coarse grained spoils. Floodplain access is poor due to the confining berms. Restoration efforts in the reach should include the following elements:

- Removal or regrading of spoil berms to promote floodplain access;
- Reconstruction of the channel to increase sinuosity and alleviate any perching that drives low flow infiltration;
- Habitat enhancement in the restored channel through construction of pool/riffle sequences;
- Incorporation of large woody debris elements to promote scour and provide cover; and,
- Revegetation of reconstructed bank and floodplain areas.

The restoration elements described above would greatly improve overall habitat complexity in the reach. Increased shade would also reduce the temperature of flows entering upper Nevada Creek, which is listed as impaired due to high temperatures. It is critical however that any channel restoration efforts be coupled with Grazing BMPs, Riparian Area BMPS, and Water

Conservation BMPs to ensure that the restored channel is provided conditions necessary for post-restoration recovery and long-term habitat sustainability. Grazing BMPs are an important means of contributing to the integrity and stability of streambanks as well as the recovery of woody bank vegetation. Providing sufficient minimum flows to promote the flushing of fine sediment and nourishment of riparian vegetation will improve overall habitat conditions by forming pools, deepening pools, developing a source of habitat-forming woody debris, and increasing shade.

Grazing BMPs and Upland BMPs such as a riparian buffer or filter strip would help reduce sediment from hill slope sources. Revegetation of areas where timber harvesting has occurred would also reduce sediment delivery as would the use of Forestry BMPs in future harvesting activities.

Two road crossings were examined in 2005 and found BMPs to be lacking. Measurements also show culverts at these road crossings as perched and one is at risk for failure due to a constriction ratio of 0.8 (RDG, 2006). While roads do not contribute a large amount of sediment, opportunities for maintenance or installation of BMPs should be explored particularly where fish passage barriers are present and fill failure is possible.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment and habitat conditions or creating additional water quality concerns related to low flows, nutrients, temperature, or metals in upper Jefferson Creek.

Monitoring Needs
No immediate monitoring needs are present in upper Jefferson Creek.

10.2.2.9 Jefferson Creek (Lower)

Lower Jefferson Creek extends from one mile above Madison Gulch to the mouth where it enters Nevada Creek. Lower Jefferson Creek is primarily on private lands and consists of a single reach, Jeff2 (**Appendix A; Appendix B**). Lower Jefferson Creek flows through a broad open valley to its confluence with Nevada Creek, a distance of approximately 2 miles. The creek is sparsely vegetated with willows, and the channel definition decays in the downstream direction. This reach of Jefferson Creek supports rainbow trout (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Lower Jefferson Creek was included on the 1996 303(d) List as impaired due to flow alterations, habitat alterations, and siltation. In 2006, the impairment cause list for lower Jefferson Creek expanded to include metals (aluminum and iron), solids (suspended/bedload), and nutrients (TP). Data collected in support of TMDL development confirms the 1996 and 2006 listed causes of impairments.

Excess fine sediment was not observed in the bed of the creek, largely because the assessment reaches are very straight and sediment storage is minimal. In other areas where the channel is more sinuous, fine sediment is suspected as a limiting factor with regard to habitat and water quality. This is indicated by the shallow pools and low pool frequencies in sinuous reaches. High accumulations of fine sediment in areas of low flow velocity have been described in the reach in other studies (Pierce et al, 2002a) as well. Macroinvertebrate samples showed moderate to severe impairments with respect to sediment and habitat (**Section 5.0**).

Pool quality and woody vegetation extents are limited in lower Jefferson Creek, indicating poor riparian and aquatic habitat within the reach. Pool frequency is about 30% of target values while woody vegetation extent is approximately 60% of target values. Residual pool depths are approximately one half of target values, which further supports excess sediment findings (**Section 5.0**). Aerial assessments (**Appendix B**) also link a reduction in channel definition in the downstream direction through the reach due to dewatering.

Overall water quality degradation is further indicated by high measured concentrations of nutrients (TP), aluminum, and iron. Two nutrient sampling events were conducted on lower Jefferson Creek in 2003 with one TP exceedence during the eco-regional "winter season." TP levels were only slightly elevated (0.041 mg/l compared to the target of 0.03 mg/l) but it should be noted that the sample was taken on the first day of the eco-regional winter season where target concentrations increase from 0.01 mg/l to 0.03 mg/l (**Section 7.0**). Lower Jefferson Creek was sampled twice in 2003 (high and low flow) and once in 2005 (high flow) for metals. Exceedences for aluminum (2003) and iron (2005) were measured, both during high flow events (**Section 6.0**)

Suspected Sources and Causes

The total sediment load from sediment sources (bank erosion, hillslope erosion, and road erosion) is 9.3 tons per year which when compared to other watersheds in the Nevada Creek planning area is very low (**Section 9.0**). The total controllable load is less than 2 tons per year from these three sources. There are possible explanations for these findings. The area surrounding lower Jefferson Creek is fairly flat with good ground cover so sediment delivery from hill slopes is minimal. Bank erosion is likely low due to dewatering. Identified causes of bank erosion include hay production, livestock grazing practices, and placer mining. Only three road crossings were identified in lower Jefferson Creek. Sediment delivery from this crossing is probably very minor due to the flatness of the road, well-vegetated fillslopes and BMPs.

The relatively small contribution of sediment from these sources in lower Jefferson Creek suggests that excess sediment is delivered from upper Jefferson Creek. This also suggests that low flows in lower Jefferson Creek may be the primary cause of sediment issues. Insufficient in-stream flows prevent the stream from flushing sediments delivered from the upper watershed.

Low flows may also be linked to riparian habitat degradation as woody vegetation cannot be supported by current water supplies. Grazing practices and hay production in lower Jefferson Creek also likely contribute to riparian habitat degradation as woody vegetation has been removed to support these land uses.

In places, lower Jefferson Creek appears to have been modified and/or relocated to more efficiently deliver irrigation water to adjacent fields. The channel is relatively straight and mildly entrenched which partially explains the lack of in-stream habitat complexity. The removal of woody bank vegetation has compounded this issue as woody debris recruitment and the creation of habitat features is minimal.

A short segment of lower Jefferson Creek flows directly through a corral which is likely a source of nutrients. Other sources of nutrients include areas where livestock graze within or adjacent to the stream corridor.

Exceedences of iron and aluminum were observed only during high flow and high TSS events suggesting metals concentrations are linked to fine sediment sources. Sampling did not reveal a more finite metals source (**Section 9.0**).

Table 10-25. Summary of Identified Problems and Applicable Treatments, Lower Jefferson Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**None measured (however excess fine sediment from upper Jefferson Creek is suspected as source of habitat degradation)**	**Stream bank sediment (0.4 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
			Water Conservation BMPs
		Road sediment (2 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool quality and extent; woody vegetation extent**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
		Riparian degradation	Riparian Area BMPs
			Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Phosphorous**	**Livestock Grazing**	Grazing BMPs
Temperature	**NONE**		Preventative
Metals	**Aluminum**	**Sediment**	See above
	Iron		See above

Recommended Conservation Practices/BMPs

Some grazing management and off-stream watering work has been performed immediately above the highway in an effort to increase streamflows (Blackfoot Challenge, 2005).

Rehabilitation of upper Jefferson Creek to reduce downstream sediment delivery (see **Section 10.2.2.8**) and maintenance of minimum instream flows through Water Conservation BMPs are primary considerations in addressing issues on lower Jefferson Creek. Upper Jefferson Creek, which has been destabilized by historic placer mining, would be first priority for active stream channel restoration/reconstruction. Efforts in upper Jefferson Creek would translate downstream in the form of reduced sediment and metals loading in lower Jefferson Creek. If the upper creek were restored such that habitat was substantially enhanced, it would be appropriate to consider somewhat similar measures in lower Jefferson Creek.

Air photos of lower Jefferson Creek show faint channel threads on the floodplain that are much more sinuous than the existing channel. In some locations, remnant willow stands are present on the floodplain. Currently, the channel is largely straight, and alternates between being entrenched and having very poor bank definition. This suggests that the channel has been modified to facilitate water delivery. One means of improving habitat and water quality on lower Jefferson Creek would be to restore this channel segment into a sinuous, vegetated, stable channel that provides quality fish habitat, and if desired, improves habitat connectivity between upper Nevada Creek and upper Jefferson Creek. Replacement of a culvert and realignment of the stream below the crossing should also be considered in channel restoration efforts.

With or without channel restoration, Water Conservation BMPs, Riparian Area BMPs, and Grazing BMPs are recommended for lower Jefferson Creek. The pool habitat quality and riparian condition would benefit from careful management of streamflows during the irrigation season to prevent dewatering that causes sediment buildup and reduced riparian vigor. Active planting of willows in the riparian zone would increase bank integrity, provide a source of woody debris to the channel to increase aquatic habitat complexity, and provide shade to keep stream temperatures cool. Any lowering of stream temperatures on Jefferson Creek would help alleviate the high temperature problems on upper Nevada Creek. Grazing BMPs that controlled animal access to the stream and riparian area would facilitate these recovery efforts. Well-applied grazing BMPs on lower Jefferson Creek would improve riparian integrity and reduce nutrient entrainment rates.

Removal of the corral/feeding pen on lower Jefferson Creek is recommended to reduce nutrients, reduce sediment, and to improve riparian and in-stream habitat. Other effective nutrient treatments would include a reduction of overall grazing pressure in the stream corridor.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, metals, and low flow conditions or creating additional water quality concerns related to temperature in lower Jefferson Creek.

Monitoring Needs
The total phosphorous, aluminum, and iron impairment for lower Jefferson Creek are based on limited sampling in which only one exceedence for each pollutant is documented. Further sampling should be conducted to confirm these impairments and identify other potential sources.

10.2.2.10 McElwain Creek

McElwain Creek is a second order tributary to lower Nevada Creek and consists of a single reach that is of a small sinuous channel that is locally entrenched (**Appendix A; Appendix B**). The stream originates and flows for approximately three miles on public land before entering private ranch lands. McElwain Creek continues for another six miles on private lands before entering Nevada Creek. For TMDL development purposes, the single reach of McElwain Creek begins at a reservoir approximately 2 miles upstream of the mouth. The channel definition within this channel segment is poor, and is locally manifested as an indistinct swale in the valley bottom.

Riparian degradation is evident on the aerial photography. During the field investigation of July 2004, several young of year and 4” adult westslope cutthroat trout were observed in the section of stream above the Ovando-Helmville Road. McElwain Creek supports pure resident westslope cutthroat populations with densities decreasing in the downstream direction (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations

The reach of McElwain Creek that has been identified as impaired extends 2 miles upstream from its mouth. McElwain Creek was included on the 1996 303(d) List as impaired due to flow alterations, pathogens, and siltation. In 2006, impairments causes cited include alterations in stream-side or littoral vegetative covers (habitat), low flow alterations, nutrients (TN and TP), and sedimentation/siltation. Data collected in support of TMDL development confirm all identified impairments except pathogens which are currently addressed under nutrient impairments.

The data compiled for TMDL development on McElwain Creek indicate that excess fine sediment is a significant limiting factor with regard to habitat and water quality o the reach. Both pool and riffle environments have measured fine sediment fractions of 100% on McElwain Creek. Field observations indicate that the stream has a gravel bed. However that bed has been buried by several inches of silt. Habitat is limited by poor pool quality which may also be caused by excess sediment. The median residual pool depths do not exceed 0.3 ft at either of the field assessment sites (upstream and downstream of Helmville Rd); this is a significant departure from the target value of 1.5 ft (**Section 5.0**)

In-stream and riparian habitat is also impacted by low extents of woody riparian vegetation on the channel banks. The extent of bankline supporting woody vegetation is less than 22 percent, which is significantly below the target value of 74%. Woody debris aggregates in the stream channel are approximately 18% of target values which also partially explains poor pool habitat and stream complexity (**Section 5.0**).

Nutrients, in the form of total phosphorous, have also been identified as a limiting factor with respect to the water quality of McElwain Creek. Montana DEQ collected a water quality sample on August 17, 2004, at a location approximately 4.5 miles upstream from the mouth (outside of the listed reach). Sample results exceed the corresponding eco-regional growing season targets for TP (0.085 mg/L), TKN (0.4 mg/L) and $NO_{3/2}$ (0.04 mg/L) (**Section 7.0**).

Suspected Sources and Causes

Hill slope erosion in the McElwain Creek basin accounts for approximately 175 tons of controllable sediment. Vegetation removal in uplands and riparian areas associated with grazing and hay production practices is suspected as the primary cause of hill slope erosion (**Section 9.0**). Some earlier assessments of McElwain Creek attribute some of the fine sediment sourcing to logging activities.

While erosion from hill slopes represents the largest portion of controllable sediment, field assessments indicate that bank erosion is a primary contributor of sediment to the stream. In the upper portion of the listed segment, the channel is somewhat incised and the stream banks are typically unstable and bank erosion is extensive. The total sediment load from bank erosion is 333 tons/year with 120 tons/year being identified as controllable (**Section 9.0**). Land uses in this segment of McElwain Creek include livestock grazing and hay production and been identified as primary causes of bank erosion.

Roads contribute less sediment to the system at approximately 35 tons per year. Twenty-four possible road crossings were identified in McElwain Creek; each contributing an average of 4 tons of sediment per year to the stream (RDG, 2006).

The excess fines in McElwain Creek have contributed to the development of poor pool conditions. Although pool habitat units are present, they typically have up to 3 inches of silt overlying gravel. Poor pool quality and in-stream habitat complexity are also linked to low flows. The upper end of the segment has an irrigation reservoir that diverts flow away from the creek. Below the reservoir, the creek has very poor definition, and the faint swale is typically bordered by sparse woody riparian vegetation. Further downstream, below the Helmville Road, McElwain Creek is severely dewatered, and was entirely dry during the field investigation of July, 2004 (DTM and AGI, 2005). Hydrologic controls in place for irrigation contribute to low flows and the ability of the stream to flush sediments through the system.

The native woody vegetation consists primarily of alders, and is sparse. The floodplain and river corridor in this area are used for grazing and irrigated hay production which have likely removed woody riparian vegetation to accommodate these land uses. The lack of woody riparian vegetation has resulted in a declining riparian habitat, instability of stream banks, and less than optimal in-stream habitat conditions.

The suspected sources of the high nutrient levels and pathogens are stream corridor grazing and concentration of livestock in corrals that abut the stream corridor. Stream corridor grazing contributes nutrients via bank trampling and nutrient-laden sediment recruitment, as well as by direct inputs of livestock waste into the creek. Near the Helmville Road, corrals abut the stream corridor and these facilities are suspected contributors of nutrients to McElwain Creek.

Table 10-26. Summary of Identified Problems and Applicable Treatments, McElwain Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (120 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
			Water Conservation BMPs
		Hill slope sediment (175 ton/yr)	Upland BMPs
			Grazing BMPs
		Road sediment (11 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Phosphorous**	**Livestock Grazing**	Grazing BMPs
	TKN	**Stream bank sediment**	
	NO32	**Upland sediment**	
Temperature	**NONE**		Preventative
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

Some conservation practices have been implemented on McElwain Creek including the removal of a streamside feedlot and off-stream water development (Blackfoot Challenge, 2005).

In 2004, field crews noted assessed reaches as having excellent potential for improvements to habitat and water quality conditions on McElwain Creek with the application of conservation practices. Grazing and Riparian Area BMPS would help to address two major concerns on McElwain Creek; stream bank erosion and riparian vegetation. In the reach above Helmville Road, stream bank erosion could be greatly reduced through riparian grazing management practices and aggressive riparian area plantings. Stabilizing the stream banks through grading could also be considered for this reach. Similar bank erosion and riparian vegetation treatments are recommended for the lower reach of McElwain Creek. Bank erosion in the reach appears largely driven by hoof shear and woody riparian vegetation is highly degraded where livestock access the stream corridor. Locally, where willows provide shade for livestock, the banks are trampled and the channel is over-widened. In general, any conservation practices that protect and promote the recovery of riparian areas are recommended.

As discussed in the Suspected Sources and Causes section, McElwain Creek is dewatered for irrigation. Low flows created by diversions have lead to several problems including the accumulation of fine sediments, poor channel and in-stream habitat definition, and a decline in woody riparian vegetation. Supplementing in-stream flows through irrigation water management or development of irrigation water from other sources would help to address these issues by flushing sediments and aiding the recovery of woody riparian vegetation.

Two road crossings located above the listed segment of McElwain Creek were assessed in 2005 and partial BMPs were noted. Culverts at both of these road crossings were identified as being potential fish barriers and at risk for fill failure. The lowermost crossing assessed was within the listed segment on the Ovando-Helmville road also noted partial BMPs, potential fish passage barrier and at risk for fill failure. Opportunities for addressing fill failure risks, reducing sediment delivery, and fish passage barriers should be explored.

Reducing sediment from upland sources should focus on promoting sufficient vegetation in upland and riparian areas to trap and store sediment before it enters the stream. Filter strips in the riparian area could be beneficial as could controlling the removal of vegetation through Grazing and various Upland BMPs. Weeds were noted in the upper portions of the watershed during the road assessment and within the listed stream segment during stream assessments. Weed management would improve soil stability in upland and riparian areas and should be included in any conservation plan.

Grazing BMPs are recommended to reduce the delivery of nutrients to the creek. These BMPs would include reduced grazing pressure in the stream corridor, which will be an important component of riparian recovery. Additionally, any corrals that are located close to the stream corridor should be considered as nutrient sources and treated accordingly. Appropriate treatments may include relocation of the facility further away from the stream, or potentially the implementation of Riparian BMPs adjacent to the facility to reduce nutrient delivery rates through the riparian zone.

BBCTU and the North Powell CD recently began working with landowners on McElwain Creek to discuss the potential for implementing many of the conservation practices described above. While discussions are still in preliminary stages, potential projects include developing other water sources for irrigation and developing other water sources for livestock watering. If implemented, these practices would result in increased in-stream flows and protection of riparian areas.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, and low flow conditions or creating additional water quality concerns related to temperature or metals in McElwain Creek.

Monitoring Needs

While the TP exceedence measured in 2004 was significant, the impairment determination is based on one sample. Further sampling should be conducted to confirm this impairment and identify potential sources.

Measured TKN concentrations technically did not exceed standards (concentrations were at standard levels). However, the stream has been listed as impaired for TKN. Further sampling should be conducted to confirm this impairment and identify potential sources.

The effectiveness and success of completed projects on McElwain Creek have not been well documented. Monitoring and any necessary maintenance of these projects is recommended.

10.2.2.11 Murray Creek

Murray Creek is a second order tributary to Douglas Creek flowing through public (BLM) and private lands. The stream is approximately 8 miles long and consists of three reaches (**Appendix A; Appendix B**). The upstream reach is a confined, densely forested reach that flows through basaltic geology. Murr2 is also confined within steep hill slopes; in this reach the stream corridor is somewhat wider, and supports a conifer/willow riparian community. The downstream limit of Murr2 marks the emergence of the stream into an open valley; within this lowermost reach Murr3 is characterized by a small channel that is bordered by a thin band of woody riparian vegetation. The definition of the stream channel decays in the downstream direction. Murray Creek supports low densities of genetically pure WSCT in the middle and upper reaches with densities increasing in the upstream direction (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Murray Creek was included on the 1996 303(d) List as impaired due to flow alterations, habitat alterations, siltation, and thermal modifications. These listed impairments were maintained in 2006 and impairments for nutrients (TN and TP), Chlorophyll-a, and arsenic were also added. Data collected in support of TMDL development confirm that with the exception of Chlorophyll-a and arsenic, all impairment listings are justified.

Available water quality data for Murray Creek is somewhat limited. Murray Creek had several habitat assessments performed in the 1980s and early 1990s. These assessments identified degraded conditions in the middle and lower reaches of the creek (**Section 2.0**). These impacts include severe bank erosion, decadent woody riparian vegetation, and fish passage barriers. The data available for Murray Creek include macroinvertebrate analysis results and pebble count data collected from two sites in September of 2003 representing reaches Murr2 and Murr3. The riffle substrate targets were not met for either size fraction at either sample location. Existing conditions are at least twice the target values at both sites. The macroinvertebrate data show conditions very close to impairment thresholds in the confined B channel type of Murr2. The MMI and RIVPACS metrics for samples collected downstream in Murr3 show moderate and severe levels of impairment, respectively (**Section 5.0**).

In the headwaters area, the assessments indicated that the riparian zone is healthy. A subsequent assessment by DEQ similarly identified the headwaters as largely functional, with problems associated with fine sediment accumulations increasing in the downstream direction. Culvert-related fish passage barriers were still present in 2003.

Montana DEQ collected water quality samples on two dates from three locations on Murray Creek: the first in 1983 about one half mile above the mouth; another about one mile above the mouth in 2003; and a third about 6.5 miles above the mouth in 2003. All TP values exceed the eco-regional seasonal targets. The eco-regional growing season TKN target is met at the upstream site and exceeded downstream on the same day. Values of $NO_{2/3}$ from the two downstream sites meet the respective eco-regional targets; the upstream $NO_{3/2}$ exceeds the eco-regional growing season target.

Arsenic samples collected at the same time as nutrient samples in 2003 showed an exceedence at the downstream road crossing. While arsenic values were exceeded, it is unclear whether these levels are naturally high due to the area's geology or if arsenic concentrations are influenced by human activities.

Only instantaneous water temperature data is available for Murray Creek and were taken in the fall and did not address the hot summer period when stream temperatures are high (July 15th – August 15th). Other assessments performed on Murray Creek were used as indicators for temperature impairment. A macroinvertebrate sample collected in September 2003 from the downstream site had a very high biotic index, indicative of thermal alterations that create warm water conditions. Assessment of vegetation from air photos indicates a decrease in streambank woody vegetation from upstream to downstream along Murray Creek. Shade percentages estimated for reaches Murr1 through Murr3 are 58%, 29%, and 28% respectively (DTM and AGI, 2006). Temperature impairments are found in other watersheds with similar woody vegetation and shade values which support concerns of high water temperatures (**Section 8.0**). Flows, another temperature influencing factor, were measured in 2003 by Montana DEQ and show a decrease from four cfs to 0.2 cfs from the upstream to downstream monitoring sites.

The woody vegetation and flow values used in determining temperature impairment also support the riparian vegetation degradation and low flow alteration impairment listings.

Suspected Sources and Causes

With respect to the excess levels of fine sediment on Murray Creek, upland areas are suspected to be the primary sediment source. Over 3,700 tons of sediment per year is considered to be influenced by human activity and therefore controllable. Livestock grazing practices account for about 30% of this load with road extent accounting for the remaining load. The controllable sediment load from road extent is different from the controllable sediment load from road crossings. The large sediment load from road extent suggests that significant portions of roads within the Murray Creek watershed are located near streams for extensive lengths. Road density in Murray Creek is 2.6 miles per square mile which is considered to be high (USDA Forest Service, 1996). In addition to road extent, 50 road crossings in the watershed contribute sediment to the stream. Of the 100 tons per year delivered to the stream, 30 tons is considered to be controllable through management and BMPs.

Stream bank erosion is also a significant sediment source, contributing just over 600 tons of sediment per year. About 36% (224 tons/year) of the total bank erosion sediment load is considered controllable and is attributed to disturbances in the riparian area from livestock grazing practices, hay production practices, and silvicultural practices. The vast majority of sediment derived from bank erosion is sourced within the lower 3 miles of Murray Creek (**Section 9.0**).

The fine sediment loading to Murray Creek is suspected as a primary reason for the degradation of pool habitat in the channel and poor riffle substrate. Low flow alterations are also suspected as linked to fine sediment buildup and pool degradation as well as reduced extents of woody riparian vegetation. Murray Creek loses almost all of its flows to irrigation over a three mile stretch. These flows are not sufficient for flushing of sediment within the stream or maintaining desired woody bank vegetation.

The combination of low flow alterations and reduced shade from loss of woody bankline vegetation is suspected to have resulted in elevated water temperatures on Murray Creek. Removal of woody bank vegetation from grazing practices, hay production, and silvicultural practices has increased the surface area of water exposed to sunlight and caused increases in water temperatures. Estimated shade values for Murr1, Murr2, and Murr3 (58%, 29%, and 28% respectively) are well below estimated shade values (91%) needed to achieve desired stream temperatures (**Section 8.0**).

Livestock grazing is suspected as the primary source of elevated nutrient levels in Murray Creek. These practices result in sediment loading due to increased streambank and hill slope erosion, as well as direct inputs of livestock waste where cattle access the stream corridor. Corrals were identified in the lower reaches of Murray Creek that have ditches running through the enclosures. If these ditches return flow to the creek, they are likely additional contributors of nutrients.

Table 10-27. Summary of Identified Problems and Applicable Treatments, Murray Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (224 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Hill slope sediment (3,748 tons/yr)	Road BMPs
			Upland BMPs
			Grazing BMPs
		Road sediment (30 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality; woody vegetation extent**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
		Riparian degradation	Riparian Area BMPs
			Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**Total Phosphorous, TKN, NO23**	**Upland sediment Streambank sediment Livestock grazing**	Grazing BMPs
Temperature	**Water Temperatures above Natural Range**	**Riparian degradation**	Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**None**		Preventative/Monitoring

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Murray Creek (Blackfoot Challenge, 2005).

Hill slope erosion is the primary contributor of sediment to Murray Creek according to the sediment source assessment. Road extent appears to be the cause of most hill slope erosion due to proximity of roads to streams in the watershed. Restoring vegetation in riparian areas as a means to trap sediment would be effective. Where feasible, road decommissioning or road re-routing are options for sediment reduction. In addition to road extent, reduction of sediment from road crossings could be achieved through Road BMPs. Specific road crossing data was not obtained during TMDL development. However, assessments performed by Montana FWP found poor road crossings, poor road drainage, and perched and undersized culverts (Blackfoot Challenge, 2005). If restoring habitat connectivity is considered a priority on Murray Creek, fish passage barriers identified at culvert crossings should be remedied.

The primary recommended conservation practices for reduction of bank erosion in Murray Creek include Grazing BMPs and Riparian Area BMPs. Grazing BMPs should focus primarily on the recovery of adequate woody bank line vegetation and controlling animal stream access to reduce rates of stream bank erosion. This recovery of riparian vegetation could be accelerated with willow plantings, although any revegetation effort must be performed in conjunction with livestock management to optimize vegetation survival rates. Actively eroding banks would potentially benefit from engineered erosion control measures, although the application of such measures should be limited to sites of severe erosion where vegetation-based erosion control is unfeasible, such as at livestock access points. Results of the sediment source inventory indicate that the largest reductions in bank erosion are most needed in the lowermost 3 miles of Murray Creek.

Another benefit of vegetation recovery to stabilize stream banks is the associated shading provided by woody vegetation will reduce water temperatures. Water temperatures could potentially fall 7 to 10 degrees with woody vegetation recovery. Supplementing instream flows during the irrigation season through Water Conservation BMPs would also lower temperatures in Murray Creek. Additional in-stream flows also have the benefit of providing natural flushing of fine sediment from the channel bed which will improve pool and spawning habitat and will increase woody vegetation survival rates.

Implementation of Grazing BMPs will also assist with reduction of sediment and nutrients from upland sources and stream banks. Recovery of the riparian area through grazing management and revegetation would provide a filter for sediment and nutrients. Where ditches flow through corrals, those ditches should be terminated before they reach the channel to prevent excessive nutrient delivery from the corral to the creek. Or, the corrals should be relocated away from the ditch.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, temperature, and low flow conditions or creating additional water quality concerns related to metals in Murray Creek.

Monitoring Needs
Nutrient impairments for TP, NO_{23}, and TKN are based on one sampling event. Further monitoring is recommended to confirm these impairments and determine potential sources.

From available samples, it is unclear whether arsenic concentrations are a result of human activities or a natural function of the geology in the area. Further sampling is recommended to confirm these impairments and determine potential sources.

Due to a lack of data, temperature impairments were determined using indirect measures and extrapolating data from similar watersheds. Temperature monitoring is recommended to more clearly define current conditions, temperature impairment sources, and their relative contributions to thermal loading.

10.2.2.12 Nevada Creek (Upper)

Upper Nevada Creek extends from its headwaters on Nevada Mountain downstream approximately 19 miles to Nevada Lake reservoir. Upper Nevada Creek flows through a mixture of public and private lands and consists of six reaches (**Appendix A; Appendix B**). Nev1 is a steep, highly confined, and densely forested channel that flows approximately four miles through its headwaters area. Downstream, in reaches Nev2 and Nev3, the valley bottom and riparian corridor are significantly wider, such that there is typically a larger buffer between the channel bankline and adjacent hill slopes. The riparian corridor consists of herbaceous grasses, dense riparian shrubs, and conifers. In several places within Nev3, the channel abuts the valley wall, and bedrock outcrops naturally stabilize the bank toe. Nev4 marks the emergence of Nevada Creek from its confined headwaters into the open valley, and this reach is a meandering, unconfined channel that is sparsely vegetated with scattered willows. Nev5, which extends downstream to the Washington Creek confluence, has sparse woody vegetation on both the channel bankline and adjacent floodplain. The channel is moderately entrenched, and has been straightened in some areas. From the Washington Creek confluence to Nevada Reservoir, Nev6 supports primarily herbaceous vegetation with scattered riparian shrubs. The channel has a meandering plan form with large point bars and active cutbank erosion. Upper Nevada Creek supports populations of WSCT, rainbow trout, and brook trout. The USFS reports bull trout in upper reaches but in very low numbers (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Upper Nevada Creek was included on the 1996 303(d) List as impaired due to flow alterations, nutrients, habitat alterations, siltation, and temperature. In 2006, listed causes of impairment included nutrients (TN/TKN), alterations in stream-side or littoral vegetative covers (habitat), solids (suspended/bedload), physical substrate habitat alterations, and metals (cadmium, lead, mercury). Data collected in support of TMDL development confirm sediment, habitat, temperature, and nutrient impairments. In addition, these data also identify TP (total phosphorous) as a limiting factor. Metals data did not support listings for cadmium and mercury but did confirm lead impairments and also identified iron and copper as limiting factors to water quality.

With the exception of pool extent, the uppermost reaches of upper Nevada Creek (as measured in Nev2), meet all sediment and habitat related targets. The uppermost 4 miles of stream has been described as having stable banks and good overhanging cover (McGuire, 1995). However, as the stream transitions from a relatively steep, confined channel in the forested headwaters to a lower gradient meandering stream in the open valley, conditions decline. Sediment and habitat parameters of percent <2mm surface fines in riffles, pool frequency, and residual pool depth do not meet target values for any of the assessed reaches (Nev3 to Nev6). Additionally, these reaches of upper Nevada Creek appear over-widened, have excess pool tail sediment and have little woody bankline vegetation. All of these measures support excess sediment, degraded habitat, and woody bank vegetation impairment determinations. It is also worth noting the significance of departures for certain parameters. Woody vegetation and woody debris aggregates were absent in some assessed reaches. Pool frequency and pool extent were 15% and less than 1% respectively of target values. Riffle substrate (<2mm) and pool tailout surface fines were more than double targets set for C channel stream types (**Section 5.0**).

Nutrient sampling results from 1980 show elevated levels of TN and TKN during the June sampling and similar results in July, plus an elevated TP result during the growing season. Water quality sampling results from 2003 and 2004 at USGS station 12335500 include three eco-regional target exceedences for TN and eight exceedences for TP. TP values from 2003 and 2004 consistently exceeded eco-regional TP targets during both runoff and growing seasons (**Section 7.0**).

Recent metals sampling in upper Nevada Creek have measured iron, copper, and lead exceedences (**Section 6.0**). Iron concentrations for aquatic life were exceeded in both high and low flow sampling events. Copper and lead exceedences have also been measured but are limited to high flow events. Previous cadmium and mercury listings were not supported by recent sampling efforts.

Water temperatures in the headwaters of upper Nevada Creek are cool and maximum temperatures do not exceed 65 degrees. Water temperatures increase steadily downstream reaching a maximum of 74 degrees before entering Nevada Reservoir. This is an increase of 9 degrees over the length of the stream. The SNTEMP model (**Section 8.0**) indicates that maximum daily temperatures of 65 degrees are appropriate for this stream. Current modeled maximum daily temperatures are 6.4 degrees above modeled naturally occurring temperatures which support water temperature impairment determinations (**Section 8.0**).

Suspected Sources and Causes

Results of the sediment source assessment indicated that both eroding stream banks and upland areas contribute over 3,400 tons per year of fine sediment to upper Nevada Creek (**Section 9.0**). Of those two sources, sediment from hill slope erosion is slightly greater but also has a much greater controllable load. Upper Nevada Creek is a large area that drains approximately 74,000 acres of land; most of which is an agricultural valley. Agricultural uses in upper Nevada Creek include livestock grazing and hay production. The practices associated with these land uses are suspected as the primary cause of hill slope erosion.

Streambank erosion is another significant source of sediment in upper Nevada Creek and accounts for 529 tons of controllable sediment. Bank erosion and the subsequent sediment loading are believed to be caused by practices associate with numerous land uses including hay production, livestock grazing, silviculture, and placer mining. Bank erosion rates are generally low in the uppermost reaches (Nev1 and Nev2) but increase dramatically as Nevada Creek enters the valley. As the valley bottom widens, timber harvesting has occurred on the valley margins, and the valley bottom has been placer mined (Nev3). Placer mining in particular has caused instability of the stream banks although vegetation densities indicate some level of recovery from these impacts. Below the semi-confined historically placer mined section, Nevada Creek flows into a broad open valley where riparian areas are actively grazed (Nev4, Nev5, and Nev6). It is in these reaches where bank erosion rates are also the highest (**Section 9.0**).

When examining sediment from roads in upper Nevada Creek it is necessary to look at two scales. Given the area of upper Nevada Creek, sediment from 99 road crossings is fairly low (29 tons/year with 8.7 controllable tons/year). However, the contribution of sediment from roads in tributaries to upper Nevada Creek must also be considered. At least some of the 66 tons of sediment per year delivered to 303(d) Listed tributaries of upper Nevada Creek from roads will make its way to the mainstem of Nevada Creek. Up to 104 tons of sediment per year was estimated to enter unlisted 303(d) Listed tributaries as well. When other potential sediment loads from roads are factored in, the impact of roads becomes greater. Sanding of Highway 141 also contributes fine sediment to Nevada Creek. A study sponsored by the Montana Department of Transportation in 2005 and 2006 identified an 11-mile stretch of Highway 141 (both above and below Nevada Lake) where road sand is most likely delivered. This study showed that over this 11-mile stretch, 1.77 tons of road sand are delivered annually to Nevada Creek (Hydrometrics, 2007).

The fine sediment from these sources as well as channel modifications and lack of woody riparian vegetation are suspected causes of pool habitat degradation. Through the placer mined sections, the channel is relatively straight and further downstream, portions of the creek have been channelized. Alterations of the stream channel for placer mining and agricultural purposes have resulted in a decline of in-stream habitat complexity and removal of channel features. Woody vegetation, which helps create habitat features, has been almost completely removed to accommodate agricultural land uses.

Lack of shade as a result of woody riparian vegetation removal is suspected as the primary cause of elevated water temperatures. Current woody vegetation estimates are only 26% of those needed to achieve the water temperature standard (**Section 8.0**). Temperatures in upper Nevada Creek increase moving downstream. The difference in woody riparian vegetation in the upper and lower reaches explains most of the temperature gains, but several tributaries including Halfway Creek, Washington Creek and Jefferson Creek also contribute warm water.

Another contributor to elevated water temperatures in upper Nevada Creek is dewatering of streams for irrigation. These low flow alterations are also suspected source of pool infilling and woody riparian vegetation degradation. Dewatering has caused a lack of sediment flushing flows and reduced the ability of the riparian area to support more abundant woody vegetation species.

Excess metals concentrations are at least in part linked to fine sediment. All metals exceedences measured during TMDL development were associated with high flow and high suspended sediment events. Sampling did not reveal any finite metals sources (**Section 6.0**).

Grazing practices are suspected as the primary cause of elevated nutrient levels on upper Nevada Creek. These practices result in nutrient delivery through accelerated bank and hill slope erosion, as well as due to direct inputs of waste by cattle accessing the stream. Multiple corrals abut the stream corridor, and several of these corrals are within 150 feet of the stream. Although information regarding the application of fertilizers adjacent to the stream channel is not available, such applications would likely contribute to elevated nutrient levels in the stream.

Table 10-28. Summary of Identified Problems and Applicable Treatments, Upper Nevada Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (529 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
			Water Conservation BMPs
		Upland sediment (1,370 tons/yr)	Upland BMPs
			Grazing BMPs
		Road sediment (9 tons/yr)	Roads BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality; woody vegetation extent**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
			Upland BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**TKN**	**Stream bank sediment** **Upland sediment** **Livestock grazing**	Grazing BMPs Riparian Area BMPs Upland BMPs
	TN		
	Total Phosphorous		
Temperature	**Water Temperatures above Natural Range**	**Riparian degradation**	Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**Lead**	**Sediment**	See above
	Iron		
	Copper		

Recommended Conservation Practices/BMPs

The North Powell Conservation District and NRCS have been involved in correcting non-point runoff problems on private agricultural areas for several years. Fish passage improvements, channel restoration, riparian vegetation improvements, wetland improvements, improvement of range/riparian habitat, and irrigation improvement projects have all been completed in upper Nevada Creek (Blackfoot Challenge, 2005).

In the headwaters area of upper Nevada Creek, the data compiled for TMDL development indicate that habitat conditions in the headwaters are generally good. Although some sections of the upper reaches have been placer mined, the bank line vegetation has largely recovered, such that these areas have good shade and the banks are stable. However, placer mining has resulted in some loss of channel complexity, in that the stream is relatively straight, and some floodplain access has been lost. In these upper reaches, there is significant potential in improving overall habitat diversity through the selective addition of habitat elements such as large woody debris (LWD) to the system. An increase in LWD concentrations would provide cover and create scour elements that effectively form in-stream habitat. Any measures that can be taken to maintain recovery trends in the highest reaches of upper Nevada Creek should be considered in future land use plans.

Where upper Nevada Creek flows into the broad valley above the reservoir, the stream is significantly impacted by agricultural land use. Streambank erosion is a major source of sediment in these reaches (Nev3 through Nev6). Grazing BMPs such as riparian fencing, reinforcement of livestock crossings, or any other practices that will control animal use of the stream and riparian areas are recommended. Where hay meadows currently abut the stream banks, the implementation of a riparian buffer to limit bank trampling and encourage woody vegetation recovery would be appropriate. Grazing BMPs and Upland BMPs that promote improved vegetative ground cover are recommended to reduce sediment from hillslope sources. Implementation of riparian buffers described to reduce bank erosion would also help trap and store sediment from upland sources before it enters the stream channel. Implementation of these practices will also likely reduce the delivery of metals in Nevada Creek.

Recovery of woody riparian vegetation through the implementation of Riparian Area BMPs should be an important focus of water quality restoration efforts. Woody riparian vegetation will help reduce sediment from bank erosion through stabilization of stream banks and lower water temperatures through increased shade. Woody riparian vegetation can be implemented passively through riparian exclosures or potentially through active willow plantings. Field crews identified some cottonwood recruitment in upper Nevada Creek, so cottonwoods should also be considered in any revegetation plan. Grazing management should be a primary consideration in woody riparian vegetation recovery efforts.

In 2005, several road crossings were examined on the mainstem of upper Nevada Creek. Field crews noted partial implementation of BMPs to a complete absence of BMPs. Similar BMP practices were found during road crossing assessments on non-303(d) Listed tributaries in upper Nevada Creek. None of the sites assessed in upper Nevada Creek appear to present fish passage or fill failure concerns. It is important to note however that very few crossings have been examined and these problems are likely to exist elsewhere in the watershed. In 2004, field crews noted multiple logging road crossings in the upper reaches and undersized culverts have been documented by Montana FWP. Further assessment of road crossings to identified opportunities to reduce sediment from road crossings through the implementation of Road BMPs is recommended.

The reduction of sediment from these sources will improve in-stream habitat conditions. Stream and/or channel restoration is another option to address habitat conditions. In channelized reaches, the stream is lacking in habitat complexity, and would benefit from focused habitat enhancement efforts such as vegetation planting, bank grading, pool/riffle and sequence construction, and restoration of channel sinuosity. Field crews noted several placer spoils and tailings that add to degraded habitat and are a potential source of sediment. Removal of these tailings would likely aid in habitat restoration efforts.

Woody riparian vegetation recovery for the stabilization of stream banks would also greatly reduce water temperatures in upper Nevada Creek through increased stream shading. Combining Riparian Area BMPs, Grazing BMPs, and Upland BMPs, will facilitate woody riparian vegetation recovery. Supplementing in-stream flows through Water Conservation BMPs would also assist in vegetation restoration efforts by providing enough water to sustain new plant growth. Additional flows would also benefit water temperatures and siltation issues by providing an increased volume of water and flushing flows.

Increasing in-stream flows and woody riparian vegetation on the mainstem of upper Nevada Creek should result in a decline in water temperatures. To achieve desired water temperatures however, it will be necessary to seek these same measures on several tributaries that add warmer water to the main channel.

The implementation of Grazing, Riparian Area, and Upland BMPs are recommended to reduce the elevated nutrient levels in upper Nevada Creek. The reduction of grazing pressure in the stream corridor will reduce nutrient delivery from cattle that directly access the channel as well as from trampled stream banks and disturbed uplands. BMPs should also focus on relocating corrals that are located adjacent to the stream, or ensuring that Riparian Area BMPs are sufficiently in place to mitigate nutrient runoff from the corrals. If fertilizer applications are identified as a source of nutrients in upper Nevada Creek, appropriate BMPs should be applied to limit runoff and delivery of those constituents.

A project on upper Nevada Creek was completed in 2007. This project includes reconstruction and stabilization of approximately 600 feet of stream channel. Riparian planting will also be performed to promote riparian area recovery, streambank stabilization, and habitat improvements. Plantings will include native rhizomatous grass species and native willow species. Grazing management which includes fencing and off-site water development to control livestock use of the riparian areas is also part of this project.

As upper Nevada Creek is a main drainage, meeting water quality targets and restoration objectives will in part depend on addressing issues in its tributaries. These include listed tributaries (Washington Creek, Jefferson Creek, Gallagher Creek, and Buffalo Gulch) as well as non-listed tributaries.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, metals, temperature, and low flow conditions or creating additional water quality concerns related in upper Nevada Creek.

Monitoring Needs
Several water quality restoration projects have been completed in upper Nevada Creek. However, the status of these projects is unknown. Monitoring should be conducted to evaluate maintenance needs and overall project effectiveness.

While dewatering from irrigation is cited as a potential cause of several water quality impairments, irrigation systems, water conveyance networks, and irrigation return flows are not well understood. Increased understanding of irrigation systems and networks and potential for increased flows in upper Nevada Creek will be the first step in implementing any water conservation measures.

Metals impairment determinations were based on limited samples with measured exceedences occurring only during high flows. Additionally, some of the data used to make impairment determinations is over 25 years old. Further metals sampling is recommended to better determine sources and confirm impairment determinations.

Although upper Nevada Creek was not listed in 1996 as impaired for total phosphorous (TP), samples collected in 2003 and 2004 consistently exceeded eco-regional TP targets. Exceedences during both runoff and growing seasons indicate that TP loading may be significant during late winter runoff events. In order to better characterize nutrient loading in upper Nevada Creek, further nutrient sampling is recommended.

10.2.2.13 Nevada Creek (Lower)

Lower Nevada Creek extends from the reservoir outlet at Nevada Lake to the Blackfoot River, a channel distance of approximately 25 miles; all of which is through private lands. Lower Nevada Creek consists of eight stream reaches (**Appendix A; Appendix B**). For approximately 5 miles below the Nevada Reservoir outlet, Nevada Creek flows through a moderately wide valley bottom. Nev7 is a meandering channel with relatively high width to depth ratios (C-type) channel that extends from the reservoir outlet approximately 3.3 miles downstream. The riparian corridor through the reach consists of non-woody herbaceous and wetland vegetation. Stream flows through the reach are regulated by reservoir operations, and the channel is moderately entrenched. The lower end of Nev7 is marked by the Douglas Creek Canal diversion. Below this diversion structure, Nev8 is an entrenched F-type channel segment. The channel is sinuous, and it flows through a moderately dense willow corridor. Downstream of this reach, the valley widens, where Nevada Creek (Nev9, Nev10, Nev11, and Nev12) flows within a sinuous E-channel that has highly variable woody vegetation densities. The channel has a very low gradient, and some beaver dams are present. The riparian corridor ranges from total herbaceous coverage to dense willows. Nev13 extends to the Nevada Spring Creek confluence. This stream segment has a very flat gradient (.05%), forming a fine grained, sinuous C-type channel that flows through a very narrow riparian corridor. The riparian corridor consists of wetland and other herbaceous species with scattered riparian shrubs in the near stream areas, and a grassed floodplain. The lowermost reach of Nevada Creek (Nev14), which extend below the Nevada Spring Creek confluence, is a very sinuous C-channel, largely devoid of woody riparian vegetation. The channel slope throughout lowermost Nevada Creek is very flat, such that stream power is low. Rainbow trout and brown trout inhabit lower Nevada Creek in very low densities immediately below the reservoir but are absent in the lower reaches (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations

Flow alterations, habitat alterations, siltation, nutrients, and thermal modifications were listed as causes of impairment in lower Nevada Creek in 1996. These listed causes of impairment remained in 2006 and data collected in support of TMDL development confirm all of the identified water quality limitations.

E-channel types in lower Nevada Creek do not meet any sediment or habitat related targets (**Section 5.0**). Surface fines in substrates and pool tailouts measured 100% which indicate heavy siltation in the stream. Pool habitats were largely lacking in E-channel types as were instream woody debris aggregates. Woody vegetation extents are 25% less than target values and the channel is over-widened. C-channel types in lower Nevada Creek demonstrated similar sediment, habitat, and riparian vegetation impairments. Fines in riffle substrate measured 100%. Surface fines in pool tailouts faired better in C-channels but were still twice target values. Pool habitats were largely lacking as were in-stream woody debris aggregates. Woody vegetation extent was well below target values and C-channels in lower Nevada Creek appear to be over-widened.

Unlike most other streams in the planning area, lower Nevada Creek has sufficient nutrient samples for making definitive impairment determinations. Sampling for nutrient analysis has occurred at four sampling stations along lower Nevada Creek since 1974. The uppermost site is USGS station number 12336600 located just below the outlet from Nevada Lake; Montana DEQ site 4124NE01 is approximately 17 miles downstream where Highway 271 crosses Nevada Creek near the town of Helmville; and two additional USGS sites (stations 12337800 and 46533013021601) are just above the mouth of Nevada Creek. All 24 TP and 11 TKN results exceed eco-regional seasonal targets; 12 TP (50%) and two TKN (18%) results exceed eco-regional growing season targets. Thirty-six of 38 results for soluble reactive phosphorus (SRP) exceed the eco-regional seasonal target with 11 (29%) during the growing season. Twenty-two of 24 TN results exceeded the eco-regional targets with eight (33%) during the growing season. Thirteen of 43 results for $NO_{3/2}$ exceed eco-regional targets with 13 (30%) during the growing season (**Section 7.0**).

Water from upper Nevada Creek is stored in Nevada Reservoir for irrigation purposes in lower Nevada Creek. Nevada Reservoir is a bottom releasing reservoir and water temperatures that leave it are generally cool averaging around 60 degrees. Maximum temperatures can reach almost 70 degrees however as the amount of water released varies with irrigation water demands. Water temperatures at the mouth of Nevada Creek consistently exceed 70 degrees and reach temperatures of up to 76 degrees. Temperature modeling suggests that naturally occurring temperatures are around 68 degrees, about two degrees below current conditions (**Section 8.0**).

Suspected Sources and Causes

Bank erosion is a major source of fine sediment loading in lower Nevada Creek. Results of the sediment source assessment (**Section 5.0**) indicate that the majority of bank erosion occurs in three reaches (Nev7, Nev8, and Nev14). These three reaches account for 92% of the total and controllable bank erosion sediment load. Current livestock grazing practices are suspected as the primary cause of bank erosion as field crews noted evidence of grazing activities in riparian areas of assessed reaches. Locally, hay fields extend to the channel bank and hay production in the riparian corridor is also suspected as a contributing factor. Upland areas are also a significant source of sediment to lower Nevada Creek accounting for 303 tons of the total sediment load (**Section 9.0**). The two predominant land uses in lower Nevada Creek, livestock grazing and hay production are suspected as causes of hillslope erosion. Weeds in riparian and upland areas were noted by field crews at several assessment sites. Weeds contribute to soil instability and may be in part responsible for some erosion problems.

Although the estimated sediment volume derived from roads is relatively small, this source is not insignificant and thus warrants treatment consideration. There are 39 possible road crossings in lower Nevada Creek and the road density of 2.3 miles per square mile is considered high (USDA Forest Service, 1996). Crossings on the mainstem of lower Nevada Creek contribute approximately 12 tons of sediment to the stream per year. When road sediment from 303(d) Listed tributaries to lower Nevada Creek are considered, potential sediment contributions from roads increases to 598 tons per year. Up to 104 tons of sediment per year was estimated to enter Nevada Creek via unlisted and 303(d) Listed tributaries as well (**Section 5.0**).

Excess sediment from the sources described above along with channel modifications, degraded riparian vegetation and low flow alterations are suspected as causes of poor pool and in-stream habitat quality. Several assessments have identified portions of lower Nevada Creek as being straightened and over-widened (McGuire, 1995; DTM and AGI, 2005). Channel straightening is particularly evident in Nev7, Nev8, and Nev10. In Nev8, long portions of the creek have been straightened against the edge of the valley bottom. Although some areas of Nevada Creek exhibit significant in-stream habitat and channel sinuosity, straightening of the channel has locally reduced habitat complexity. Reaches Nev9 and Nev10 are characterized by split flow and abandoned side channels which suggest that lower Nevada Creek was historically multi-channeled. This historic anastomosing channel pattern likely reflects the past presence of beaver in this system. Beaver communities likely flourished in the low gradient stream environment of lower Nevada Creek. Their dams would have created backwatered areas, promoted avulsions and sustained a high water table.

The removal of woody vegetation from riparian areas for livestock grazing and hay production has lessened the source of woody debris which helps create habitat features. The loss of woody riparian vegetation and the shade it provides is also suspected of elevating water temperatures. Woody vegetation along the entire length of lower Nevada Creek is variable (higher in Nev12 than in Nev11) and average woody bankline vegetation is estimated to be 28%. A bankline vegetation density of 80% is the estimated minimum condition that will provide sufficient shade to meet water temperature targets (**Section 8.0**).

Warm water from tributaries (Douglas Creek) as well as water withdrawals for irrigation compound temperature issues in lower Nevada Creek. The majority of irrigation withdrawals occur between Nevada Reservoir and Nevada Spring Creek which coincides with significant temperature gains in Nevada Creek. Overall, approximately 80 cfs of 89 cfs released from the dam is diverted for irrigation (DTM and AGI, 2006). When water is not demanded, releases from

the reservoir drops to less than five cfs. The flow alterations in lower Nevada Creek have not only affected water temperatures. Flow alterations may also have lead to fine sediment accumulations as flushing flows have been lost and degraded riparian vegetation as current water levels cannot support necessary vegetation. Field crews noted the lack of flows and impacts to habitat in several assessment reaches.
Agricultural land use practices are suspected as the primary source of nutrients on lower Nevada Creek. Below Nevada reservoir, the corridor is actively grazed and hay cultivation is extensive. Numerous corrals/feeding pens abut the stream corridor, and at least one extends into the channel. Several other corrals are located on old side channels that currently function as ditches; this remnant channel network has the potential to convey nutrient runoff to the main channel. Although it has not been quantified, nutrients stored in Nevada Lake may be another source of nutrients in lower Nevada Creek.

Table 10-29. Summary of Identified Problems and Applicable Treatments, Lower Nevada Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (679 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
			Water Conservation BMPs; Reservoir release management
		Hill slope sediment (227 tons/yr)	Riparian Area BMPs
			Upland BMPs
			Grazing BMPs
		Road sediment (4 tons/yr)	Roads BMPs
		Low flow alterations	Water conservation BMPs
Habitat	**Pool extent and quality; woody vegetation extent**	**Excess fine sediment**	See above
		Channel modifications	Stream BMPs
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**TN**	**Stream bank sediment** **Livestock grazing**	Grazing BMPs Riparian Area BMPs
	Total Phosphorous		
	NO32		
	SRP		
Temperature	**Water Temperatures above Natural Range**	**Riparian degradation**	Riparian Area BMPS
			Grazing BMPs
			Stream BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

Grazing management improvement projects have been completed in some portions of lower Nevada Creek. Fish ladders were installed on several irrigation diversions. Additionally fish passage improvements, channel restoration, riparian vegetation improvements, improvement of wetlands, range/riparian habitat improvements, and improvements to irrigation have all been undertaken on lower Nevada Creek (Blackfoot Challenge, 2005). In addition to the projects that have been completed, there are numerous opportunities to improve water quality conditions on lower Nevada Creek through the implementation of conservation practices and BMPs.

Grazing BMPs are one means of reducing bank erosion. Implementation of these practices should focus on protecting the riparian corridor from excessive livestock use to facilitate woody vegetation regeneration and stabilization of stream banks. In some areas (i.e. Nev9) livestock crossings should be reinforced or removed to reduce sediment delivery to the creek. Woody vegetation is another effective means of stabilizing stream banks and controlling erosion. In areas where woody riparian vegetation is more abundant, such as Nev10 and Nev12, efforts such as restricted or excluded use should be made to maintain those conditions. In areas where woody vegetation is less abundant, active revegetation and protection of the stream banks and riparian areas are recommended.

In reaches of lower Nevada Creek where bank erosion is highest (Nev7, Nev8, and Nev14), where the channel has been straightened (e.g. Nev7 and Nev8), or where the channel is over-widened (e.g. Nev7) Stream BMPs that include channel restoration and/or habitat rehabilitation should be considered. Because of the low gradient on lower Nevada Creek, simple resloping of the banks may be a cost-effective means of reducing bank erosion in certain reaches. Channel restoration efforts should focus on creating habitat and bedform features where they are currently lacking; channel narrowing through bed excavation and bar construction on overwidened reaches would reduce the width to depth ratio of the stream, and thereby increase flow depths and sediment transport capacities. If mechanical treatments of the stream are not feasible, the same results could potentially be achieved through the implementation of an appropriate combination of Grazing and Riparian Area BMPs.

In addition to helping to reduce stream bank erosion, recovery of woody bank vegetation through Grazing BMPs and Riparian Area BMPs would effectively reduce water temperatures in lower Nevada Creek. Several other conservation measures would also be beneficial in temperature reduction efforts. Channel narrowing through mechanical treatments or land use management would increase flow depths and reduce water temperatures. An increase in flows will help reduce temperature gains in lower Nevada Creek through increased water volume. Increased flows would also enhance the flushing of fine sediments from the channel bed and pool tailouts, and increase the regeneration and survival rates of woody bank vegetation. It is important that flushing flows are applied to the entire stream and not just the reach above the Douglas Canal Diversion as the very low slope in lower reaches results in chronic sediment infilling under low flow conditions. To achieve increased streamflows, it will be necessary to implement Water Conservation BMPs by working with individual operators. An evaluation of water storage in and operations of Nevada Reservoir to identify opportunities for a better water balance between irrigation use and water quality is also recommended.

Most Upland BMPs would be beneficial on a case by case basis in reducing sediment and nutrient delivery. The implementation of filter or riparian buffer strips would be particularly effective where hay fields extend up to the stream bank and all vegetation is removed. Filter strips promote vegetation encroachment and sediment deposition in the channel margins rather than the channel bed. Grazing BMPs in upland areas should focus on improving the timing, frequency and intensity of livestock grazing to promote increased vegetation and ground cover for sediment and nutrient trapping capabilities. Weed management in upland and riparian areas would also help stabilize soils and reduce soil loss from erosion. Corrals that are within or adjacent to the stream corridor should be assessed in terms of their potential for surface runoff and nutrient delivery to the stream. Any corrals that have a high potential for elevating nutrients in the channel should be addressed through relocation or effective Grazing BMPs and Riparian Area BMPs.

A reduction of sediment from bank erosion and hill slope sources will improve the capacity of lower Nevada Creek to meet sediment and habitat targets. Additionally, roads are another source of fine sediment that requires attention in lower Nevada Creek. Two road crossings were assessed in 2005 and partial BMPs were noted at both. The lower site was noted as being skewed with the stream and identified as at risk for fill failure and as a fish passage barrier. The culvert at this site should be considered for replacement. Filter strips were recommended at the upper assessment site to reduce sediment. This site was also noted as potentially having impacts to the stream channel. The number of crossings assessed in lower Nevada Creek was minimal. Further investigations should be conducted to review current road BMP status and opportunities for sediment reduction.

As lower Nevada Creek is a main drainage, meeting water quality targets and restoration objectives will in part depend on addressing issues in its tributaries. These include listed tributaries (Braziel Creek, Douglas Creek and its tributaries, Nevada Spring Creek, and McElwain Creek) as well as non-listed tributaries and upper Nevada Creek. Additionally, in order to effectively address water quality impairments in lower Nevada Creek, multiple conservation practices will need to be considered in a comprehensive plan. Two projects currently under development with landowners in lower Nevada Creek demonstrate how different BMPs will be utilized in conjunction with one another to achieve desired results.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, nutrient, temperature, and low flow conditions or creating additional water quality concerns related to metals in lower Nevada Creek.

Monitoring Needs

While dewatering from irrigation is cited as a potential cause of several water quality impairments, irrigation systems, water conveyance networks, and irrigation return flows are not well understood. Increased understanding of irrigation systems and networks and potential for increased flows in lower Nevada Creek will be the first step in implementing any water conservation measures.

It may be appropriate to evaluate the flow release patterns at the reservoir outlet to assess the role of flow ramping on bank failure rates. If bank failure is related to rapid changes in flows, the release pattern should be modified to minimize those effects. Evaluating storage and flow release from the reservoir may also be appropriate to determine if additional flows are available for the improvement of water quality in lower Nevada Creek.

Sediment, nutrients, and metals stored in Nevada Reservoir are released with flows. It may be appropriate to evaluate the reservoir as a potential source of these pollutants and its relative contribution to these pollutant loads as this was not done during the development of TMDLs

Sampling in lower Nevada Creek has measured elevated concentrations of iron, manganese, copper and lead. Further sampling is recommended to identify potential metals related impairments.

10.2.2.14 Nevada Lake

Nevada Lake or Nevada Reservoir is located approximately 19 miles from the headwaters of Nevada Creek and 25 miles above the mouth of Nevada Creek. The reservoir is managed by Montana DNRC and provides stored water for irrigation in lower Nevada Creek. Montana FWP sampled Nevada Lake in 2006 and found a community largely made of up yellow perch (introduced illegally), rainbow trout, WSCT (FWP began planting WSCT in 2002), suckers, red side shiners. Prior to installation of the reservoir, this area supported a community of bull trout, WSCT, and whitefish.

Indicators of Habitat and Water Quality Limitations
Nevada Lake was included on the 1996 303(d) List as impaired due to nutrients, organic enrichment (DO) and siltation. These listings remained in 2006.

Out of seven samples taken in Nevada Lake between 2003 and 2005 three showed dissolved oxygen concentrations above target values (**Section 7.0**). Half of the Chlorophyll-a and TSI values exceeded targets in samples taken between 2003 and 2004 (**Section 7.0**). TP samples taken at the same time also exceeded targets. These findings support the 1996 and 2006 listings for Nevada Lake

Suspected Sources
A detailed assessment of potential nutrient sources to Nevada Lake was not conducted during TMDL development. Atmospheric, groundwater, and tributary inputs are however suspected as likely contributors of nutrients in Nevada Lake.

Recommended Conservation Practices/BMPs
At this time the primary recommendation for addressing nutrient related impairments in Nevada Lake are to address nutrient sources identified in upper Nevada Creek tributaries. These include upper Nevada Creek, Jefferson Creek, and Gallagher Creek. Other tributaries may also contribute to nutrient loading in Nevada Lake but have not been quantified.

Monitoring Needs
Very little is known about nutrient sources and loading in Nevada Lake. A more comprehensive review of existing data as well as a more detailed assessment of potential nutrient sources and restoration opportunities for Nevada Lake is highly recommended.

10.2.2.15 Nevada Spring Creek

Nevada Spring Creek is a spring-fed stream just over 3 miles long, flowing from its spring headwaters to its confluence with Nevada Creek. Nevada Spring Creek is comprised of two reaches (**Appendix A; Appendix B**). The upstream reach, Nev1, is a sinuous channel that was markedly over-widened on 1995 aerial photography (**Appendix A; Appendix B**). Since 1995, this reach has been completely reconstructed to the north of the old channel. The new channel is markedly narrower and more sinuous than that present in the 1995 imagery. Nev2 consists of the lowermost 0.7 miles of channel; this reach displays less widening and apparent instability relative to upstream in the 1995 aerial photography. The reach supports sparse woody riparian vegetation stands. Nevada Spring Creek supports very low densities of WSCT and brown trout in the upper and lower reaches and very low densities of bull trout in the lower reaches (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Nevada Spring Creek was included on the 1996 303(d) List as impaired due to habitat alterations and siltation. Impairment causes in 2006 include alterations in stream-side or littoral vegetative covers (habitat) and sedimentation/siltation. Data reviewed in support of TMDL development confirm the sediment and habitat related impairments on Nevada Spring Creek.

Although extensive restoration efforts have greatly improved the morphology and complexity of Nevada Spring Creek, the overall habitat and water quality of the creek remains somewhat limited due to fine sediment accumulations in lower reaches and sparse woody vegetation density on the stream banks (**Table 10-30**). Measured fine sediment values in riffles within NevSpr1 are almost double the target established for E-channel types in the Nevada Creek planning area. Woody bank vegetation is severely lacking throughout the entire length of the stream and well below the 74% needed to achieve habitat targets (**Section 5.0**).

Suspected Sources and Causes
The suspected sources of sediment in Nevada Spring Creek include stream banks and roads. Prior to restoration, stream bank erosion was believed to be caused by grazing practices and hay production in the riparian area. These land uses have been absent in this area for several years and restoration efforts are believed to have addressed the majority of sediment loading from bank erosion. Although the banks appear to be stable, the lack of woody bank vegetation may contribute to some instability and subsequent erosion.

Through GIS analysis, 5 road crossings identified in the Nevada Spring Creek basin contribute an estimated 8 tons of sediment per year to the stream.

While it has not been quantified, sediment and residual materials derived from restoration efforts, including the recently completed reconstruction of Wasson Creek, may be the primary source of sediment in the Nevada Spring Creek system. Sediment produced from these disturbances is expected to decline over time as the streams recover and stabilize.

Similar to lower Nevada Creek, Nevada Spring Creek has a very low slope which may cause of some fine sediment accumulations. Because the slope of the channel is low, and the creek is largely spring-fed, sediment transport capacities are naturally low and the system will be prone to aggradation if sediment influxes are high.

Restoration efforts in Nevada Spring Creek have greatly improved in-stream habitat and channel morphology. However, riparian habitat continues to be a concern. Historic grazing practices and hay production have removed most woody riparian vegetation. Despite the removal of these practices and restoration efforts, woody riparian vegetation has been slow to recover.

Table 10-30. Summary of Identified Problems and Applicable Treatments, Nevada Spring Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (8 tons/year)**	Riparian Area BMPs
		Road sediment (2 tons/year)	Road BMPs
		Hill slope sediment (0 tons/year)	Prentative
		Restoration activities: not quantified	Continue to monitor flushing of fine sediment derived from restoration efforts
Habitat	**NONE:**		Continue to monitor in-stream fine sediment as potential exists for setbacks in restoration work
	Woody Vegetation Extent	**Riparian degradation**	Riparian Area BMPs
Nutrients	**NONE**		Preventative
Temperature	**Restoration efforts have improved conditions, although shade remains limited**	**Riparian degradation**	Riparian Area BMPs
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

Since 2001, Nevada Spring Creek has been the focus of concerted restoration efforts over its entire length, which included channel reconstruction, instream flow enhancement, and riparian grazing changes (FWP, 2006 and Blackfoot Challenge, 2005).

The fine sediment accumulations measured in lower Nevada Spring Creek may represent an ongoing post-restoration sediment flush, and if so, the percent fines values will decrease with time. The system will take time to recover and continued monitoring of the completed restoration projects will be needed to assess recovery and whether additional conservation practices are needed. Monitoring of the project so far has revealed the need for localized floodplain work to better maintain cross-sections. This work is under development.

As grazing and hay production are no longer the primary land uses, recovery of the riparian area through revegetation should be considered a priority. Reestablishing woody vegetation on the stream banks and riparian areas will further stabilize stream banks, decrease water temperatures and improve habitat.

No road crossings were assessed during the sediment source assessment. Road crossings and areas where the road is near the stream should be assessed to determine if reductions in sediment delivery are possible through the implementation of Road BMPs.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment and habitat conditions or creating additional water quality concerns related to low flows, nutrients, temperature, or metals in Nevada Spring Creek.

Monitoring Needs
Continued monitoring of completed restoration projects on Nevada Spring Creek is recommended. If fine sediment does not decline as the system recovers, a more detailed sediment source assessment may be necessary. In the future, a habitat/sediment assessment similar to those completed on other streams in the Nevada Creek planning area may be warranted to confirm water quality impairment status as the data used to determine water quality impairment status for this document was not necessarily collected for this purpose.

10.2.2.16 Washington Creek (Upper)

Washington Creek is a 2nd order tributary to upper Nevada Creek flowing approximately 11 miles through mixed public (BLM and Helena National Forest) and private ownership. Upper Washington Creek is approximately 6 miles long, extending from its headwaters to the Cow Gulch confluence. An aerial photo assessment of upper Washington Creek in 2004 divided the segment into two reaches (**Appendix A; Appendix B**). The upper reach, Wash1, is a high gradient, entrenched headwater stream with stable bedrock and boulder banks. The riparian corridor consists of moderately dense riparian and upland shrubs, herbaceous species, and conifers. Groundwater is contributed to the channel via bank seepage, and small pocket pools and step pools are common habitat units. Wash2, located downstream, is relatively straight and entrenched. The woody vegetation density on the streambank is low. Placer spoils follow the riverbanks, and some vegetation has colonized these spoils. Washington Creek contains resident WSCT and resident brook trout throughout the drainage (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Upper Washington Creek was included on the 1996 303(d) List as impaired due to flow alterations, habitat alterations, and siltation. Listed causes of impairment in 2006 included low flow alterations and sedimentation/siltation. Data collected in support of TMDL development confirm all listed causes of impairment for upper Washington Creek.

The primary indicators of habitat and water quality limitations on upper Washington Creek are excess fine sediment, relatively poor residual pool depths, and low flows. The excess fine sediment limitations are indicated by McNeil Core data in which all measured fine sediment substrate values exceed targets. Additionally, residual pool depths are very near but still below target values and periphyton analysis on upper Washington Creek showed a high siltation index (**Section 5.0**).

Suspected Sources and Causes
The primary suspected source of fine sediment on upper Washington Creek is streambank erosion. Within the two reaches of upper Washington Creek, the lower reach (Wash2) accounts for 95% of the total streambank erosion load (**Section 9.0**). Livestock grazing practices are suspected as the primary cause of bank erosion. Disturbances in the riparian area and stream channel from silviculture and placer mining have also contributed to instability of the streambanks and subsequent bank erosion.

Sediment from hill slope erosion also contributes to fine sediment accumulations in upper Washington Creek. Hill slope erosion accounts for approximately 46 tons of controllable sediment. Historic placer mining, livestock grazing practices, and hay production practices are suspected as the primary causes of hill slope erosion.

The results of the sediment source assessment indicate that roads produce a relatively small amount of sediment to the stream (2.4 tons/year of controllable sediment). Road density in upper Washington Creek is considered moderate (1.0 miles per square mile) (USDA Forest Service, 1996). GIS analysis identified 9 possible road-stream crossings in upper Washington Creek. These nine crossings are estimated to deliver 8 tons of sediment per year to the stream (**Section 5.0**).

On the lower portions of upper Washington Creek, flow alterations are also suspected as a contributing factor to fine sediment buildup and pool degradation. Insufficient flows to do not allow the flushing of fine sediment from the system. Irrigation withdrawals are believed to be the cause of flow alterations but these impacts are not well quantified or understood. Channel alterations as a result of historic placer mining may also contribute to the loss of flows.

Table 10-31. Summary of Identified Problems and Applicable Treatments, upper Washington Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (119 tons/yr)**	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Road sediment (2 tons/yr)	Roads BMPs
		Hill slope sediment (46 tons/yr)	Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool Quality**	**Excess fine sediment**	See above
		Low flow alterations	Water Conservation BMPs
Nutrients	**NONE**		Preventative
Temperature	**NONE**		Preventative
Metals	**NONE**		Preventative

Recommended Conservation Practices/BMPs

Patented mine reclamation occurred in upper Washington Creek in 2001 and 2002 (Blackfoot Challenge, 2005).

The uppermost reach of upper Washington Creek (Wash1) appears to be in relatively stable condition. However, upper Washington Creek has had a long history of human disturbance due to placer mining. In some areas, mining has been followed by channel remediation efforts including retention pond construction and channel armoring. These efforts do not necessarily optimize long-term water quality or habitat conditions in the reach. It is therefore recommended that Washington Creek be assessed with respect to overall restoration feasibility in placer mined reaches. This will allow an evaluation of the performance of existing remediation measures, and determination of potential benefits of additions or modifications to those projects.

In Wash2, there are numerous conservation practices that could be applied to address sediment loading from bank and hill slope erosion. Grazing BMPs that control livestock access to the stream would help stabilize stream banks and reduce erosion. Riparian Area BMPs such as use exclusion would also provide overall protection of the stream banks and riparian areas. Improving sediment removal efficiency in upland areas through improved vegetation conditions could be achieved through Grazing BMPs. Similarly, several Upland BMPs provide means to achieving improved vegetation conditions and sediment trapping capacity. Stream BMPs would be appropriate in sections of Wash2 that have been straightened and/or entrenched due to placer mining.

Road assessments have been performed by the Helena National Forest in upper Washington Creek. These assessments were used to quantify sediment loading from roads for this water quality restoration plan, however, BMP status was not documented during these assessments. The relatively low volume of sediment estimated to be delivered to the stream suggests that some BMPs are in place. An assessment of BMP status should be conducted to determine if current BMPs are effective and whether additional BMPs could be implemented.

The cause of low flows in upper Washington Creek is not well known. Irrigation withdrawals are believed to contribute to low flows and opportunities to supplement in-stream flows through Water Conservation BMPs should be identified. Numerous diversions have been identified most of which are unscreened and create fish passage issues. Improvements to these diversions for water conservation and fish passage are recommended. Channel restoration in placer mined areas will also improve the ability of the stream to hold and convey flows as well as facilitate fish passage.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in upper Jefferson Creek.

Monitoring Needs
An assessment of irrigation withdrawals and potential impacts to in-stream flows and fine sediment accumulation is recommended.

The status of completed mine reclamation projects in upper Washington Creek is not well documented. Monitoring is recommended to assess the effectiveness of these projects and to identify any potential maintenance needs.

10.2.2.17 Washington Creek (Lower)

Washington Creek is a 2nd order tributary to upper Nevada Creek flowing approximately 11 miles through mixed public (BLM and Helena National Forest) and private ownership. Lower Washington Creek is approximately 5 miles long and extends from Cow Gulch to its confluence with Nevada Creek. Lower Washington Creek consists of a single reach (Wash3), which is an F-type stream channel that is slightly entrenched (**Appendix A; Appendix B**). Results of the aerial assessment (**Appendix B**) indicate that the reach has been locally straightened and cleared of riparian vegetation. Washington Creek contains resident WSCT and resident brook trout throughout the drainage (Blackfoot Challenge, 2005).

Indicators of Habitat and Water Quality Limitations
Lower Washington Creek was included on the 1996 303(d) List as impaired due to flow alterations, habitat alterations, and siltation. Low flow alterations and sedimentation/siltation were cited as causes of water quality impairment in 2006. Data collected in support of TMDL development confirm the 1996 and 2006 listed causes of impairment and also identify metals (aluminum and iron) as a limiting factor of water quality in lower Washington Creek.

Excess fine sediment has been identified as a contributing factor in reduced habitat and water quality conditions on lower Washington Creek. Of 12 possible sediment/habitat related targets for lower Washington Creek only 3 were met. Pool frequency, pool extent, and residual pool depth in lower Washington Creek are well below target values suggesting fine sediment accumulations and loss of habitat complexity. The channel also appears to be over-widened in some areas. Woody bank vegetation is approximately 85% of target values which has affected in-stream woody debris recruitment and the formation of habitat features. Macroinvertebrate data show severe impairment conditions with respect to sediment (**Section 5.0**).

Three metals samples were collected in lower Washington Creek between 2003 and 2005. Iron exceedences were measured in two out of the three samples and were observed in both high and low flow sampling events. One low flow sampling event was below standards with iron concentrations of 970 µg/L. This result is however very close to the standard of 1,000 µg/L (**Section 6.0**). The sampling events also returned an exceedence for aluminum.

Flow alterations were identified by field crews as a contributing factor towards the degraded habitat conditions on lower Washington Creek. The poor pool conditions in lower Washington Creek are probably due in part to a lack of sufficient flow energy to flush fines from the channel bed. This poor sediment transport condition can be partially attributed to numerous irrigation diversions that are present in the reach.

Suspected Sources and Causes
Results of the sediment source assessment indicate that stream banks are the primary source of sediment to lower Washington Creek (**Section 9.0**). Instability in the stream banks and subsequent erosion is believed to be caused by hay production in the riparian area, livestock grazing on stream banks, and reduced levels of woody bank vegetation. Hill slope and road surface erosion account for the remaining controllable sediment load. Excessive removal of vegetation from upland areas from livestock grazing practices is suspected as the primary cause of hill slope erosion (**Section 9.0**). Road density in lower Washington Creek is considered to be moderate (1.0 miles per square mile) (USDA Forest Service, 1996). GIS analysis identified 4 road-stream crossings in lower Washington Creek that delivery an estimated 7 tons of sediment per year to the stream (**Section 5.0**).

The fine sediment from these sources is considered a cause of pool habitat degradation; likely due to pool infilling by excess fine sediment. Another suspected cause of habitat degradation is reduced levels of woody riparian vegetation as woody debris recruitment and the formation of habitat features is low. Woody riparian vegetation in lower Washington Creek has likely been removed to facilitate agricultural land uses.

Low flow alterations from irrigation withdrawals are suspected as an exacerbating effect with regard to sediment infilling of pools as well as with regard to reductions in woody vegetation extents. However, the effects of irrigation withdrawals on in-stream flows have not been assessed in lower Washington Creek and thus the impacts of flow diversions on channel morphology can only be inferred from aerial photos and field notes.

Metals concentrations exceedences were observed during high flow and high TSS events suggesting a link between metals and sediment. Sampling did not reveal any finite metals sources (**Section 9.0**).

Table 10-32. Summary of Identified Problems and Applicable Treatments, lower Washington Creek

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	**Excess Fine Sediment**	**Stream bank sediment (234 tons/year)**	Riparian Area BMPs
			Grazing BMPs
			Upland BMPs
			Stream BMPs
		Road sediment (2 tons/yr)	Roads BMPs
		Hill slope sediment (4 tons/yr)	Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	**Pool extent and quality; woody vegetation extent**	**Excess fine sediment**	See above
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Nutrients	**NONE**		Preventative
Temperature	**Slightly elevated temperatures measured at Hwy 141; substantial increases below suspected**	**Riparian degradation**	Riparian buffer or filter strip
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Metals	**Aluminum**	**Sediment**	See above
	Iron		See above

Recommended Conservation Practices/BMPs
No water quality or fisheries restoration related projects have been documented in lower Washington Creek (Blackfoot Challenge, 2005).

Addressing sediment from bank erosion should be a primary consideration for restoring water quality in lower Washington Creek. Grazing BMPs that focus on controlling livestock access to the stream will increase bank stability and reduce erosion. Riparian Area BMPs that protect the stream bank and riparian areas would also be beneficial. In areas where woody bank vegetation is low, plantings are encouraged to promote streambank stability. Stream BMPs that provide protection of streambanks should also be considered. In some cases, channel restoration could be considered to reduce bank erosion. In areas where hay production encroaches on the stream bank, a riparian buffer or filter strip may be an appropriate measure to increase bank stability. Increasing sediment removal efficiency in upland areas through improved vegetation conditions will reduce sediment from hillslope sources. This can be achieved through management of vegetation removal using Grazing and Upland BMPs. These actions will also likely address metals sources and loading in lower Washington Creek.

Three road crossings were assessed in lower Washington Creek in 2005. Field crews noted lacking to partial BMPs. The uppermost crossing assessed was a ford with no structure (bridge, culvert) at the crossing. Stream banks were noted as raw and disturbed at this site. Installation of a crossing structure is recommended for this site. Other road crossings assessed noted partial BMPs with minimal sediment delivery. At least one of these sites was however found to be a fish passage barrier and at risk for fill failure due to constriction ratio. The culvert at this crossing should be evaluated for replacement to address these issues.

Reduction of sediment will help to address habitat concerns but additional measures would be beneficial. Recovery of woody vegetation would improve riparian habitat as well as in-stream habitat conditions through increased woody debris recruitment. This recovery of riparian vegetation could be accelerated with willow plantings, although any revegetation effort must be performed in conjunction with livestock management to optimize vegetation survival rates. The implementation of these conservation practices would also help to narrow the channel where it has been over-widened. Enhancement of in-stream flows through Water Conservation BMPs would also assist in vegetation recovery efforts and would provide flows for flushing of fine sediment from the reach.

While temperature has not been identified as limiting water quality in lower Washington Creek, elevated stream temperatures have been observed. Conservation practices described above (woody vegetation recovery and flow enhancement) would help to reduce temperatures in the stream by providing shade, narrowing the channel, and providing an increased volume of water. Reducing temperatures in lower Washington Creek would also benefit temperature reduction efforts in upper Nevada Creek.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in **Appendix H** to avoid exacerbating existing sediment, habitat, metals, and low flow conditions or creating additional water quality concerns related to nutrients or temperature in lower Washington Creek.

Monitoring Needs
An assessment of irrigation withdrawals and potential impacts to in-stream flows and fine sediment accumulation is recommended.

Arsenic exceedences were noted during sampling events conducted as part of TMDL development. From the limited samples, it is unclear as to whether arsenic exceedences are a result of local geology, human activities, or both. Further monitoring is recommended to confirm possible arsenic sources and impairments.

10.3 Implementation Strategy

Successful implementation of this restoration plan and achievement of water quality targets will depend on many factors. This section outlines key elements, strategies, resources, and tools for implementation. Implementation of this plan will ultimately depend on the ability, willingness, and priorities of landowners and land managers.

10.3.1 Key Elements and Approaches

Section 10.2 of this plan describes recommended management actions specific to water quality causes and sources for each impaired water body. The following are key elements to be considered during the implementation of this water quality restoration plan as part of larger watershed efforts.

Partnerships are a primary reason for the success of restoration and conservation efforts in the Blackfoot watershed and continuing this approach is crucial to successful implementation of this plan. Partnerships allow organizations to pool resources, meet multiple management objectives, and reduce duplicative efforts. Equally important is the continued cooperation and involvement of local landowners as a number of water quality impairment issues and much of the restoration needed will occur on private lands. Implementation and achievement of water quality targets will depend largely on the cooperation and support of private landowners and watershed stakeholders and a willingness to work across ownership and management boundaries.

Whenever possible, water quality restoration objectives should include or be included in comprehensive management plans. Comprehensive management is a holistic approach in which a number of resource concerns are addressed through a series of management actions. Comprehensive management allows multiple resource objectives to be met while meeting landowner objectives. It also ensures that benefits from implementation of conservation practices are not offset by failures elsewhere.

Similarly, water quality restoration objectives should integrate or be integrated into existing management directives. In 2005, the Blackfoot Challenge and its partners developed the "Basin-wide Restoration Action Plan for the Blackfoot Watershed." This plan examines the three primary programs currently driving stream restoration in the Blackfoot (native fisheries restoration, water conservation, and water quality restoration) and their relationships. The results of this analysis show a strong correlation between streams needing some level of restoration as identified by these three programs. When restoration projects are being developed, this document can serve as a valuable resource for identifying multiple programmatic objectives.

Selection of conservation practices should be site specific. The effectiveness of conservation practices can vary from site to site. Water quality restoration objectives, other resource management objectives, and landowner needs should be evaluated when developing comprehensive management plans to achieve all potential benefits.

Once conservation practices have been implemented, it is important that the practices be maintained and properly managed. To avoid failure and further degradation, implemented practices should be monitored regularly by the lead partner or landowner (**Section 10.4**).

It is essential to protect or maintain areas where water quality targets and objectives are being met. Areas where restoration has already occurred or areas that are trending towards recovery are significant and current management practices should be maintained. If disturbance is necessary, steps should be taken (BMP implementation) to ensure impacts are minimal.

The TMDL process cannot possibly identify all impaired streams or water bodies. There are a number of streams not assessed during this process where water quality could be improved. These un-assessed streams are also likely to contribute to water quality concerns at a watershed scale. Streams not included on the 303(d) List or not assessed during TMDL development should not be excluded from water quality restoration efforts.

10.3.2 Partners and Priorities

The Blackfoot watershed has a long history of restoration, conservation, cooperation and partnerships. Organizations such as the Blackfoot Challenge and the Big Blackfoot Chapter of Trout Unlimited (BBCTU) have facilitated public-private partnerships in an effort to address natural resource issues on a watershed-wide scale. These partnerships have led to a tremendous amount of successful on-the-ground restoration and conservation projects. While this plan recognizes that partners will pursue restoration projects based on organizational priorities and management directives, it strongly encourages partnerships as a means of implementation. The following describes water quality related management activities, directives, and priorities of major stakeholders in the Blackfoot watershed.

The Blackfoot Challenge is a landowner based watershed group whose mission is to "enhance, conserve and protect the natural resources and rural lifestyle of the Blackfoot River Valley for present and future generations." The Blackfoot Challenge is involved with a number of natural resource related issues including weed management, wildlife and wildlife habitat management, conservation of large landscapes, drought and water conservation, and education. The Blackfoot Challenge has also served as the primary facilitator of stakeholder involvement in the water quality restoration planning and TMDL development process in the Blackfoot watershed and will continue to work with all partners and private landowners on implementation of this plan and restoration of water quality.

For the past 20 years, the Big Blackfoot Chapter of Trout Unlimited (BBCTU) has lead native fish recovery efforts in the Blackfoot watershed. With their partners, BBCTU has completed hundreds of projects that have improved fish habitat, fish migration, wetlands, riparian areas, and water quality throughout the watershed. In the future, BBCTU will continue to develop and implement projects that aid in the recovery of native fisheries on both private and public lands. These projects will undoubtedly have positive impacts on water quality.

Much of the success of the Blackfoot Challenge and BBCTU has been due to the participation and support of private landowners. Private landowners have played a critical role in the development of this water quality restoration plan by allowing access to lands, sharing knowledge of streams and management practices, and participating in public forums during its development. Their support and participation will become even more important as this plan is implemented. Much of the private land in the Blackfoot watershed is under agricultural production. While some may view agriculture and water quality as being at odds, there are management practices that can benefit both. Landowners in the Middle Blackfoot and Nevada Creek planning areas identified several high priority management issues during a meeting in February 2007. Weeds are a major concern for landowners in these planning areas. By assisting with weed management activities under this plan, soil stability in upland and riparian areas would improve and reduce erosion in these areas. In addition, promoting native vegetation would provide increased forage for livestock resulting in better distribution. Landowners are also interested in increasing the availability of off-stream water which can provide a better distribution of livestock and relieve stress on riparian areas. Improvement of grazing management through fencing and water gaps was also discussed. These practices would help reduce sediment and nutrients from various sources while aiding in riparian vegetation recovery. Some landowners are willing to pursue more active restoration involving channel restoration and almost all would likely pursue the installation of fish screens on irrigation ditches. An important issue that landowners felt has been overlooked in this planning process is the management of wildlife habitat. Many landowners have cited large populations of elk as substantially contributing to riparian and stream degradation in some areas and felt that additional management activities could be undertaken to improve wildlife habitat in uplands.

The Natural Resource Conservation Service (NRCS) focuses primarily on agricultural land – grazing land and cropland, the predominate use of private land in Montana. NRCS emphasizes voluntary, science based assistance, partnerships, and cooperative problem solving at the community level through the locally-led conservation process. NRCS offers numerous programs to private landowners and agricultural producers for the implementation of conservation practices. Sustainable agriculture as well as the improvement and protection of streams, riparian areas, water quality – specifically sediment and nutrient reduction, and water quantity are primary program objectives of the NRCS.

Plum Creek Timber Company owns and manages approximately 183,000 acres in these planning areas. The Plum Creek Native Fisheries Habitat Conservation Plan describes primary restoration objects for basins within the Blackfoot watershed. The PCNFHCP includes specific timeframes for upgrading roads in all drainages by 2010 and 2015 of which substantial work has been done to date. Fish passage barrier removal is being done in conjunction with road improvements. Riparian protection, research and monitoring, grazing leases, range management plans are also included in this plan.

The Nature Conservancy currently owns and manages approximately 65,000 acres in these planning areas. However, ownership of most of these lands is temporary and will be sold to various public agencies and private landowners. TNC is very active with its grazing lessees implementing weed management programs as well as overall improvements in grazing practices and riparian areas. TNC and its lessees regularly monitor riparian area grazing activities and make adjustments to grazing plans as necessary. In some areas, TNC is considering channel restoration and culvert replacements to correct a number of resource concerns. For the remainder of its land ownership, TNC expects to continue these activities.

The U.S. Forest Service manages approximately 156,000 acres in these planning areas. With respect to water quality, the primary focus of the Helena and Lolo National Forests is reducing sediment delivery from roads through implementation of Road BMPs and general road improvements. The Lolo National Forest is committed to improving water quality by implementing BMPs for all projects and through other general road improvements. Undersized stream crossings are being upgraded to better accommodate aquatic organisms, sediment, and debris and to reduce sedimentation. With each new project, existing roads are evaluated and unneeded roads may be scheduled for decommissioning. In the Middle Blackfoot the Lolo National Forest was a major partner for the Dunham Creek restoration project and is also helping to develop several other stream restoration projects with partners in the valley. Recently a new grazing management plan was completed for the Monture Creek grazing allotment. Forestry BMPs used by the Lolo National Forest on timber harvest and road projects are typically more stringent than the State of Montana's recommended forestry BMPs and required SMZ laws. The Helena National Forest is actively working with thirteen grazing lessees on grazing management on national forest lands.

Montana Department of Natural Resources and Conservation (DNRC) manages lands in both planning areas. DNRC's on-going projects include implementation of road and forestry BMP's and the Montana Streamside Management Zone (SMZ) Law to reduce erosion, sedimentation and protect water quality. Projects may include road inventory, maintenance and road improvements/removal such as the upgrade of existing roads and stream crossings constructed prior to BMP to improve water quality and allow for fish passage. DNRC also utilizes extended SMZ widths on sites with high erosion risk or on streams supporting cold-water fish species to protect fish habitat. DNRC is and will continue to be an active partner with landowners and agencies for restoration activities to improve water quality, conservation activities, and fish habitat.

Montana Fish, Wildlife and Parks (FWP) is responsible for the management of rivers and streams in Montana. The primary focus of Montana FWP will continue to be native fisheries recovery and management. Montana FWP has been a significant partner in efforts to date.

The Montana Department of Environmental Quality (DEQ) is charged with oversight and implementation of the Non-Point Source (NPS) Program. DEQ has provided technical and financial assistance to the development of TMDLs in the Middle Blackfoot and Nevada Creek planning areas. Through the 319 program DEQ will also be able to provide technical and financial assistance to the implementation and monitoring activities described in this restoration plan.

The U.S.Geological Survey (USGS) collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. This is evident in the Blackfoot as USGS maintains five continuous flow and temperature gages and has provided assistance to multiple organizations in the collection and analysis of water quality data. USGS will continue to aid in the understanding of water quality issues and solutions through future monitoring.

The water quality related management activities and directives described above offer numerous opportunities for implementing this restoration plan through partnerships. The Blackfoot Challenge and BBCTU will continue their partnership to implement projects that lead to improved water quality, native fish recovery, and water conservation. Much of the work needed to achieve water quality targets and objectives will occur on private lands. The Blackfoot Challenge, BBCTU, local Conservation Districts, and the Natural Resource Conservation Service (NRCS) have a long history of private lands restoration and conservation and working together will likely be the lead organizations developing and implementing water quality restoration projects in cooperation with private landowners. The Blackfoot Challenge and BBCTU have also worked extensively with other private organizations and public agencies to implement restoration projects and conduct monitoring. These are just a few examples of the partnerships at work in the Blackfoot. Strengthening these partnerships and forming new partnerships will allow partners to meet internal water quality management objectives as well as those of this plan.

10.3.3 Water Quality Restoration Projects

Section 10.2 of this plan provides specific management recommendations for achieving water quality targets for impaired streams in the Middle Blackfoot and Nevada Creek planning areas. Numerous projects and opportunities are possible based on these recommendations but will require further development prior to implementation. **Table 10-33** presents a list of projects on listed and non-listed streams in the Middle Blackfoot and Nevada Creek planning areas that are under development or slated for implementation in the near future by various partners.

Table 10-33. Water Quality Restoration Projects

Stream / Watershed	Project Partners	Project Description	Water Quality Component	Status
Nevada Creek (upper)	Blackfoot Challenge / NPCD	Channel restoration; grazing management; livestock watering facilities; fencing; riparian revegetation	Habitat improvement; sediment, nutrient, metals, and temperature reduction; riparian area improvements	Under development
Nevada Creek (lower)	Blackfoot Challenge / NPCD	Channel restoration; grazing management; livestock watering facilities; fencing; riparian revegetation	Habitat improvement; sediment, nutrient, metals, and temperature reduction; riparian area improvements	Under development
Nevada Creek (lower)	Blackfoot Challenge / NPCD	Channel restoration; grazing management; livestock watering facilities; fencing; riparian revegetation	Habitat improvement; sediment, nutrient, metals, and temperature reduction; riparian area improvements	Under development
Braziel Creek	Blackfoot Challenge / NPCD	Channel restoration; grazing management; livestock watering facilities; fencing; riparian revegetation	Habitat improvement; sediment, nutrient, metals, and temperature reduction; riparian area improvements	Under development
Dick Creek (tributary to Monture Creek)	BBCTU	Replace existing culvert with bridge; grazing management; channel restoration; road improvements	Fish passage; habitat improvements; riparian area improvements; sediment reduction	Under development
Jacobsen Spring Creek (tributary to the North Fork)	BBCTU / MT FWP / Landowners / USFWS	Channel restoration; grazing management; livestock watering facilities; fencing; riparian revegetation	Habitat improvements; riparian area improvements; sediment and temperature reduction	Ongoing
Rock Creek	BBCTU / FVLT / TNC / NRCS / MT FWP / Chutney Foundation	Revegetation of woody riparian species along approximately 14,500 feet along Rock, Salmon, and Dry Creek	Riparian area improvements	Implementation in 2007 and 2008

Table 10-33. Water Quality Restoration Projects

Stream / Watershed	Project Partners	Project Description	Water Quality Component	Status
Rock Creek	BBCTU	Install bridge at existing fjord	Habitat improvements; streambank stabilization; sediment reduction; fish passage; improve road drainage	Under development
McElwain Creek	BBCTU / NPCD	Off-site water development, irrigation system improvements, fencing, fish passage barrier removal	Increase in-stream flows; riparian area improvements; fish passage	Under development (some elements being implemented in 2007)
Wasson Creek (tributary to Nevada Spring Creek	BBCTU	Installation of fish screen	Prevent fish entrainment	Implementation in 2007
Canarway Creek (2nd order tributary to Nevada Creek)	Helena National Forest	Range improvements; livestock watering facilities	Habitat improvements; riparian area improvements	Under development
Chicken Creek (tributary to lower Nevada Creek)	Helena National Forest	Road rehabilitation and BMPs; replace 3 culverts	Sediment reductions; fish passage; habitat improvements	Under development
Clear Creek Watershed (tributary to Buffalo Gulch)	Helena National Forest	Road rehabilitation and BMPs; replace 2 culverts and failing bridge	Sediment reduction; fish passage; habitat improvements	Under development
Huckleberry Creek (tributary to upper Nevada Creek)	Helena National Forest	Road rehabilitation and BMPs; replace culvert	Sediment reduction; fish passage; habitat improvements	Under development
Madison Gulch (tributary to upper Jefferson Creek)	Helena National Forest	Road rehabilitation and BMPs; replace culvert	Sediment reduction; fish passage; habitat improvements	Under development
Nevada Creek (upper)	Helena National Forest	Remove old mine tailings near stream and site rehabilitation	Prevent future delivery of metals to stream	Under development
Washington Creek (upper)	Helena National Forest	Repair multiple road and stream channel fords	Habitat improvements; sediment reduction	Under development
Cottonwood Creek (Middle Blackfoot)	Lolo National Forest	Channel restoration; riparian area restoration	Habitat improvements; riparian area improvements	Under development
Monture Creek Watershed (Middle Blackfoot)	Lolo National Forest	Road decommissioning and culvert replacements throughout Monture watershed	Reduce road density; sediment reduction; improve hydrologic function	Under development

Table 10-33. Water Quality Restoration Projects

Stream / Watershed	Project Partners	Project Description	Water Quality Component	Status
Shanley Creek (tributary to Cottonwood Creek – Middle Blackfoot)	Lolo National Forest	Channel restoration; riparian area restoration	Habitat improvements; riparian area improvements	Under development
Shanley Creek (tributary to Cottonwood Creek – Middle Blackfoot)	Lolo National Forest	Road decommissioning and culvert replacement	Reduce road density; sediment reduction; improve hydrologic function	Under development
Benedict Creek (tributary to Clearwater River above Seeley Lake)	Lolo National Forest	Road decommissioning (2.5 miles)	Reduce road density; sediment reduction; improve hydrologic function	Under development
Spring Creek (tributary to upper Clearwater River)	Lolo National Forest	Road decommissioning	Reduce road density; sediment reduction; improve hydrologic function	Under development
Marshall Creek (tributary to Clearwater River)	Lolo National Forest	Road decommissioning and culvert replacement	Reduce road density; sediment reduction; improve hydrologic function	Under development

10.3.4 Funding

A number of funding sources are available for implementation of water quality restoration projects and monitoring under this restoration plan. **Table 10-34** contains a list of funding opportunities including state, federal, and private sources. The funding limits, funding cycle, eligible applicants, and a description are provided for each grant source. This is a fairly comprehensive list of potential funding sources for project implementation. There are likely numerous other potential funding sources for implementation of this restoration plan which are not listed and further research is required.

Table 10-34. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
DEQ 319 Program	1.5 million annually	Annual	Government Entities and Non-profit Organizations	Funds must be used for water quality protection, improvement, or planning; 4 categories of applications - Watershed TMDL Planning, Watershed Restoration, Groundwater, and Information/Education
MT FWP Future Fisheries	~$750,00 annually	6 months	Anyone, but coordination with local fisheries biologist recommended	Projects that restore or enhance habitat for naturally reproducing populations of wild fish.
DNRC RRGL Planning Grant	Varies	Biennial	Government Entities	Must be for the conservation, management, development, or protection of a renewable resource in Montana. 50% cash match required unless sponsored by a non-revenue producing entity such as a CD
DNRC RRGL Grant	4 million biennial	Biennial	Government Entities	Must be for the conservation, management, development, or protection of a renewable resource in Montana.
DNRC RDGP	4 million biennial	Biennial	Government Entities	Projects that reclaim lands damaged by mining; activities that address crucial state needs. Projects must provide benefits in one or more of the following: reclamation, mitigation, and research related to mining and exploration; identification and repair of hazardous waste sites, research to assess existing or potential environmental damage.
DNRC Private Grants	$100,000 biennial	Biennial	An individual association, for-profit corporation or non-profit corporation	Projects relating to water where the quantifiable benefits exceed the costs
NRDP - Large Grants	6.5 - 8.5 million annually	Annual	Government Entities, Privates, Non-profits	Projects must restore, replace, or acquire the equivalent of injury natural resources and/or lost services covered in Montana v. ARCO lawsuit
NRDP - Project Development Grants or Small Projects	$200,000 annually	Annual	Government Entities, Privates, Non-profits	Projects must restore, replace, or acquire the equivalent of injury natural resources and/or lost services covered in Montana v. ARCO lawsuit
USFWS Fish & Habitat Conservation - Fish Passage	Nationally 3.6 million in 2005	Annual	Unrestricted	Project funding is for fish passage restoration by removing or bypassing barriers to fish movement such as dam removal, culvert renovation, designing and installing fish ways, installing fish screens, and barrier inventories to identify additional fish passage impediments.

Table 10-34. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
USFWS Partners for Fish & Wildlife Program	Nationally 16.8 million in 2005	Annual	Some restrictions	This program provides technical and financial assistance to private landowners for habitat restoration on their lands. A variety of habitats can be restored to benefit federal trust species (for example migratory birds and fish and threatened and endangered species).
USFWS Private Stewardship Grants Program	Nationally 6.5 million in 2005	Annual	Some restrictions	This program provides grants and other assistance to individuals and groups engaged in private, voluntary conservation efforts that benefit species listed or proposed as endangered or threatened under the ESA. Eligible projects include those by landowners and their partners who need technical and financial assistance to improve habitat or implement other activities on private lands.
USFWS Cooperative Endangered Species Conservation Fund (Section 6)	Not specified	Annual	State governments that have a current cooperative agreement with the Secretary of the Interior	This program funds a wide array of voluntary conservation projects for candidate, proposed, and listed endangered species.
USFWS Cooperative Conservation Initiative	Not specified	Annual	Not specified	Support efforts that restore natural resources and establish or expand wildlife habitat
USFWS Fisheries Restoration & Irrigation Mitigation Act (FRIMA)	Not specified	Annual	Local and state governments, partnerships, and Conservation Districts. Landowner is often a co-applicant	Design, construction, and installation of fish screens, fish ladders, or other fish passage devices associated with water diversions. Projects may also include modifications to water diversion structures that are required for effective functioning of fish passage devices.
USFWS Dingell-Johnson Sport Fish Restoration	Nationally ~293 million in 2005 & 2006	Annual	State fish & wildlife agencies	Support activities designed to restore, conserve, manage, or enhance sport fish populations and the public use benefits from these resources; and to support activities that provide boating access to public waters. Projects supported include fish habitat improvement, research on fishery problems, surveys and inventories of fish populations, provision for public use of fishery resource, and lake and stream rehabilitation.
USFWS Landowner Incentive	Nationally 18 million in 2005; 34 million in 2006	Annual	State fish & wildlife agencies	These grants are available for conservation efforts to be carried out on private lands, to provide technical or financial assistance to private landowners for the purpose of benefiting Federally listed, proposed or candidate species.

Table 10-34. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
USFWS North American Wetlands Conservation Fund (NAWCA)	61 million in 2005; 75 million in 2006	Annual	Public and private organizations or individuals who have developed partnerships to carry out wetland conservation projects	Funds may be used to restore, manage, and/or enhance wetland ecosystems and other habitat for migratory birds and other fish and wildlife. Lands and waters must have as their primary purpose long-term water conservation for the benefit of migratory birds and other wildlife.
NRCS Environmental Quality Incentives Program	Not specified - varies from national to state level	Annual	Private landowners that are agricultural producers (can be assisted by conservation groups, consultants, etc.)	Provides voluntary conservation program for farmers and ranchers that promote agricultural production and environmental quality as compatible national goals.
NRCS Wildlife Habitat Incentives Program	Not specified - varies from national to state level	Annual	Private landowners (can be assisted by conservation groups, consultants, etc.)	Voluntary program for people who want to develop and improve wildlife habitat primarily of private lands. This program provides both technical and cost share assistance to establish and improve fish and wildlife habitat.
FSA Conservation Reserve Program	Acreage capped program - currently 39.2 million acres nationally	Annual	Private landowners that are agricultural producers (can be assisted by conservation groups, consultants, etc.)	Program offers annual rental payments, incentive payments, and cost-share for establishment of grasslands, riparian habitat, and wetlands on marginal cropland and pastureland.
NRCS Wetlands Reserve Program	Not specified - varies from national to state level	Annual	Private landowners (can be assisted by conservation groups, consultants, etc.)	Voluntary wetland conservation program that offers perpetual easements, 30-year easements, and 10-year restoration cost-share agreements. NRCS holds CEs; private landowner controls access and performs management.
BOR Water Conservation Field Services Program	$450,000	Annual	Unrestricted	Financial assistance for demonstration programs and pilot projects to promote and implement improved water management and conservation. Also for planning, designing, and construction improvements that will conserve water, increase water use efficiency, or enhance water management through measurement or automation, at existing water supply projects within the 17 western states.
Columbia Basin Water Transaction	Not specified	Not specified	Qualified Local Entities (Trout Unlimited)	Improve flows to streams and rivers in the Columbia Basin through water acquisitions, boosting efficiency, conserving habitat, rethinking the source, pools, and banks.

Table 10-34. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
Tri-County Resource Advisory Council	Varies - designated by counties each fiscal year. $100,000 was available for the 2005 fiscal year	Annual - The SRSCSDA expires on September 30, 2006. Congress will need to re-approve this Act for funding past this date	Unrestricted - preference is for projects with several partners	Projects must be located within one of the three counties covered by the Tri-County RAC (Deer Lodge, Granite, or Powell). Funds must be spent on projects that benefit federal land, although projects do not have to be located on federal land. Eligible projects include watershed restoration and maintenance; restoration, maintenance, and improvement of wildlife and fish habitat; or reestablishment of native species.

10.4 Evaluating Success and Adaptive Management

This plan acknowledges the uncertainties and limitations associated with setting water quality restoration targets and timelines for achieving those objectives. Stakeholders recognize that this plan is only the first step in a cyclical process that will be employed to restore water quality in these planning areas. Water quality restoration targets and objectives as well as the expectations for achieving them will likely need to be modified over time as implementation occurs, natural conditions change, and new knowledge is gained.

In order to determine whether the causes and sources of water quality impairment have been properly identified, whether water quality restoration targets are being achieved as a result of implementation, where additional work is needed, and if adjustments to the plan are necessary it will be important to establish a program for measuring success. This section describes key elements needed for evaluating the restoration of water quality in the Middle Blackfoot and Nevada Creek TMDL planning areas and strategies for adaptation based on experiences and new knowledge.

10.4.1 Tracking Implementation

A system for tracking completed projects and monitoring is necessary to evaluate the local and cumulative effects of restoration on water quality. The "Basin-Wide Restoration Action Plan" proposes such a tracking system but it has not yet been developed. An integral part of evaluating the success of this water quality restoration plan will be to develop, implement, and maintain this tracking system. The Blackfoot Challenge maintains a small internal database of completed projects and monitoring in which it has been a partner. The Blackfoot Challenge will continue to update and maintain this database with projects it implements under this restoration plan. The Blackfoot Challenge will also pursue the development of a watershed project database in which partners can regularly update information.

10.4.2 Monitoring

Monitoring at various scales will also be critical to evaluating the success of this restoration plan. Monitoring is required to assess the effectiveness of restoration activities both locally and at the watershed scale, to assess whether water quality restoration targets are being met as a result of restoration activities, provide justification to modify restoration strategies, numeric targets, load allocations, or timelines for achieving water quality restoration objectives when appropriate; and to identify or better delineate additional causes and sources of water quality impairment. The following describes four levels of monitoring that are recommended under this plan.

10.4.2.1 Restoration Effectiveness Monitoring

Site specific restoration monitoring will be used to evaluate the effectiveness of restoration in achieving water quality restoration targets for a given stream or stream reach. Monitoring parameters will vary based on the 303(d) Listed stream and its associated impairments and specific monitoring plans will need to be developed based on the project. The Restoration Effectiveness Monitoring Protocol of the “Basin-Wide Restoration Action Plan” was written to provide restoration planners with a common reference for determining the appropriate monitoring parameters/activities to utilize on a given project. **Table 10-35** comes directly from the Restoration Effectiveness Monitoring Protocol and shows suggested monitoring parameters to be used for restoration projects depending on the restoration goals and/or the particular water quality impairment.

Table 10-35. Restoration Monitoring Matrix

METRICS	RESTORATION PROJECT OBJECTIVES/IMPAIRMENT CAUSES							
	In-Stream Flow Maintenance	Habitat Restoration	Reduce Substrate Siltation	Reduce Thermal Modification	Reduce Ag Runoff	Riparian Area Restoration	Reduce Elevated Metals	Reduce Elevated Nutrients
BIOLOGICAL METRICS								
Fish Population Surveys	X	**X**	X	X	X	X		
Redd Counts	X	**X**	X	X	X	X		
Macroinvertebrate Sampling	X	X	X	X	X	X	X	X
Periphyton Sampling	X	X	X	X	**X**			X
Chlorophyll-a					**X**			X
PHYSICAL PARAMETERS								
Habitat Assessments	X	**X**				**X**		
Riparian Assessment		X	X	X	X	**X**		
Water Temperature	X	X	X	**X**	X	**X**		
Flow Monitoring	**X**			X			**X**	**X**
Photo Points	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
WATER CHEMISTRY								
TSS Samples			**X**		**X**		X	X
Nutrient Sampling					**X**			**X**
Metals Sampling							**X**	
STREAM SUBSTRATE COMPOSITION								
McNeil Core Samples		X	**X**			X		
Percent Fine Sediment Content		X	**X**			X		

X – Metrics marked in bold should be given primary consideration for monitoring
TSS- Total Suspended Sediment

The Blackfoot Challenge has recently been involved with site specific project monitoring for projects in which it is a partner. The Blackfoot Challenge has used the Restoration Effectiveness Monitoring Protocol to determine appropriate monitoring parameters. The Blackfoot Challenge will continue to conduct site specific restoration monitoring on projects where it is a partner and will continue to track these data collection efforts. Other partners often collect site specific restoration data. Data collected by various partners should be viewed collectively when evaluating the project effectiveness. A variety of methodologies for data collection are also utilized. Whenever possible, site specific restoration monitoring on previously assessed locations will utilize previous assessment methods to ensure consistency.

10.4.2.2 Status and Trends Monitoring

Over the past 15 years, hundreds of stream related projects have been implemented by various partners in the Blackfoot watershed (Blackfoot Challenge, 2005). These projects have improved conditions locally and have undoubtedly had a cumulative impact on water quality and fisheries resources throughout the watershed. In addition to measuring the effectiveness of individual projects, monitoring will occur at the watershed scale. In 2004, partners in the Blackfoot developed and implemented the Blackfoot Watershed Status and Trends Water Quality Monitoring Program. “The purpose of this program was to develop a fixed set of locations to evaluate and describe the status, spatial patterns, and time trends in water quality in the Blackfoot watershed” (Land & Water 2002). In 2004 and 2005 water quality data was collected at 12 stations in the Blackfoot providing baseline conditions. Of these 12 stations, 6 are located within the Middle Blackfoot and Nevada Creek planning areas (Land and Water, 2004). An additional station, Nevada Creek above Nevada Reservoir, was monitored in 2004 using the same monitoring parameters as other stations. Monitoring at this scale is important to understanding water quality in the Blackfoot. Due to the expense of this monitoring program, it is not feasible to perform this monitoring on an annual basis. However, monitoring at these stations at least every 3 to 5 years is recommended.

10.4.2.3 Additional TMDL Assessments

Several cases arose during the development of TMDLs for the Middle Blackfoot and Nevada Creek planning areas where additional assessments or monitoring are needed to better understand conditions, better delineate, quantify, or identify water quality impairment sources including natural or anthropogenic sources, or identify additional water quality impairments or impaired streams. The following describes additional TMDL assessment needs.

- The scale of the SWAT model used to determine the sediment load from hill slope sources was broad and coarse. Continued refinement or redevelopment of a predictive sediment loading model with improved sub-basin resolution, improved landcover characteristics, and more accurate flow characterizations is recommended.
- The application of a reservoir response model to simulate the effects of Nevada Lake on the sediment budget for Lower Nevada Creek is recommended.
- Further monitoring of metals impaired streams is recommended to provide a more comprehensive understanding of potential sources, causes, and opportunities for mitigation.

- Based on recent studies conducted by Plum Creek Timber Company and the University of Montana, base erosion rates (10 tons/acre/year)chosen to calculate road sediment loads should be reevaluated during the five-year TMDL review. Sugden and Woods (2007) found that the estimated base erosion rate of 10 tons/acre/year are three to ten times higher than actual measured values.
- Several streams in both planning areas had sampled exceedences for arsenic. These streams include Douglas Creek, Murray Creek, Wilson Creek, Halfway Creek, lower Nevada Creek, Frazier Creek, Wales Creek, Black Bear Creek, Buffalo Gulch, Washington Creek, and Richmond Creek. As described in **Section 6.0**, the source of arsenic is believed to be natural based on geology of these areas. However, further investigations into potential anthropogenic contributions are recommended.
- Cottonwood Creek, Douglas Creek, and Halfway Creek in the Nevada Creek planning area also had measured iron exceedences. Due to a lack of data at the time this document was written however, impairment determinations were not possible. Continued metals related monitoring on these streams is recommended.
- Several exceedences and elevated levels of metals have been observed in lower Nevada Creek. Additional sampling should be pursued to determine if metals are a limiting factor to water quality in lower Nevada Creek, potential metals sources, potential causes of metals impairments, and potential actions to mitigate metals impairments.
- In general, nutrient impairment determinations are based on a limited number of samples limiting the understanding of sources and causes of impairments. Further nutrient sampling should be pursued to verify impairments and to identify potential sources, causes, and actions necessary to mitigate nutrient impairments.
- Studying the connection between groundwater and surface water (particularly in lower Nevada Creek) with respect to nutrient loading is recommended.
- Continued refinement or redevelopment of a predictive nutrient loading model with improved sub-basin resolution, improved landcover characteristics, and more accurate flow characterizations is recommended.
- As noted in **Section 8.0**, overall irrigation operations and efficiency in lower Nevada Creek are not defined well enough to fully understand the impacts of irrigation (withdrawals, return flows, dam operations) on water temperatures. A full assessment of irrigation operations and efficiency in lower Nevada Creek is recommended. Maintaining the USGS gage station at the mouth of Nevada Creek will be essential to understanding irrigation and hydrology.
- In addition to assessing and understanding irrigation operations, a more directed and comprehensive assessment of temperature and flow conditions (including the influence of groundwater and limitations presented by drought) in listed streams is recommended. An assessment of this nature will allow for future modeling and potential refinement of current temperature target parameters (shade, flow, and channel morphology) and potential adjustments to other pollutant category targets.
- Halfway Creek is a tributary to upper Nevada Creek. While it is not a 303(d) Listed stream, it is believed to have significant impacts on water quality in Nevada Creek. Recent monitoring on Halfway Creek shows arsenic and iron exceedences (Hydrometrics 2005 and 2006). Temperature data from Halfway Creek also indicates a potential impairment. However, not enough data was available at the time of this document to

make impairment determinations. A full water quality assessment of Halfway Creek is recommended to understand local conditions as well as impacts to Nevada Creek.

- Water quality in the Clearwater River drainage is not well documented or understood. Based on recent fisheries work by Montana FWP and public comments, an assessment of water quality in Emerald Lake, Placid Lake, Fish Creek, Morrell Creek, Trail Creek, Owl Creek, Placid Creek, and the Clearwater River (between Seeley and Salmon Lakes and upstream of the Blackfoot River) is recommended.
- A more detailed review of existing data and the development and implementation of a more comprehensive monitoring plan are recommended for Seeley Lake and Salmon Lake to assess water quality conditions. Comments received during the review period suggest nutrients, chemical contamination, and temperature in Salmon Lake and Seeley Lake be evaluated.

10.4.2.4 Five-Year Review

Five years following TMDL development, Montana DEQ evaluates the Watershed Restoration Plan and all other available sources of information for BMP implementation, criteria attainment, beneficial use support, and the degree to which TMDL objectives have been met (Montana DEQ Framework for TMDL Five-Year Review, December 2006). The Blackfoot Challenge and its partners will work with DEQ on the five-year evaluation.

REFERENCES

Administrative Rules of Montana. 1996. Surface Water Quality Standards and Procedures. ed State of Montana Helena, MT: Secretary of State.

Alt D, and Hyndman DW. 1986. Roadside Geology of Montana. Missoula, MT: Mountain Press Publishing Company.

Anderson B, and Walker M. 2004. Nevada Creek TMDL: 2003 Nutrient/Metals Sampling Project Summary Report. Helena, MT: Hydrometrics Inc.

Bahls L. 2004. Biological Integrity of Streams in the Blackfoot River TMDL Planning Area Based on the Structure and Comparison of the Benthic Algae Community. Helena, MT: Hannaea.

Bartholow JM. 2002. SSTEMP for Windows: The Stream Segment Temperature Model. U.S. Geological Survey.

Bengeyfield P. 2002. Unpublished Draft Analysis of Yellowstone National Park Reference Reach Data, U.S. Forest Service.

Berg RK. 2003. Fish Population Status in Eight Major Lakes in the Clearwater River Drainage, Montana, 1995-2002. Helena, MT: Montana Fish, Wildlife and Parks.

Blackfoot Challenge. 2003. Water Quality Restoration Sites. Ovando, MT: Blackfoot Challenge.

Blackfoot Challenge. 2004. Summary of Flow Monitoring Efforts in the Blackfoot Watershed. Missoula, MT: Blackfoot Challenge.

Blackfoot Challenge. 2005. A Basin-Wide Restoration Action Plan for the Blackfoot Watershed. Missoula, MT: Blackfoot Challenge.

Blackfoot Challenge. 2006. Arrastra Creek Culvert Replacement Project Design. Ovando, MT: Blackfoot Challenge.

Bollman W. 1997. 1996 Habitat and Macroinvertebrate Survey East Fork Big Spring Creek and Beaver Creek, Fergus County, Montana. Missoula, MT: Fergus County Conservation District.

Bollman W. 1998. Improving Stream Bioassessment Methods for the Mountain Valleys and Foothill Prairies Ecoregion. Improving Stream Bioassessment Methods for the Mountain Valleys and Foothill Prairies Ecoregion, University of Montana.

Bollman W. 2004. Biological Assessment of Sites in the Ninemile Creek Drainage, Missoula County, Montana TMDL-C04 July 2003. Missoula, MT: Rhithron Associates Inc.

Bollman W. 2005. A Biological Assessment of Sites in the Blackfoot River Watershed, Prerestoration. Helena, MT: Rhithron Associates, Inc.

Cahoon J, Stein O, Blank M, McMahon TA, and Burford D. 2005. Fish Passage at Road Crossings in a Montana Watershed. Fish Passage at Road Crossings in a Montana Watershed, Montana State University.

Carlson RE, and Simpson J. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. Madison, WI: North American Lake Management Society.

Carlson RE. 1977. A Trophic State Index for Lakes. *Limnology and Oceanography* 22 (2): 361-369.

Carstarphen CA, Mason DM, Smith LN, LaFave JI, and Richter MG. 2003. Data for Water Wells Visited during the Lolo-Bitterroot Area Ground-Water Characterization Study. Butte, MT: Montana Bureau of Mines and Geology.

Castelle A, and Johnson AW. 2000. Riparian Vegetation Effectiveness. Research National Park, NC: National Council for Air and Stream Improvement.

Cladouhos JW. 1971. The Water Quality and Cultural Eutrophication of Seeley Lake, Montana. The Water Quality and Cultural Eutrophication of Seeley Lake, Montana, University of Montana.

Dalby C. 2006. Use of Regressiona dn Time-Series Methods to Estimate a SEdiment Budget for Nevada Creek Reservoir, Montana, USA. 26 6 A.D., at Missoula, MT.

Drake M. 2007. Estimating Sampling Effort for Biomonitoring of Near Shore Fish Communities in Small Central Minnesota Lakes. *North American Journal of Fisheries Management* (27): 1094-1111.

Drever JI. 1988. The Geochemistry of Natural Waters. Englewood Cliffs, NJ: Prentice Hall, Inc.

DTM Consulting, and Applied Geomorphology Inc. 2005. Analysis of Base Parameter and Erosion Inventory Data for Middle Blackfoot and Nevada Creek TMDL Development. Bozeman, MT: DTM Consulting Inc.

DTM Consulting, and Applied Geomorphology Inc. 2006. Temperature Analysis and Modeling of 303(d) List Streams in the Blackfoot River Watershed, Montana. Bozeman, MT: DTM Consulting Inc.

DTM Consulting. 1999. SWAT Model Development for the Blackfoot River Watershed, Montana. Bozeman, MT: DTM Consulting Inc.

DTM Consulting. 2004. Field Updated Quality Assurance Project Plan and Sampling and Analysis Plan MIddle Blackfoot and Nevada Creek TMDL PLanning Areas. Bozeman, MT: DTM Consulting Inc.

DTM Consulting. 2004. Results of Phase 1 Air Photo Interpretation and Reconnaissance Assessments of the Nevada Creek and MIddle Blackfoot TMDL Planning Areas.

Dunham J, and Rieman BE. 1999. Metapopulation Structure of Bull Trout: Influences of Physical, Biotic, and Geometrical Landscape Characteristics. *Ecological Applications* 9 (2): 642-655.

Dunne T, and Leopold LB. 1977. Water in Environmental Planning. New York, NY: W.H. Freeman and Company.

Economic Research Station. 1997. Agricultural Resources and Environmental Indicators. Washington, D.C.: United States Department of Agriculture.

Feldman D. 2006. A Report to the DEQ Water Quality Planning Bureau on the Proper Interpretation of Two Recently Developed macroinvertebrate Bioassessment Models. Helena, MT: Montana Department of Environmental Quality.

Fitzgerald G. 1996. Inventory and Analysis of Riparian Vegetation Along Lower Nevada Creek. n.p.: n.p.

Gibson G, Carlson R, Simpson J, Smeltzer E, Gerritsen J, Chapra SC, Heiskary S, Jones J, and Kennedy R. 2000. Nutrient Criteria Technical Guidance Manual - Lakes and Reservoirs. Washington, D.C.: U.S. Environmental Protection Agency.

Harmon W. 1999. Best Management Practices for Grazing. Helena, MT: Montana Department of Natural Resources and Conservation.

Heberling P. 2000. Umpqua Basin Update: Stream Temperature. Salem, OR: Oregon Department of Environmental Quality.

Helsel DR, and Hirsch RM. 1995. Statistical Methods in Water Resources. *Studies in Environmental Science* (49): 7356-7363.

Hook PB. 2003. Sediment Retention in Rangelands Riparian Buffers. *Journal of Environmental Quality* (32): 1130-1137.

Hydrometrics Inc. 2004. Nevada Creek TMDL Nutrient/Metals Sampling Project Summary Report. Helena, MT: Hydrometrics Inc.

Hydrometrics Inc. 2005. Restoration Effectiveness Demonstration Report for Kleinschmidt Creek. Helena, MT: Hydrometrics Inc.

Hydrometrics Inc. 2005. Sampling and Analysis Plan for Surface Water Monitoring in Nevada Creek and Kleinschmidt Creek Drainages in Support of Metals TMDL Development. Helena, MT: Hydrometrics Inc.

Hydrometrics Inc. 2006. Updated Data Compilation and Preliminary Development of Total Maximum Daily Loads for Metals in Nevada Creek Watershed and Kleinschmidt Creek, Powell and Lewis and Clark Counties, Montana. Helena, MT: Hydrometrics Inc.

Idaho Department of Environmental Quality. 2008. Big Lost River Watershed Subbasin Assessment and TMDL. Boise, ID: Idaho Department of Environmental Quality.

Ingman GL, Kerr M, and McGuire DL. 1990. Water Quality Investigations in the Blackfoot River Drainage, Montana. Helena, MT: Montana Department of Health and Environmental Sciences.

Interagncy Lakes Coordinating Committee. 2008. Developing a Lake Management Plan. St.Paul, MN: Interagency Lakes Coordinating Committee.

Jones DS, Suter GW, II, and Hull RN. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Charlotte, NC: Lockheed Martin Energy Systems, Inc.

Jorgenson N, Laursen A, Viksna NP, and Holm PE. 2005. Multi-Elemental EDXRF mapping of Polluted Soil from Former Horticultural Land. *Environmental International* 31 (1): 43-52.

Land & Water Consulting Inc. 2002. Design Considerations and a Framework for Improving Water Quality Monitoring Programs in the Blackfoot Watershed. Missoula, Montana: Land & Water Consulting Inc.

Langmuir DP, Chrostowski B, Vigneault B, and Chaney R. 2004. Issue Paper on the Environmental Chemistry of Metals. Submittal to U.S. EPA Risk Assessment Forum: Papers Addressing Scientific Issues in the Risk Assessment of Metals.

Larix Systems Inc. 2006. Algal Perception Survey: Statistical Survey Analysis Report. n.p.: n.p.

Ledwith T. 1996. "The Effects of Buffer Stream Width on Air Temperature and Relative Humidity in a Stream Riparian Zone." Available from http://www.watershed.org/news/sum_96/buffer.html.

Lewis RS. 1998. Geologic Map of the Butte 1o X 2o Quadrangle, Southwestern Montana.

Logan RS. 2001. Water Quality BMPs (Best Management Practices) for Montana Forests. Bozeman, MT: Montana State University Extension Publications.

McBain & Trush. 2001. Spawning Gravel Composition and Permeability within the Garcia River Watershed, California. Ukiah, CA: Mendocino County Resource Conservation District.

McCuen RH. 1997. Hydrologic Analysis and Design. Upper Saddle River, NJ: Prentice Hall.

McGuire DL. 1994. Montana Reference Streams: 1993 Aquatic Macroinvertebrate Surveys. Espanola, NM: Montana Department of Health and Environmental Sciences.

McGuire DL. 1995. Habitat and Aquatic Macroinvertebrate Survey. Espanola, NM: McGuire Consulting.

Montana Bull Trout Scientific Group. 1995. Blackfoot River Drainage: Bull Trout Status Report. Helena, MT: Montana Bull Trout Scientific Group.

Montana Code Annotated. 2005. Montana Code Annotated.

Montana Department of Environmental Quality. 2003. 2003 Reassessment Work, West Fork Clearwater River. Helena, MT.

Montana Department of Environmental Quality, DTM Consulting, Applied Geomorphology Inc., Blackfoot Challenge, and Confluence Consulting Inc. 2004. Blackfoot Headwaters Planning Area Water Quality and Habitat Restoration Plan and TMDL for Sediment. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality. 2004. Circular WQB-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality (MDEQ).

Montana Department of Environmental Quality. 2006. 2006 Integrated 305(b)/303(d) Water Quality Impairment List and Reports. Helena, MT: Montana Department of Environmental Quality (MDEQ).

Montana Department of Environmental Quality. 2006. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality. 2006. Standard Operating Procedure, Water Quality Assessment Process and Methods. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Fish, Wildlife and Parks. 1977. Interagency Stream Fishery Data.

Montana Department of Fish, Wildlife and Parks. 1991. Dewatered Streams List. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Montana Department of Fish, Wildlife and Parks. 1992. Montana Rivers Information System. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Montana Department of Fish, Wildlife and Parks. 1994. Environmental Assessment Big Springs Trout Hatchery. Lewistown, MT: Montana Department of Fish, Wildlife, and Parks.

Montana Department of Fish, Wildlife and Parks. 1997. Montana Warm Water Fisheries Management Plan, 1997-2006.

Montana Department of Natural Resources and Conservation. 1995. Nevada Creek Reservoir Manual for Operations and Maintenance. Helena, MT: Montana Department of Natural Resouces and Conservation.

Mosley JC, Cook PS, Griffis AJ, and O'Laughlin J. 1997. Guidelines for Managing Cattle Grazing in Riparian Areas to Protect Water Quality: Review of Research and Best Management Practices Policy. Moscow, ID: Idaho Forest, Wildlife and Range Experiment Station, Idaho Forest, Wildlife and Range Policy Analysis Group.

Mudge MR, Earhart RL, Whipple JW, and Harrison JE. 1982. Geologic and Structure Map of the Choteau 1º x 2º Quadrangle, Western Montana. Reston, VA: Montana Bureau of Mines and Geology, Department of the Interior, United States Geological Survey.

Natural Resources Conservation Service. 1997. National Engineering Handbook Irrigation Guide. Washington, D.C.: Natural Resources Conservation Service.

Natural Resources Conservation Service. 2002. Prescribed Grazing (Code 528A), Montana Conservation Practice Specification in Draft. Helena, MT: Montana Natural Resources Conservation Service.

Natural Resources Conservation Service. 2004. Powell County Field Office Technical Guide (Practice Standard 393). Washington, D. C.: Natural Resources Conservation Service.

Natural Resources Conservation Service. 2007. Electronic Field Office Technical Guide, Powell County, Montana. Washington, D.C.: Natural Resource Conservation Service.

Negri D, and Hanchar JJ. 1989. Water Conservation Through Irrigation. Washington, D.C.: Economic Research Service.

Neitsch SL, Arnold JG, Kiniry JR, and Williams JR. 2002. Soil and Water Assessment Tool Theoretical Documentation. Temple, TX: Agricultural Research Service; Texas Agricultural Experiment Station.

Norbeck PM, and McDonald C. 1998. Ground-Water Evaluation, Seeley Lake, Montana. Butte, MT: Montana Bureau of Mines and Geology.

Omang RJ. 1992. Analysis of the Magnitude and Frequency of Floods and the Peak-Flow Gaging Network in Montana. Helena, MT: U.S. Geological Survey.

Omernik JM. 1987. Ecoregions of the Conterminous United States (map). *Annals of the Association of American Geographers* 77 (1): 118-125.

Osgood RA. 1988. Lake Mixis and Internal Phosphorus Dynamics. *Archiv fur Hydrobiologie* 113: 629-638.

Patton CJ, and Kryskalla JR. 2003. Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory - Evaluation of Alkaline Persulfate Digestion as an Alternative to Kjeldahl Digestion for Determination of Total and Dissolved Nitrogen and Phosphorus in Water. Denver, CO: U.S. Geological Survey.

PBS&J. 2006. Blackfoot Watershed Water Quality Status and Trends Monitoring Project: 2004 Summary Report. Helena, MT: PBS&J.

Peters DJ. 1990. Inventory of Fishery Resources in the Blackfoot River and Major Tributaries. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Peters DJ. 2004. 2004 Monitoring Report, Nevada Spring Creek, Phase 2. Florence, MT: DJP Aquatic Consulting, LTD.

Pfankuch DJ. 1978. Stream Reach Inventory and Channel Stability Evaluation.

Phillips GR, and Bahls L. 1994. Lake Water Quality Assessment and Contaminant Monitoring of Fishes and Sediments From Montana Waters. Helena, MT: Montana Fish, Wildlife and Parks.

Phillips GR, and Humphrey AB. 1987. Inventory of Placer Mining Effects on Stream Resources in the Vicinity of the Helena National Forest. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R, and Peters DJ. 1990. Aquatic Investigations in the Middle Blackfoot River, Nevada Creek and Nevada Spring Creek Corridor. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R, and Podner C. 2000. Blackfoot River Fisheries Inventory, Monitoring and Restoration Report 2000. Missoula, MT: Montana Fish, Wildlife and Parks.

Pierce R, and Schmetterling D. 1999. Blackfoot River Restoration Project: Monitoring and Progress Report 1997-1998. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R, Anderson R, and Podner C. 2004. Big Blackfoot River Restoration Progress Report for 2002-2003. Missoula, MT: Montana Fish, Wildlife and Parks.

Pierce R, Peters DJ, and Swanberg TR. 1997. Blackfoot River Restoration Project: Progress Report. Missoula, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R, Podner C, and McFee J. 2001. Blackfoot River Fisheries Inventory, Monitoring and Restoration Report 2001. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R, Podner C, and McFee J. 2002. The Blackfoot River Fisheries Inventory, Restoration and Monitoring Progress Report for 2001. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R. 1991. Stream Habitat and Fisheries Analysis for Six Tributaries to the Big Blackfoot River. Missoula, MT: Montana Department of Fish, Wildlife and Parks.

Pierce R. 2002. A Heirachical Strategy for Prioritizing the Restoration of 83 Impaired Tributaries of the Big Blackfoot River. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Pierce RS, and Podner C. 2006. The Big Blackfoot River Fisheries Restoration Report for 2004 and 2005. Helena, MT: Montana Fish, Wildlife and Parks.

Plafkin JL, Barbour MT, Porter KD, Gross S, and Hughes RM. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Washington, D.C.: U.S. Environmental Protection Agency.

Relyea CB, Minshall GW, and Danehy RJ. 2000. Stream Insects as Bioindicatores of Fine Sediment. Paper presented at Water Environment Federation Specialty Conference, at Boise, ID.

Rezanka RL, and Butler MG. 1998. Variation Among Benthic Invertebrate Communities From Lakes in a Five-State Region. Variation Among Benthic Invertebrate Communities From Lakes in a Five-State Region, Department of Zoology, North Dakota State University.

Rieman BE, and McIntyre JD. 1993. Demographic and Habitat Requirements for Conservation of Bull Trout. Ogden, UT: Intermountain Research Station.

River Design Group. 2006. Field-Updated Implementation Report and Data Analysis and Results Summary Middle Blackfoot and Nevada Creek TMDL Planning Area Roads Assessment. Whitefish, MT: River Design Group.

Roberts M, and Waren K. 2001. North Fork Blackfoot River Hydrologic Study. Helena, MT: Montana Department of Natural Resources and Conservation.

Rosgen DL. 1994. A Classification of Natural Rivers. *Catena* 22: 169-199.

Rosgen DL. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology.

Rosgen DL. 2000. A Practical Method of Computing Streambank Erosion Rate. Pagosa Springs, CO: Wildland Hydrology.

Smedley PL, and Kinniburgh DG. 2002. A Review of the Source, Behaviour and Distribution of Aresenic in Natural Waters. *Applied Geochemistry* 17 (5): 517-568.

South Dakota Department of Environment and Natural Resources. 2005. Targeting Impaired Lakes in South Dakota. Pierre, SD: Watershed Protection Program.

Spence LE. 1975. Upper Blackfoot River Study, A Premining Inventory of Aquatic and Wildlife Resources. Helena: Montana Department of Fish and Game.

Streebin LE, Robertson J, Allen SM, Heller WB, and Westhoff J. 1973. Water Quality Study of the Clearwater River and Selected Tributaries. Missoula, MT: Lolo National Forest, Missoula Ranger District.

Stumm W, and Morgan JJ. 1995. Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters. Hobeken, NJ: Wiley Interscience.

Suplee MW, Varghese A, and Cleland J. 2008. Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method. *Journal of the American Water Resources Association* 43 (2): 456-472.

Suplee MW. 2004. Wadeable Streams of Montana's Hi-line Region: An Analysis of Their Nature and Condition, with an Emphasis on Factors Affecting Aquatic Plant Communities and Recommendations to Prevent Nuisance Algae Conditions. Helena, MT: Montana Department of Environmental Quality.

Suplee MW. 2005. Best Use of the June 2005 Nutrient Data Statistical Summaries. Helena, MT: Montana Department of Environmental Quality.

Swanberg TR. 1997. Movement and Habitat Use of Radio Tagged Bull Trout in the Upper Blackfoot River Drainage. Missoula, MT: Montana Fish, Wildlife and Parks.

Swanberg TR. 1997. The Movement and Habitat Use of Fluvial Bull Trout in the Upper Clark Fork Drainage. *American Fisheries Society* 126: 735-746.

Tepper H. 2003. Monitor and Protect Wigwam River Bull Trout for Koocanusa Reservoir. Portland, OR: Bonneville Power Administration.

Theurer FD, Voos KA, and Miller WJ. 1984. Instream Water Temperature Model: Instream Flow Inf. Pap. 16 Coop. Instream Flow and Aquatic System Group. Fort Collins, CO: United States Fish and Wildlife Service.

Thomas G. 1992. Status Report: Bull Trout in Montana. Helena, MT: Montana Department of Fish, Wildlife and Parks.

Thorne CR, Hey RD, and Newson MD. 1998. Applied Geomorphology for River Engineering and Management. Hobeken, NJ: Wiley and Sons.

U.S. Environmental Protection Agency, and Ingersoll CG. 1996. Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomus riparius. Chicago, IL: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. 1997. Climate Change and Montana. Washington, D.C.: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. 1998. Garcia River Sediment Total Maximum Daily Load. San Fransisco, CA: U.S. Environmental Protection Agency, Region 9.

U.S. Environmental Protection Agency. 1999. Protocol for Developing Sediment TMDLs. First Edition. Washington, D.C.: U.S. Environmental Protection Agency.

USDA Forest Service. 1996. Integrated Scientific Assessment for Ecosystem Management in the Interior Columbia Basin and Portions of the Klamath and Great Basins. Portland, OR: USDA Forest Service.

USDA Forest Service. 1999. Nevada / Dalton Project: Draft Environmental Impact Statement. Helena, MT: USDA Forest Service.

USDA Forest Service. 2000. Bitterroot Section 7 Watershed Baseline - Bull Trout. Hamilton, MT: USDA Forest Service.

USDA National Agricultural Statistics Service. 2002. "Census of Agriculture." 2007. Available from http://www.agcensus.usda.gov/Publications/2002/Census_by_State/Montana/index.asp.

Varghese A, and Cleland J. 2005. Seasonally Stratified Water Quality Analysis for Montana Rivers and Streams. Fairfax, VA: ICF Consultants.

Ver Hey ME, and Woessner WW. 1985. Documentation of the Degree of Waste Treatment Provided by Septic Systems, Vadose Zone and Aquifer in Intermountain Soils Underlain by Sand and Gravel. 14 1987, at St. Joseph, MI.

Ward AD, and Trimble SW. 1995. Environmental Hydrology. Boca Raton, FL: Lewis Publishers.

Washington Forest Practices Board. 2001. Standard Methodology for Conducting Watershed Analysis. Olympia, WA: Washington State Department of Natural Resources.

Weaver TM, and Fraley JJ. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Weaver TM. 1996. Fisheries Monitoring on Swan River and Stillwater State Forests. Kalispell, MT: Montana Department of Fish, Wildlife and Parks.

Weber EE. 2004. Blackfoot Watershed Water Quality Status and Trends: Periphyton Monitoring 2004. East Helena, MT: PhycoLogic.

Welch A. 2005. Evaluation of the 1996 Salinity/TDS/chlorides impairment listing for Douglas Creek.

Whitney AN, and Averett RC. 1958. Western Montana Fishery Study: Comparisons of Fish Populations of Six Clearwater Lakes: May 1, 1957 to April 30, 1958. Helena, MT: Montana State Department of Fish and Game.

Whitney AN, Averett RC, Huston JE, Boland RW, Domrose RJ, Opheim BR, Seaburg K, and Marcoux RG. 1973. Western Montana Fisheries Study: Inventory of Waters of the Project Area. Helena, MT.

Whittier TR, Paulsen SG, Larsen DP, Peterson SA, Herlihy AT, and Kaufmann PR. 2002. Indicators of Ecological Stress and Their Extent in the Population of Northeastern Lakes: A Regional Scale Assessment. *BioScience* 52 (3): 235-257.

Williams JR. 1975. Sediment-Yield Prediction with Universal Equation Using Runoff Energy Factor. Oxford, MS: USDA Sedimentation Lab.

Wishmeier WH, and Smith D. 1965. Predicting Rainfall Erosion Losses from Cropland East of the Rocky Mountains. Washington, D.C.: United States Government Print Office.

Wishmeier WH, and Smith D. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Washington, D.C.: United States Department of Agriculture.

Zaroban DW, and Sharp DD. 2001. Palisades Subbasin Assessment and Total Maximum Daily Load Allocations. Boise, ID: Idaho Department of Environmental Quality.

ACRONYMS

AGI Applied Geomorphology, Inc.
Al Aluminum
ARLSWCP All reasonable land, soil, and water conservation practices
ARM Administrative Rules of Montana
BBCTU Big Blackfoot Chapter of Trout Unlimited
BDNF Beaverhead/Deerlodge National Forest
BER Board of Environmental Review
BLM Bureau of Land Management
BMP Best Management Practice
BUD Beneficial Use Determination
CFR Code of Federal Regulations
Cfs Cubic Feet per Second
Chl-*a* Chlorophyll-*a*
CWA Federal Clean Water Act
DEQ Montana Department of Environmental Quality
DHES Montana Department of Health and Environmental Sciences
DNRC Montana Department of Natural Resources and Conservation
DO Dissolved Oxygen
EPA United States Environmental Protection Agency
EPT Ephemeroptera, Plecoptera, Tricoptera
ESA End Species Act
Fe Iron
FWP Montana Department of Fish, Wildlife and Parks
GAP Water Quality Model
HRU Hydrologic Response Unit
INFISH Inland Native Fish Strategy
ITL Instantaneous Thermal Load
JCU Jackson Candle Unit
LA Load Allocation
LSP Water Quality Model
MBPA Middle Blackfoot Planning Area
MCL Max Contaminant Level
MFISH Montana Fisheries Information System
MMI Multi Metric Index
Mn Maganese
MOS Margin of Safety
MUSLE Modified Universal Soil Loss Equation
MWQA Montana Water Quality Act
NLCD National Land Cover Database
NOAA National Oceanic and Atmospheric Administration
NRCS Natural Resources Conservation Service
NWIS National Water Information System
PCB Polychlorinated Biphenyl
PCTC Plum Creek Timber Company
RDG River Design Group

RIVPACS River Invertebrate Prediction and Classification System
SCD Sufficient Credible Data
SCD/BUD Sufficient Credible Data / Beneficial Use Determination
SMZ Streamside Management Zones
SNOTEL Snowpack Telemetry
SNTMP Stream Network Temperature Model
SRP Soluable Reactive Phosphorus
STATSGO State Soil Geographic Database
SWAT Soil and Water Assessment Tool
TDS Total Dissolved Solids
TKN Total Kjeldahl Nitrogen
TMDL Total Maximum Daily Loads
TP Total Phosphorus
TPA TMDL Planning Area
TSI Trophic State Index
TSS Total Suspended Solids
UAA Use Attainability Analysis
USFS United States Forest Service
USFWS United States Fish and Wildlife Service
USGS United States Geological Survey
USLE Universal Soil Loss Equation
W:D Ratio Width to Depth Ratio
WCT Westslope Cutthroat Trout
WLA Waste Load Allocation
WQPB Water Quality Planning Bureau
WQRP Water Quality Restoration Plan
WSCT Westslope Cutthroat Trout

ERRATA SHEET FOR THE "MIDDLE BLACKFOOT-NEVADA CREEK TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY IMPROVEMENT PLAN"

The Middle Blackfoot-Nevada Creek TMDL was approved by EPA on September 22, 2008. Several copies were printed and bound for distribution or sent electronically on compact disks. The original version had minor changes that are explained and corrected in this errata sheet. If you have a bound copy, please note the corrections below or simply print out this 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.

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

TABLE EDITS

Changes are noted in the shaded cells.

Document Location:

Page 262, Section 9.1.7, Table 9-8

Original Table:

Table 9-8. Nevada Creek and Middle Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Crossings	Rural Residential
Middle Blackfoot Planning Area							
Yourname Creek	181	130	1	1	1	48	0
Wales Creek	87	52	29	29	0	6	0
Frazier Creek	17	7	0	0	0	10	0
Ward Creek	48	22	0	8	0	18	0
Kleinschmidt Creek	12	1	0	0	0	11	0
Rock Creek	754	503	0	219	0	32	0
Warren Creek	128	13	1	4	0	110	0
Monture Creek	342	36	0	146	0	160	0
Blackfoot River (Nevada Cr. to Monture Cr.)	2560	1127	876	504	0	54	0
Cottonwood Creek (Blackfoot)	583	286	7	241	0	213	0
Richmond Creek	13	0	0	1	0	12	0
West Fork Clearwater River	175	0	0	90	0	85	0
Deer Creek	271	0	0	148	0	124	0
Blanchard Creek	146	21	0	7	0	119	0
Blackfoot River (Monture Cr. To Clearwater River)	948	477	64	0	0	280	127
Totals	**6,265**	**2,675**	**978**	**1,431**	**1**	**1,052**	**127**

Corrected Table:

Table 9-8. Nevada Creek and Middle Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Crossings	Rural Residential
Middle Blackfoot Planning Area							
Yourname Creek	181	130	1	1	1	48	0
Wales Creek	87	52	29	0	0	6	0
Frazier Creek	17	7	0	0	0	10	0
Ward Creek	48	22	0	8	0	18	0
Kleinschmidt Creek	12	1	0	0	0	11	0
Rock Creek	754	503	0	219	0	32	0
Warren Creek	128	13	1	4	0	110	0
Monture Creek	342	36	0	146	0	160	0
Blackfoot River (Nevada Cr. to Monture Cr.)	2560	1127	876	504	0	54	0
Cottonwood Creek (Blackfoot)	583	286	7	77	0	213	0
Richmond Creek	13	0	0	1	0	12	0
West Fork Clearwater River	175	0	0	90	0	85	0
Deer Creek	271	0	0	148	0	124	0
Blanchard Creek	146	21	0	7	0	119	0
Blackfoot River (Monture Cr. To Clearwater River)	948	477	64	0	0	280	127
Totals	**6,265**	**2,675**	**978**	**1,205**	**1**	**1,282**	**127**

TEXT EDITS

Shaded text shows the text in error and the corrected text.

Location in the TMDL	Original Text	Corrected Text
Page 319, Section 10.2.1.5, paragraph under the "Suspected Sources and Causes" title.	The suspected causes of degradation on Cottonwood Creek include excess sediment production and delivery, removal of bankline vegetation, and low flow alterations (**Table 10-4**). In terms of sediment supply, results of the sediment source assessment indicate that upland areas are the largest contributors of sediment to the stream. Sediment from hill slope erosion accounts for 994 tons of controllable sediment. Timber harvesting in the uppermost reaches is believed to be the cause of most hill slope generated sediment. Sediment produced from livestock grazing practices and hay production in the valley reaches	The suspected causes of degradation on Cottonwood Creek include excess sediment production and delivery, removal of bankline vegetation, and low flow alterations (**Table 10-4**). In terms of sediment supply, results of the sediment source assessment indicate that upland areas are the largest contributors of sediment to the stream. Sediment from hill slope erosion accounts for 994 tons of controllable sediment. Grazing accounts for the majority of the controllable hillslope load; therefore, it receives the highest percentage of the allocated load at 90%. The remaining 10% is allocated to the smaller forestry hillslope load

	accounts for 35% of the hill slope sediment load.	(Table J-9).

APPENDIX A
FIGURES AND MAPS

Watershed Characterization

Figure A-1. Location of the Blackfoot River Watershed

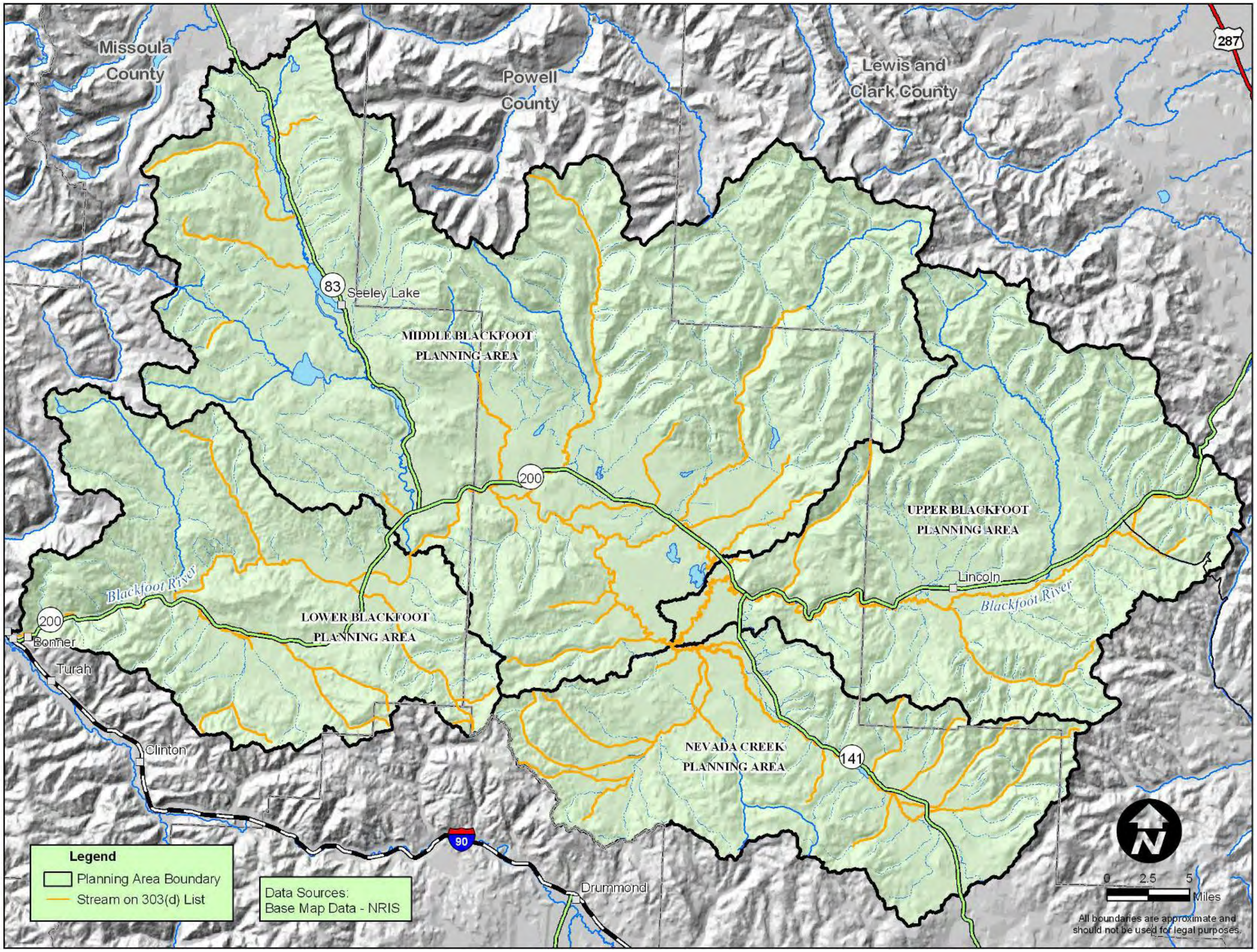


Figure A-2. TMDL Planning Areas in the Blackfoot River Watershed

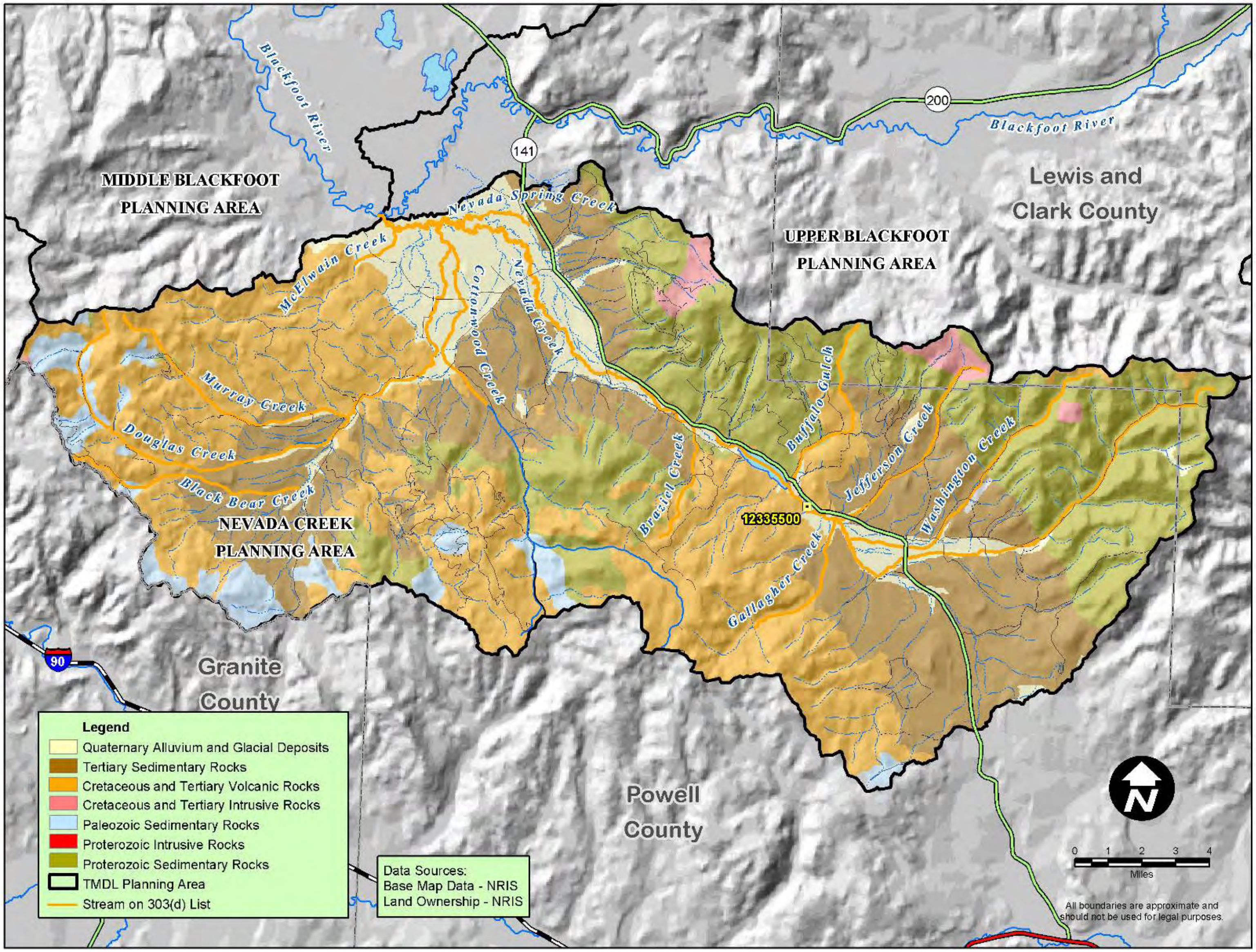


Figure A-3. Geology of the Nevada Creek Planning Area

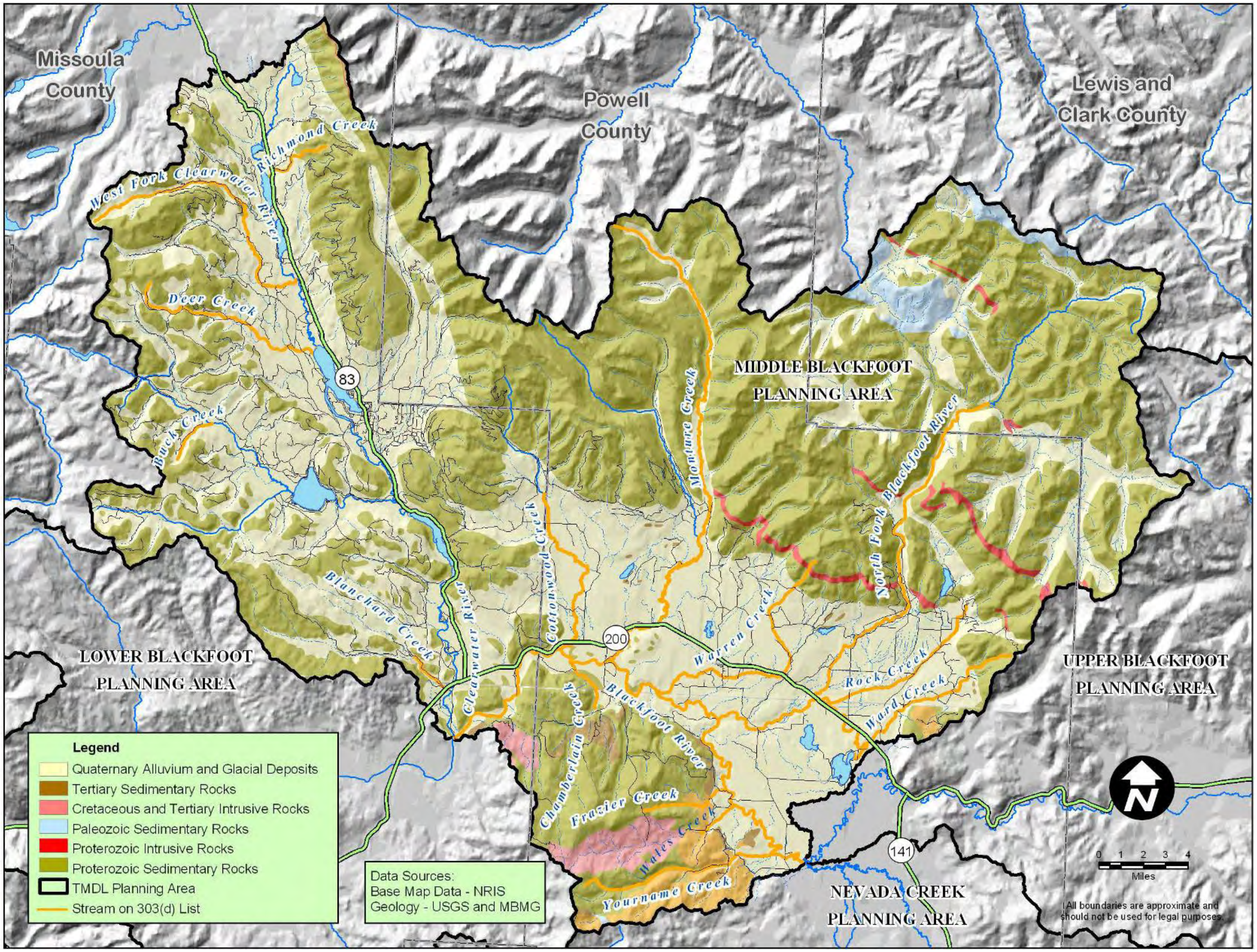


Figure A-4. Geology of the Middle Blackfoot Planning Area

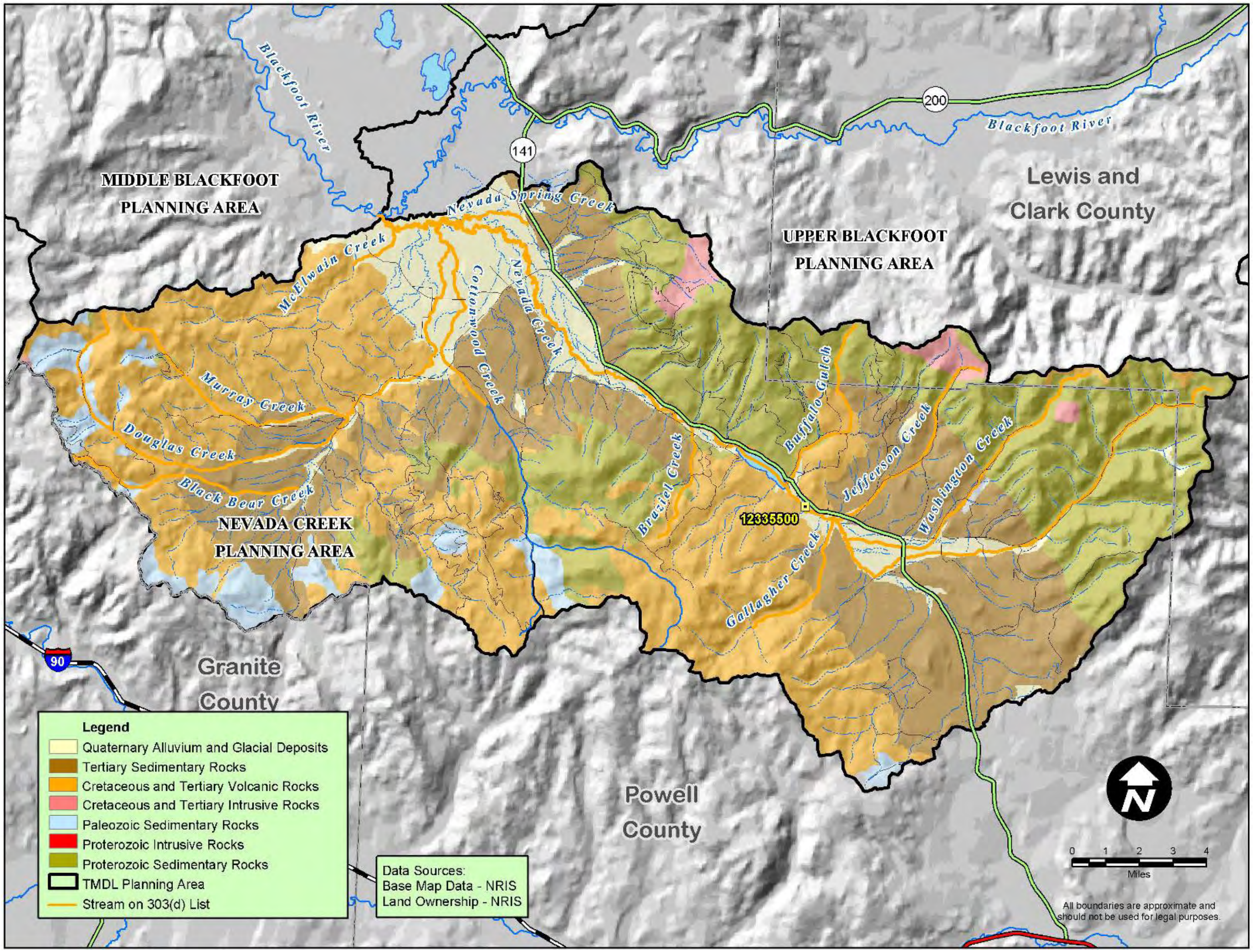


Figure A-5. Soils in the Nevada Creek planning area

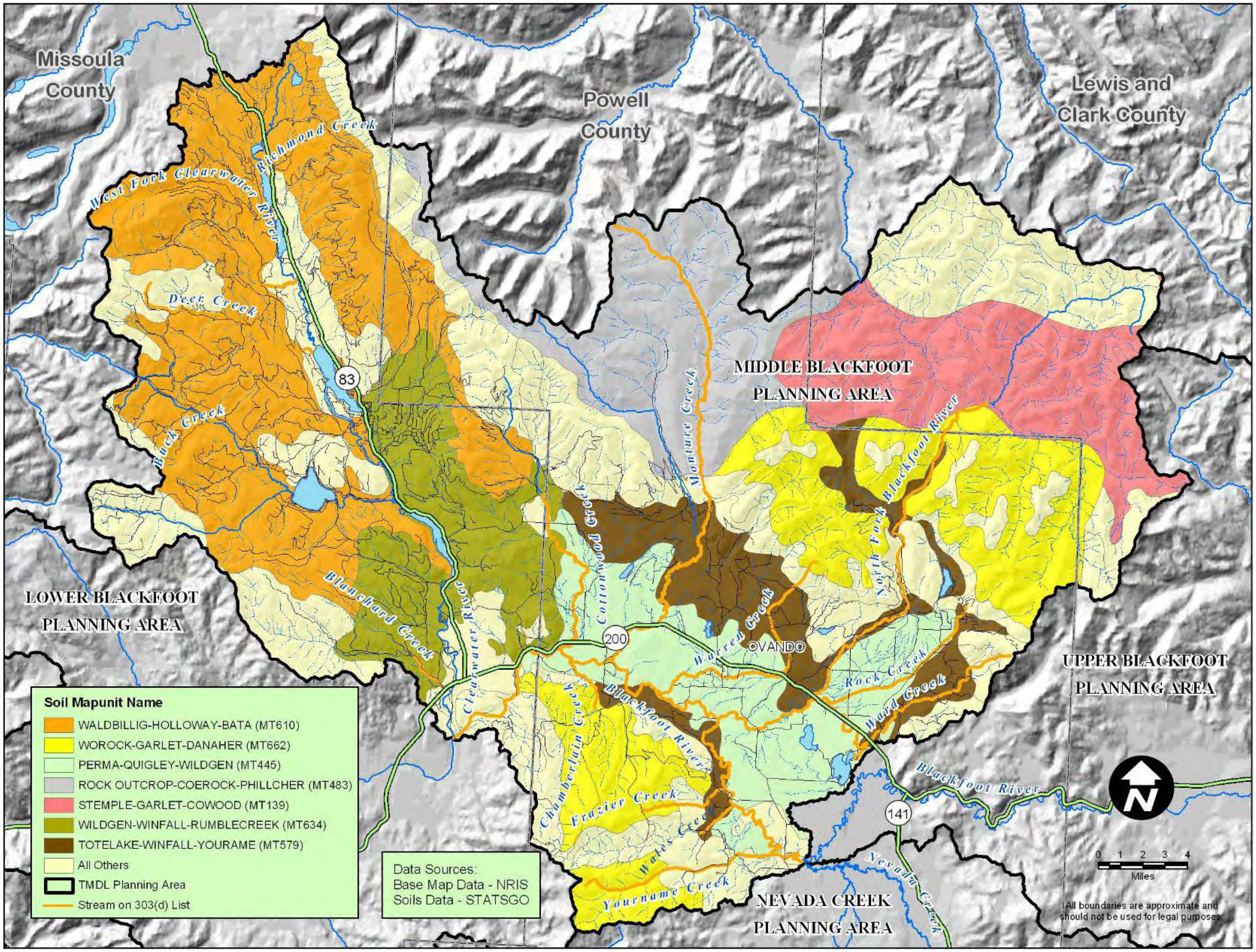


Figure A-6. Soils in the Middle Blackfoot Planning Area

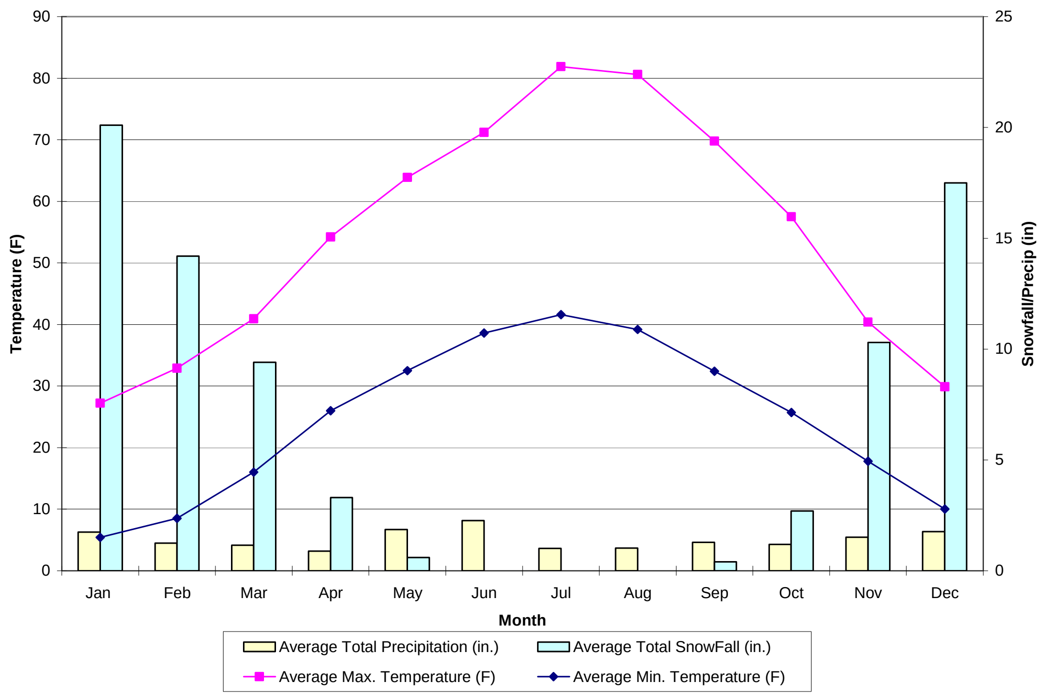


Figure A-7. Average Total Precipitation, Total Snowfall, Average Maximum Temperature and Minimum Temperature at NOAA Ovando Station #246302

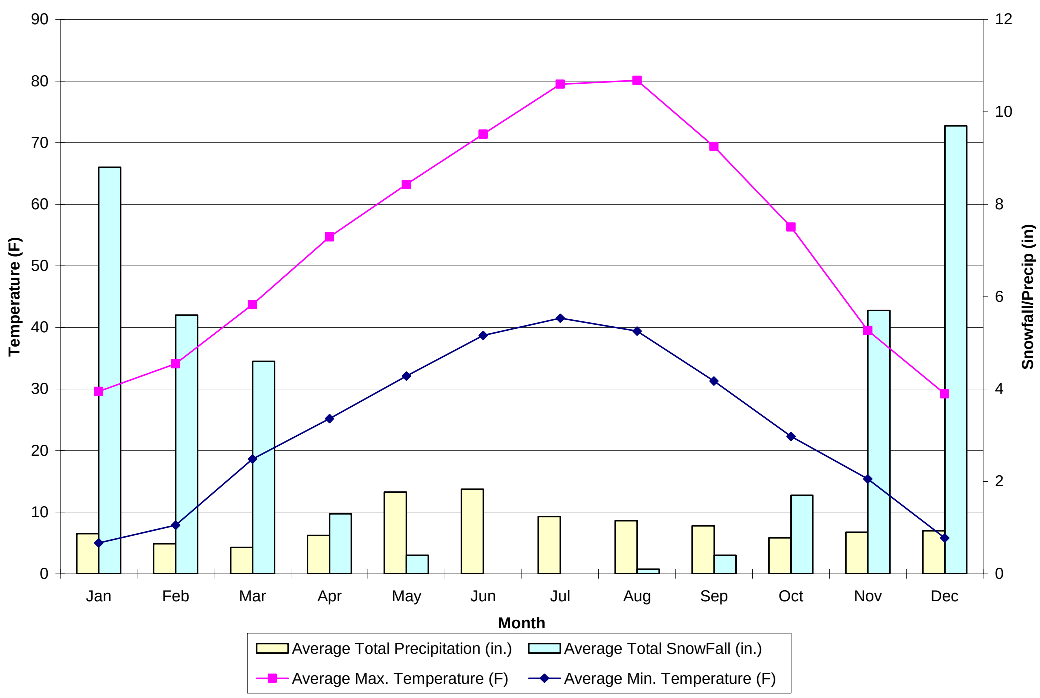


Figure A-8. Average Total Precipitation, Total Snowfall, Average Maximum Temperature and Minimum Temperature at NOAA Ovando 9 SSE Station #246304

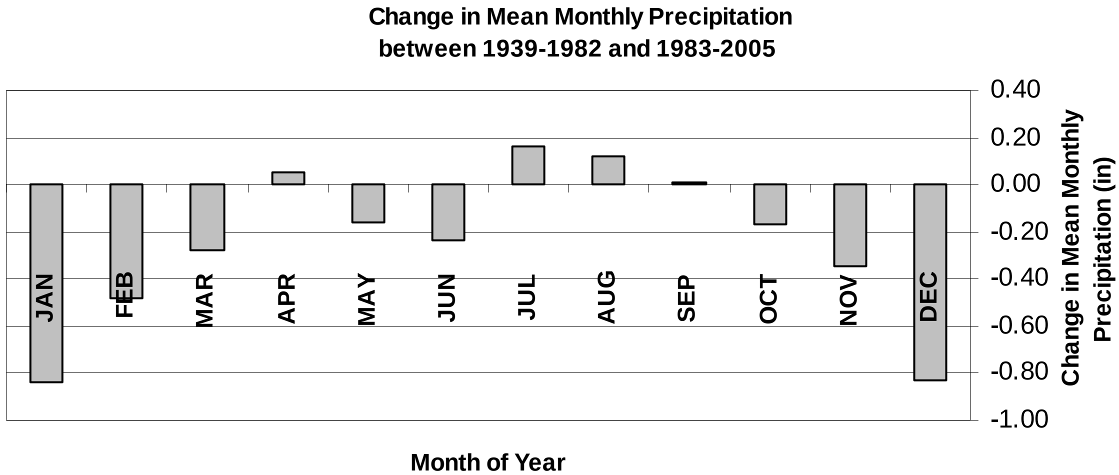


Figure A-9. Change in Mean Monthly Precipitation (Inches) From 1939-1982 and 1983-2005 Recorded at the Ovando Climate Stations

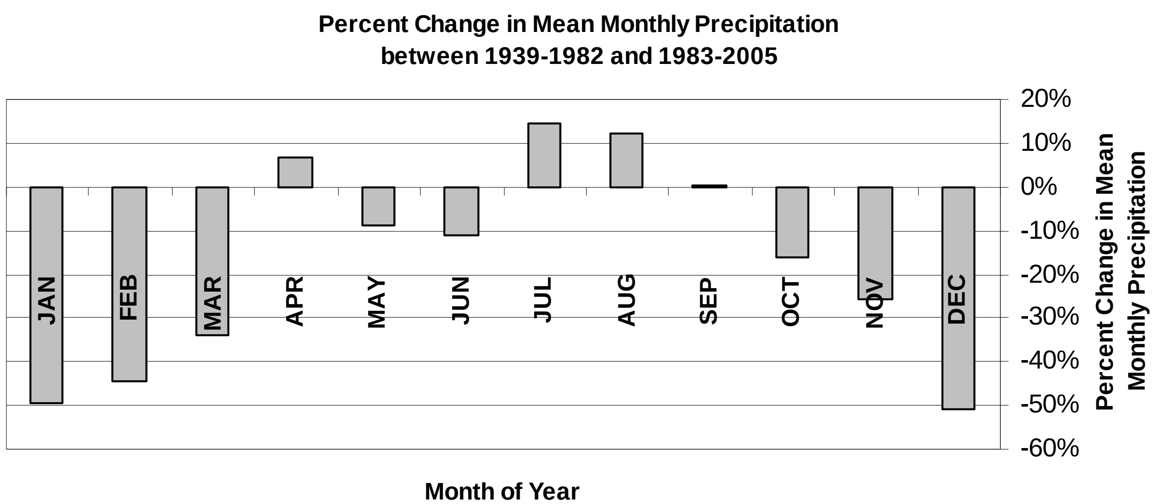


Figure A-10. Percent Change in Mean Monthly Precipitation (Inches) From 1939-1982 and 1983-2005 Recorded at the Ovando Climate Stations

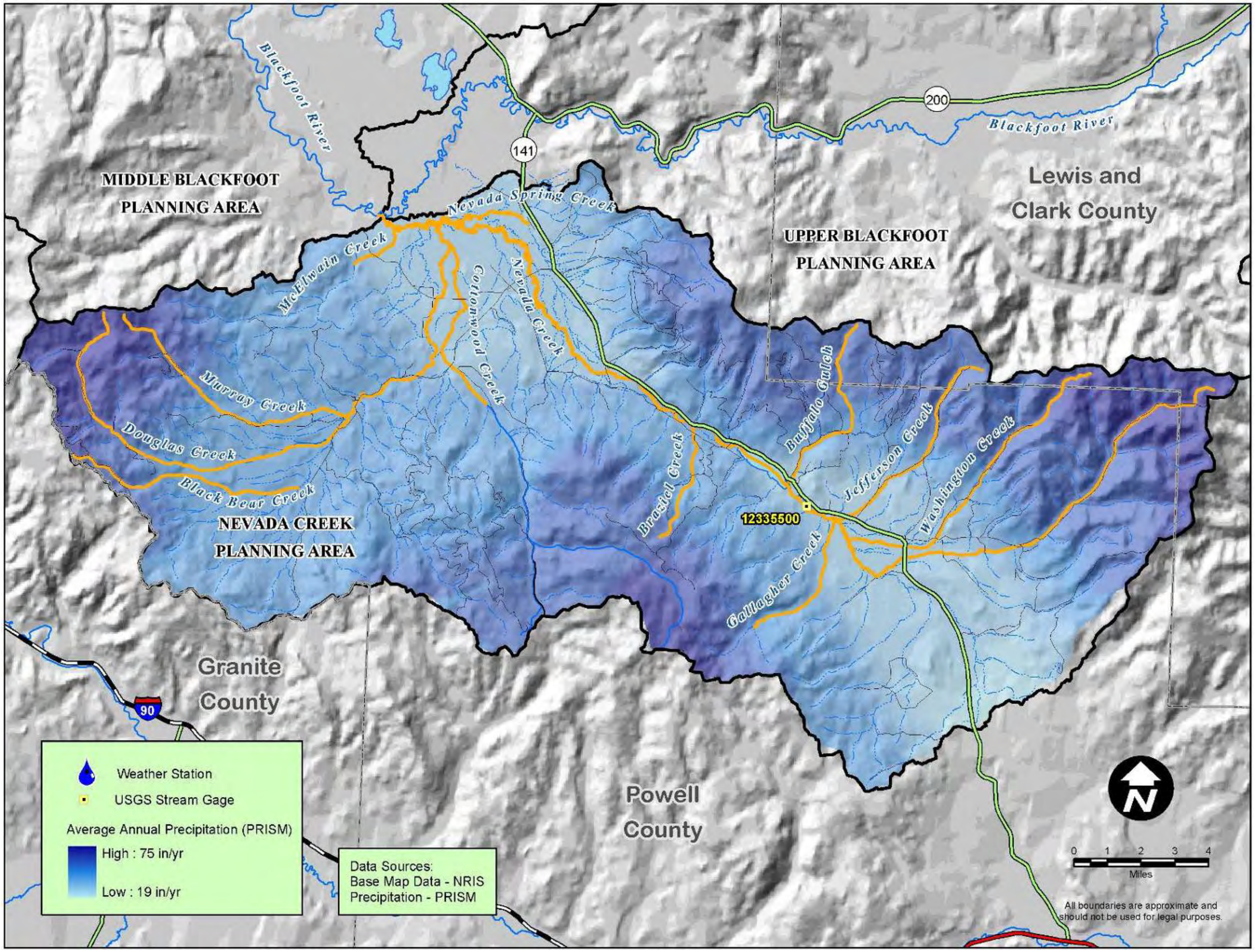


Figure A-11. Precipitation in the Nevada Creek Planning Area (PRISM data)

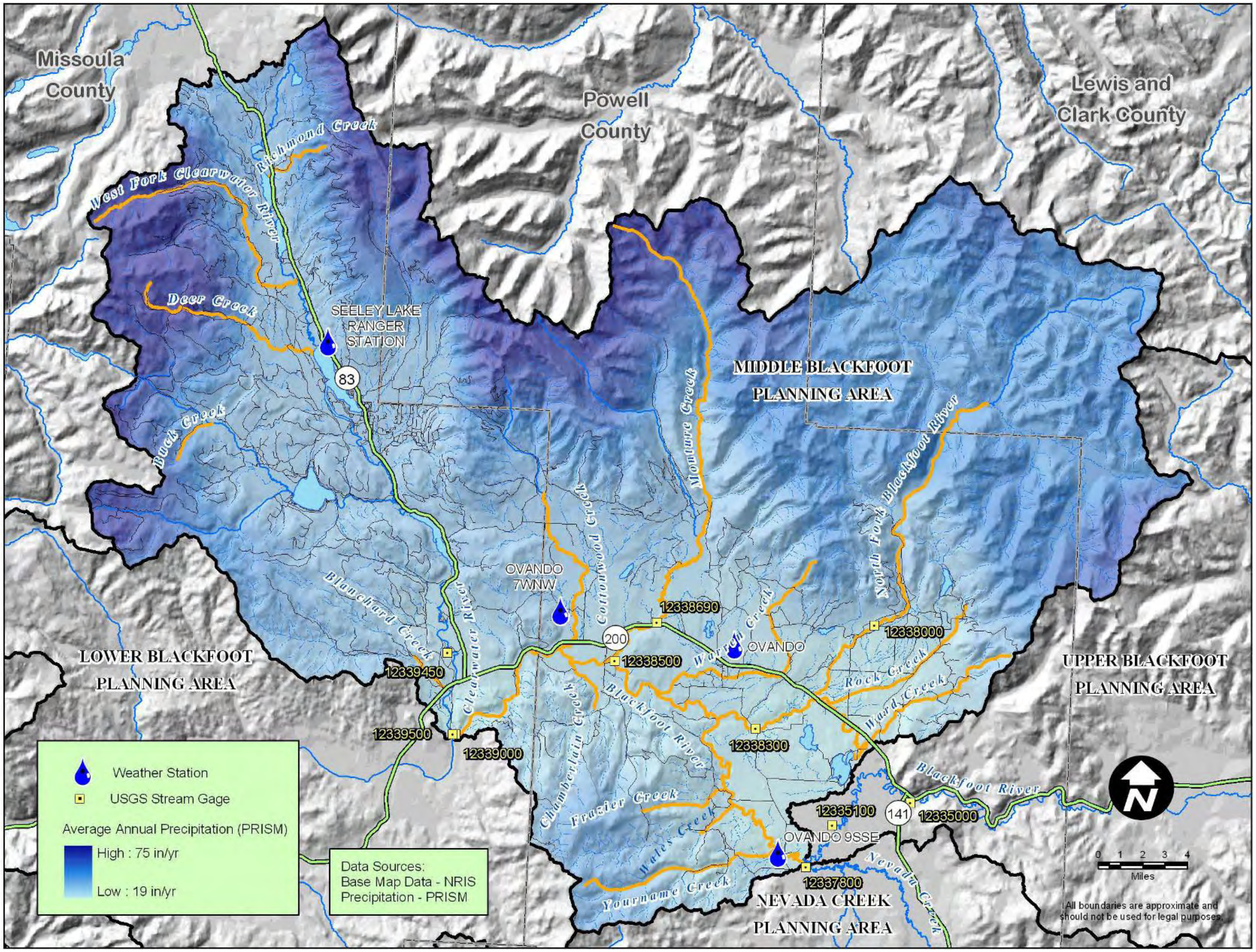


Figure A-12. Precipitation in the Middle Blackfoot Planning Area (PRISM data)

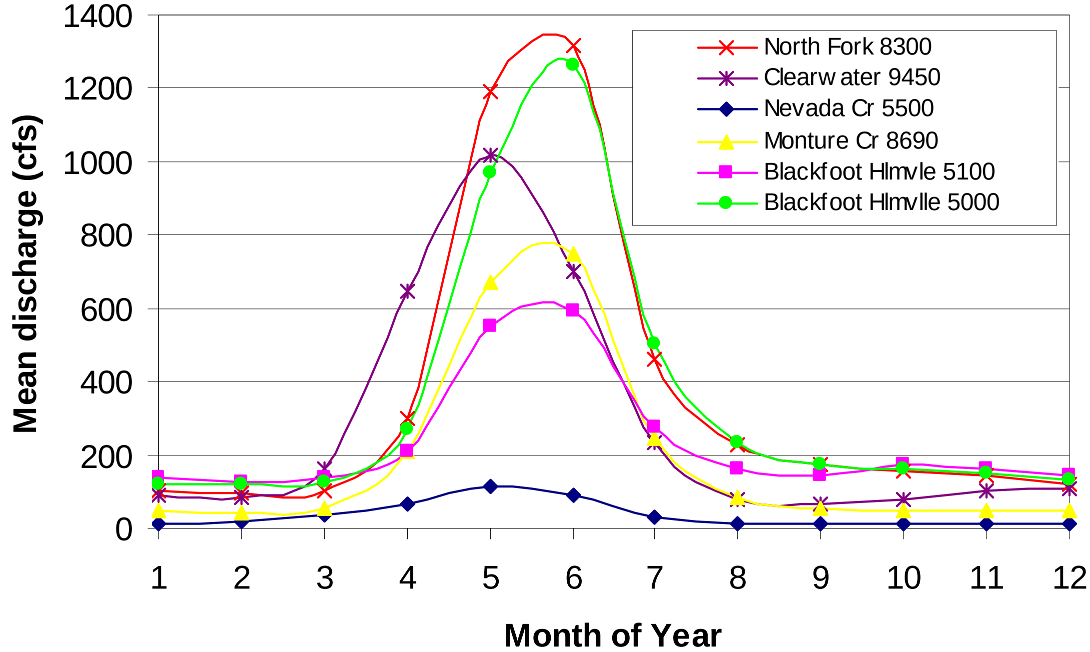


Figure A-13. Mean Monthly Discharge, Blackfoot River and Tributaries

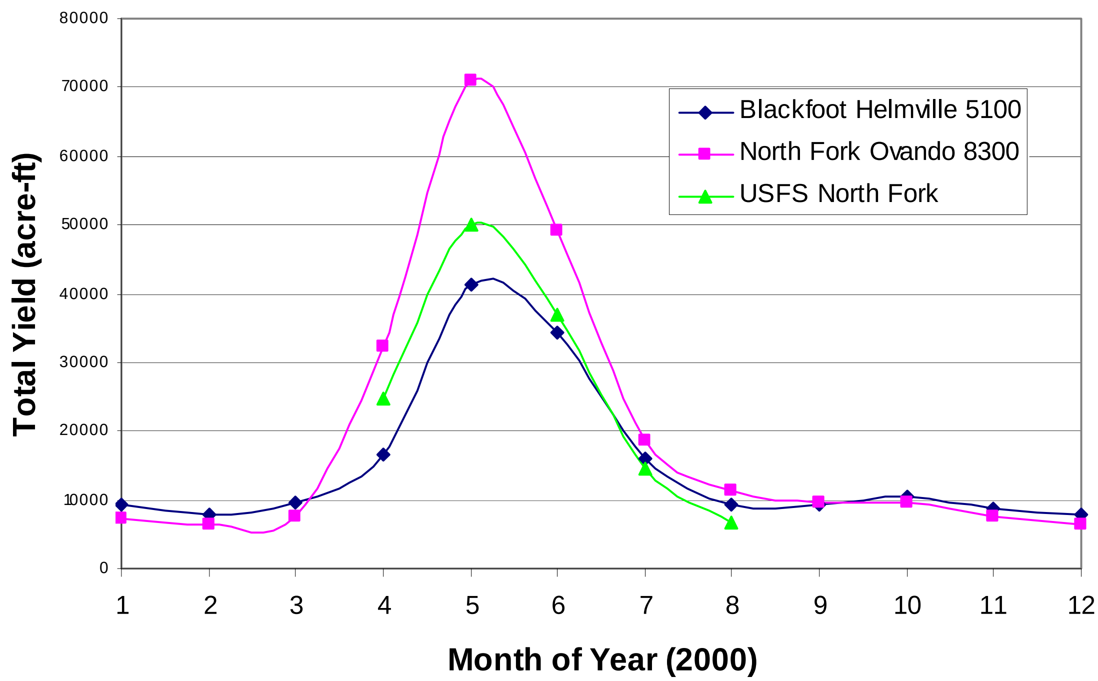


Figure A-14. Monthly Yield for the North Fork and Mainstem Blackfoot River, 2000

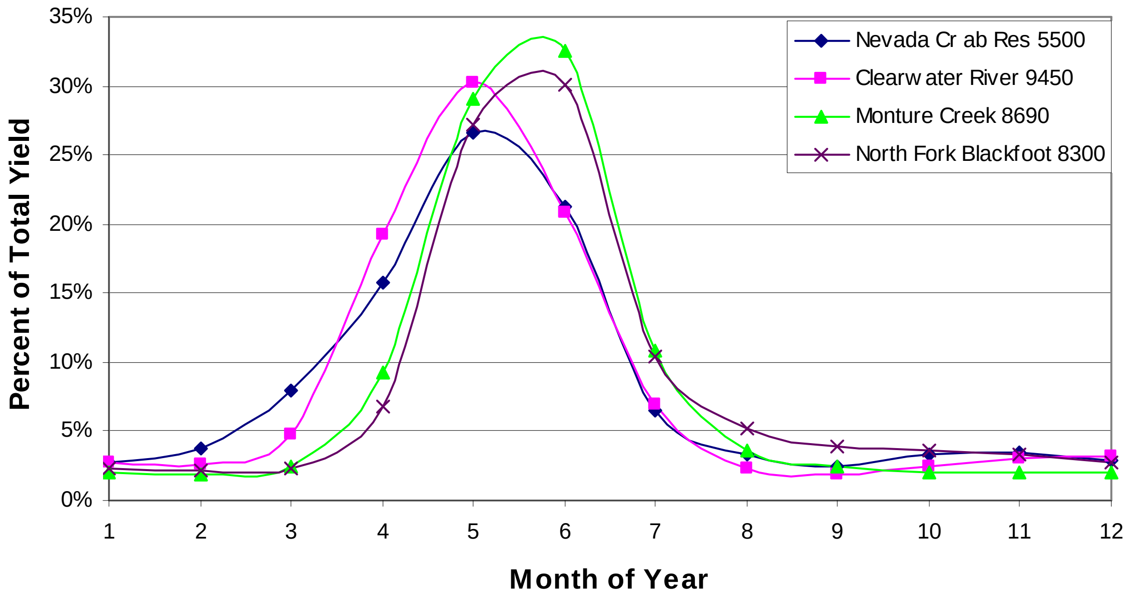


Figure A-15. Percent of Total Annual Water Yield by Month, for Major Blackfoot River Tributaries

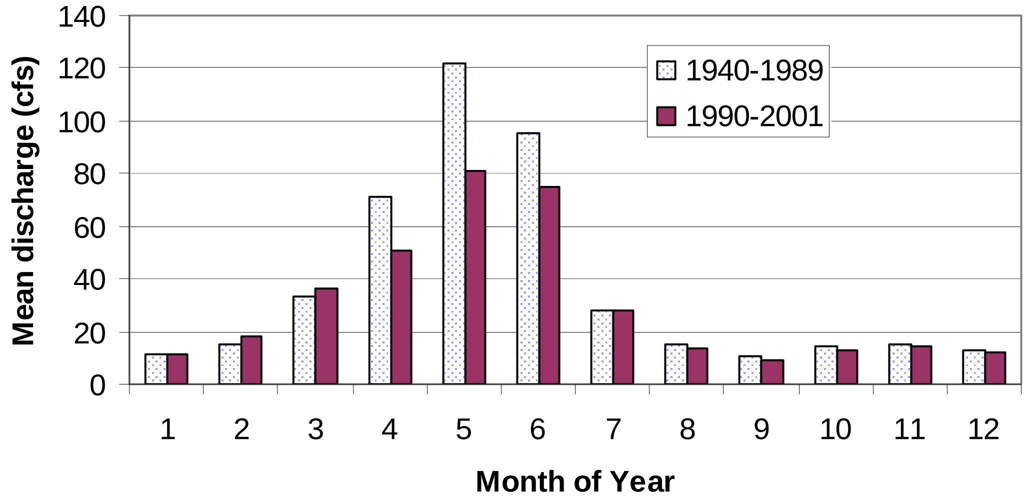


Figure A-16. Mean Monthly Discharge, Nevada Creek Above Nevada Lake (USGS Gage 12335500)

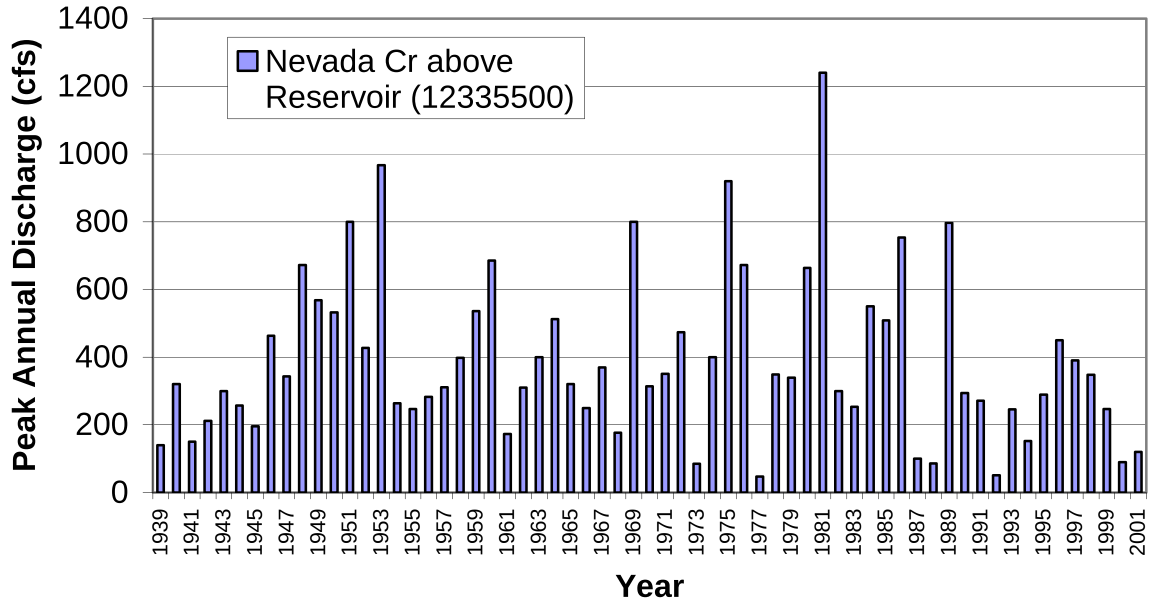


Figure A-17. Annual Peak Flows, Nevada Creek above the Reservoir (12335500)

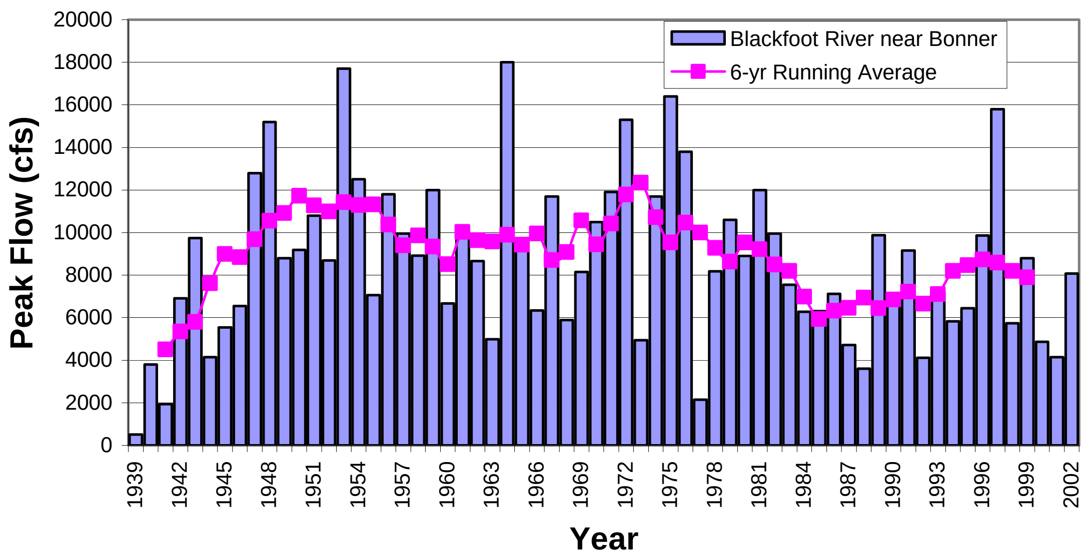


Figure A-18. Annual Peak Discharge, Blackfoot River near Bonner (12340000)

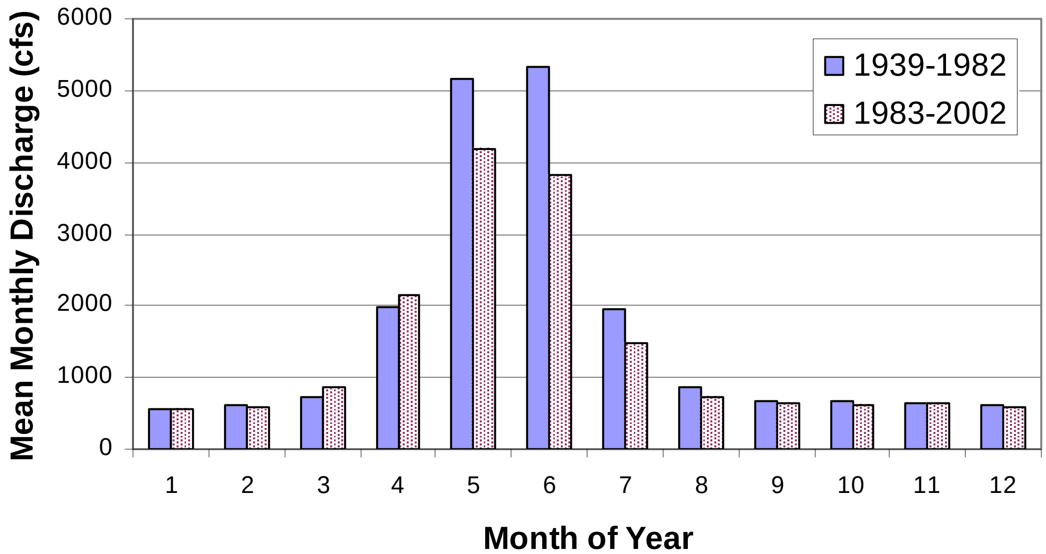


Figure A-19. Mean Monthly Discharge, Blackfoot River near Bonner (1234000), 1939-1982 and 1983-2002

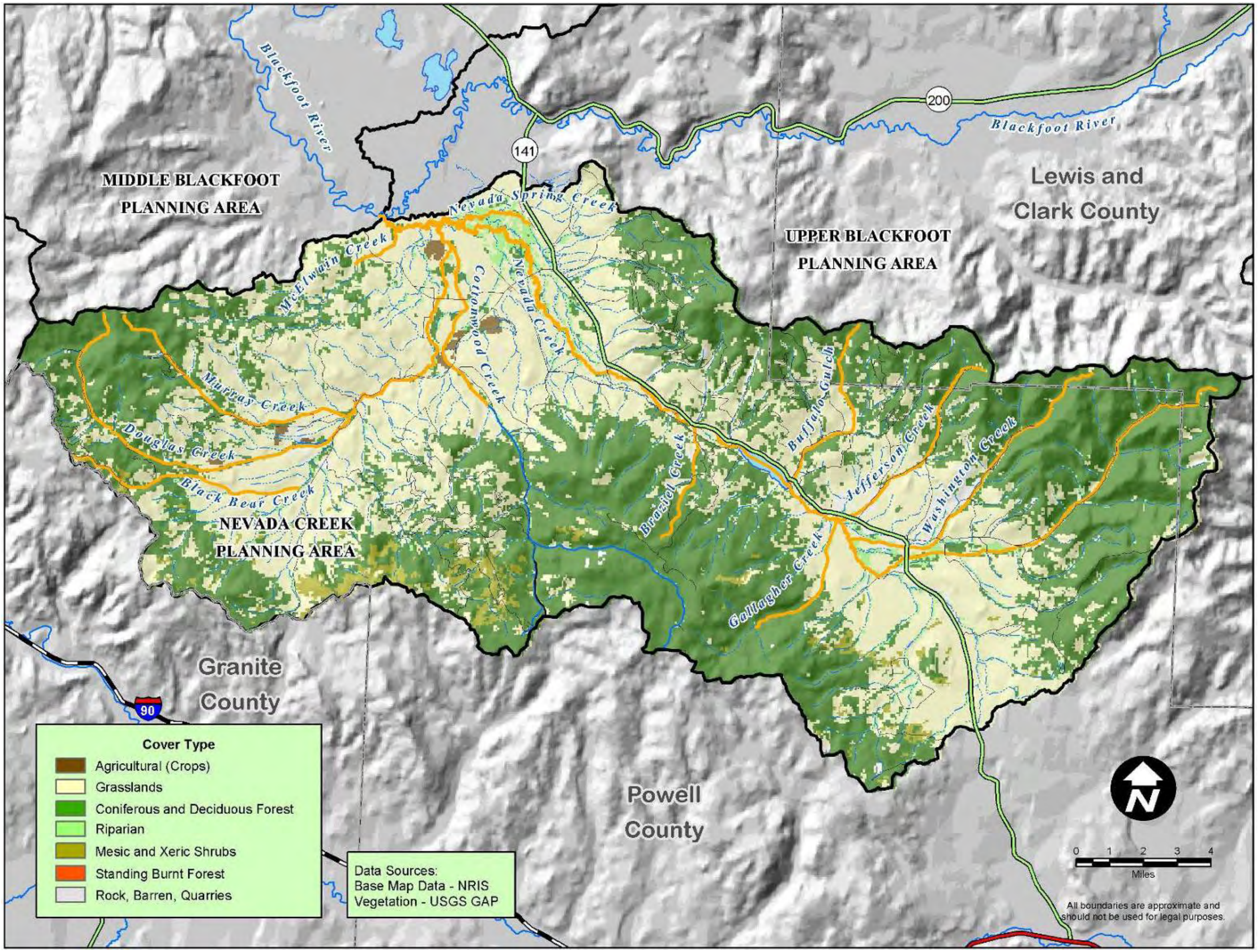


Figure A-20. Major Vegetation Cover Types in the Nevada Creek Planning Area (USGS GAP)

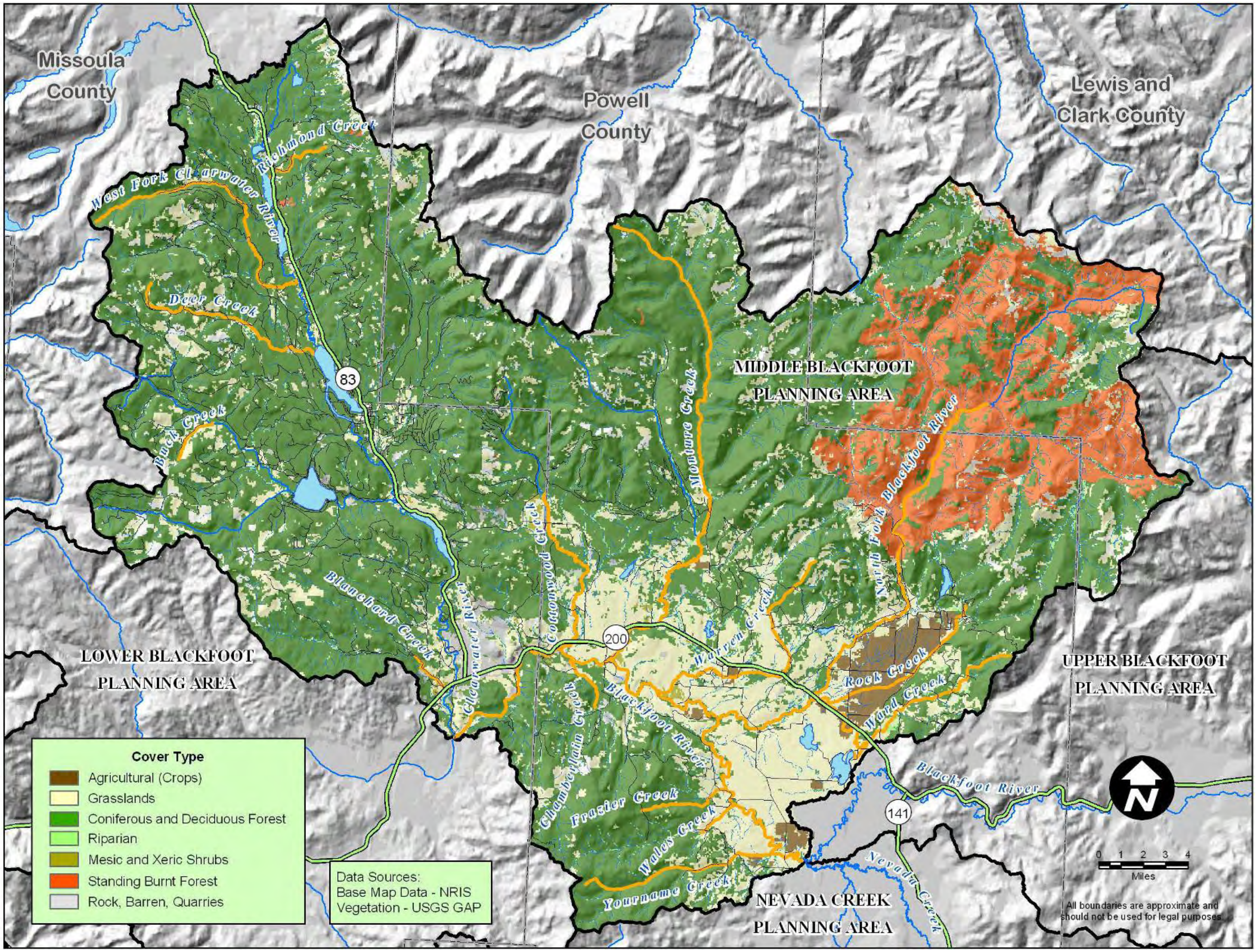


Figure A-21. Major Vegetation Cover Types in the Middle Blackfoot Planning Area (USGS GAP)

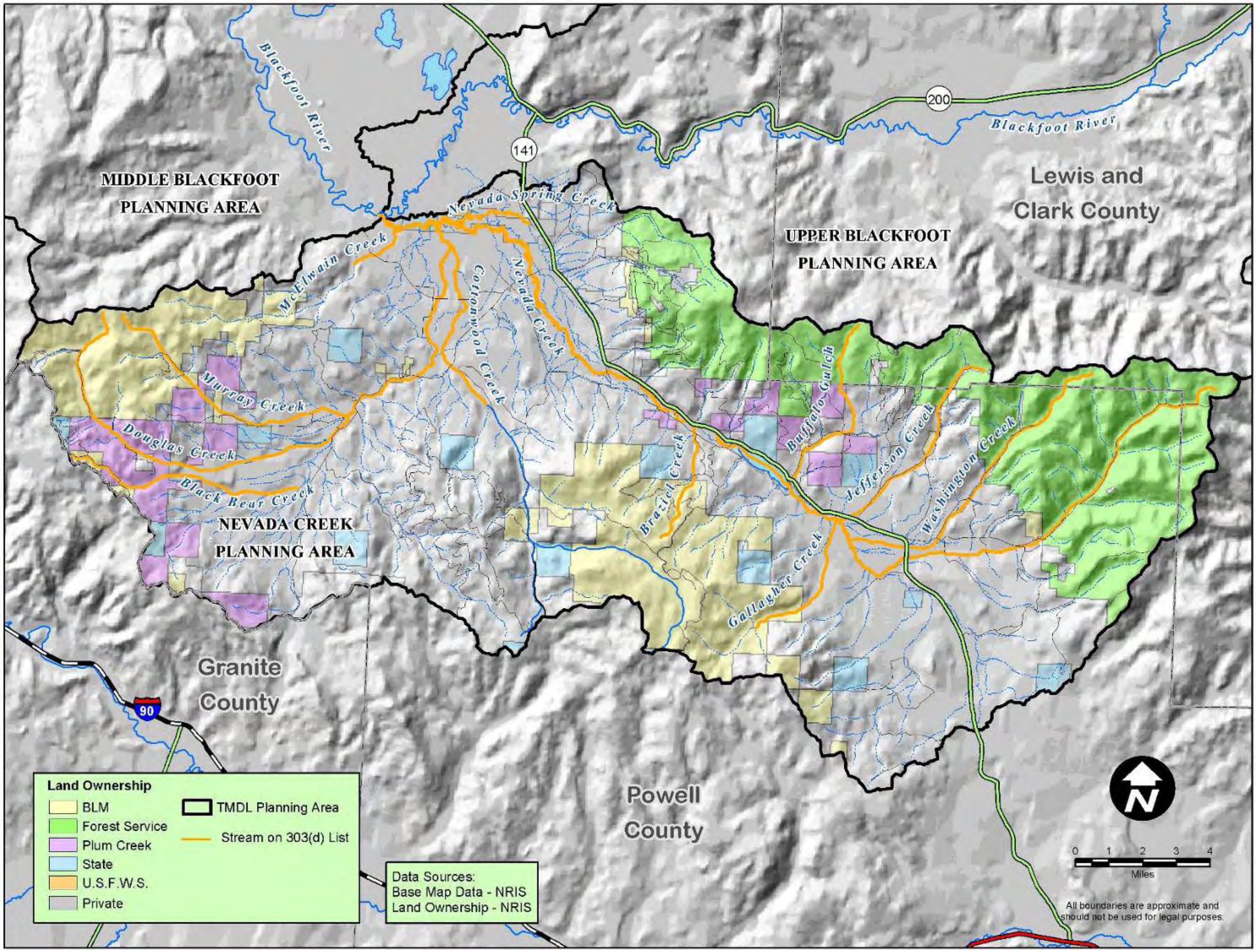


Figure A-22. Land Ownership in the Nevada Creek Planning Area

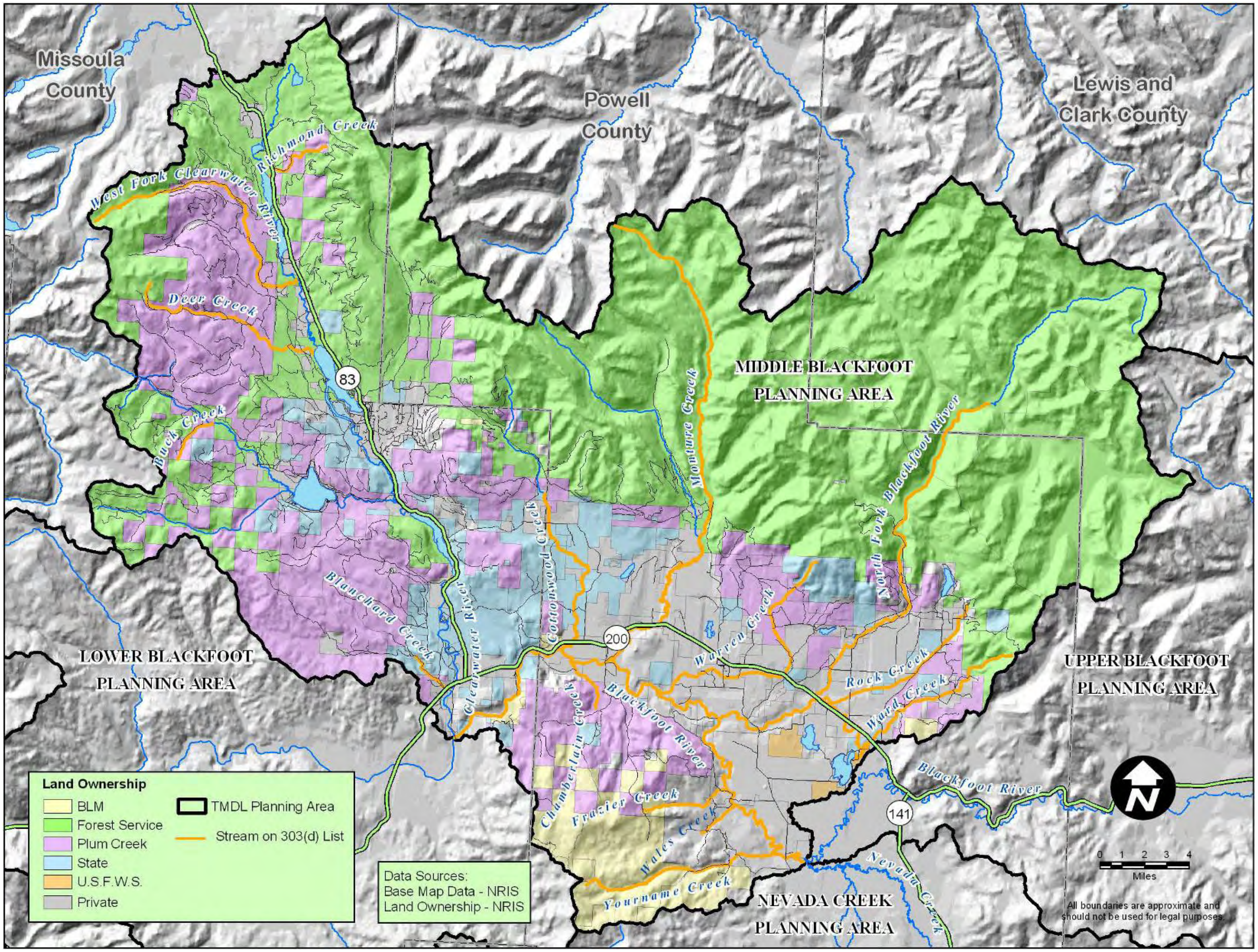


Figure A-23. Land Ownership in the Middle Blackfoot Planning Area

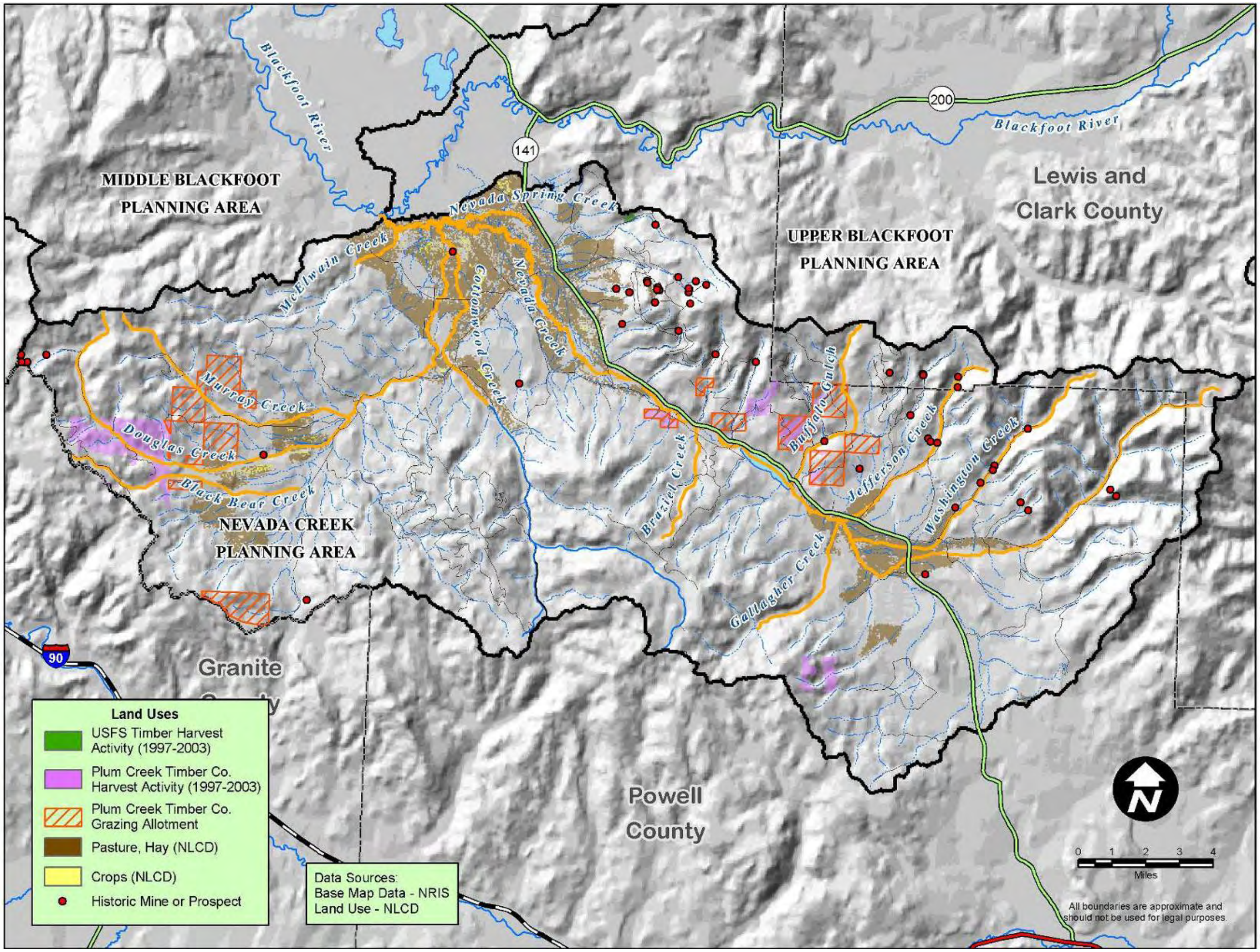


Figure A-24. Land Uses in the Nevada Creek Planning Area

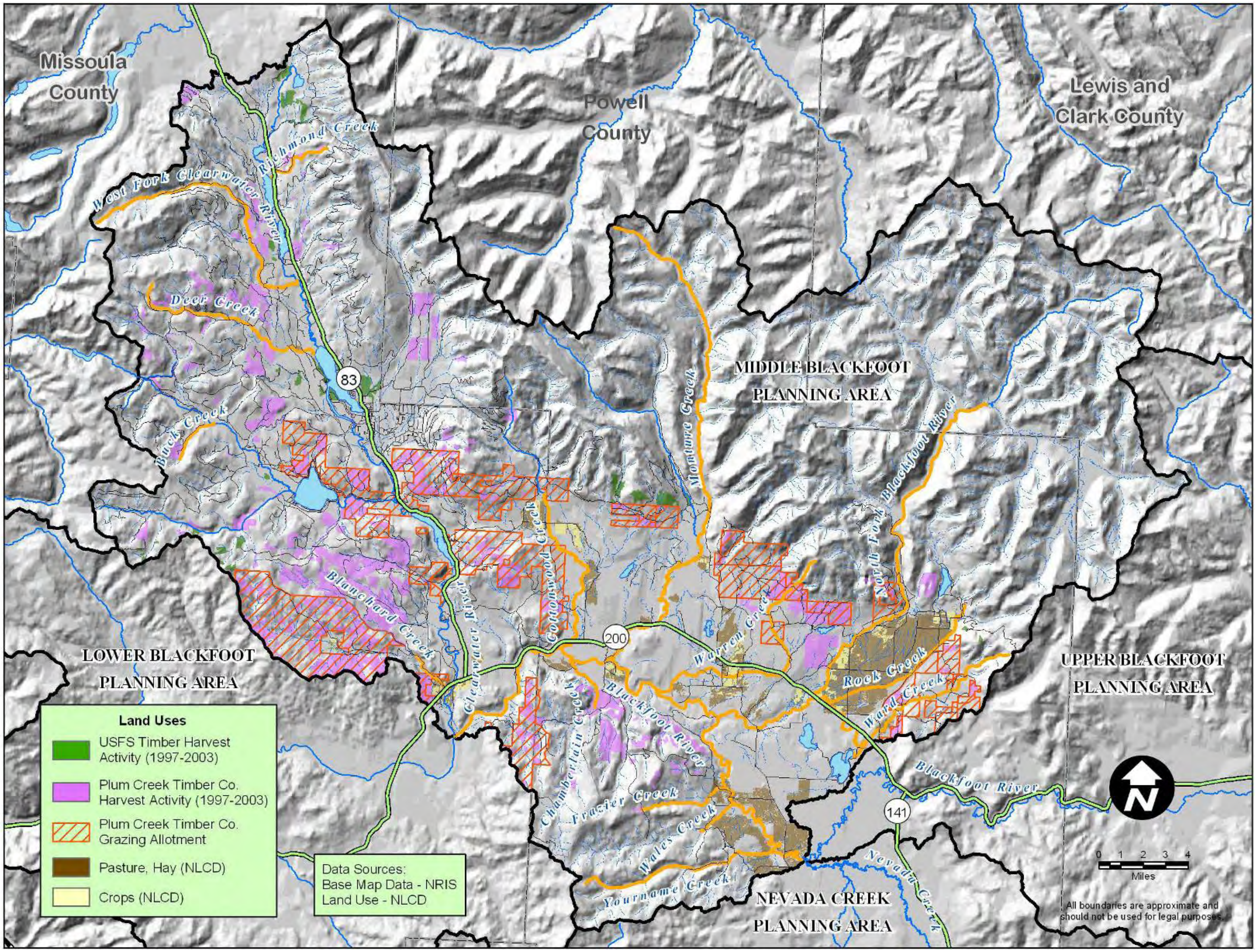


Figure A-25. Land Uses in the Middle Blackfoot Planning Area

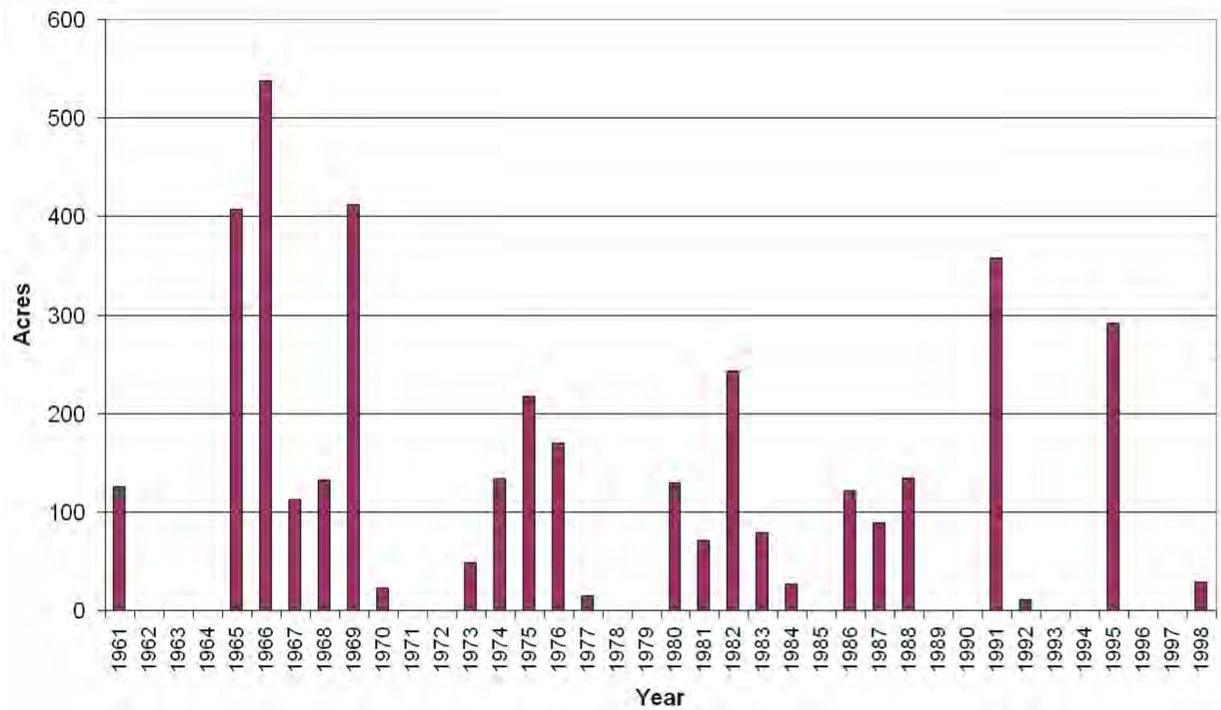


Figure A-26. Helena National Forest Timber Harvest History, Nevada Creek Panning Area

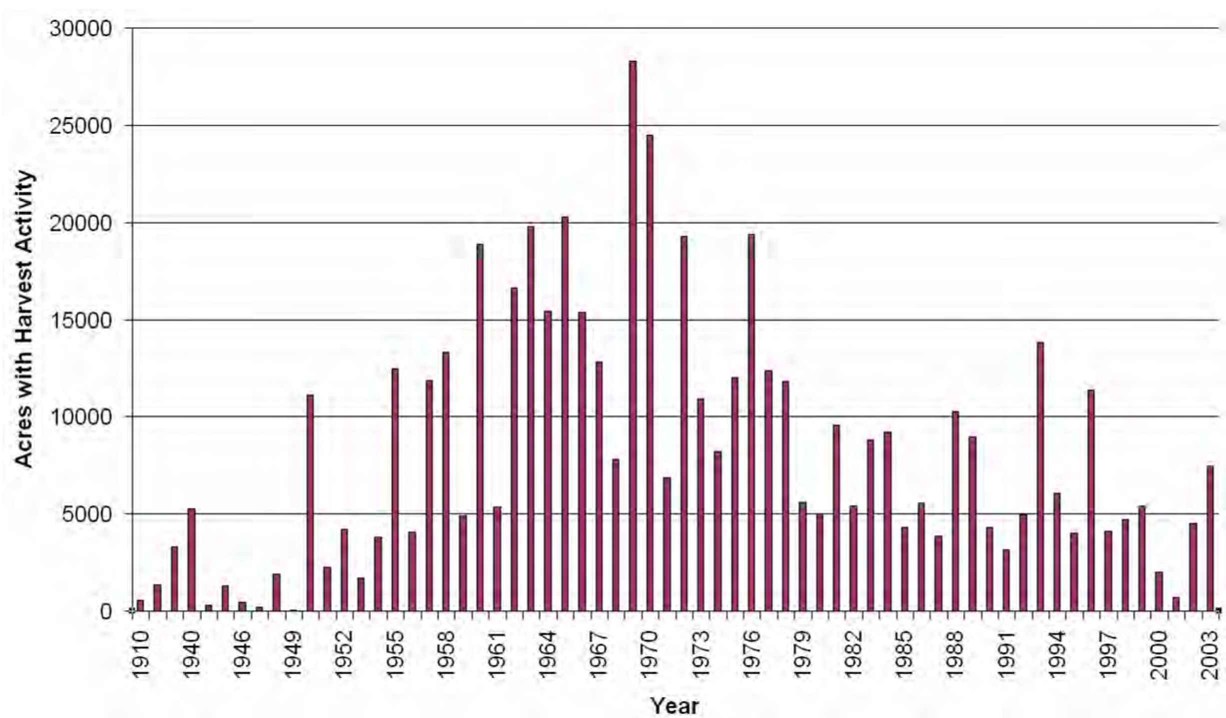


Figure A-27. Lolo National Forest Timber Harvest Activity over Time

Base Parameter and Erosion Inventory

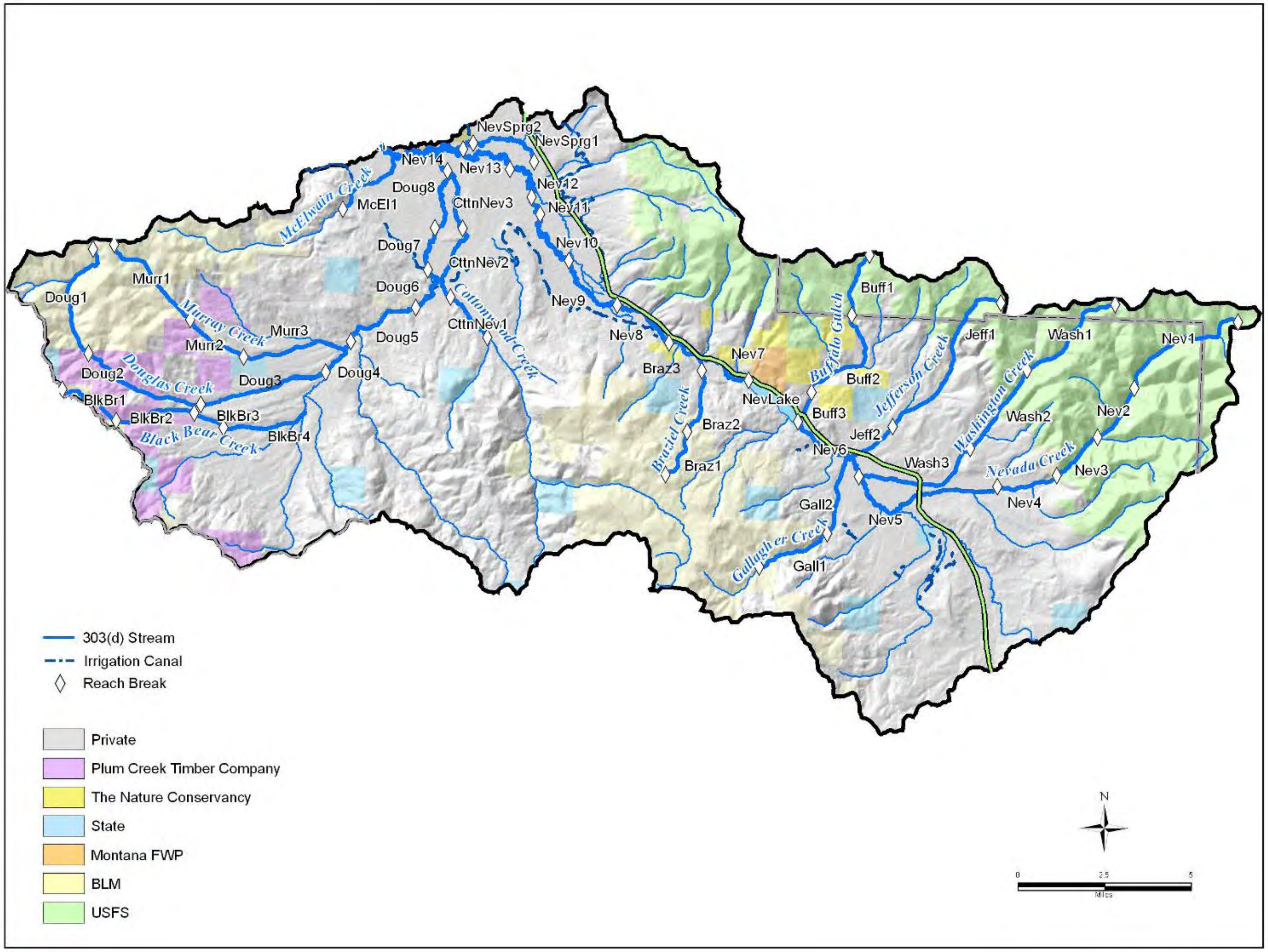


Figure A-28. Stream assessment reaches, Nevada Creek planning area.

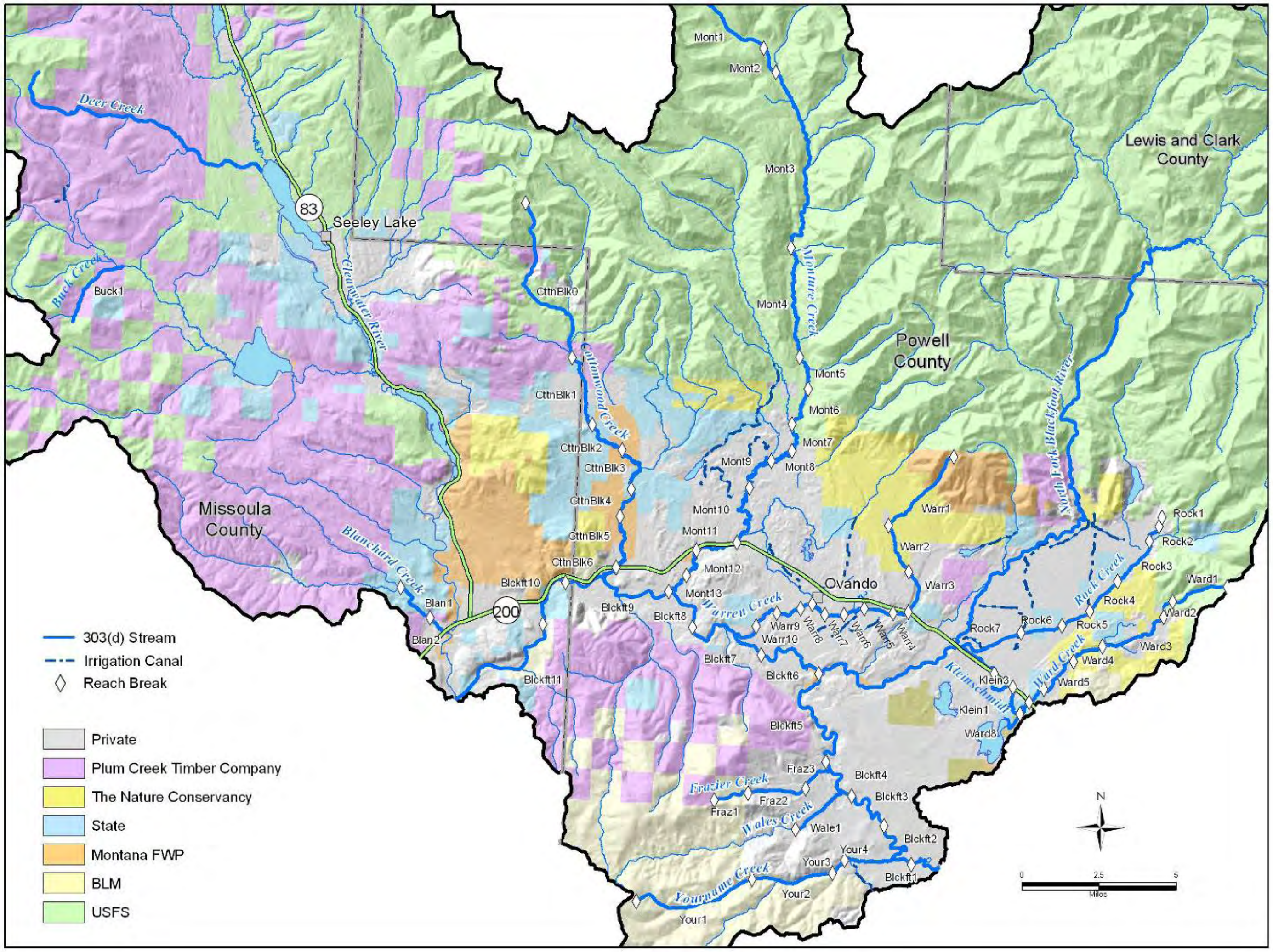


Figure A-29. Stream assessment reaches, middle Blackfoot River planning area.

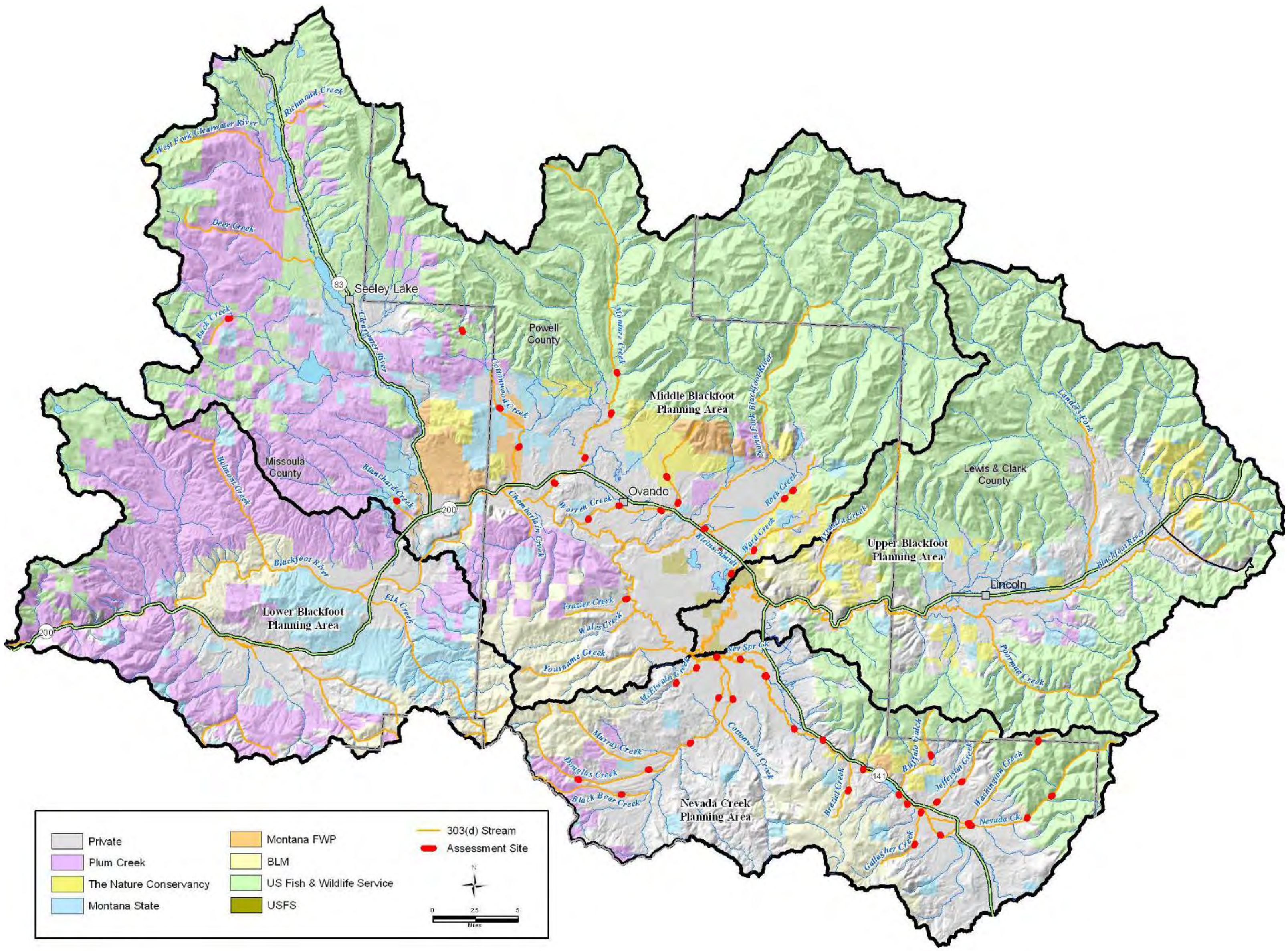


Figure A-30. Assessment Sites in the Nevada Creek and Middle Blackfoot Planning Areas

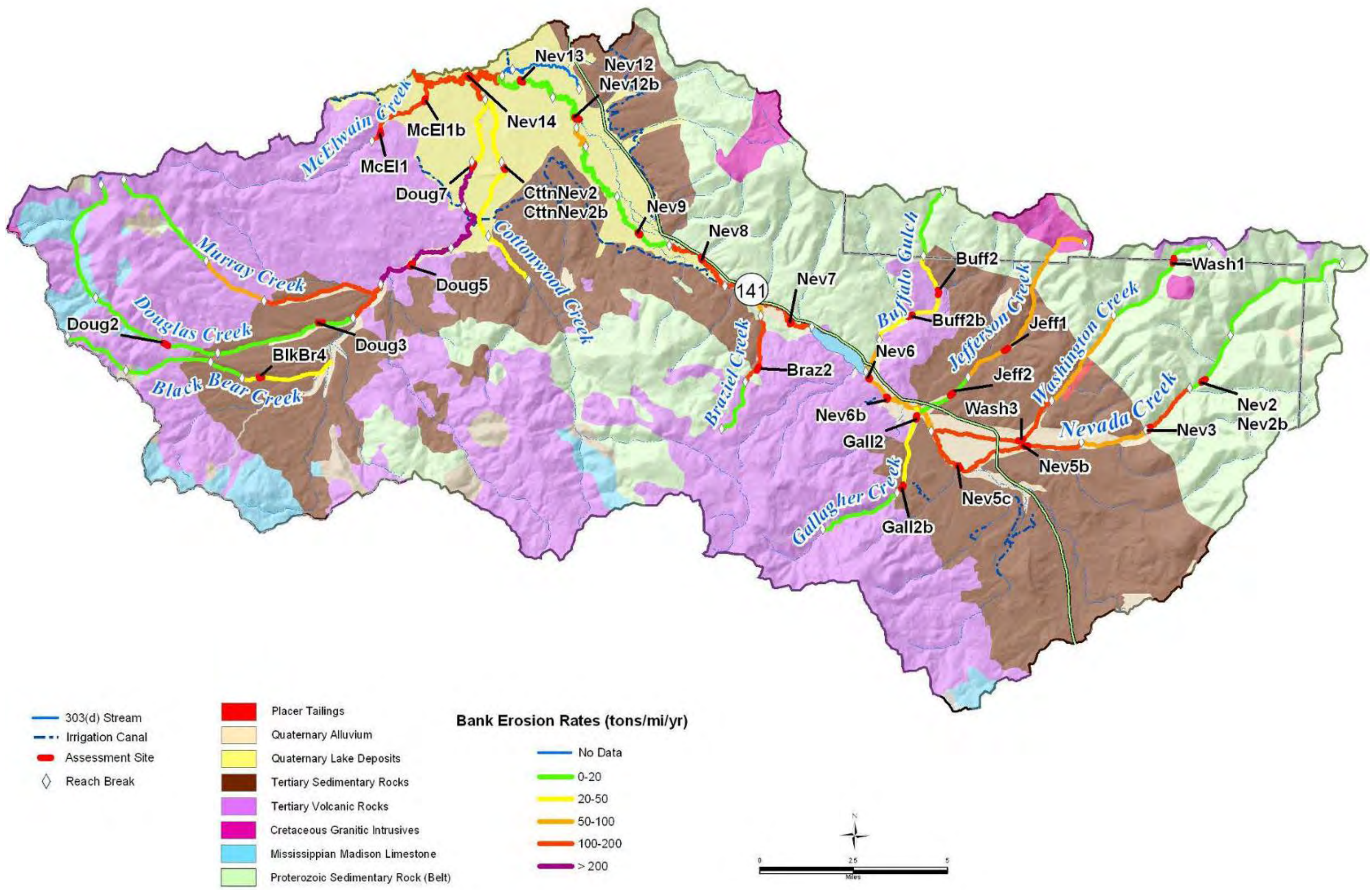


Figure A-31. Bank Erosion Rates by Reach in the Nevada Creek Planning Area

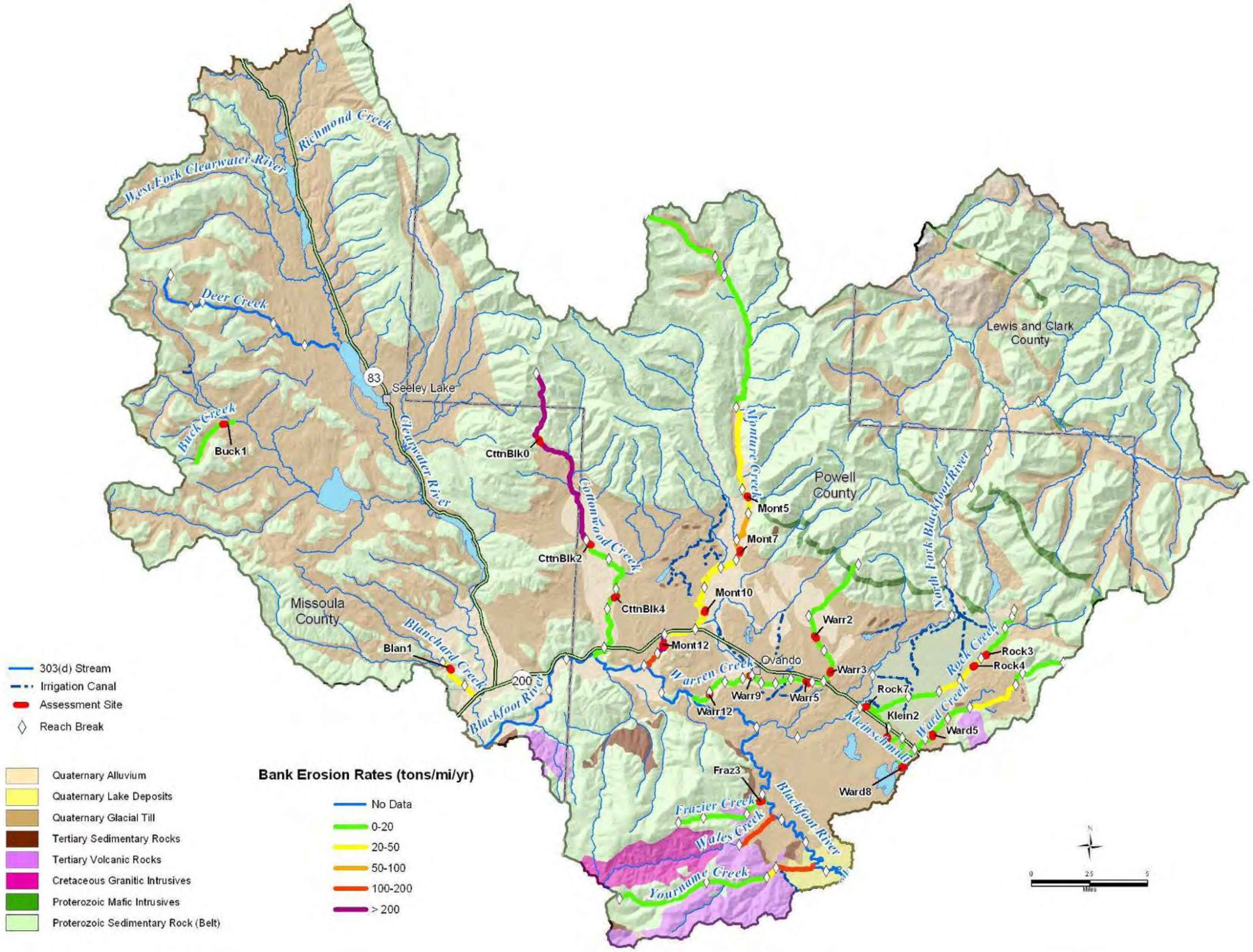


Figure A-32. Bank Erosion Rates by Reach in the Middle Blackfoot Planning Area

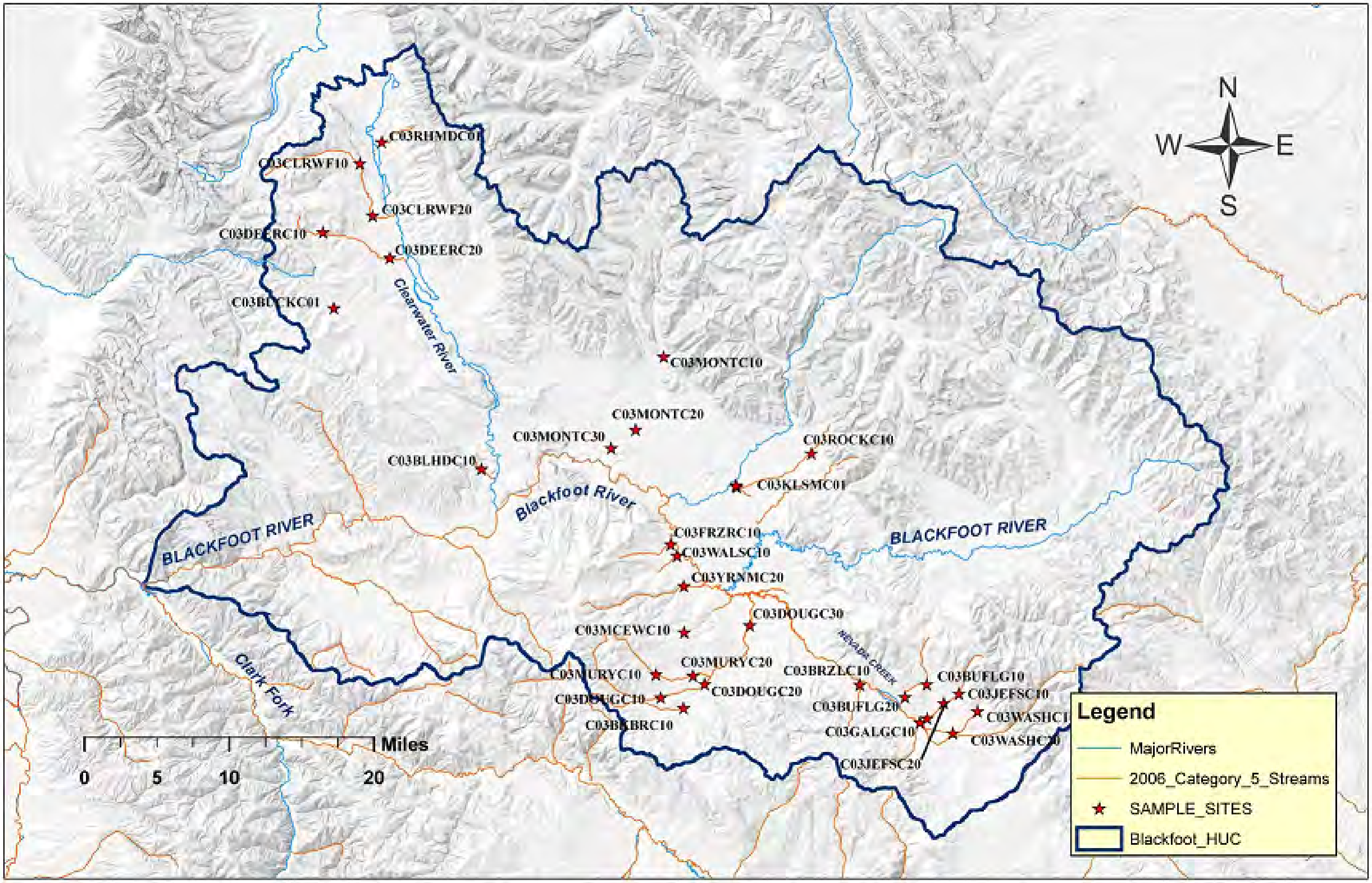


Figure A-33. Nutrient Monitoring Sites, Middle Blackfoot-Nevada Creek TMDL Planning Area

Temperature

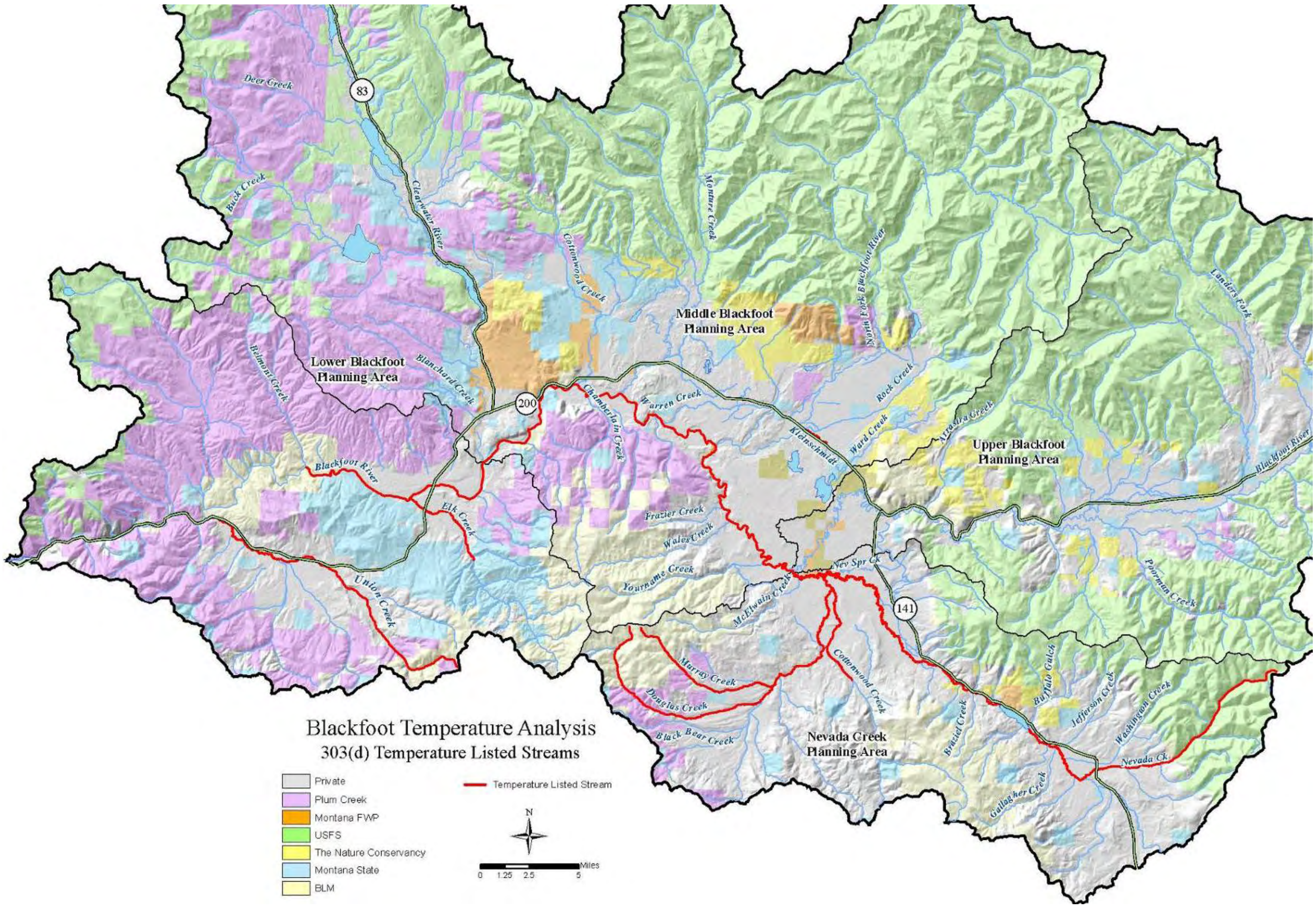


Figure A-34. Streams on the 303(d) List for Temperature in the Nevada Creek and Middle Blackfoot Planning Areas

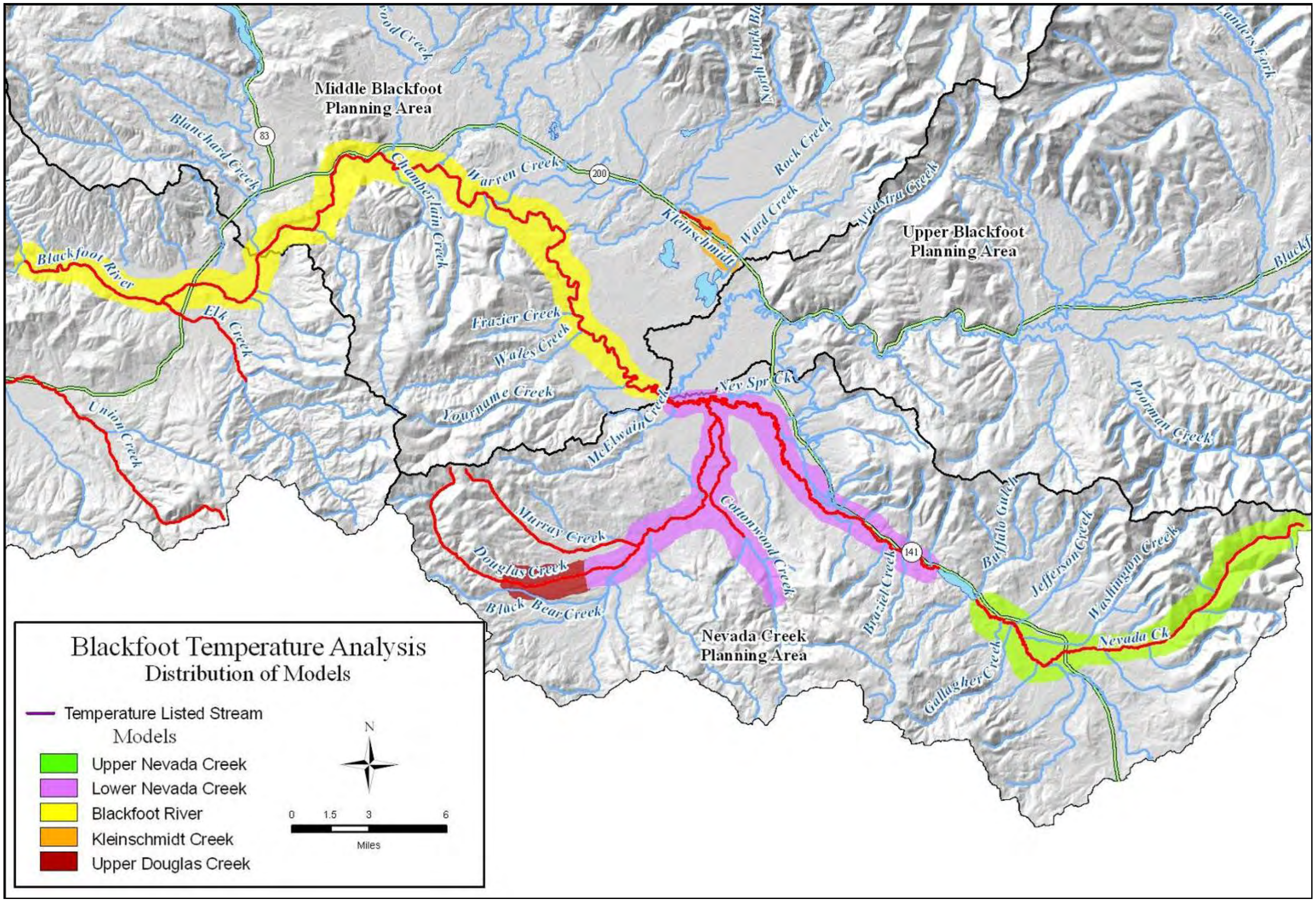


Figure A-35. Extent of SNTEMP Temperature Models Developed for the Nevada Creek and Middle Blackfoot Planning Areas

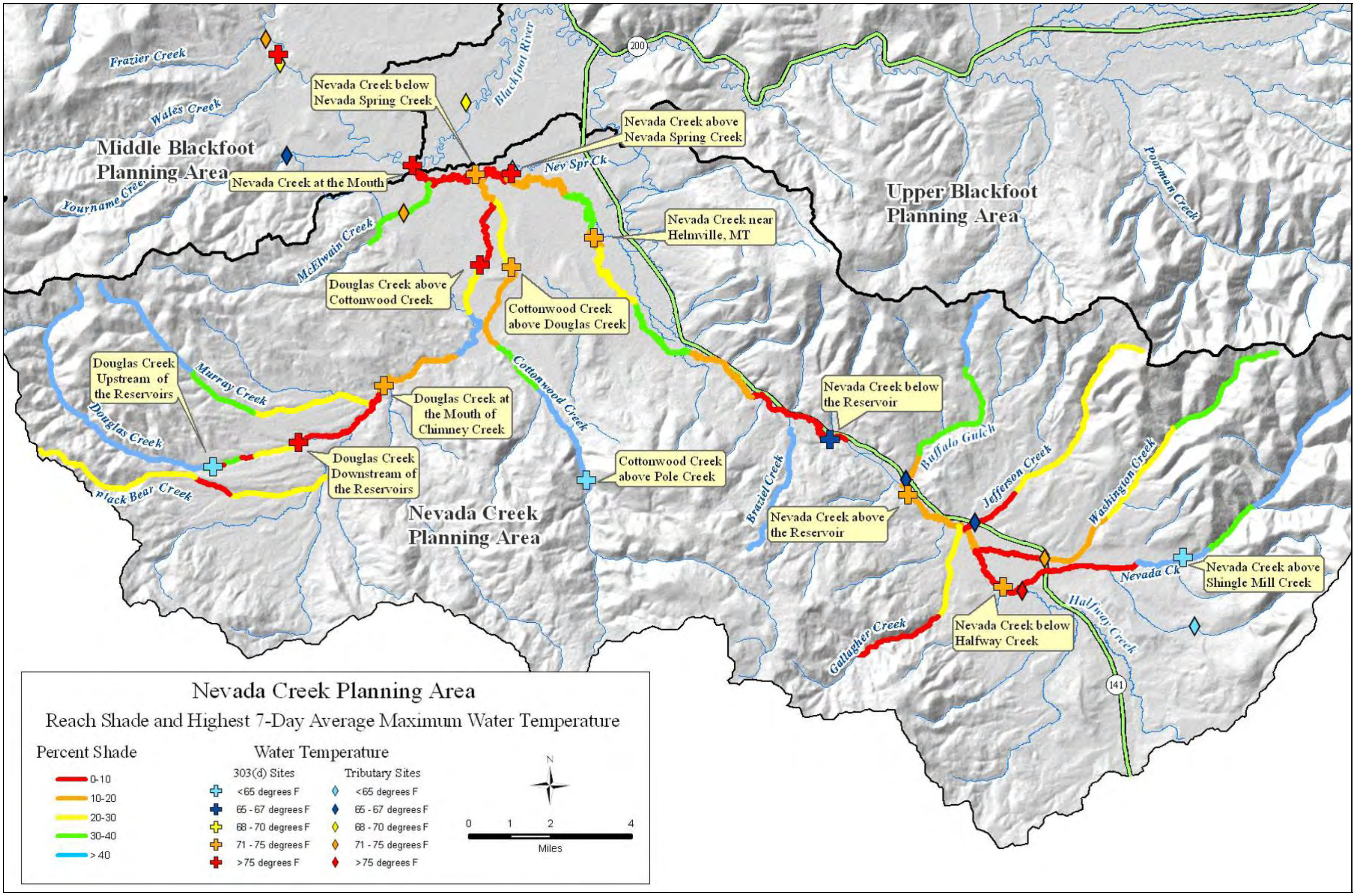


Figure A-36. Reach Shade and Highest 7-day Average Maximum Temperature, Nevada Creek Planning Area

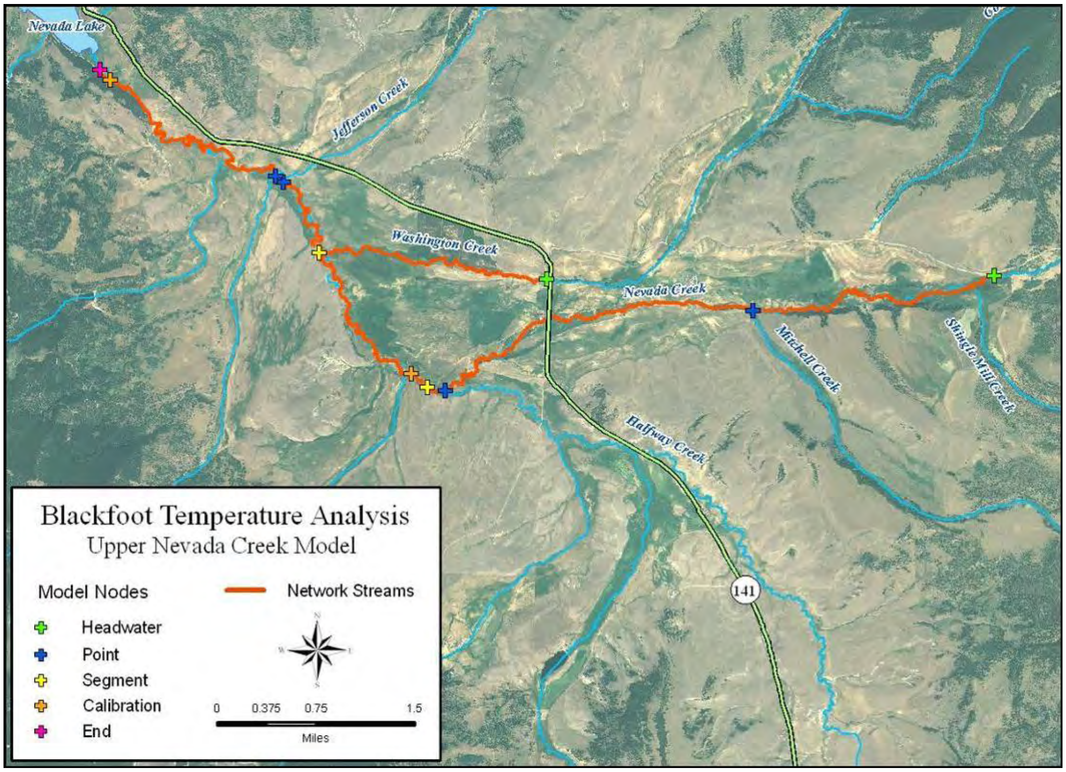


Figure A-37. Construction of the Upper Nevada Creek SNTEMP Model

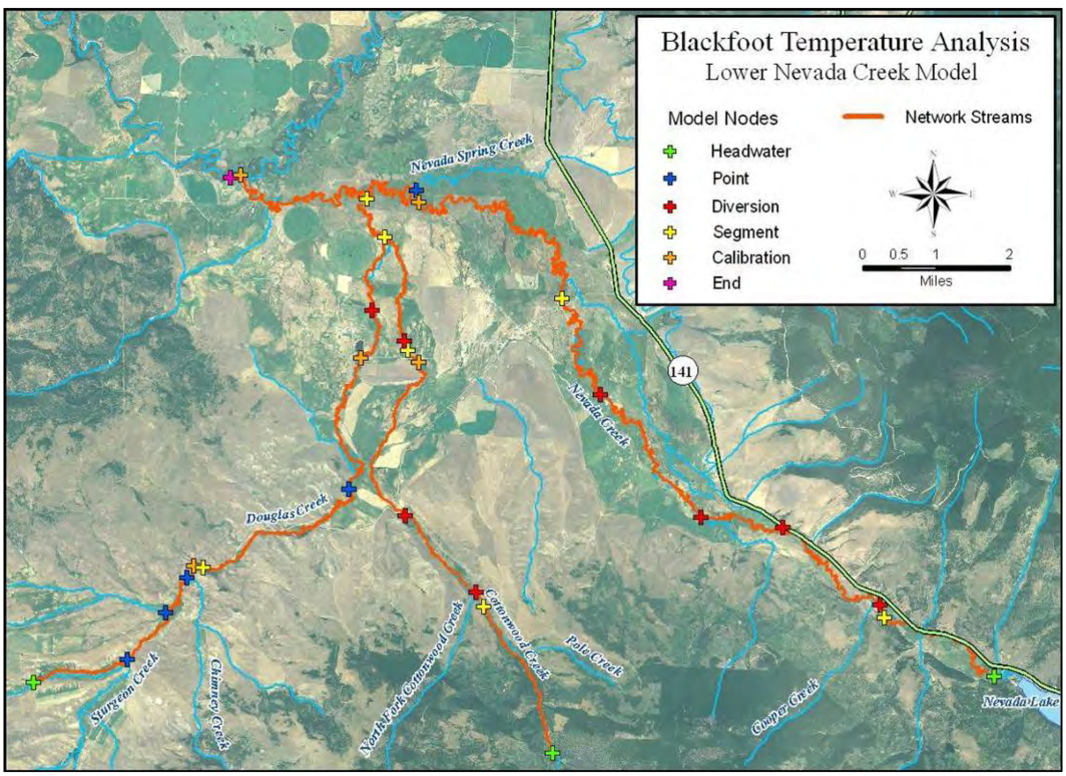


Figure A-38. Construction of the Lower Nevada Creek SNTEMP Model

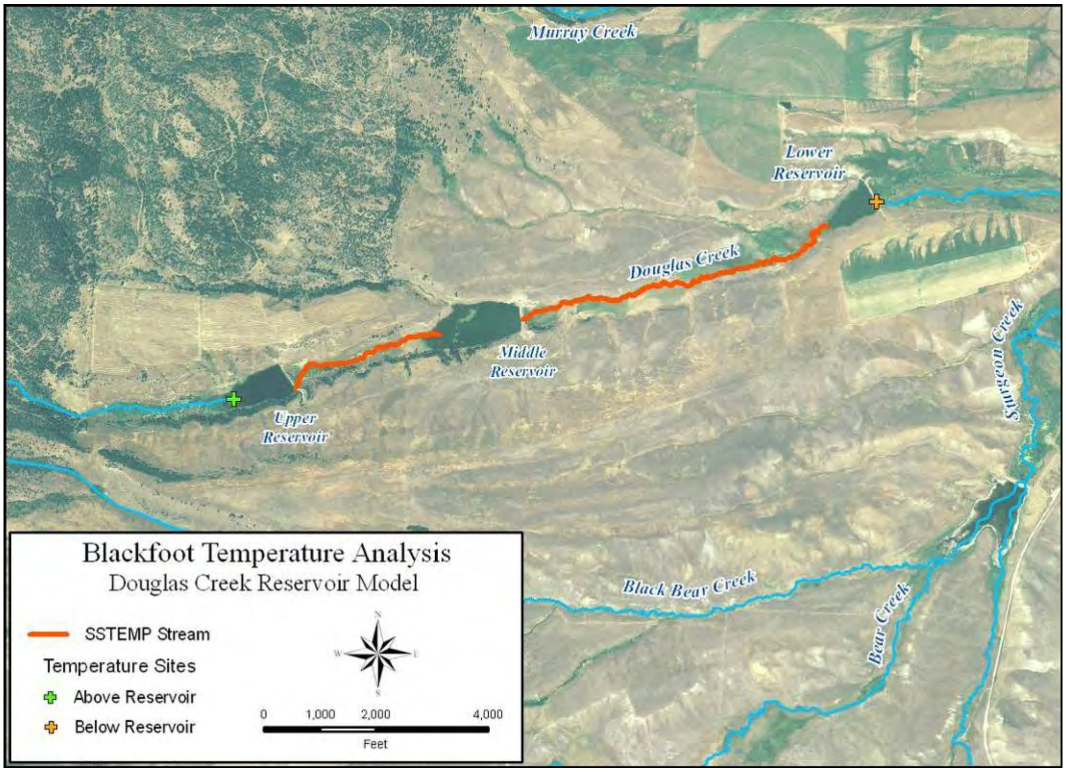


Figure A-39. Construction of the Upper Douglas Creek SNTEMP Model

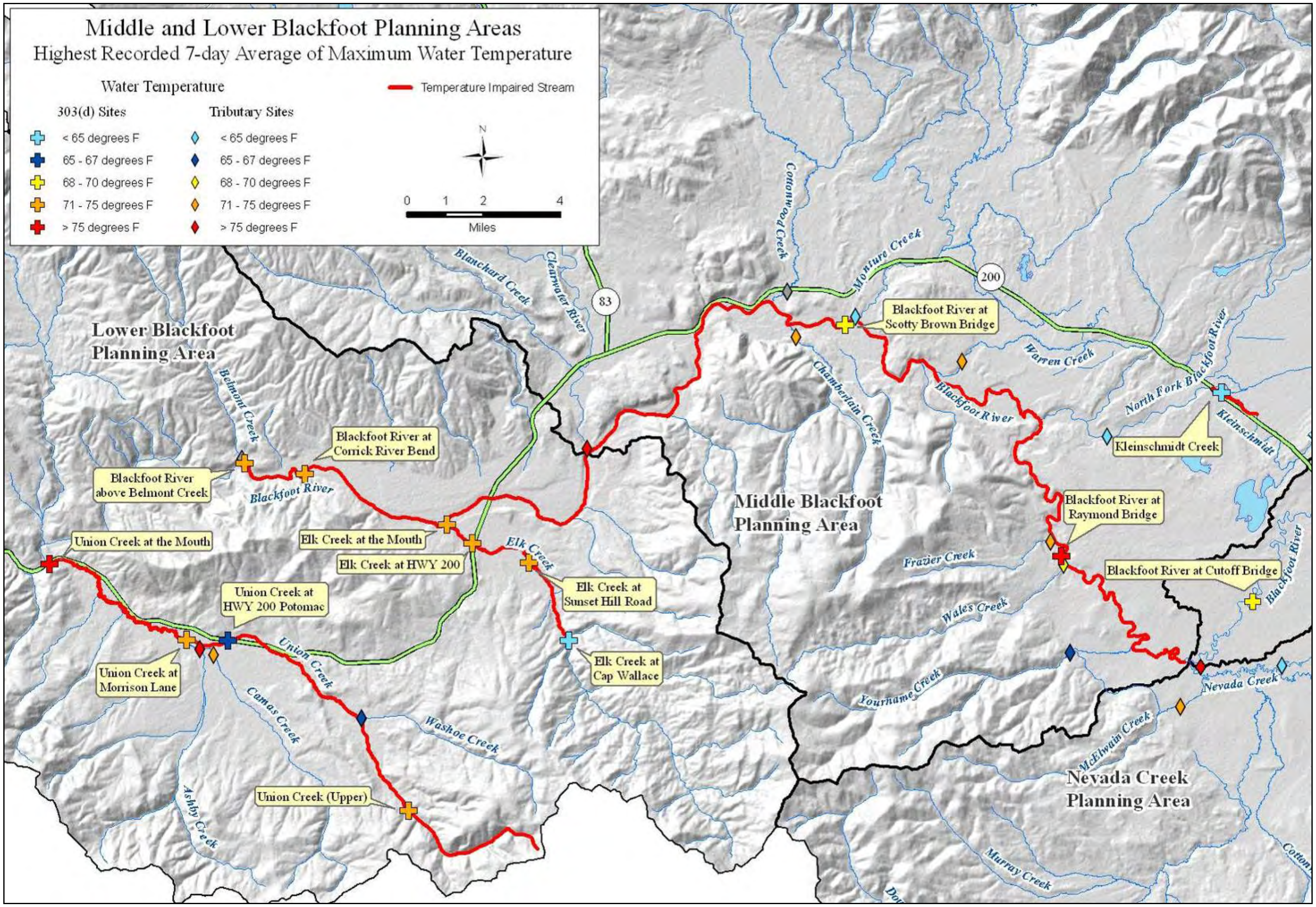


Figure A-40. Highest 7-day Average Maximum Temperature, Middle Blackfoot Planning Area

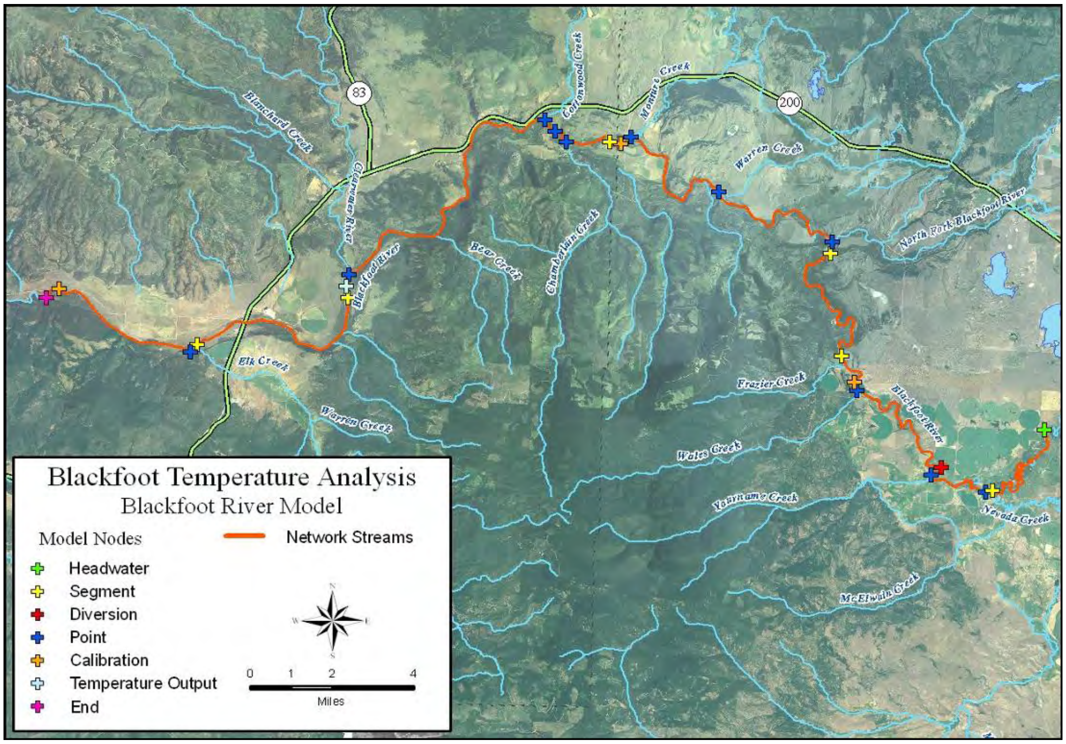


Figure A-41. Construction of the Blackfoot River SNTEMP Temperature Model

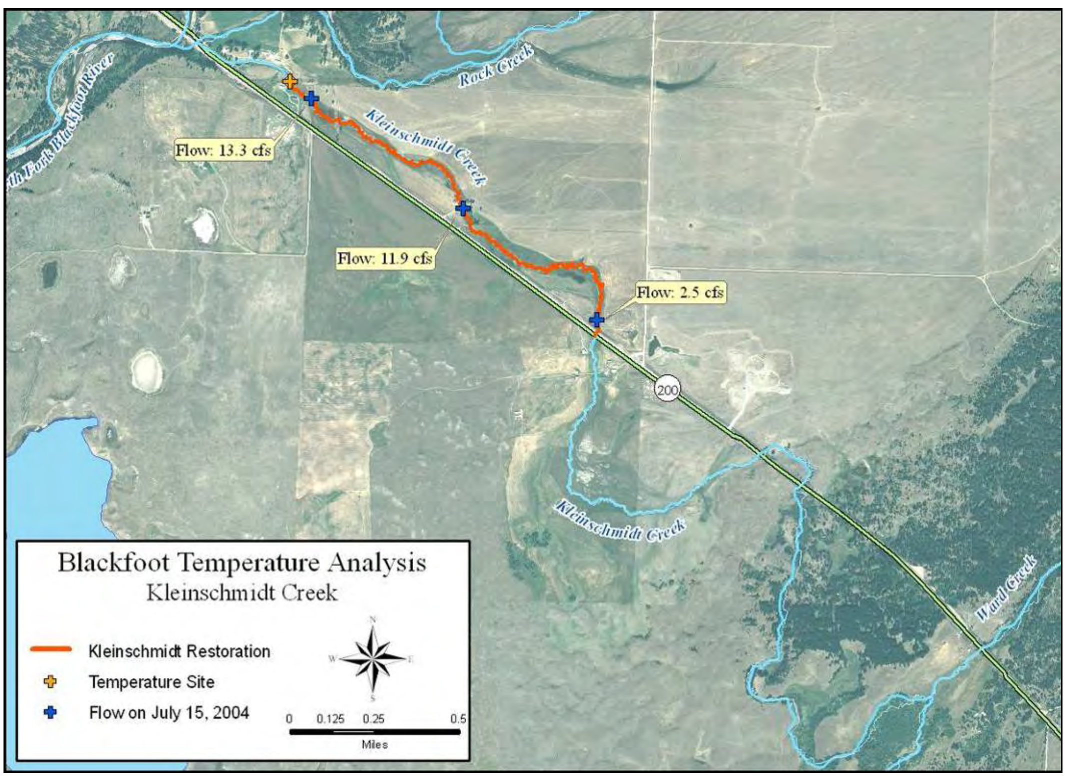


Figure A-42. Construction of the Kleinschmidt Creek SNTEMP Temperature Model

APPENDIX B
AERIAL ASSESSMENT AND RECONNAISSANCE RESULTS

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Washington Creek (upper)	NOT PREVIOUSLY LISTED	Flow Alteration, Other Habitat Alterations	Flow Alteration, Habitat	Resource Extraction, Dredge Mining, Abandoned mining	Not Visited	3.36	Wash1	A / B	Dense	Conifer	Not evident	None	Ysn, Ysh, Yns	Upper end high gradient, deeply entrenched A3 channel type with stable bedrock / boulder banks. Most fish habitat plunge pools.
						2.93	Wash2	B	Sparse	Disturbed	Placer mining	Riparian degradation, habitat alterations	Ysn, Ysh, Ts (basalt)	Relatively recent valley bottom placer mining. Alluvial disturbance, riparian degradation. Channel is straight and entrenched. Mining disturbances include a straightened channel with berms 8-10 ft in height that have stabilized over time.
Washington Creek (lower)	Flow Alteration, Siltation, Other Habitat Alterations	Flow Alteration, Siltation	Flow Alteration, Siltation	Agriculture, Grazing related Sources	Grazing	3.91	Wash3	E / F	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation, channelization, flow alterations	Qs	Highly impacted reach in valley bottom. Locally channelized through fields, extensive riparian clearing. Locally dense patches of woody riparian vegetation (e.g. between two road crossings). Multiple flow diversions. Deep and narrow E4 / E5 channel types Site has improved since 1994 BMPs were implemented Dewatering, erosion, sedimentation still noted High levels of fines in sediment cores
Jefferson Creek (upper)	Flow Alteration, Other Habitat Alterations, Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Did not meet SCD	Not Visited	5.49	Jeff1	B / G	Moderate	Conifer / willow	Placer mining	Riparian degradation, channelization	Kgd, Yms, Ts	Extensive placer disturbance in narrow valley bottom. Riparian degradation evident along channel. Dredge spoils entrench straight channel. Linear woody riparian vegetation trends indicate some riparian colonization on spoil piles.
Jefferson Creek (lower)	Flow Alteration, Other Habitat Alterations, Siltation	Flow Alteration, Other Habitat Alterations	Flow Alteration, Other Habitat Alterations	Agriculture, Crop-related Source, Irrigated Crop Production, Grazing related Sources, Resource Extraction, Dredge Mining	Historic mining; Grazing	1.60	Jeff2	E / F	Sparse	Willow / herb.	Ag: Irrigated hay / pasture	Riparian degradation, channelization, flow alterations	Ts, Qs	Downstream loss of channel definition due to dewatering. Riparian degradation, channel degradation. E4 channel type
Gallagher Creek	Flow Alteration	Other Habitat Alterations	Other Habitat Alterations	Agriculture, Crop-related Sources, Irrigated Crop Production	Not Visited	2.21	Gall1	B	Dense	Conifer	Not evident	None	Tab (Basalt)	Confined channel in upper reach. Cobble dominated, moderately entrenched B3 channel. Healthy community with generally stable stream banks; high amounts of woody debris and low sediment levels.
						2.47	Gall2	E	Moderate	Willow / herb.	Ag: Irrigated hay / pasture	Riparian degradation, flow alterations	Ts, Qs	Channel emerges from confined headwaters valley onto terrace / alluvial fan complex, flowing northeast to Nevada Cr confluence. Downstream reduction in woody riparian extent, channel definition.
Buffalo Gulch	NOT PREVIOUSLY LISTED	Siltation, Other Habitat Alterations	Siltation, Other Habitat Alterations	Agriculture, Grazing related Sources, Silviculture, Logging Road Construction / Maintenance	Historic mining; Grazing	2.00	Buff1	B	Dense	Conifer	Timber Harvest	Road encroachment	Yms	Off-channel clearcuts in adjacent uplands. Extensive road network
						3.48	Buff2	E / C	Mod / Sparse	Conifer / willow	Timber Harvest	Road encroachment, placer mining	Tab (Basalt)	Abrupt reduction in vegetative cover relative to upstream USFS land (also shift to Tertiary basaltic rocks from Proterozoics). Reference to grazing impacts converting channel morphology from E to C channel type . Placer spoils / degradation identified in field reconnaissance. DEQ cites severe impairment due to sediment.
						0.96	Buff3	E	Moderate	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	Approaching Nevada Cr reservoir, channel flows into willow bottoms. One small stock pond / reservoir on upstream end of reach. Described as stable with low sediment levels

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Braziel Creek	Siltation, Other Habitat Alterations	DID NOT MEET SCD	DID NOT MEET SCD	Did not meet SCD	Grazing; Irrigation	1.57	Braz1	B	Dense	Conifer	Not evident	None	Tab (Basalt)	Forested headwaters; no evidence of impairments
						2.04	Braz2	B / C	Mod	Willow	Timber Harvest	Riparian degradation, road encroachment	Tab, Ys, Yms, Ts	Constructed roads border valley bottom; evidence of riparian clearing. Several road crossings. On downstream end, narrow willow corridor on channel margins.
						0.35	Braz3	C	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation, channelization, loss of channel form	Qs	Channel emerges onto irrigated alluvial fan.
Nevada Creek (headwaters to Nevada Lake)	Flow Alteration, Nutrients, Other Habitat Alterations, Siltation, Thermal Modifications	Metals, Nitrogen, Nutrients, Habitat, Suspended Solids	Metals, Nitrogen, Nutrients, Habitat, Suspended Solids	Agriculture, Grazing related Sources, Range grazing – Riparian, Resource Extraction, Placer Mining	Grazing; Mining	4.14	Nev1	B	Dense	Conifer	Not Evident	None	Yc, Ysn	Highly confined forested valley
						1.85	Nev2	B / C	Mod / Dense	Conifer / willow	Timber Harvest	Riparian degradation, road encroachment, possible placer mining	Ysn	Wider valley bottom relative to upstream. Hillslope timber harvesting, road construction.
						1.71	Nev3	C	Moderate	Willow	Timber Harvest, Placer Mining	Road encroachment	Ysn, Yms	Relatively narrow riparian corridor in valley. Channel appears locally incised.
						1.93	Nev4	C / E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation		Wide valley bottom with locally wide willow corridor.
						5.35	Nev5	C / E / F	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, local channelization	Qs, Ts	To Washington Cr confluence; increased riparian degradation; local channelization against valley wall.
						3.60	Nev6	C / E / F			Ag: Irrigated hay / pasture	Riparian degradation, local channelization	Qs, Tab	To Buffalo Gulch confluence; sediment storage increases towards Nevada Cr reservoir; may indicate sediment influx.
Nevada Lake	Nutrients, Organic Enrichment / DO, Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Did not meet SCD	None	1.86	NevLake	Reservoir	N / A	N / A	Not Evident		Qs, Tab, Yms	Nevada Creek Reservoir

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Nevada Creek (Nevada Lake to Blackfoot River)	Flow Alteration, Nutrients, Other Habitat Alterations, Siltation, Thermal Modifications	Metals, Nitrogen, Suspended Solids, Other Habitat Alterations, Nutrients	Metals, Nitrogen, Suspended Solids, Other Habitat Altera-tions, Nutrients	Agriculture, Grazing related Sources, Range Grazing – Riparian, Resource Extraction, Placer Mining	Dewatering; Reservoir release patterns; Grazing	3.30	Nev7	C / F	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qs, Yms	Highly irregular banklines relative to reaches upstream of reservoir; may relate to flow release patterns. Substantial channelization; some cutoff channel segments still evident. Douglas Cr. canal diversion on d / s end of reach
						2.37	Nev8	E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qs	Locally dense riparian corridor; intermittent channelized segments.
						2.70	Nev9	E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	Valley bottom widens significantly. Narrow riparian fringe on channel. Extensive secondary channels / swales on floodplain. Downstream end of reach is fenceline boundary and abrupt change in riparian corridor.
						2.96	Nev10	E / Da	Mod / Dense	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qs	Sinuous channel (E) with locally active secondary channels in dense willow corridor (Da). Channelization through ranch facility.
						1.03	Nev11	E	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	Highly denuded riparian corridor. Helmville Road Crossing
						2.41	Nev12	E	Mod / Dense	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	Dense willow corridor, with intermittent clearing on left bank of channel. Typically excellent willow corridor on right bank, denuded left bank. Evidence of intensive grazing on left (west) floodplain surface. Standing water on east floodplain surface; secondary channel segments evident
						3.65	Nev13	C / E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	To Nevada Spring Creek confluence: Narrow riparian fringe with extensively cleared overbanks. Highly sinuous channel in broad alluvial valley; little evidence of active lateral channel migration or in-channel sediment storage. Short avulsed channel segment at Nevada Spring Cr confluence
						6.64	Nev14	C / E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	To Blackfoot River: Highly sinuous channel with narrow riparian fringe. Some center pivot irrigation on left floodplain. Recumbent bends with high amplitudes; little evidence of rapid lateral migration or recent cutoff.
Nevada Spring Creek	Siltation, Other Habitat Alterations	Habitat; Siltation	Habitat; Siltation	Agriculture, Grazing Related Sources, Pasture grazing – Riparian, Hydromodification, Flow Regulation / Modification	Not Visited	2.26	NevSprg 1	C / G	Sparse	Herb.	Ag: Irrigated hay / pasture	Channel widening, riparian degradation	Qs	Sinuous, E channel type that appears overwidened. From headwaters, channel width increases markedly in downstream direction. Variable channel width, in stream sediment storage indicate bank destabilization, channel widening. Floodplain scars from historic channel avulsion.
						0.66	NevSprg 2	E	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation	Qs	From bridge crossing to Nevada Creek confluence: less widening, instability relative to upstream. Minimal woody riparian vegetation. Avulsed channel segments visible on floodplain

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Black Bear Creek	Siltation, Other Habitat Alterations	Habitat	Habitat	Agriculture, Grazing Related Sources, Habitat Modification-other than Hydromodification, Bank or Shoreline Modification / Destabilization	Grazing; logging	1.98	BlkBr1	B	Mod / Sparse	Conifer	Timber Harvest	Riparian degradation, road encroachment	Tab	Headwaters section; extensive timber harvesting, creek follows access road. Potential channelization of creek along road.
						2.39	BlkBr2	B	Dense	Conifer	Timber Harvest	Riparian degradation, road encroachment	Tab, Ts	Emergence into alluvial valley of Tertiary sediments. Access roads cross creek and follow narrow corridor.
						1.01	BlkBr3	No channel observed	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation, loss of channel definition	Ts	Very poor channel definition until channel reaches Bear Cr at downstream end of reach. Channel course appears structurally controlled by parallel ridge to north.
						2.20	BlkBr4	B	Sparse	Willow	Ag: Pasture	Riparian degradation	Ts	Very narrow corridor within Tertiary sediments. Minimal active floodplain. Narrow riparian fringe. Some open bar sediment storage in upper reach. Cattle grazing evident in corridor. Linear feature parallel to stream corridor may be infrastructure, such as a buried pipeline.
Murray Creek	Flow Alteration, Thermal Modification, Other Habitat Alterations, Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Did not meet SCD	Not Visited	3.37	Murr1	B	Dense	Conifer	Not Evident		Tab	Headwaters section; forested confined valley in basalts. Linear trend of channel / valley suggests structural control; basaltic rocks support relatively low conifer densities on south facing hillslopes.
						2.00	Murr2	B	Moderate	Conifer / willow	Timber Harvest	Riparian degradation, road encroachment	Tab	Hillslope timber harvesting, road access along corridor.
						3.26	Murr3	E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, loss of channel definition	Tab, Ts, Qs	Emergence into valley; numerous diversions northward throughout reach. Channel definition decays in downstream direction. Narrow riparian fringe, valley bottom width variable due to valley wall encroachment.
Douglas Creek (upper)	Thermal Modifications, Other Habitat Alterations, Siltation, Nutrients, Salinity / TDS / Chlorides, Flow Alteration	Habitat; Thermal Alterations	Habitat; Thermal Alterations	Agriculture, Grazing Related Sources, Hydromodification		3.73	Doug1	B	Dense	Conifer	Timber Harvest		Tab, PDs	Confined channel in upper reach. Access road locally in corridor. Some clearcut harvesting in uplands.
						3.86	Doug2	B / E	Moderate	Conifer / willow	Timber Harvest	Riparian degradation	Tab, Ts	Increased upland timber harvesting in downstream direction. Channel flows through confined valley with intermittent meadow E channel segments. Low density timber / selective harvesting evident on valley walls and uplands. Extensive access road complex.
						4.18	Doug3	E	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, loss of channel definition	Ts, Qs	Emergence into valley; several irrigation impoundments and associated diversions. Diversions on north valley wall clearly seeping and overtopping diverted water back to valley bottom. Narrow riparian fringe, valley bottom width variable due to valley wall encroachment. Relatively wide valley bottoms cleared for ag use.
						1.39	Doug4	E / G	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation	Tab, Ts, Qs	Sinuous E channel in irrigated valley bottom. Local corridor encroachment by road. Reconnaissance investigation identified reach as incised. Abandoned channel remnant in floodplain appears perched. Channel locally confined by volcanic, tertiary sediment valley wall rocks.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Douglas Creek (lower)	Thermal Modifications, Other Habitat Alterations, Siltation, Nutrients, Salinity / TDS / Chlorides, Flow Alteration	Habitat; Thermal Alterations	Habitat; Thermal Alterations	Agriculture, Grazing Related Sources, Range Grazing – Riparian, Hydromodification	Grazing; channelization	2.65	Doug5	E	Moderate	Willow	Ag: Irrigated hay / pasture	Riparian degradation, road encroachment	Qs	Local volcanic valley wall constrictions. Channel confined by highway, and locally channelized against valley wall to enlarge narrow valley bottom hayfields.
						1.71	Doug6	E	Dense	Willow	Ag: Irrigated hay / pasture		Qs, Tab	Dense willow corridor in wide valley bottom that intermittently abuts Tab valley wall on west side. Ditch from Nevada Cr terminates at Douglas Cr in middle of reach.
						1.50	Doug7	E	Moderate	Cottonwood / willow	Ag: Irrigated hay / pasture, crops	Riparian degradation	Qs	Channel flows through corridor bound by young terrace surfaces. Flood irrigated bounding floodplain. Local channelization; riparian grazing.
						2.20	Doug8	E	Sparse	Willow	Ag: Irrigated hay / pasture, crops	Riparian degradation, loss of channel definition	Qs	To Cottonwood Cr confluence: Sparse woody riparian vegetation; channel definition poor relative to upstream. Off-line storage reservoir on upstream end of reach. Locally, multiple channels are active; secondary channels may be employed to convey flows to adjacent irrigated fields.
						1.08	Doug9	E	Mod / Sparse	Willow	Ag: Irrigated hay / pasture, crops	Riparian degradation	Qs	Increased channel definition downstream of Cottonwood Cr confluence. Highly sinuous channel with narrow riparian fringe. Proximal center pivot west of channel
Cottonwood Creek	Flow Alteration, Nutrients, Salinity / TDS / Chlorides, Siltation, Thermal Modifications	Flow Alteration	Flow Alteration	Agriculture	Irrigation; grazing	1.65	CttnNev 1	E	Mod / Sparse	Cottonwood / willow	Ag: Pasture	Riparian degradation	Ts, Qs	Channel flows through valley mapped as Ts rocks that form moraine features. Valley bottom grazing.
						2.53	CttnNev 2	C / E / F	Sparse	Cottonwood / willow	Ag: Irrigated hay / pasture, crops	Riparian degradation, channelization, loss of channel definition	Ts, Qs	Sparse cottonwood thread and willow fringe; Douglas Cr canal crosses channel (augments) in reach. Extensive diversions, downstream reduction in channel definition.
						2.04	CttnNev 3	E	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, loss of channel definition	Qs	To Douglas Cr confluence: Channel flows across broad flat parallel to Douglas Cr. Narrow riparian fringe, small channel flowing through extensive flood irrigated fields.
McElwain Creek	Siltation, Flow Alteration, Pathogens	DID NOT MEET SCD	DID NOT MEET SCD	Did not meet SCD	Irrigation; grazing	1.94	McEl1	C / E	Sparse	Willow / herb.	Ag: Irrigated hay / pasture	Riparian degradation, loss of channel definition	Qs	Reach begins at storage reservoir where most flow is evidently diverted. Ditch from Yourname Creek diversion crosses McElwain Creek at the reservoir. Channel has very poor definition, and is locally manifested as swale in valley bottom. Grazing, flood irrigation evident.
Yourname Creek	Flow Alteration	Flow Alteration	Flow Alteration	Agriculture, Irrigated Crop Production	Grazing, flow diversion	4.32	Your1	A / B	Dense	Conifer	Not Evident	None	Ybo, Yms	Forested headwaters; no evidence of impairments
						2.73	Your2	B	Moderate	Conifer	Timber Harvest	Road encroachment	Ybo, Tab	Channel flows through valley bounded by basalts; harvested hillslopes and access road network. Road follows channel corridor. Dense forest on south valley wall, sparse to north (south facing). Locally, relatively wide valley bottoms may support E channel types that could be effective at absorbing hillslope derived sediment.
						0.63	Your3	C	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qs	Continuous narrow riparian fringe in partially cleared narrow alluvial valley bottom. Flows diverted within reach.
						1.87	Your4	E	Sparse	Willow	Ag: Irrigated hay / pasture, crops	Riparian degradation, loss of channel definition	Qs	Channel definition severely diminishes between road crossing and Blackfoot River confluence.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Frazier Creek	Flow Alteration	Habitat Alterations	Habitat Alterations	Agriculture, Irrigated Crop Production, Range Grazing - Riparian	Not Visited	1.21	Fraz1	A / B	Dense	Conifer	Not Evident		Yms	Highly confined, densely forested valley
						2.00	Fraz2	A / B	Moderate	Conifer	Timber Harvest	Road encroachment	Yms, Tab	To on-line storage reservoir on margin of Blackfoot River Valley: semi-confined forested valley with harvested hillslopes and extensive access road network
						1.21	Fraz3	C / E	Mod / Sparse	Cottonwood	Ag: Irrigated hay / pasture, crops	Riparian degradation, loss of channel definition	Qs	To Blackfoot River: Loss of channel definition in downstream direction; near the mouth, no discreet channel discernible on photography. Two on-line storage reservoirs in reach. Local, dense cottonwood galleries. Center pivot on southern margin.
Wales Creek	Flow Alteration; Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Agriculture, Irrigated Crop Production	Not Visited	2.23	Wale1	B / E	Moderate	Cottonwood / willow	Timber harvest, Ag: irrigated hay / pasture	Riparian degradation	Qs	Reach begins at on-line storage reservoir. Extensive adjacent hillslope logging, and road access within corridor. Substantial proportion of flows appear to be diverted at reservoir. Flood irrigation south of channel downstream of impoundment. Channel maintains narrow riparian fringe to Blackfoot River confluence.
Ward Creek	Flow Alteration	Siltation, Other Habitat Alterations	Siltation, Other Habitat Alterations	Agriculture, Irrigated Crop Production	Grazing, Flow diversions, Logging	1.81	Ward1	A / B	Dense	Conifer	Not Evident	None	Yh	Confined, densely forested valley in Helena Formation.
						0.74	Ward2	B	Moderate	Conifer	Timber Harvest	Road encroachment	Qg	Channel emerges onto hummocky glacial geology. Clearcut timber harvesting adjacent to mapped channel. Channel form through clearcuts not visible on photography
						2.55	Ward3	E	Mod / Sparse	Herb.	Ag: Pasture	Riparian degradation	Qg	Broad, open meadows with E channel types with localized constrictions formed in glacial terrain. Channel definition and riparian vegetation through meadows is variable, suggesting local dewatering and loss of corridor integrity. Valley walls show evidence of extensive historic timber harvesting.
						1.20	Ward4	B	Moderate	Conifer	Timber Harvest	Riparian degradation	Qg	Relatively confined section bound by harvested valley walls. Hummocky glacial topography. Numerous access roads.
						1.62	Ward5	E	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation	Qg	Open meadows, with channel relocated / channelized on valley margin. Small, on-line glacial pothole pond may provide sediment trap.
						0.68	Ward6	B / E	Dense	Cottonwood / willow	Ag: Pasture		Qg	To Highway 200: Narrow, straight channel with small on-line impoundment. Timber harvest / clearing on left overbank
						0.54	Ward7	E	Dense	Willow, aspen, cottonwood	Not evident	Riparian degradation	Qg	From Hwy 200 to Rd #112 xing : Small E channel with herbaceous bank / floodplain vegetation near highway abruptly transitions to short section of dense woody riparian vegetation (this short section may be the headwater spring area for Kleinschmidt Creek)
						0.83	Ward8	E	Sparse	Herb.	Not evident	Riparian degradation	Qg	Rd #112 xing to Browns Lake: E channel with herbaceous vegetation. Field reconnaissance indicated channel degradation due to grazing in this section.

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Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Rock Creek	Flow Alteration; Habitat Alterations Siltation	Flow Alteration; Habitat Alterations	Flow Alteration; Habitat Alterations	Agriculture, Aquaculture, Flow Reg / Modification, Highway / Road / Bridge Construction, Irrigated Crop Production, Range Land, Removal of Riparian Vegetation	Grazing, logging, dewatering, riparian clearing, hillslope erosion	0.31	Rock1	B	Dense	Conifer	Timber Harvest	None	Qg	Confined headwaters in forested valley. Glacial deposits above Kleinschmidt Flat.
						0.73	Rock2	B / C	Moderate	Conifer	Rural residential development	Riparian degradation	Qg	Transition zone as channel flows onto Kleinschmidt flat. 303D mapped channel is mis-located--channel appears to flow onto margin of flat at mapped downstream end of reach. Upper end of reach may be modified as part of rural residential development.
						1.81	Rock3	E	Sparse	Herb.	Ag: Pasture	Riparian degradation	Qs	E channel type on hillslope / flat boundary. Hillslopes harvested for timber. Very limited riparian corridor. Distinct glacial outwash channel remnants trend toward creek from center of flat; such outwash channels may form important subsurface alluvial heterogeneities and associated groundwater flow paths. Lower end of reach has been restored since 1995 photography (GPS Pt #12).
						1.37	Rock4	E	Mod	Cottonwood / willow	Ag: Pasture	Riparian degradation	Qs	Abrupt increase in woody riparian vegetation relative to reach upstream. Channel follows margin of Kleinschmidt Flat. Road closely follows left margin of stream corridor.
						1.05	Rock5	C	Sparse	Herb.	Ag: Pasture	Riparian degradation	Qs	Channel crosses onto Kleinschmidt flat, and enters losing reach on glacial outwash deposits. Channel is low sinuosity, with no evident riparian vegetation. Channel segment has been described as widened with unstable stream banks (DNRC).
						1.41	Rock6	C	Sparse	Herb.	Ag: Pasture	Riparian degradation	Qs	Reach begins at fence line in middle of Kleinschmidt flat where there is an abrupt reduction in woody riparian corridor extent relative to upstream. A comparison of the two reaches indicates that there is some potential for woody riparian on Rock Creek as it traverses the flat.
						2.41	Rock7	C / E	Mod / Sparse	Willow / herb.	Ag: Irrigated hay / pasture	Riparian degradation	Qs	To North Fork Blackfoot River. Channel gains flow between axis of Kleinschmidt flat and confluence with North Fork. Channel enlarges, and woody riparian corridor extent increase in downstream direction.

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Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
North Fork Blackfoot River	Habitat Alterations; Siltation	NONE--FULLY SUPPORT-ING	NONE--FULLY SUP-PORTING	Harvesting, Restoration, Residue Management, Natural Sources Silviculture	No Visual Impairments	1.50	NFBlk1	A / B	Sparse	N / A	Not evident	None	Ysn, Qa	Upper reach, short bedrock canyon above confluence with Dry Fork Blackfoot River. Hillslopes have experienced recent fire (1988 Canyon Cr. Fire).
						2.21	NFBlk2	B	Sparse	Burnt conifer	Not evident	None	Qa	Confined B channel in recently burned watershed. Sediment storage in channel may reflect increased sediment yields due to fire.
						1.76	NFBlk3	B	Sparse	Burnt conifer	Not evident	None	Qa	High hillslope sediment contribution: hillslopes on west side of channel (Yh Helena Fm) have multiple debris flow channels that extend into stream corridor. Referred to as "Big Slide" on topo map. Downstream end of reach is approximate wilderness boundary
						4.54	NFBlk4	B	Sparse		Timber harvest	None	Qa, Qg, Yh	Downstream end of reach is approximate USFS boundary. Entrenched channel with road crossings, upland timber harvesting. Large escarpment on left valley wall in Helena Formation.
						2.76	NFBlk5	B	Sparse		Timber harvest	Riparian degradation	Qa, Qg, Ys, Ye	Extensive timber harvesting on hillslopes and valley bottom margins. Road access network
						4.96	NFBlk6	C	Moderate	Cottonwoo d	Rural residential developme nt; Ag: irrigated hay / pasture; minor gravel extraction	Riparian degradation	Qa, Qg	Channel emerges onto Kleinschmidt flat and transitions into a meandering C channel with bar storage, channel migration, and bendway cutoff. Lateral migration / cutoff rates appear relatively high, which may be in part related to 1995 sediment loading conditions following upper watershed fire in 1988.
						1.91	NFBlk7	C / D	Moderate	Cottonwoo d	Ag: Irrigated hay / pasture	Riparian degradation	Qa, Qg	To Hwy 200, Rock Cr confluence: Local braided reach indicates high sediment loads and channel adjustment. Bendway cutoffs record a reduction in overall channel sinuosity, likely due to a channel recovery following a sediment pulse. Large cutoff at Hwy 200 may be engineered to maintain channel alignment at bridge.
						3.47	NFBlk8	C	Moderate	Cottonwoo d	Ag: Pasture	None	Qa	To Rd 104 Bridge (Harry Morgan Fishing Access): Well-defined C channel flows within entrenched corridor through glacial deposits. Distinct open point bars with active riparian succession. Some split flow. Meander scars indicate historic migration / cutoff. Abandoned channel segments form arcuate wetland depressions.
						2.49	NFBlk9	C	Moderate	Cottonwoo d	Ag: Pasture	None	Qa	To Blackfoot River confluence: Entrenched corridor within glacial deposits. Channel intermittently abuts right valley wall which forms cliffs mapped as till. Broad, elongated point bars with some mid channel bars in confined valley reach. Large bar at mouth indicates that the North Fork conveys substantial sediment loads to the Blackfoot.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Kleinschmidt Creek	NOT PREVIOUSLY LISTED	Metals (copper); Thermal Modification; Habitat Slterations, Riparian Degradation; Fish Habitat Degradation	Copper, Fish Habitat Degra-dation, Metals, Other Habitat Altera-tions, Riparian Degra-dation, Thermal Mod-ification	Agriculture, Grazing Related Sources, Hydromodification, Dam Construction, Habitat Modification (other than Hydromodification), Bank or Shoreline Modification / Destabilization	Grazing, trampling, riparian clearing, road crossings	1.50	Klein1	B / E	Mod / Dense	Willow	Ag: Pasture	Riparian degradation	Qa	From boggy area on upstream end of channel near Ward Creek to Highway 200 crossing: Upstream reach flows through densely vegetated bogs that provide seepage to Kleinschmidt channel. Channel flows through glacial hummocks, which are locally forested. Field recon identified aquatic vegetation types that reflect significant groundwater contributions.
						1.41	Klein2	E	Sparse	Herb.	Ag: Pasture	Riparian degradation	Qa	Downstream of (first) Highway 200 crossing: Severe riparian degradation. Field reconnaissance indicates that historic E5 channel now has over-widened C-type cross section due to land use impacts. Numerous road crossings in reach; these could be reduced with restoration / relocation efforts by moving channel to south side of highway in reach.
						1.67	Klein3	N / A	Sparse	Herb.	Ag: Pasture	Riparian degradation, degradation of channel form	Qa	Downstream of (third) Highway 200 crossing, channel is largely impounded by a series of in-stream berms. Seepage and associated groundwater inputs from Kleinschmidt flat outwash channels evident as base flow contribution in lower reach. Field recon indicates that since 1995 photography, channel has been partially restored, although continued riparian degradation due to livestock access was noted.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Warren Creek	Flow Alteration	Flow Alteration; Habitat Alterations	Flow Alteration; Habitat Alterations	Agriculture, Crop-Related Sources, Grazing related Sources, Hydromodification, Channelization	At GPS 021: Channelization / dredging / berming (riparian has recovered significantly). Riparian clearing / flow diversion	3.27	Warr1	B	Dense	Conifer	Not evident	None	Yes, Ys, Qg, Qa	Channel originates on flanks of Ovando Mtn. On flanks of mtn, channel flows off of bedrock and into glacial deposits. Valley is well-defined and moderately confined. No riparian corridor evident.
						1.76	Warr2	E	Moderate	Herb. / willow	Ag: pasture	None	Qa, Qg	Channel flows into broader valley with meadow bottoms. Some pasture use may have impacted riparian corridor integrity.
						1.56	Warr3	E / F	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qa, Qg	To Hwy 200: Abrupt increase in riparian degradation as channel flows onto private property from Plum Cr. lands. Flow diversions and local channelization through irrigated fields. Potential riparian reference reach on lower end near Hwy 200. This reach has been used as a reference for downstream conditions (Water Consulting), although their work noted that "impacts to the reference reach from upstream watershed degradation make this reach less than pristine with higher than expected width / depth ratios, relatively small substrate size, and other adversely impacted characteristics".
						0.57	Warr4	F	Mod	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qa, Qg	Short reach downstream of Hwy 200 channelized. Field recon documented F channel type with significant riparian colonization of bounding dredge berms.
						1.01	Warr5	E / F	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization, loss of channel form	Qa, Qg	Severe riparian degradation and loss of channel definition within reach. Most flows clearly diverted to adjacent pasture. Historic channel appears abandoned.
						0.72	Warr6	E / F	Mod	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization, loss of channel form	Qa, Qg	Channel has been relocated northward of historic course. Riparian corridor on current course is a well defined narrow thread (evidently following a ditch), and corridor along historic course is severely denuded.
						0.74	Warr7	E	Sparse	Herb. / willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization, loss of channel form	Qa, Qg	Channel definition is variable. Diversion at head of reach. On lower end, channel is highly sinuous E channel. Boggy areas within valley bottom along with increased channel definition on lower end of reach suggest groundwater seepage inputs to base flow within reach. Field reconnaissance identified base flow contributions and aquatic vegetation indicative of groundwater inputs.
						0.63	Warr8	E	Mod	Willow	Ag: Irrigated hay / pasture	Riparian degradation, loss of channel definition	Qa, Qg	From Rd 104 downstream: Significant increase in riparian cover relative to upstream. E channel flows through boggy wetland. Identified on reconnaissance as potential reference reach, however riparian thread is narrow due to land use impacts.
						0.45	Warr9	E	Sparse	Herb.	Ag: Irrigated hay / pasture	Riparian degradation	Qa	Highly sinuous E channel with severely degraded riparian corridor.
						0.93	Warr10	E	Mod	Herb. / willow	Ag: Irrigated hay / pasture	Riparian degradation	Qa	Locally boggy, multithreaded E channel indicates substantial groundwater seepage and base flow contribution.
						1.02	Warr11	E / F	Sparse	Herb. / willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qa	Sinuous E channel with localized channelized segments through irrigated fields. Severely degraded riparian corridor.
						0.98	Warr12	E	Mod / Sparse	Herb. / willow	Ag: Pasture	Riparian degradation	Qa	Upstream end highly sinuous E channel with degraded riparian corridor. Lower end flows into Blackfoot River entrenchment, possibly forming B-channel conditions. Riparian corridor extent increases in downstream direction towards Blackfoot River.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Monture Creek	Habitat Alterations; Siltation	Habitat Alterations	Habitat Alterations	Agriculture, Natural Sources, Range Land, Streambank Modification / Destabilization, Erosion and Sedimentation, Pasture Grazing-Riparian	No Visual Impairments in Upper Reaches, Grazing, Riparian Clearing in Lower Reaches	3.59	Mont1	A / B	Mod / Dense	Conifer	Not Evident	None	Qg, Yms	Headwaters section; forested confined valley.
						0.95	Mont2	B / C	Mod / Dense	Conifer / herb.	Not Evident	None	Qa, Qg	Relatively open narrow valley bottom; sinuous channel with active bar deposition
						6.91	Mont3	B	Mod / Dense	Conifer	Not Evident	None	Qa, Yms, Ysh	Entrenched, low sinuosity mountain channel in confined forested valley
						4.09	Mont4	B / C	Mod / Dense	Conifer / herb.	Not Evident	None	Qa, Yh, Qg	Entrenched, low sinuosity channel with localized areas of valley bottom widening, sediment deposition, and herbaceous cover.
						1.40	Mont5	B / C	Mod / Dense	Conifer / herb.	Timber Harvest	Riparian degradation	Qa, Qg	To Rd 107 bridge: Entrenched, moderately sinuous stream with active bar formation, channel migration, and sediment storage. Field reconnaissance documented woody debris jams, and storage of coarse bed load sediment on bars and around jams. Locally vegetation patterns indicate historic riparian timber harvest.
						1.55	Mont6	C	Mod / Dense	Conifer / herb. / willow	Timber Harvest	Riparian degradation	Qa	To Dunham Cr. confluence: C channel with sediment storage in point bars and mid-channel bars. The relatively open valley bottom and grassed valley bottom / bar surfaces suggest historic riparian timber harvest.
						1.11	Mont7	C	Mod / Dense	Conifer / herb. / willow	Timber Harvest	Riparian degradation	Qa	Confined forested valley with sediment laden channel. Timber harvest on hillslopes, and apparent historic riparian harvest. Sinuous channel with active channel migration and bar storage.
						1.20	Mont8	C	Mod / Dense	Herb. / willow	Ag: Irrigated hay / pasture, crops	None	Qa	To road crossing: channel emerges from forested valley to flow through wetland complexes and against irrigated fields to east. Where the channel is well-defined, substantial sediment is stored in unvegetated bars.
						2.04	Mont9	C	Mod / Dense	Herb. / willow	Not Evident	None	Qa, Qg	Channel flows though intermittent wetland complexes, such that cross section definition is variable. Locally, channel is eroding into glacial deposits that form west valley wall.
						2.94	Mont10	C	Moderate	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qa, Qg	To Hwy 200: Meandering, sinuous channel intermittently abuts against glacial deposits to east. Some riparian degradation associated with land use. Abandoned channel segments support wetlands. Channel plan form anomalies suggest geologic control or erosion control efforts. Riparian corridor narrows in downstream direction.
						1.52	Mont11	C	Mod / Sparse	Willow	Ag: Pasture	Riparian degradation	Qa, Qg	Downstream of Hwy 200: Left bank follows forested hillslope; right bank riparian degraded. Moderately sinuous channel with little observable open bar area. Field reconnaissance identified geologic control of left valley wall as Belt rocks overlain by till.
						1.19	Mont12	C	Mod / Dense	Willow	Not Evident		Qa, Qg	Moderately dense willow corridor downstream of degraded reach. At fishing access (GPS 049), channel described as over-widened with fine sediment substrate capping gravel bars. Stream flows through entrenched alluvial valley bound by glacial deposits
						1.05	Mont13	B / C	Mod / Sparse	Willow	Ag: Pasture	Riparian degradation	Qa, Qg	Channel becomes more entrenched as it approaches Blackfoot River confluence. Channel corridor is encroached by ranching / residential infrastructure. Reconnaissance effort identified fine sediment accumulations at mouth.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Cottonwood Creek	Flow Alteration; Habitat Alterations; Siltation	NONE--FULLY SUP-PORTING	NONE--FULLY SUPPOR-TING	Agriculture, Irrigated Crop Production, Natural Sources, Range Land	Grazing	2.28	CttnBlk1	C	Mod / Sparse	Conifer	Timber harvest, Ag: irrigated hay / pasture	Riparian degradation	Qa	Headwaters area: channel flows on eastern margin of depression that appears to have been an old glacial lake. The depression is currently irrigated. Much of the reach has had timber harvesting on channel margins.
						1.61	CttnBlk2	E	Mod / Dense	Willow	Not Evident	None	Qa	Channel flows through moderately confined valley in thick willow bottom with intermittent wetland complexes.
						2.16	CttnBlk3	E	Mod / Dense	Willow	Ag: Irrigated hay / pasture	Riparian degradation	Qa, Qg	Wide valley bottom with locally dense willows, and locally cleared corridor. Reach likely has internal E / Riparian reference conditions.
						1.16	CttnBlk4	E / F	Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qa, Qg	Channelized reach through narrow riparian willow thread. Lateral diversions into off-channel storage reservoir.
						2.32	CttnBlk5	E / Da	Mod / Sparse	Willow	Ag: Irrigated hay / pasture	Riparian degradation, channelization	Qa	To Hwy 200: Split flow through multiple channels. Primary western channel conveys diverted flow to storage reservoir. West channel appears to be abandoned Da channel used to convey diverted flows. Broad wetland areas with extensive willows present on eastern channel course. East channel could potentially provide internal reference for west channel.
						0.86	CttnBlk6	C	Moderate	Willow	Ag: Pasture	Riparian degradation	Qa	From Hwy 200 to Blackfoot River, channel enters Blackfoot entrenchment. Local wetlands, moderate willow corridor.
Chamberlain Creek	Flow Alteration; Habitat Alterations; Susp solids	NONE--FULLY SUP-PORTING	NONE--FULLY SUPPOR-TING	Agriculture, Harvesting, Restoration, Residue Management, Irrigated Crop Production, Logging Road, Construction / Maintenance, Range Land, Silviculture	No Visual Impairments	2.27	Cham1	B / E	Dense	Conifer / willow	Timber Harvest	Riparian degradation	Ysh, Qa	Extensive timber harvesting of confined valley hillslopes, and road encroachment along most of corridor. Several road crossings. Locally dense willow corridor, although narrow corridor is further limited in extent by road.
						0.40	Cham2	E	Sparse	Willow	Ag: Pasture	Riparian degradation	Qa	Channel emerges onto ranch compound, where riparian corridor has been locally degraded. Off-line pond on property. Lower end of reach flows through dense riparian forest of Blackfoot River corridor.
Blanchard Creek	Habitat Alterations; Siltation	Habitat Alterations; Siltation	Habitat Altera-tions; Siltation	Agriculture, Pasture Grazing-Riparian	Flow diversions, Grazing, road grading	1.58	Blan1	C / B	Moderate	Conifer / willow	Timber Harvest		Qa, Qg, Ysn	Confined valley with harvested hillslopes. Field recon identified extensive dewatering within reach. Ongoing DNRC restoration / monitoring efforts include fencing, bank shaping, willow planting.
						0.77	Blan2	C	Mod / Sparse	Cottonwoo d / willow	Ag: Pasture	Riparian degradation	Qa	Channel emerges onto alluvial fan. Riparian corridor locally degraded through ranch facilities.
Buck Creek	Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Silviculture	Did not visit	2.53	Buck1	C	Mod / Sparse	Conifer / willow	Timber Harvest	Riparian degradation	Qg	Extensive clearcutting on hillslopes and valley bottom. Channel flows through local willow thickets and wetlands, however riparian corridor is largely degraded.
Deer Creek	Non-Priority Organics; Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Harvesting, Restoration Residue Management, Silviculture	Logging, roads	2.29	Deer1	B	Mod / Sparse	Conifer / willow	Timber Harvest	Riparian degradation	Qg	Extensive timber harvesting on hillslopes and valley bottom.
						0.77	Deer2	E	Moderate	willow	Timber Harvest	Riparian degradation	Qg	Series of wetland areas. Extensive hillslope timber harvesting.
						3.48	Deer3	B	Moderate	Conifer / willow	Timber Harvest	Riparian degradation	Qg	Extensive timber harvesting on hillslopes and valley bottom.
						1.89	Deer4	B / C	Dense	Conifer	Timber Harvest	None	Qg	Transitional B / C channel in less intensively harvested reach. Thick corridor in valley bottom
						2.20	Deer5	C / E	Moderate	Conifer / willow	Timber Harvest	Riparian degradation	Qg	Locally dense riparian corridor; also local riparian degradation at residential property. Reconnaissance identified increasing sediment storage in downstream direction (transition from B to C channel from headwaters)

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
West Fork Clearwater River	Non-Priority Organics; Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Harvesting, Restoration Residue Management, Silviculture	Logging, roads	0.00					Not Evident			--NO IMAGERY AVAILABLE--
Richmond Creek	Non-Priority Organics; Siltation	DID NOT MEET SCD	DID NOT MEET SCD	Harvesting, Restoration Residue Management, Silviculture	Hillslope erosion, logging, roads	0.00					Not Evident			--NO IMAGERY AVAILABLE--

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Blackfoot River (Nevada Creek to Monture Creek)	Nutrients Siltation	Nutrients; Thermal Mods	Nutrients; Thermal Mods	Agriculture, Natural Sources, Silviculture, Crop-Related Sources, Irrigated Crop Production	Main stem fine sediment delivery	1.62	Blckft1	C	Mod / Dense	Cottonwood / willow	Ag: Irrigated hay / pasture	Riparian degradation	Qa	From Nevada Cr. Confluence to Cedar Meadow Fishing Access: sinuous channel with recent bendway cutoff. Some relatively dense riparian, but local topbank clearing. Recent channel shortening from cutoff may have caused local base level lowering and upstream downcutting. Riparian corridor narrows into terrace confinement downstream; bridge is in a good location with respect to channel migration trends.
						2.84	Blckft2	F	Sparse	Cottonwood / willow	Ag: Irrigated hay / pasture	Riparian degradation	Qa (Qg)	To downstream of Yourname Cr confluence: Entrenched channel with very narrow riparian thread. Channel flows through glacial deposits (mapped as Qa on Butte geo map), and intermittently abuts high bluff on right bank. Bluffs appear gullied, and sediment contributions from these high banks may be exacerbated by floodplain / terrace irrigation. However, no evidence of increased sediment storage (open bar area) downstream of bluffs. No evidence of discreet pool / riffle sequences, such that the channel may be planar bed (armored with coarse sediment; little sediment differentiation within cross section).
						2.32	Blckft3	C	Mod / Dense	Cottonwood / willow	Ag: Irrigated hay / pasture	Riparian degradation, bank erosion	Qa (Qg)	Sinuous channel with large meanders. Outside bends abut high bluffs of glacial deposits on right bank; high bluffs are gullied, and sediment contributions off of the bluffs may be accelerated due to irrigation. Meanders appear incised below historic point bar areas, which are now forested. In middle of reach, left bank is cleared, and bankline appears to be gullied / failing. Channel migration rates are slow, and riparian succession trends consequently spatially limited.
						1.72	Blckft4	C / F	Mod / Sparse	Cottonwood	Ag: Pasture	Riparian degradation	Qa (Qg)	To just downstream of Frazier Cr. Confluence. Narrow riparian thread in sinuous reach. Channel may be entrenched; meander scars indicate historic migration, but old channels may be perched and detached from active floodplain / migration corridor.
						4.92	Blckft5	C / F	Mod / Dense	Cottonwood	Timber Harvest	Possible siltation in lower end of reach	Qa, Ysh, Ts	To North Fork confluence: Sinuous, entrenched meanders with forested valley margins. Left bank locally abuts valley wall of Ysh and Ts units. Mature cottonwood scroll lines on inside meanders without point bar development and young riparian succession suggests that the channel has historically downcut, and transitioned from a C channel type to a C / F channel. Sediment input from valley walls may be accelerated due to overbank timber harvesting; in-stream sediment storage increases in downstream direction through reach.
						2.97	Blckft6	C	Moderate	Conifer / cottonwood / willow	Ag: Irrigated hay / pasture, crops	Riparian degradation, siltation, bank erosion	Qa (Qg)	Meandering channel with open bar areas, riparian successional trends, and active channel migration. Point bars and bank-attached bars are present, indication relatively high sediment storage volumes and potential siltation impairments. Irrigated valley bottom on right bank in middle of reach abuts outer bend, and irrigation combined with riparian clearing may have affected migration rates in the reach. Low terrace features are discernible on north side of channel. Southern hillslopes have been harvested for timber.
						3.32	Blckft7	C / F	Moderate	Conifer / cottonwood / willow	Timber Harvest	None	Qg, Qa, Ysn	To downstream of Warren Cr confluence. Channel flows against southern valley margin, and is entrenched, and laterally stable. Right (north) bank appears to be low terrace in alluvium. Southern hillslopes have been harvested for timber. Sediment storage, bank erosion is minor. Good buffer between harvested southern hillslopes and river corridor. One high, open bank on right bank just upstream of lower reach break appears to be contributing sediment (mapped as Ysn). No evidence of human impacts that would be accelerating that natural sediment contribution.
						1.73	Blckft8	C	Mod / Sparse	Cottonwood	Ag: Irrigated hay / pasture, crops	Riparian degradation, siltation, bank erosion	Qa, Qg	To Monture Cr confluence: center pivots on left bank terrace. Narrow riparian thread. High right bank bluff (mapped as till) appears to be contributing sediment. Low, vegetated bars suggest fine sediment storage on channel margins.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Sources	Recon Sources of Impairment	Reach Length (mi)	Reach Name	Channel Type	Woody Vegetation Density	Dominant Stream-Side Veg. Type	Apparent Land Use (Aerial Photos)	Geomorphic Indicators of Degradation	Bounding Geology	Geomorphic Comments
Blackfoot River (Monture Creek to Clearwater River)	Nutrients Siltation	Nutrients; Thermal Mods	Nutrients; Thermal Mods	Agriculture, Crop-Related Sources, Natural Sources, Silviculture, Flow Regulation / Modification, Erosion, Sedimentation	No Visual Impairments	4.33	Blckft9	C	Moderate	Cottonwood	Ag: Irrigated hay / pasture	Riparian degradation, siltation, bank erosion	Qg, Qa, Ysn	To Russell Gates fishing access: sinuous C channel with active channel migration, sediment storage, and riparian succession. Numerous meander scars create wetland areas. Reach includes confluences of Chamberlain and Cottonwood Creeks. Just downstream from Chamberlain Creek, Ysn outcrops provide bedrock control on right bank. Appears to be reach of low slope with significant sediment storage. Limited riparian degradation; just upstream of where channel abuts highway, bendway migration may be accelerated due to land use.
						2.00	Blckft10	C / F	Moderate	Conifer / cottonwood / willow	Timber harvest, rural residential	Riparian degradation	Yms	Downstream of Russell Gates, channel is entrenched and confined between valley wall to south and highway to north. Channel shows no evidence of channel migration, and sediment storage is minor. Southern hillslopes have been harvested for timber. Rural residential developments present on right bank terrace, downstream of highway encroachment.
						4.72	Blckft11	B	Mod / Dense	Conifer	Not Evident	None	Qs, Ysn, Ts	To Clearwater confluence: Entrenched, relatively steep channel is confined by steep forested valley walls. Minimal evidence of channel migration or sediment storage; clearly a transport reach. Timber harvesting on south valley walls.

APPENDIX C
STREAM BANK EROSION INVENTORY

Concurrent with the base parameter assessment conducted in 2004, field crews inventoried eroding banks to determine the amount of sediment they contribute to the overall sediment load (DTM and AGI, 2005).

Data Collection

The bank erosion inventory recorded the location and characteristics of stream banks with discernable bank erosion within assessed reaches. These data provide the basis for developing a sediment source assessment and load allocation from eroding banks. For tributary streams, this inventory was performed on 1000 foot transects along both banks of the stream coincident with base parameter data collection. For the mainstem Blackfoot River, all eroding banks were mapped and assessed by a field crew floating the river. Reaches Blkft2 through Blkft8 were mapped in this fashion. Reaches Blkft1 and Blkft9 through Blkft11 have extrapolated bank erosion values (see **Section 2.1** below).

The erosion site assessment includes description of each eroding bank within a given assessment reach, including the following:

- length
- height
- location (mapped)
- BEHI rating
- BEHI rating condition
- bank materials
- topbank vegetation type
- topbank vegetation density
- proximal land use

The bank condition evaluation utilized the BEHI method (Rosgen, 2000) and incorporated the following parameters into numerical ratings.

- Bank height/bankfull height ratio
- Root depth/bank height ratio
- Root density percent
- Bank angle
- Surface protection percent

Eroding bank lengths were measured by tape along the thalweg of the stream. Bank height was measured using a stadia rod extended from the toe of the eroding bank to the top of the bank. Location is recorded using the continuous stationing method. The Bank Erosion Hazard Index (Rosgen, 2000), which allows the determination of the severity of mapped eroding streambanks, was performed according to procedures laid out in the Quality Assurance Project Plan and Sampling and Analysis Plan (DTM and AGI, 2004).

Data Analysis

Analysis of stream bank erosion inventory data involved five tasks:

- Calculation of erosion rates based on condition and distribution of eroding banks mapped at assessment sites.
- Extrapolation of these rates to reaches of 303(d) streams not assessed.
- Determination of erosion rates of streams not on the 303(d) List.
- Calculation of the total sediment load from bank erosion.
- Estimation of the natural and anthropogenic components of the sediment load.

Calculation of Erosion Rates

The BEHI bank condition evaluation generated a cumulative rating that provides a qualitative erosion severity assessment (very low to extreme). A literature review provided a range of probable bank retreat rates corresponding to the severity assessment. Retreat rates developed by Zaroban and Sharp (2001) for the Palisades TMDL in Idaho were most applicable (**Table C-1**).

Table C-1. Eroding Bank Retreat Rates Used for the Sediment Source Assessment

Zaroban and Sharp (2001) Condition	Zaroban and Sharp (2001) Bank Retreat Rate (feet/yr)	Middle Blackfoot/Nevada Creek Eroding Bank Condition Rating	Middle Blackfoot/Nevada Creek Bank Retreat Rate (feet/yr)
Slight	0.1	Very low	0.10
		Low	0.17
Moderate	0.23	Moderate	0.23
		High	0.31
		Very High	0.39
Severe	0.47	Extreme	0.47

Multiplying eroding bank length times height times retreat rate yielded a yearly volume of sediment from eroding banks. Multiplying these volumes by the density of soils from SSURGO soils data yields a yearly tonnage of sediment from bank erosion for each stream.

Extrapolation of Bank Erosion to Reaches Not Assessed

Calculating the bank erosion rate for each stream on the 303(d) List, required extrapolating erosion rates to reaches not assessed. This required identifying a list of controlling factors on bank erosion, supported by existing data that are simple enough to use for this extrapolation (**Table C-2**). This approach required using one of two processes:

- Identify assessed reaches with similar upstream precipitation, geology, vegetation, and land use as those not assessed and assign the same erosion rate to the un-assessed streams.
- If no directly analogous assessed stream exists, average the erosion rate of assessed upstream and downstream reaches.

Table C-2. Criteria Used to Extrapolate Bank Erosion Rates to Un-Assessed Reaches

Controlling Factor on Bank Erosion	Effect on Sediment Loads	Available data
Stream Power	Stream power directly influences stress on stream banks and is a function of discharge and slope.	A surrogate for stream power is the amount of average annual precipitation upstream from a given reach.
Geology	Geology and derived soils directly influence erodibility of stream banks	Generalized geologic mapping and NRCS soils mapping data are available for the project area.
Vegetation	Vegetation density and type influence stream bank resilience.	Topbank vegetation type density data was collected during the field assessment at the reach and eroding bank scale
Land Use	Land use can influence vegetation density, which influences bank resilience. Upland vegetation clearing can increase runoff and stream power. Roads can directly contribute sediment loads. Mining can influence bank resilience (e.g. placer tailings), and vegetation.	Land use data was collected during the field assessment at the reach and individual eroding bank scales. DEQ data provides stream scale land use information.

Determination of Background Bank Erosion Rates

Streams not on the 303(d) List are also a source of sediment from bank erosion. To estimate this portion of the sediment load, the relationships between upstream precipitation, channel type, geology, woody vegetation density, and land use with measured bank erosion rate were examined. The comparison of upstream precipitation with bank erosion rate has the clearest relationship. **Figure C-1** illustrates this relationship for the Nevada Creek Planning Area.

A continuous grid dataset for the study area that represents the upstream average annual precipitation for each cell in the grid was developed to apply the numerical relationship between upstream precipitation and bank erosion rates. Only grid cells that intersect stream channels have values. Multiplying each grid cell by 0.002 yields a bank erosion grid. The bank erosion grid was then summarized for non-303(d) streams.

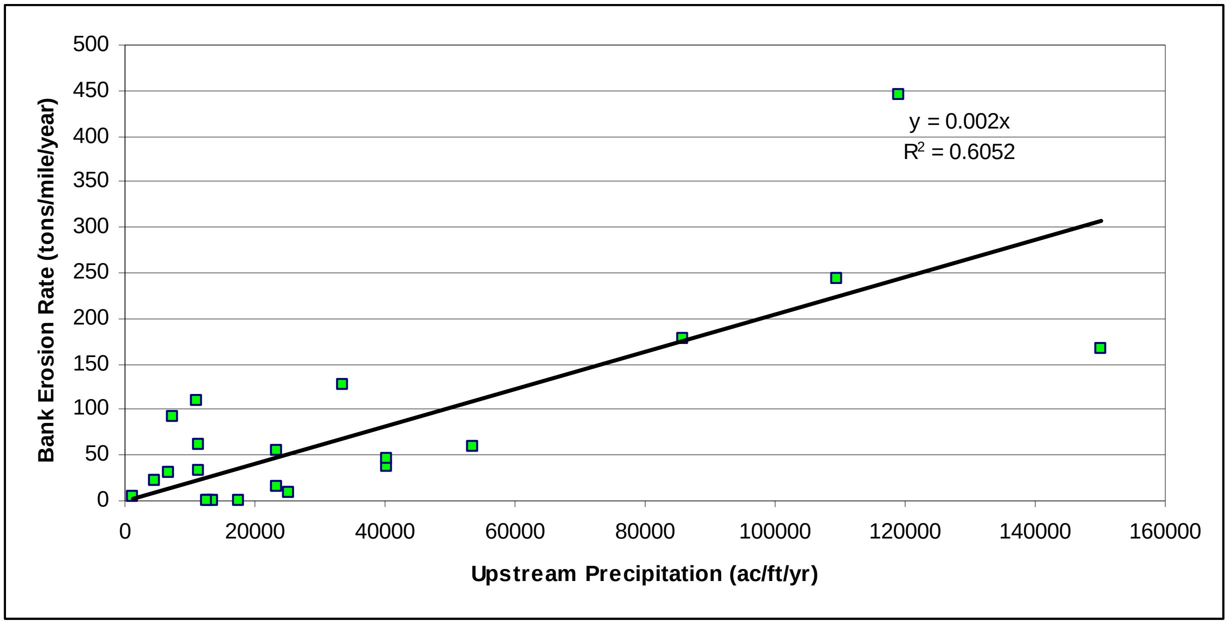

Figure C-1. Scatter Plot of Upstream Precipitation vs. Measured Bank Erosion Rate, Nevada Creek Planning Area

The formula defined in **Figure C-1** is:

Bank Erosion Rate = 0.002 * (Upstream Precipitation)

This formula was then applied to the grid, along with a unit conversion multiplier, to yield a stream network grid where each cell represents the predicted bank erosion rate of a portion of a stream. Summarizing the grid cell values for the Nevada Creek planning area yielded a modeled sediment contribution for the entire watershed. The sediment contribution for non-303(d) List streams is then the modeled sediment contribution minus the measured and extrapolated sediment contribution from 303(d) List streams. The same method provided an estimate of background bank erosion rates for the Middle Blackfoot Planning Area.

Total Sediment Load from Bank Erosion

The total sediment load from bank erosion is the sum of the three components described above:

- The sediment load from eroding banks measured on 303(d) streams.
- The sediment load from eroding banks extrapolated to un-assessed reaches on 303(d) streams.
- The background sediment load from eroding banks on non-303(d) List streams.

Natural vs. Anthropogenic Components of Bank Erosion Sediment

The approach used to estimate the anthropogenic component of bank erosion for eroding banks with a recorded human influence was to estimate a reduced severity of bank erosion without human impacts. A reduced human impact would improve vegetation density on both the topbank and eroding bank surface, as well as improve the root depth and density in the eroding bank. Bank height should be unaffected, and bank angle may improve slightly over time.

Estimating of the amount of change in the five BEHI rating parameters likely from passive restoration for a series of representative eroding banks evaluated the potential change in bank condition from removing the human influence. This allowed calculation of an estimated cumulative BEHI rating for eroding banks rated extreme, very high, high, moderate, low, and very low if human influence was absent. This difference in severity translated to a change in bank retreat rates. The resultant change between the measured and estimated values represents the reduction in sediment load from removing the human influence (i.e. the anthropogenic component). The estimated rates for each eroding bank were then applied to all banks, and the anthropogenic component was calculated for all assessed reaches. Reaches where bank erosion rates were extrapolated from an assessed reach were assigned the anthropogenic percentage of the assessed reach.

APPENDIX D
SEDIMENT/HABITAT TARGET DEVELOPMENT

The development of sediment/habitat target values for the Middle Blackfoot and Nevada Creek watersheds requires the identification of parameters that are closely linked to a cold water fishery or aquatic life beneficial use support. In some cases the parameters also relate to the contact recreation beneficial use. That is, some streams have been listed as non-supporting or partially supporting of primary contact recreation due in part to problems with substrate or flow conditions, both of which can be assessed using parameters described below. The parameters for which target values have been developed to help determine the sediment/habitat impairment status include the following:

- Percent surface fines in riffles measured by pebble count
- Percent subsurface fines measured by McNeil Core
- Pool frequency
- Residual pool depth
- Width to depth ratio
- Percent surface fines in pool tailouts
- Woody bankline vegetation extent
- Macroinvertebrate metrics
- Pool extent
- Entrenchment Ratio
- Woody debris aggregate extent

These parameters address a broad range of direct habitat measures, channel condition measures, and direct measures of aquatic life.

Ideally, reference values for each of the parameters listed above would be directly measured from reference water bodies where all sediment and habitat conditions are functioning at their potential given historic land uses and the application of all reasonable land, soil, and water conservation practices. In general, however, there was very little internal reference data identified in the Middle Blackfoot and Nevada Creek Planning Areas. Some assessment sites do represent minimally impacted conditions for certain parameters, and those data have been compiled into reference datasets wherever possible. In other cases, target values are derived from a statistical analysis of the entire dataset for the planning area, as well as from regional data derived from outside the area. The following sections describe the approach taken in developing specific target values for the parameters utilized in the impairment assessment.

Substrate: Pebble Count Surface Fines in Riffles

Target values for percent surface fines provide important criteria used to help define whether excess sediment loading has resulted in a siltation related cause of impairment. The targets developed for surface fines concentrations of less than 2mm reflect statistically-derived values from the Middle Blackfoot/Nevada Creek planning areas (**Table D-1; Table D-2; Figure D-1**).

In the Nevada Creek Planning Area, B channel types were assigned a <10% target value for <2mm riffle surface fines concentrations. This value is based on the 75th percentile value (Q3) measured on minimally impaired B channels in the Nevada Creek planning area. The <2mm riffle substrate targets for C channels of the Nevada Creek planning areas is <7%, which reflects the 25th percentile values (Q1) for C channel type assessment reaches. For E channel types, the 25th percentile value of 20 percent for <2mm riffle surface fines was selected as a target for the Nevada Creek Planning Area.

Table D-1. Summary of Target Values for Percent Riffle Surface Fines <2mm and <6mm

Planning Area	Size Fraction	Channel Type	Value	Basis*
Nevada Creek	<2mm	B	≤10	NCPA reference 75th percentile
		C	≤7	NCPA 25th percentile
		E	≤20	NCPA 25th percentile
	<6mm	B	≤20	BDNF 75th percentile
		C	≤22	BDNF median
		E	≤36	MBPA reference 75th percentile; BDNF 75th percentile
Middle Blackfoot	<2mm	B	≤10	NCPA reference 75th percentile
		C	≤11	MBPA 75th percentile
		E	≤34	MBPA reference 75th percentile
	<6mm	B	≤20	BDNF 75th percentile
		C	≤22	BDNF median
		E	≤36	MBPA reference 75th percentile; BDNF 75th percentile

*NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area, BDNF: Beaverhead-Deerlodge National Forest

In the Middle Blackfoot Planning Area, the dataset contains only one B type channel (Buck Creek). As such, the dataset is too small to develop surface fines targets for the planning area. Because of the single B channel assessment site in the Middle Blackfoot Planning Area, the targets developed for the Nevada Creek Planning Area were also applied to Buck Creek. Based in part on best professional judgment, this value of <10% for surface fines of <2mm is considered appropriate for meeting beneficial use objectives in the Middle Blackfoot Planning Area B channel types. Measured fines concentrations in C channel types in the Middle Blackfoot are notably low with a 75th percentile value of 11%. The 25th percentile value is 3% surface fines <2mm. As the Middle Blackfoot C channels are characterized by very low percent fines values in riffles, the 75th percentile value (11%) was selected as a target in order to set an appropriate goal for meeting beneficial uses. A total of four E channel segments in the Middle Blackfoot planning area were identified as potentially showing minimally impaired conditions (DTM and AGI, 2004). The 75th percentile value for riffle surface fines <2mm was selected from these sites to define the target value; this value of <34% reflects the typical fine grained nature of E channel types in the area.

The <6mm targets are defined by statistics derived from the Beaverhead-Deerlodge National Forest dataset (Bengeyfield, 2006). This dataset provides <6mm measurements and associated statistics for an extensive number of assessment sites. The 75th percentile values for the BDNF data were adopted for the B and E channel types based on best professional judgment of feasible substrate values and provision of beneficial use support. Further support for the target value is the fact that the 75th percentile value for the BDNF E channel types is very close to that of the least impaired streams of the Middle Blackfoot Planning Area. The median value of 22% for C channels in the BDNF dataset was also considered appropriate for meeting beneficial use support in the Middle Blackfoot and Nevada Creek planning areas.

The riffle surface fines targets values are applied to each channel in terms of its general (Level I) classification (Rosgen, 1996). As such, streams have not been segregated by substrate in either the data analysis or target application. This is because all of the streams in both planning areas are considered to have some potential for developing relatively coarse riffle substrates. Streams of a given channel type that currently have very high concentrations of riffle fines (eg. Nevada Creek Planning Area E channel types; **Figure D-1**) were not segregated from the dataset, because these channels were identified as having potential for fines reductions. It is recommended that the streams be monitored according to the targets set forth herein, and, if the fines targets are not feasible due to natural factors controlling the substrate gradation, that the targets be adjusted appropriately.

Table D-2. Summary Statistics for Percent Surface Fines Measurements

Fraction/Planning Area	Channel Type	Data Source*	Min	Q1**	Med	Q3**	Max	N
<2mm Nevada Creek Planning Area	B	NCPA reference sites	1	1	1	10	19	3
	C	NCPA all sites	6	7	8	16	100	9
	E	NCPA all sites	6	20	63	100	100	8
<2mm Middle Blackfoot Planning Area	B	NCPA reference sites	1	1	1	10	19	3
	C	MBPA all sites	0	3	5	11	43	11
	E	MBPA reference sites	1	4	9	34	100	4
<6mm Both Planning Areas	B	Beaverhead/ Deerlodge NF	0	6	9	20	58	40
	C	Beaverhead/ Deerlodge NF	6	14	22	29	55	184
	E	Beaverhead/ Deerlodge NF	1	4	10	36	100	4

*NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area
** Q1 = 25th percentile, Q3 = 75th percentile

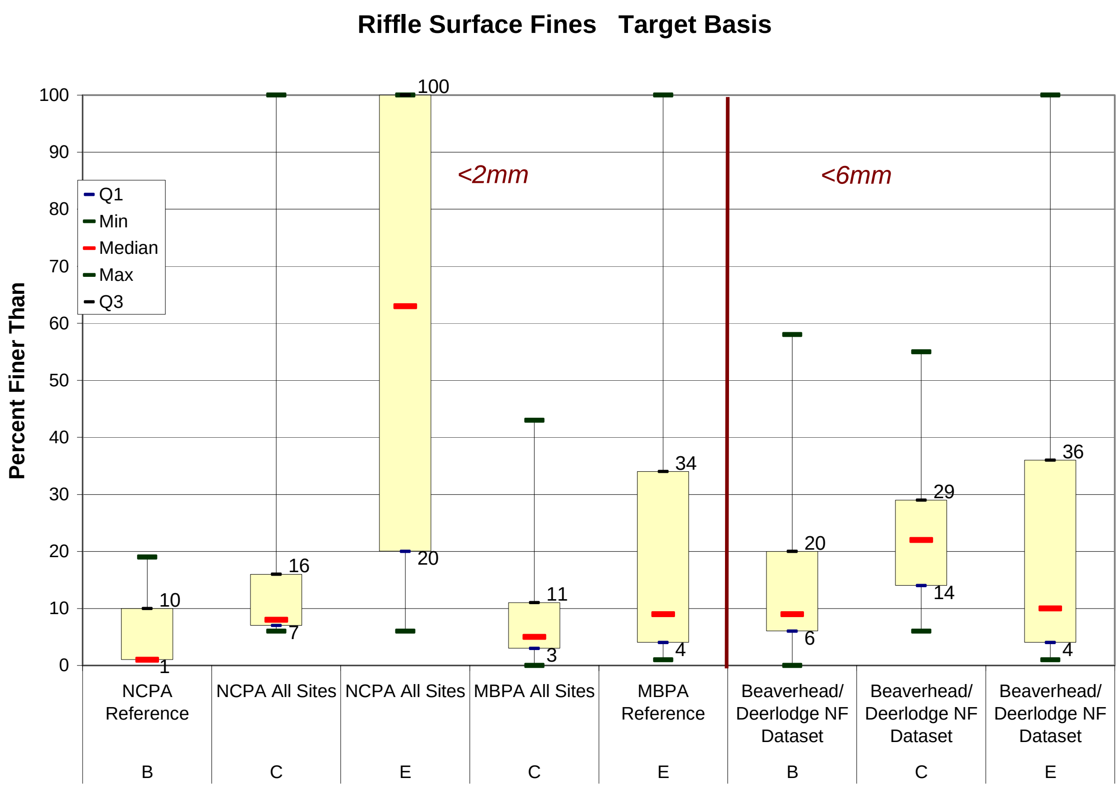

Figure D-1. Distributional Statistics for Riffle Percent Fines

Substrate: McNeil Cores

McNeil Core data provide a quantitative measurement of subsurface fines concentrations in pool tailouts. These measurements are important indicators of excess sediment loading and associated siltation impairment causes. A significant inverse relationship has been observed between the amount of material <6.35mm and bull trout fry emergence success (Weaver and Fraley, 1991). Weaver (1996) stated that streams are threatened as bull trout spawning/rearing streams when the <6.35mm value exceeds 35% in any given year. Based on Weaver and Fraley's data (1991), Tepper (2003) predicted an 8.4% decrease in egg fry emergence success with an increase in the <6.35mm substrate fraction from 25% to 31.7%.

McNeil Core data have been utilized to develop targets for three size fractions in pool tails (**Table D-3**). These data were collected in the Blackfoot River watershed between 2003 and 2006 (Helena National Forest). The targets reflect the 25th percentile value for the given size gradation and channel type. A summary of the statistics used in developing targets for B channel types are shown in **Table D-4** and **Figure D-2**. Similar data for C channel types are compiled in **Table D-5** and **Figure D-3**. The target value of 27% for the <6.35 size fraction reflects the 25th percentile value for samples collected in the watershed since 2003. This value is less than the 35% threshold value described as threatening bull trout spawning/rearing streams by Weaver (1996).

Table D-3. Target Values for Percent Subsurface Fines from McNeil Cores

Planning Area	Size Fraction	Channel Type	Value (%)	Basis
Nevada Creek **Middle Blackfoot**	<6.35mm	B	≤27	25th percentile for all data collected 2003-2006
		C	≤27	25th percentile for all data collected 2003-2006
	<2mm	B	≤12	25th percentile for all data collected 2003-2006
		C	≤15	25th percentile for all data collected 2003-2006
	<0.85mm	B	≤6	25th percentile for all data collected 2003-2006
		C	≤6	25th percentile for all data collected 2003-2006

Table D-4. Summary Statistics for McNeil Core Measurements on B Type Channels

Statistic	Mean % <6.3 mm	Mean % <2 mm	Mean % <0.85 mm
Q1	27	12	6
Minimum	19	9	4
Median	33	17	9
Maximum	49	35	24
Q3	38	24	14
N	21	19	21

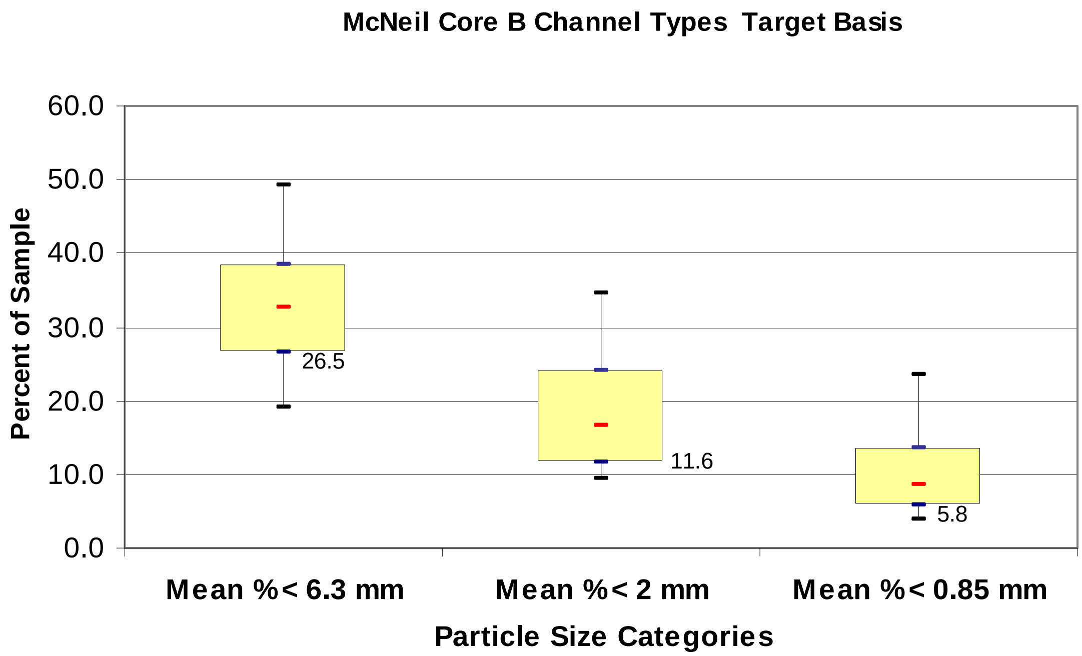

Figure D-2. Distributional Statistics for McNeil Cores from B Type Channels

Table D-5. Summary Statistics for McNeil Core Measurements on C type Channels

	Mean % <6.3 mm	Mean % <2 mm	Mean % <0.85 mm
Q1	27	15	6
Minimum	20	14	6
Median	29	18	8
Maximum	46	31	16
Q3	34	21	12
N	12	8	12

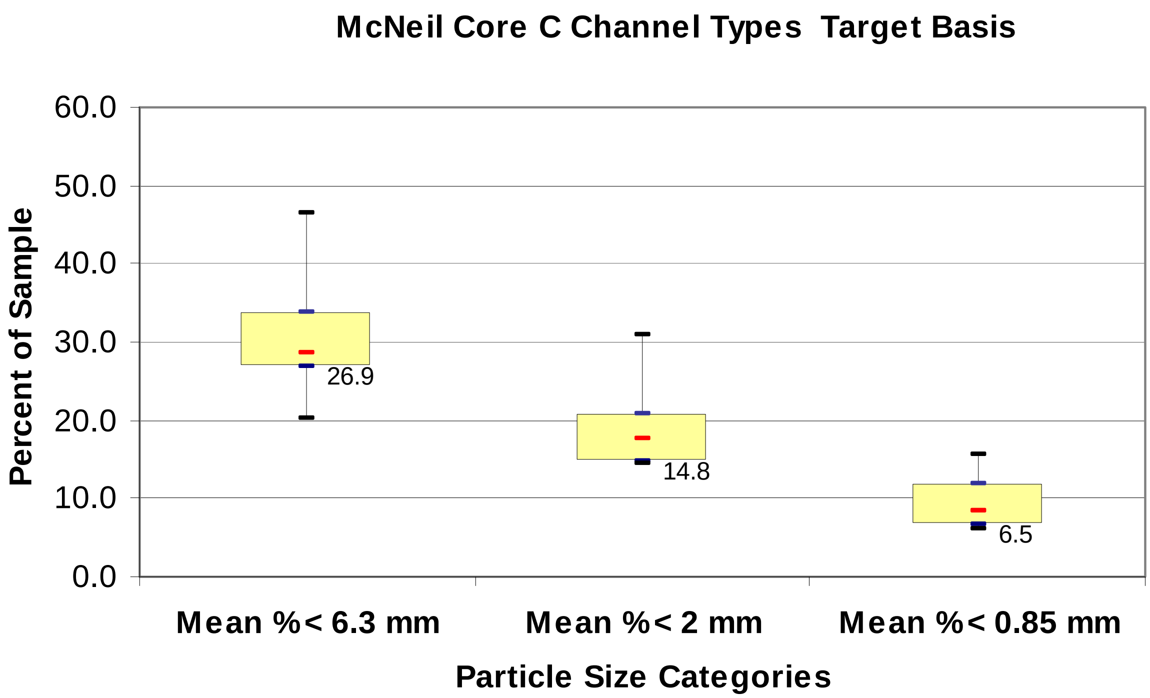

Figure D-3. Distributional Statistics for McNeil Cores from C Type Channels

Pool Frequency

Pool frequency is an important measure of stream habitat conditions. Pools provide critical habitat for cold-water fish and are linked to the storage, deposition, and sorting of sediment within a channel. The target values developed for pool frequency are summarized in **Table D-6**. The supporting statistics for these values are shown in **Table D-7** and **Figure D-4**.

Table D-6. Target Values for Pool Frequency

Planning Area	Channel Type	Target Value	Basis*
Nevada Creek	B	≥20	NCPA 75th percentile; Reference stream median
	C	≥46 for streams <30ft topwidth; ≥26 for streams >30 ft topwidth)	75th percentile for streams <30 ft topwidth; Measured Nev7 value and 5-7 width multiplier for >30 ft topwidth
	E	≥40	NCPA 75th percentile; MBPA reference 75th percentile
Middle Blackfoot	B	≥20	NCPA 75th percentile; Reference stream median
	C	55 for <40 ft topwidth 33 for >40 ft topwidth	MBPA 75th percentile
	E	≥40	NCPA 75th percentile; MBPA reference 75th percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

The selected pool frequency target for B channel types is 20 pools per mile for both planning areas. This value reflects the 75^{th} percentile value for all measured B channel segments in the Nevada Creek planning area, and the value also correlates to the median value for B type streams identified as least impaired with respect to in-channel habitat. The pool frequency targets for C channels have been stratified by width. This width-based target reflects the fact that, in pool/riffle channel types, pools tend to occur on the order of every 5-7 channel widths (Thorne, 1997). Thus pool frequency on a per mile basis decreases as streams become larger. Pool frequency targets developed for the Nevada Creek Planning Area use the 75th percentile of all C channel assessments for streams that are less than 30 ft in width (46 pools per mile). For wider stream segments, which are present on lower Nevada Creek, the selected target reflects a width-depth reference value from Nev7, which appropriately correlates to a value defined by channel width multiplier of six. In the Middle Blackfoot Planning Area, targets were developed for streams less than and more than 40 ft in width to separate out Monture Creek from the remaining dataset. The 75th percentile value for the Middle Blackfoot Planning Area C channels of each width category was adopted for the pool frequency target.

The pool frequency target values for E channel types reflect the 75th percentile values for all E channel assessments of the Nevada Creek Planning Area, which is also the median value measured for Middle Blackfoot Planning Area E channel segments identified as displaying minimally impaired conditions.

Table D-7. Summary Statistics for Pool Frequency

	Nevada Creek Planning Area			Middle Blackfoot Planning Area		
Statistic*	**B**	**C<30 ft topwidth**	**E**	**C (Monture)**	**C (Others)**	**E (ref)**
Min	6.6	0.0	0.0	13.2	19.8	33
Q1	13.2	6.6	6.6	13.2	19.8	36.3
Median	16.5	26.4	13.2	23.1	29.7	39.6
Q3	19.8	46.2	39.6	33.0	54.5	42.9
Max	79.2	59.4	72.6	33.0	72.6	46.2
N	6	9	9	4	6	3

* Q1 = 25th percentile, Q3 = 75th percentile

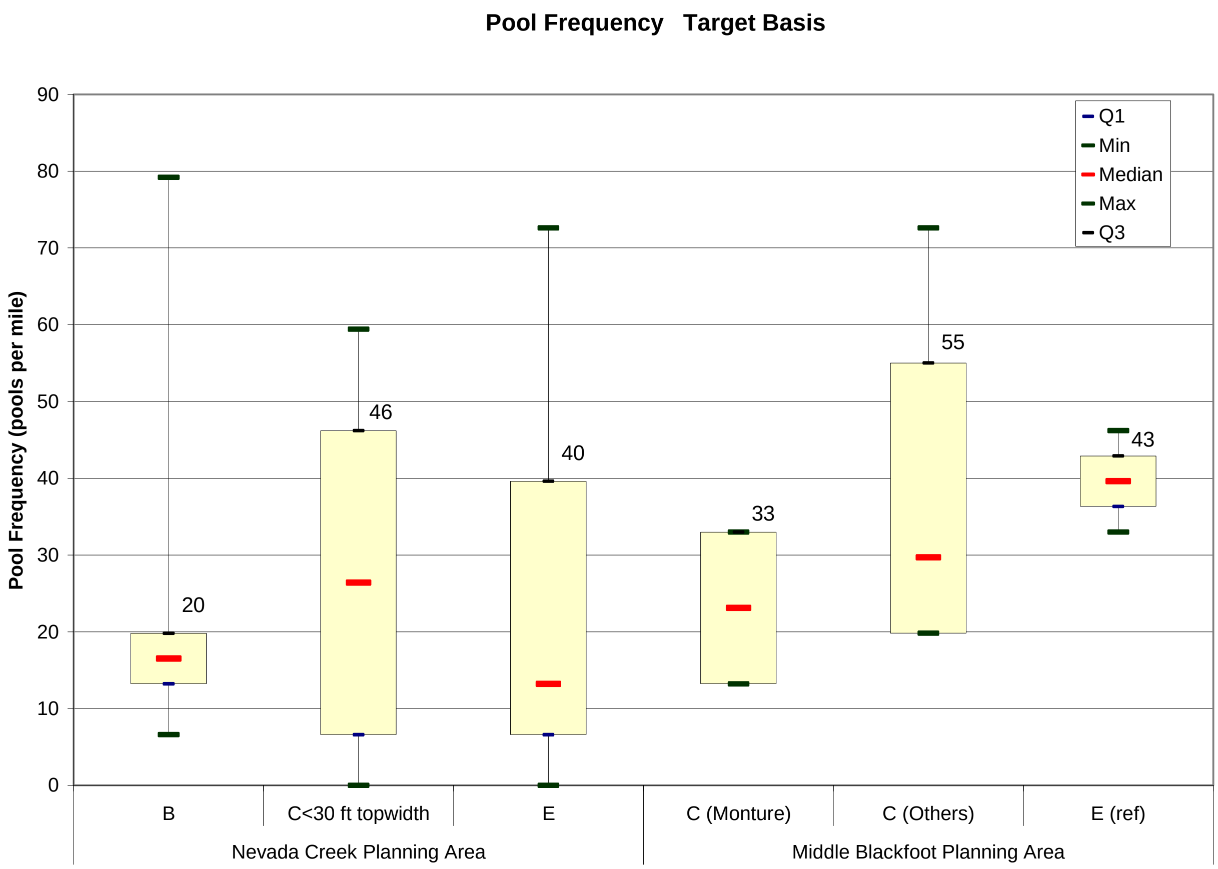

Figure D-4. Distributional Statistics for Pool Frequency

Residual Pool Depth

Residual pool depth is a general descriptor of overall pool quality. Pools provide important winter habitat for juvenile fish, as well as refuge from thermal stressors, cover from predators, food, and rearing areas. Pools also provide a general indicator of overall stream complexity. A summary of targets adopted for residual pool depth is shown in **Table D-8**. These targets were developed from base parameter assessment data statistics. For each of the channel types assessed, residual pool depth values equating to the 75th percentile value were adopted as targets (**Table D-9; Figure D-5**).

Table D-8. Target Values for Residual Pool Depth

Planning Area	Channel Type	Target Value	Basis*
Nevada Creek	B	≥0.6	NCPA 75th percentile
	C	≥2	NCPA reference 75th percentile; MBPA 75th percentile
	E	≥1.5	NCPA 75th percentile
Middle Blackfoot	B	≥0.6	NCPA 75th percentile
	C	2.0 for <40 ft topwidth 4.1 for >40 ft topwidth	NCPA reference 75th percentile; MBPA 75th percentile
	E	≥1.5	MBPA reference 75th percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

Table D-9. Summary Statistics for Residual Pool Depth

	B	C			E	
Statistic*	**NCPA**	**NCPA Reference**	**MBPA <40 ft topwidth**	**MBPA >40 ft topwidth**	**NCPA**	**MBPA Reference**
Q1	0.4	1.5	1.1	1.4	0.5	0.6
Min	0.2	1.2	0.5	0.7	0.0	0.2
Median	0.5	1.7	1.4	2.2	0.7	1.0
Max	0.9	2.4	2.8	6.9	2.6	2.9
Q3	0.6	2.0	2.0	4.1	1.5	1.5
N	23	7	35	14	20	18

* Q1 = 25th percentile, Q3 = 75th percentile

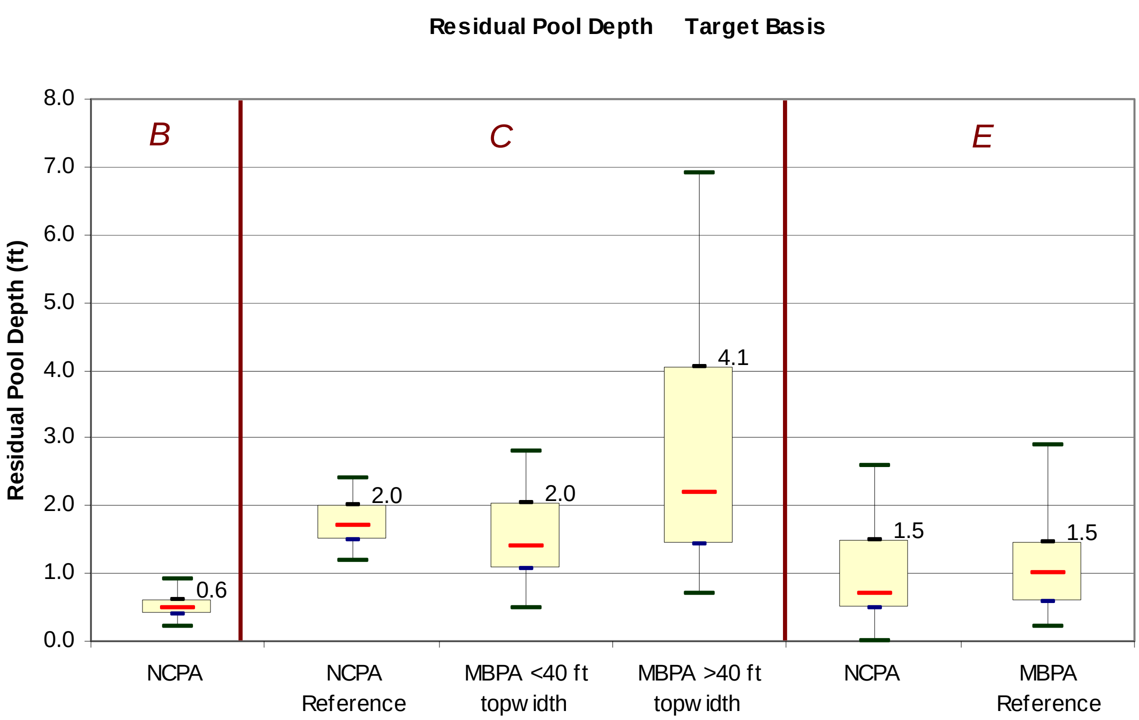

Figure D-5. Distributional Statistics for Residual Pool Depth

Width to Depth Ratio

Width to depth ratio, measured as the ratio of bankfull width to mean bankfull depth at riffle cross sections, is an important measure of overall channel form. The parameter is commonly used as a primary stream classification criteria (Rosgen, 1996) and means of site stratification. Width to depth ratios also can provide some indication of channel function, as alluvial streams that undergo significant changes in hydrology, sediment load, or bank stability will respond morphologically and thereby display altered channel cross sections. Reference data sets for width to depth ratio include the Beaverhead/Deerlodge National Forest dataset (Bengeyfield, BDNF), and internal reference reach data from the Middle Blackfoot/Nevada Creek Planning areas.

Target values for width to depth ratio consist of an optimal range for a given channel type. Although the range expresses a typical minimum value for a given channel type, departures are identified in terms of an exceedence of the maximum value of the range (excessively high width to depth ratios). In some cases, the measured width to depth ratio is lower than the expressed minimum of the range. These cases of low width to depth ratios typically reflect natural erosion resistance of bank materials. As a result, measured width to depth ratios below the minimum value do not indicate impairment with respect to aquatic life or the cold water fishery.

The targets developed for width to depth ratio are summarized in **Table D-10**. The statistics utilized to define those target values are shown in **Table D-11** and **Figure D-6**. Reference values developed for B channel types in both the Nevada Creek and Middle Blackfoot Planning Areas reflects the minimum width to depth ratio used to define the B channel type (Rosgen, 1996). The maximum, which is not defined in the channel classification, has been defined by reference B channel types in the Beaverhead/Deerlodge National Forest, as well as the 75th percentile value for all B channel assessment values in the Nevada Creek Planning Area. Data from the Middle Blackfoot Planning Area were not used to define the value as there it contains only one B channel assessment reach (Buck Creek).

Table D-10. Target Values for Width-To-Depth Ratio

Planning Area	Channel Type	W:D Reference Value Range	Basis*
Nevada Creek	B	12-16	Minimum: B type classification Maximum: Beaverhead/Deerlodge National Forest (BDNF) 75th percentile; NCPA 75th percentile
	C	12-20	Minimum: C type classification Maximum: NCPA median
	E	6-11	Minimum: E type classification, NCPA 25th percentile Maximum: E type classification, NCPA 75th percentile
Middle Blackfoot	B	12-16	Minimum: B type classification Maximum: Beaverhead/Deerlodge National Forest (BDNF) 75th percentile; NCPA 75th percentile
	C	12-19 (<40 ft topwidth) 12-29 (>40 ft topwidth)	Minimum: C type classification Maximum: MBPA median
	E	6-11	Minimum: E type classification, MBPA 25th percentile Maximum: E type classification, MBPA 75th percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

The minimum width-to-depth value for C channel types is similarly defined by the Rosgen classification scheme (Rosgen, 1996). The upper limit of appropriate width to depth ratios for C channels reflects the median measured values in each planning area. The median value was selected as the upper end target based on best professional judgment regarding the appropriate maximum width to depth ratio for the C type channels in this region. The E channel range reflects the 25th and 75th percentile values measured in each planning area, and these values correlate to the range defined by the Rosgen classification (Rosgen, 1996).

Table D-11. Summary Statistics for Width-To-Depth Ratio

	NCPA All Sites	Bengeyfield Reference	NCPA All Sites	MBPA >40 ft	MBPA <40 ft	NCPA All Sites	MBPA All Sites
Statistic*	**B**	**B**	**C**	**C**	**C**	**E**	**E**
Q1	9.5	9.0	16.4	27.0	14.9	5.8	6.4
Min	6.2	3.2	10.1	19.3	10.8	3.0	3.9
Median	10.9	12.7	20.0	28.8	18.9	7.9	9.7
Max	30.8	29.1	35.2	40.1	32.7	14.5	14.0
Q3	14.4	15.7	23.3	31.0	22.9	10.3	11.1
N	17	41	25	9	17	20	25

* Q1 = 25th percentile, Q3 = 75th percentile

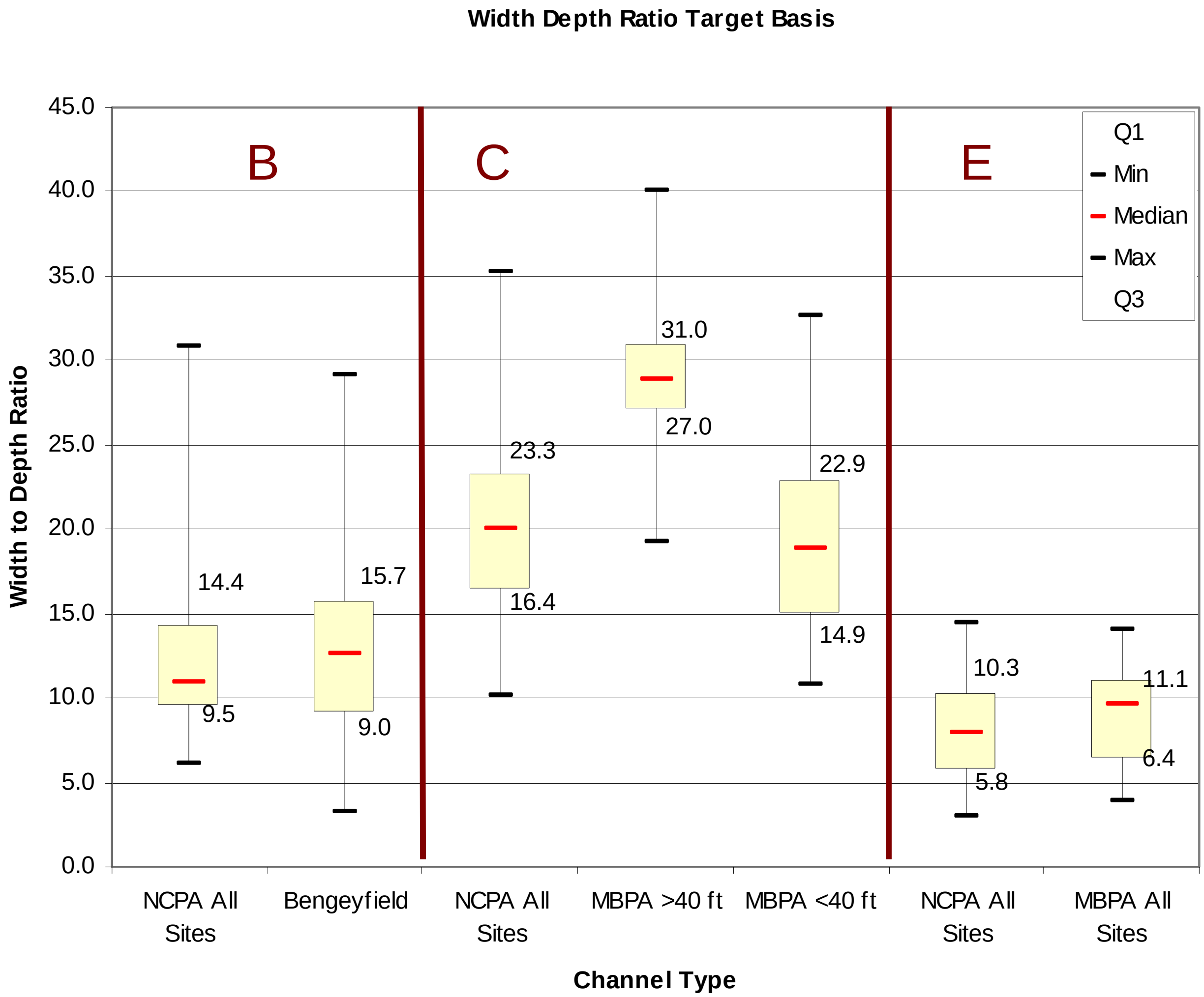

Figure D-6. Distributional Statistics for Width-To-Depth Ratio

Percent Surface Fines in Pool Tails

Target values developed for surface fines <6mm on the channel bed surface in pool tail environments provide criteria used to help define whether excess sediment loading has resulted in a siltation related cause of impairment. The targets developed for percent surface fines in pool tails are all derived from the Nevada Creek Planning Area and Middle Blackfoot Planning Area base parameter datasets. The target values are summarized in **Table D-12**. Statistics developed from the internal datasets from which the targets are derived are shown in **Table D-13** and **Figure D-7**.

In the Nevada Creek Planning Area, the target value of 17% developed for B channel types is derived from the 75th percentile value for all B channel assessment sites. This value was selected rather than the 25th percentile value as it is considered to be sufficiently low to achieve use support. For C channel types of the Nevada Creek Planning Area, assessment reaches that were identified as least impaired stratified well against all data (DTM and AGI, 2005). As such, the

75th percentile value of 23% for these least impaired streams has been adopted as the target value. For E channel types, the 25th percentile for all of the assessed sites is 82%, which reflects the high concentrations of fines in the E channels of the Nevada Creek Planning Area. Recognizing the natural tendency for fine grained accumulations in pool tailouts of E channels in the Nevada Creek Planning Area, the adopted target value for these streams is 82%.

Table D-12. Target Values for Pool Tailout Surface Fines

Planning Area	Channel Type	Target Value	Basis*
Nevada Creek	B	≤17	NCPA 75th Percentile
	C	≤23	NCPA Reference 75th Percentile
	E	≤82	NCPA 25th Percentile
Middle Blackfoot	B	≤17	NCPA 75th Percentile
	C	≤20	MBPA 75th Percentile
	E	≤48	MBPA Reference 75th Percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

In the Middle Blackfoot Planning Area, all targets are based on the 75th percentile values of data summarized by channel type. Due to a lack of B channel types in the MBPA (N=1), the target is based on Nevada Creek Planning Area sites. For C channel types, the target of 20% is the 75th percentile value for all assessment sites. As the E channel sites described as having potential reference conditions stratified favorably against the entire dataset (DTM and AGI, 2005), the reference dataset was used to define the target for E channels. These targets are appropriate for streams that are not wholly fine grained in nature and thus capable of producing relatively coarse grained pool tail environments. As field observations indicate that virtually all of the E channels in the Middle Blackfoot Planning Area have the potential for fines reductions in the pool tailouts, the targets have been applied to all E channel types in the Planning Area. It is important to monitor these substrate conditions, however, so that, if it becomes clear that the targets are unfeasible in some streams due to natural loading of fine sediment, their application can be managed adaptively.

Table D-13. Summary Statistics for Pool Tailout Surface Fines

	B	C		E	
Statistic*	NCPA	NCPA Reference	MBPA	NCPA	MBPA Reference
Q1	8%	4%	9%	82%	8%
Min	4%	0%	4%	35%	0%
Median	13%	10%	10%	98%	16%
Max	100%	86%	37%	100%	100%
Q3	17%	23%	20%	98%	48%
N	5	28	10	4	72

* Q1 = 25th percentile, Q3 = 75th percentile

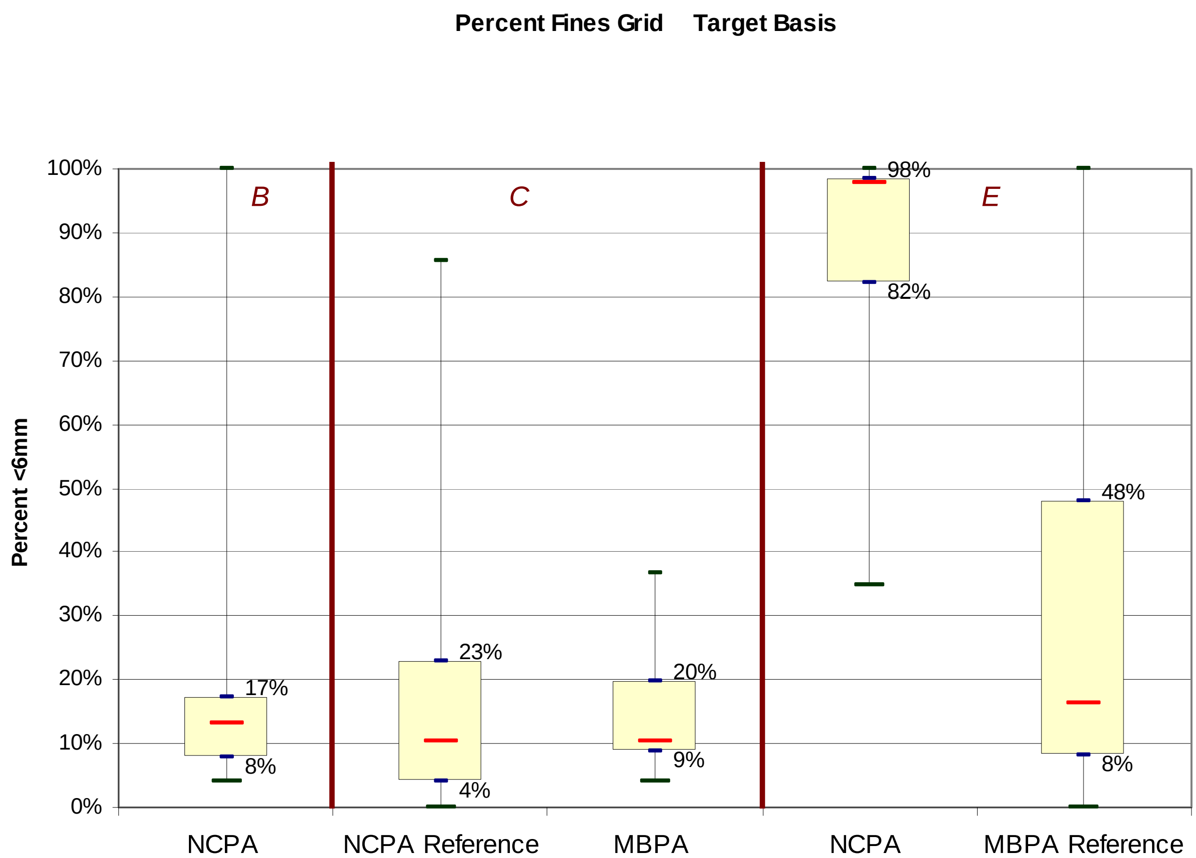

Figure D-7. Distributional Statistics for Pool Tailout Surface Fines

Macroinvertebrates

Targets developed for macroinvertebrate data reflect two macroinvertebrate assessment models described by Feldman (2006). These models are the Multimetric Indices (MMI), and the River Invertebrate Prediction and Classification System (RIVPACS). The models allow the determination of the degree of impairment based on MMI and RIVPACS scores. The range of model scores for each impairment condition is summarized in **Table D-14**.

Table D-14. Impairment Levels for the MMI and RIVPACS Macroinvertebrate Bioassessment Models

Measure	Site Classification	Unimpaired Range	Moderate Impairment Range	Severe Impairment Range
Multimetric Index (MMI)	Low Valley	≥48	38-47	≤37
	Mountain	≥63	29-62	≤28
Predictive Model Observed/Expected (RIVPACS)	N/A	≥0.8	0.44-0.79	≤0.43

Woody Vegetation Extent

The extent of woody vegetation on either channel bank is an important indicator for stream condition related to habitat in terms of cover, shade, and woody debris recruitment. Woody vegetation also adds to bank stability, and can thereby reduce sediment loading to streams. The targets developed for extent of bankline woody vegetation are all based on the base parameter datasets (**Table D-15**). These values reflect the 75th percentile (Q3) for each stream type (**Table D-16; Figure D-8**). The target values range from 61% on C channel types in the Nevada Creek Planning Area to 88% on B channel types for both planning areas. This 88% value for B channel types is derived solely from the Nevada Creek Planning Area dataset due to presence of only one B channel type in the listed stream segments of the Middle Blackfoot Planning Area.

Table D-15. Target Values for Bankline Woody Vegetation Extent

Planning Area	Channel Type	Target Value	Basis*
Nevada Creek	B	>88 %	NCPA 75th Percentile
	C	>61%	NCPA 75th Percentile
	E	>74%	NCPA 75th Percentile
Middle Blackfoot	B	>88 %	NCPA 75th Percentile
	C	>84%	MBPA 75th Percentile
	E	>69%	MBPA 75th Percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

Table D-16. Summary Statistics for Bankline Woody Vegetation Extent

	B	***C***		***E***	
Statistic*	**NCPA**	**NCPA**	**MBPA**	**NCPA**	**MBPA**
Q1	41%	31%	39%	45%	7%
Min	15%	0%	9%	29%	0%
Median	80%	46%	69%	55%	50%
Max	100%	70%	100%	89%	99%
Q3	88%	61%	84%	74%	69%
N	7	9	11	10	3

* Q1 = 25th percentile, Q3 = 75th percentile

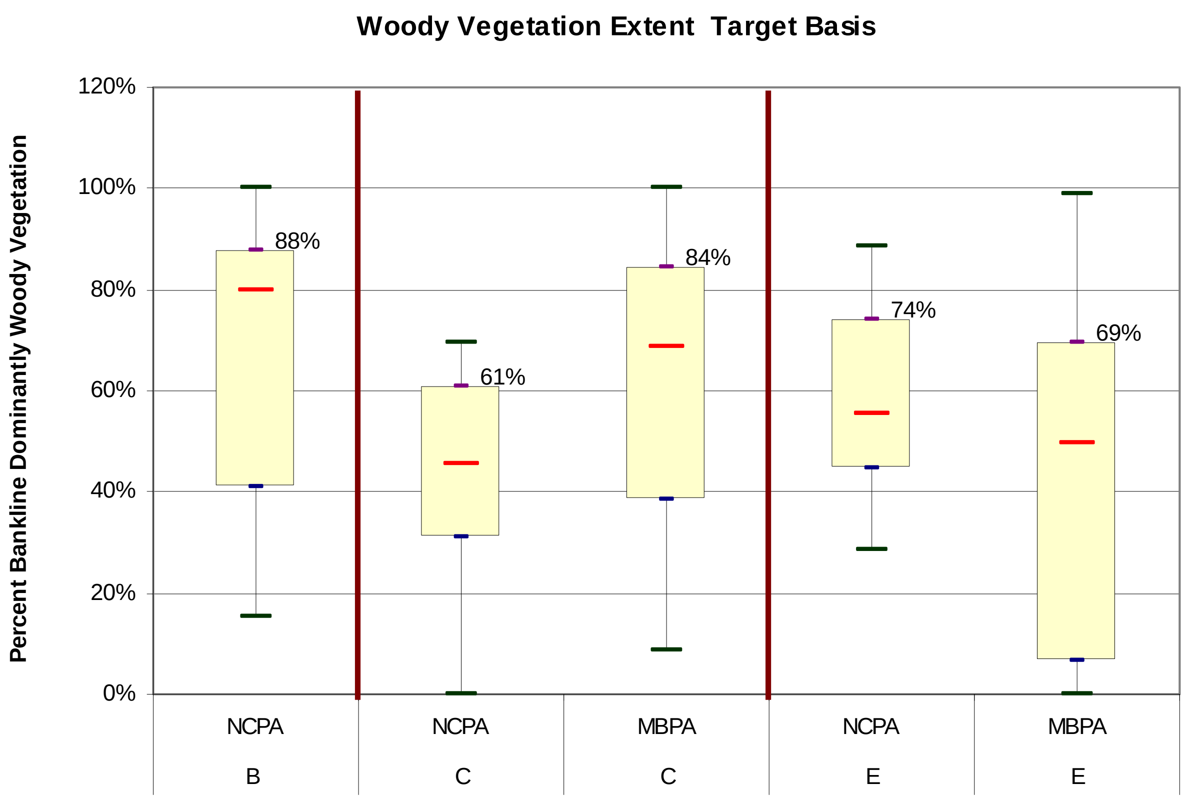

Figure D-8. Distributional Statistics for Bankline Woody Vegetation Extent

Entrenchment Ratio

Entrenchment ratio targets are applied to channels for which entrenchment is identified as a negative alteration of the natural channel form. An entrenched condition on open valley stream types reflects a loss in floodplain access. This may occur from channel incision below the active floodplain or potentially from channel widening and consequent reduction in mean channel depth. Entrenched channels classified as F or G channel types have an entrenchment target of >2.2, which defines the classification boundary between entrenched and unentrenched streams in the Rosgen classification scheme (Rosgen, 1996).

Pool Extent

The pool extent parameter refers to the percent of total channel length that is comprised of mapped pools units. This measure is linear, and does not reflect pool width or overall volume. However, it is a general indicator of overall channel complexity and extent of pool habitat area. Pool extent targets are based upon the 75th percentile values derived from the base parameter assessment data for the Nevada Creek and Middle Blackfoot planning areas (**Table D-17**). A summary of the internal data set statistics used to develop the targets is shown in **Table D-18** and **Figure D-9**. The pool extent target of ≥10% for B channel types reflects the Nevada Creek planning area reference B channel type compilation; this target has been applied to both planning areas due to an insufficiency in data from the Middle Blackfoot Planning Area. For C channels, the 75th percentile value of 35% pool extent for all sites is derived from both planning area datasets. The 75th percentile value for pool extent in NCPA streams is 29%, which is somewhat higher than the 19% value derived for the MBPA E reference channel types.

Table D-17. Target Values for Pool Extent

Planning Area	Channel Type	Target Value	Basis*
Nevada Creek	B	≥10	NCPA Reference 75th Percentile
	C	≥35	NCPA 75th Percentile; MBPA 75th Percentile
	E	≥29	NCPA 75th Percentile
Middle Blackfoot	B	≥10	NCPA Reference 75th Percentile
	C	≥35	NCPA 75th Percentile; MBPA 75th Percentile
	E	≥19	MBPA 75th Percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

Table D-18. Summary Statistics for Bankline Woody Vegetation Extent

	B	**C**		**E**	
Statistic*	**NCPA Reference**	**NCPA**	**MBPA**	**NCPA**	**MBPA Reference**
Q1	5%	1%	11%	7%	8%
Min	3%	0%	8%	2%	0%
Median	7%	24%	24%	15%	12%
Max	14%	72%	37%	59%	38%
Q3	11%	34%	35%	29%	19%
n	3	9	10	8	4

* Q1 = 25th percentile, Q3 = 75th percentile

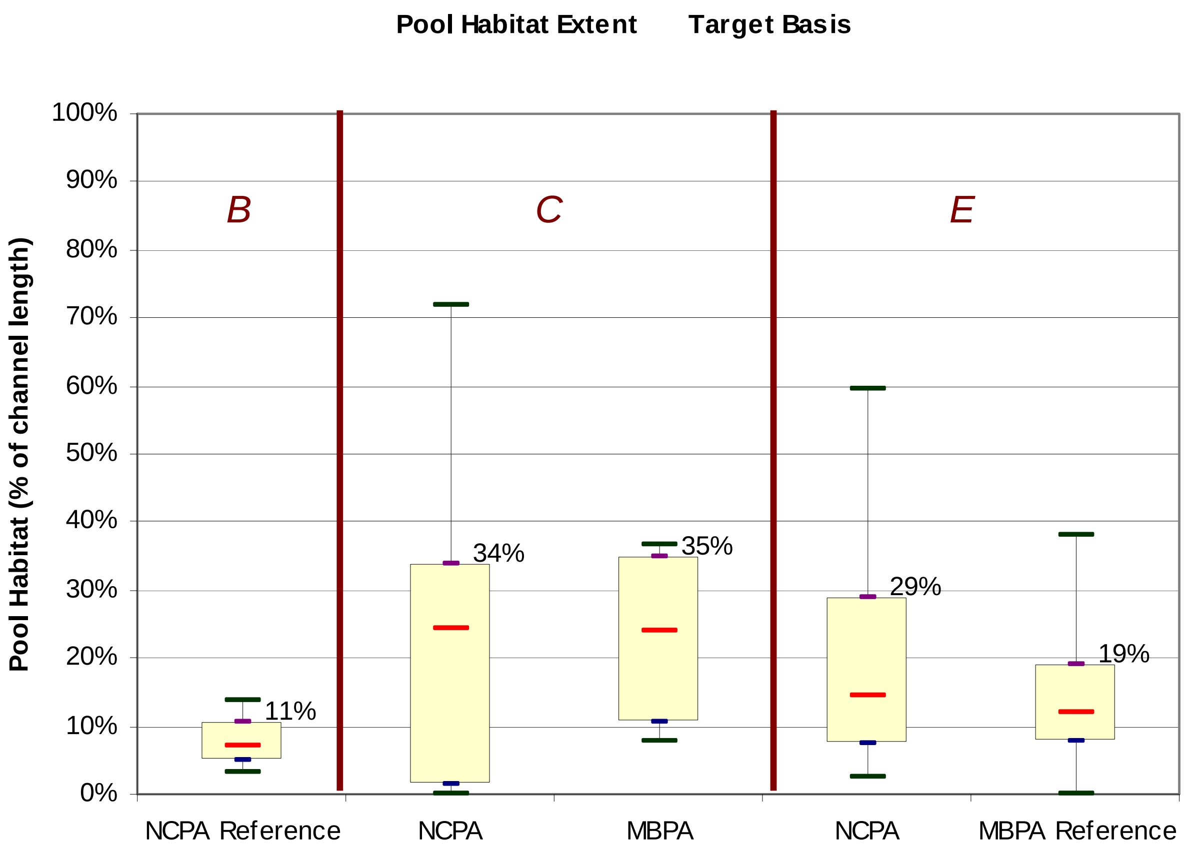

Figure D-9. Distributional Statistics for Pool Extent

Woody Debris Aggregate Extent

The percent of total channel length occupied by woody debris aggregates is a general indicator of channel complexity. The targets developed for this parameter all reflect 75th percentile values for the base parameter data (**Table D-19**). These targets are all less than 15% total channel length, reflecting the limited extent of woody debris aggregates in assessed reaches in both planning areas (**Table D-20; Figure D-10**).

Table D-19. Target Values for Woody Debris Aggregate Extent

Planning Area	Channel Type	Target Value	Data Source
Nevada Creek	B	>3 %	NCPA 75th Percentile
	C	>7%	NCPA 75th Percentile
	E	>12%	MBPA Reference 75th Percentile
Middle Blackfoot	B	>4 %	MBPA 75th Percentile
	C	>8%	MBPA 75th Percentile
	E	>12%	MBPA Reference 75th Percentile

* NCPA: Nevada Creek Planning Area, MBPA: Middle Blackfoot Planning Area

Table D-20. Summary Statistics for Woody Debris Aggregate Extent

Percent Jam Length				
	B	**C**		**E**
Statistic*	***NCPA***	***NCPA***	***MBPA***	***MBPA***
Q1	2.1%	0.0%	2.4%	0.5%
Min	0.6%	0.0%	0.0%	0.0%
Median	2.8%	1.4%	4.8%	2.5%
Max	4.4%	18.1%	29.4%	35.0%
Q3	3.2%	7.0%	8.4%	12.0%
n	6	9	10	4

* Q1 = 25th percentile, Q3 = 75th percentile

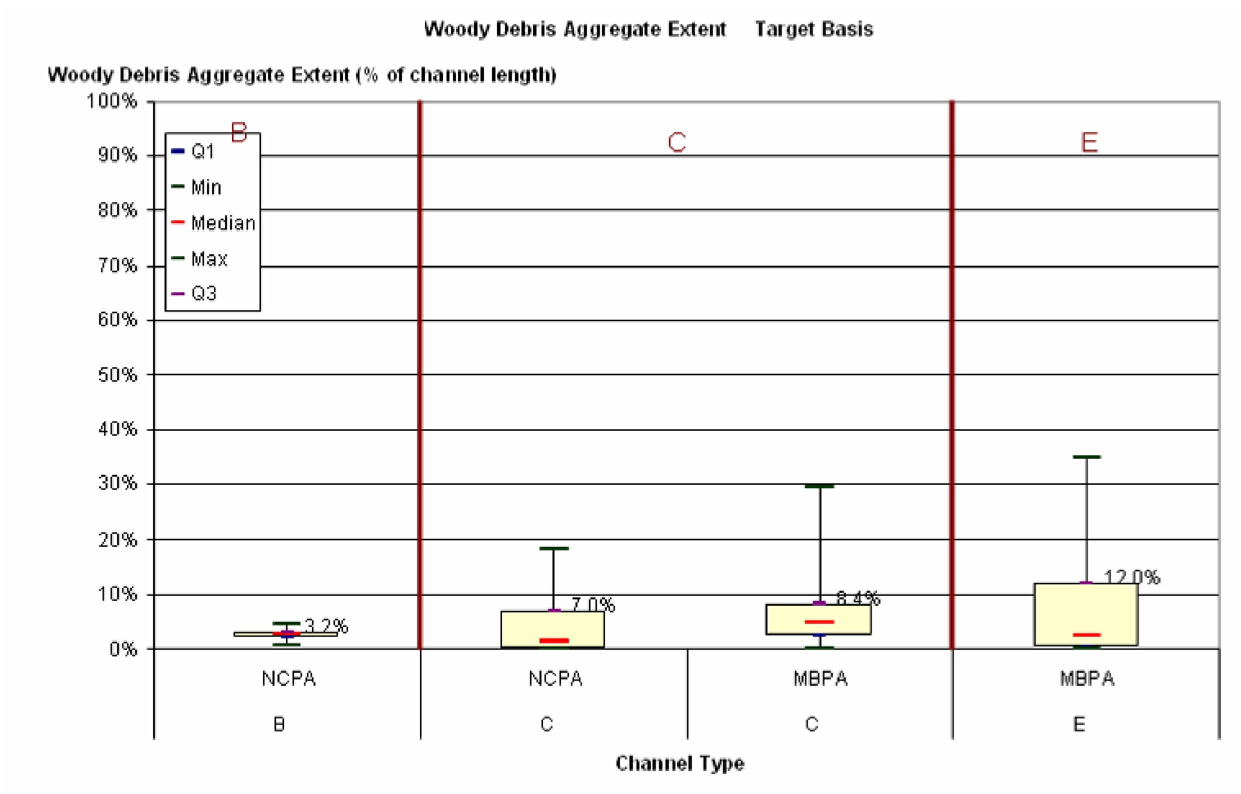

Figure D-10. Distributional Statistics for Woody Debris Aggregate Extent

APPENDIX E
EXAMPLE OF DAILY SEDIMENT TMDLS, UPPER NEVADA CREEK

As described in **Section 9.1.8**, a current annual sediment load of 3,501 tons per year was estimated for upper Nevada Creek. This value is the sum of 1,826 tons from hillslope erosion 1,635 tons from bank erosion, 29 tons from road surface erosion, and 11 tons from culvert failure. **Figure E-1** below illustrates the current and total maximum daily sediment loading for upper Nevada Creek.

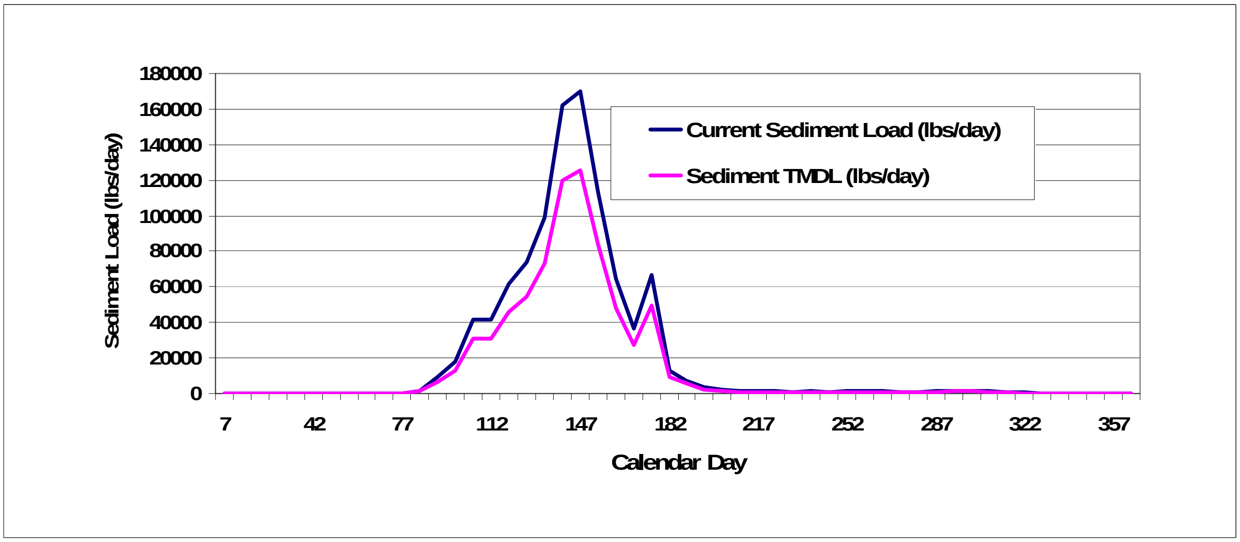

Figure E-1. Current and Maximum Daily Sediment Loading For Upper Nevada Creek

The sediment TMDL for upper Nevada Creek is 26% annual reduction in loading. The reduction is allocated to each of five land use categories in upper Nevada Creek as specified in **Table 9-7**. To satisfy the requirement for daily loads and allocations, the reduction in sediment loading needed each day is calculated for each of the five land use categories according to the values in **Table 9-7** for upper Nevada Creek. **Table E-1** below contains the daily sediment load reductions allocated to each land use category. **Table E-1** serves as an example of daily load reductions allocated to land uses. Daily sediment reduction allocations for other sediment impaired streams and land uses can be produced in a similar fashion. The upper Nevada Creek example is used here to demonstrate the daily allocation process while saving the material costs required for such a table for each of the remaining 30 sediment impaired streams.

Table E-2 contains example TMDLs and land use allocations for the remaining 30 sediment impaired stream segments. For each segment the TMDLs and allocations are given for mid-winter, peak runoff, and mid-summer dates.

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
1	107	27.87	11.98	15.05	0.56	0.14	0.06
2	106	27.46	11.81	14.83	0.55	0.14	0.06
3	104	27.09	11.65	14.63	0.54	0.14	0.06
4	102	26.63	11.45	14.38	0.53	0.13	0.06
5	101	26.15	11.24	14.12	0.52	0.13	0.06
6	106	27.64	11.88	14.92	0.55	0.14	0.06
7	105	27.18	11.69	14.68	0.54	0.14	0.06
8	103	26.75	11.50	14.44	0.53	0.13	0.06
9	102	26.46	11.38	14.29	0.53	0.13	0.06
10	100	25.92	11.15	14.00	0.52	0.13	0.06
11	98	25.50	10.97	13.77	0.51	0.13	0.05
12	96	25.05	10.77	13.53	0.50	0.13	0.05
13	95	24.63	10.59	13.30	0.49	0.12	0.05
14	93	24.19	10.40	13.06	0.48	0.12	0.05
15	92	24.02	10.33	12.97	0.48	0.12	0.05
16	91	23.62	10.16	12.76	0.47	0.12	0.05
17	89	23.23	9.99	12.55	0.46	0.12	0.05
18	88	22.89	9.84	12.36	0.46	0.11	0.05
19	87	22.53	9.69	12.17	0.45	0.11	0.05
20	101	26.28	11.30	14.19	0.53	0.13	0.06
21	100	25.89	11.13	13.98	0.52	0.13	0.06
22	98	25.47	10.95	13.75	0.51	0.13	0.05
23	97	25.10	10.79	13.55	0.50	0.13	0.05
24	95	24.73	10.63	13.35	0.49	0.12	0.05
25	101	26.25	11.29	14.18	0.53	0.13	0.06
26	103	26.66	11.46	14.40	0.53	0.13	0.06
27	100	26.02	11.19	14.05	0.52	0.13	0.06
28	98	25.36	10.90	13.69	0.51	0.13	0.05
29	95	24.80	10.66	13.39	0.50	0.12	0.05
30	94	24.53	10.55	13.24	0.49	0.12	0.05
31	94	24.37	10.48	13.16	0.49	0.12	0.05
32	93	24.13	10.38	13.03	0.48	0.12	0.05
33	90	23.50	10.10	12.69	0.47	0.12	0.05
34	88	22.98	9.88	12.41	0.46	0.11	0.05
35	87	22.60	9.72	12.20	0.45	0.11	0.05
36	85	22.19	9.54	11.98	0.44	0.11	0.05
37	84	21.90	9.42	11.82	0.44	0.11	0.05
38	83	21.53	9.26	11.63	0.43	0.11	0.05
39	83	21.52	9.25	11.62	0.43	0.11	0.05
40	82	21.43	9.22	11.57	0.43	0.11	0.05
41	80	20.79	8.94	11.23	0.42	0.10	0.04

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
42	86	22.33	9.60	12.06	0.45	0.11	0.05
43	84	21.92	9.43	11.84	0.44	0.11	0.05
44	83	21.59	9.28	11.66	0.43	0.11	0.05
45	82	21.24	9.13	11.47	0.42	0.11	0.05
46	80	20.91	8.99	11.29	0.42	0.10	0.04
47	79	20.58	8.85	11.11	0.41	0.10	0.04
48	78	20.29	8.73	10.96	0.41	0.10	0.04
49	77	19.97	8.59	10.78	0.40	0.10	0.04
50	76	19.67	8.46	10.62	0.39	0.10	0.04
51	75	19.40	8.34	10.48	0.39	0.10	0.04
52	73	19.09	8.21	10.31	0.38	0.10	0.04
53	72	18.60	8.00	10.04	0.37	0.09	0.04
54	75	19.52	8.39	10.54	0.39	0.10	0.04
55	77	19.98	8.59	10.79	0.40	0.10	0.04
56	68	17.81	7.66	9.62	0.36	0.09	0.04
57	75	19.60	8.43	10.59	0.39	0.10	0.04
58	78	20.19	8.68	10.90	0.40	0.10	0.04
59	80	20.76	8.93	11.21	0.42	0.10	0.04
60	70	18.22	7.83	9.84	0.36	0.09	0.04
61	66	17.13	7.37	9.25	0.34	0.09	0.04
62	64	16.77	7.21	9.05	0.34	0.08	0.04
63	70	18.29	7.86	9.88	0.37	0.09	0.04
64	69	17.84	7.67	9.64	0.36	0.09	0.04
65	75	19.49	8.38	10.52	0.39	0.10	0.04
66	74	19.23	8.27	10.39	0.38	0.10	0.04
67	73	19.04	8.19	10.28	0.38	0.10	0.04
68	72	18.79	8.08	10.14	0.38	0.09	0.04
69	71	18.40	7.91	9.94	0.37	0.09	0.04
70	73	19.00	8.17	10.26	0.38	0.09	0.04
71	72	18.83	8.10	10.17	0.38	0.09	0.04
72	69	17.98	7.73	9.71	0.36	0.09	0.04
73	71	18.45	7.93	9.96	0.37	0.09	0.04
74	68	17.78	7.64	9.60	0.36	0.09	0.04
75	69	17.95	7.72	9.69	0.36	0.09	0.04
76	71	18.46	7.94	9.97	0.37	0.09	0.04
77	72	18.62	8.01	10.06	0.37	0.09	0.04
78	85	21.98	9.45	11.87	0.44	0.11	0.05
79	84	21.86	9.40	11.80	0.44	0.11	0.05
80	91	23.79	10.23	12.84	0.48	0.12	0.05
81	1114	289.73	124.58	156.45	5.79	1.45	0.62
82	6631	1723.98	741.31	930.95	34.48	8.62	3.71
83	1591	413.67	177.88	223.38	8.27	2.07	0.89

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
84	1665	433.01	186.19	233.82	8.66	2.17	0.93
85	6424	1670.37	718.26	902.00	33.41	8.35	3.59
86	1832	476.35	204.83	257.23	9.53	2.38	1.02
87	2775	721.61	310.29	389.67	14.43	3.61	1.55
88	1179	306.64	131.85	165.58	6.13	1.53	0.66
89	631	164.03	70.53	88.58	3.28	0.82	0.35
90	9242	2403.04	1033.31	1297.64	48.06	12.02	5.17
91	41028	10667.32	4586.95	5760.35	213.35	53.34	22.93
92	64524	16776.14	7213.74	9059.12	335.52	83.88	36.07
93	13709	3564.32	1532.66	1924.73	71.29	17.82	7.66
94	6261	1627.90	700.00	879.07	32.56	8.14	3.50
95	4236	1101.44	473.62	594.78	22.03	5.51	2.37
96	4024	1046.15	449.84	564.92	20.92	5.23	2.25
97	3993	1038.05	446.36	560.55	20.76	5.19	2.23
98	26939	7004.19	3011.80	3782.27	140.08	35.02	15.06
99	14015	3644.00	1566.92	1967.76	72.88	18.22	7.83
100	14568	3787.58	1628.66	2045.29	75.75	18.94	8.14
101	27645	7187.72	3090.72	3881.37	143.75	35.94	15.45
102	34060	8855.63	3807.92	4782.04	177.11	44.28	19.04
103	70290	18275.27	7858.37	9868.65	365.51	91.38	39.29
104	98883	25709.60	11055.13	13883.18	514.19	128.55	55.28
105	30913	8037.31	3456.04	4340.15	160.75	40.19	17.28
106	21889	5691.02	2447.14	3073.15	113.82	28.46	12.24
107	17721	4607.52	1981.23	2488.06	92.15	23.04	9.91
108	30005	7801.42	3354.61	4212.77	156.03	39.01	16.77
109	39638	10305.81	4431.50	5565.14	206.12	51.53	22.16
110	31690	8239.45	3542.96	4449.30	164.79	41.20	17.71
111	33318	8662.72	3724.97	4677.87	173.25	43.31	18.62
112	118414	30787.62	13238.68	16625.32	615.75	153.94	66.19
113	96785	25164.18	10820.60	13588.66	503.28	125.82	54.10
114	50824	13214.31	5682.15	7135.73	264.29	66.07	28.41
115	40629	10563.57	4542.33	5704.33	211.27	52.82	22.71
116	32258	8387.13	3606.46	4529.05	167.74	41.94	18.03
117	71250	18524.98	7965.74	10003.49	370.50	92.62	39.83
118	102533	26658.49	11463.15	14395.58	533.17	133.29	57.32
119	38278	9952.22	4279.45	5374.20	199.04	49.76	21.40
120	32200	8372.06	3599.99	4520.91	167.44	41.86	18.00
121	168075	43699.60	18790.83	23597.78	873.99	218.50	93.95
122	59491	15467.53	6651.04	8352.47	309.35	77.34	33.26
123	62946	16366.02	7037.39	8837.65	327.32	81.83	35.19
124	65624	17062.33	7336.80	9213.66	341.25	85.31	36.68
125	58173	15125.08	6503.79	8167.54	302.50	75.63	32.52

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

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126	72427	18831.05	8097.35	10168.77	376.62	94.16	40.49
127	52640	13686.41	5885.16	7390.66	273.73	68.43	29.43
128	62917	16358.34	7034.09	8833.50	327.17	81.79	35.17
129	71173	18504.89	7957.10	9992.64	370.10	92.52	39.79
130	91725	23848.60	10254.90	12878.25	476.97	119.24	51.27
131	90164	23442.55	10080.30	12658.98	468.85	117.21	50.40
132	97566	25367.14	10907.87	13698.26	507.34	126.84	54.54
133	224481	58365.13	25097.01	31517.17	1167.30	291.83	125.49
134	204006	53041.67	22807.92	28642.50	1060.83	265.21	114.04
135	146198	38011.40	16344.90	20526.16	760.23	190.06	81.72
136	150236	39061.25	16796.34	21093.08	781.23	195.31	83.98
137	161461	41979.92	18051.37	22669.16	839.60	209.90	90.26
138	135365	35194.93	15133.82	19005.26	703.90	175.97	75.67
139	112805	29329.28	12611.59	15837.81	586.59	146.65	63.06
140	110214	28655.64	12321.92	15474.04	573.11	143.28	61.61
141	155020	40305.27	17331.27	21764.85	806.11	201.53	86.66
142	211202	54912.48	23612.37	29652.74	1098.25	274.56	118.06
143	161467	41981.45	18052.02	22669.98	839.63	209.91	90.26
144	217446	56536.04	24310.50	30529.46	1130.72	282.68	121.55
145	190344	49489.50	21280.48	26724.33	989.79	247.45	106.40
146	141638	36825.95	15835.16	19886.01	736.52	184.13	79.18
147	122648	31888.54	13712.07	17219.81	637.77	159.44	68.56
148	116764	30358.56	13054.18	16393.63	607.17	151.79	65.27
149	124800	32447.96	13952.62	17521.90	648.96	162.24	69.76
150	115111	29928.75	12869.36	16161.52	598.57	149.64	64.35
151	115049	29912.65	12862.44	16152.83	598.25	149.56	64.31
152	97194	25270.39	10866.27	13646.01	505.41	126.35	54.33
153	90979	23654.41	10171.40	12773.38	473.09	118.27	50.86
154	130891	34031.59	14633.58	18377.06	680.63	170.16	73.17
155	85909	22336.21	9604.57	12061.56	446.72	111.68	48.02
156	79545	20681.79	8893.17	11168.17	413.64	103.41	44.47
157	70573	18348.97	7890.06	9908.44	366.98	91.74	39.45
158	60216	15656.25	6732.19	8454.38	313.13	78.28	33.66
159	54143	14077.29	6053.24	7601.74	281.55	70.39	30.27
160	51973	13513.07	5810.62	7297.06	270.26	67.57	29.05
161	48914	12717.58	5468.56	6867.49	254.35	63.59	27.34
162	38971	10132.35	4356.91	5471.47	202.65	50.66	21.78
163	40383	10499.70	4514.87	5669.84	209.99	52.50	22.57
164	39481	10265.02	4413.96	5543.11	205.30	51.33	22.07
165	38234	9940.84	4274.56	5368.05	198.82	49.70	21.37
166	34976	9093.73	3910.30	4910.61	181.87	45.47	19.55
167	37020	9625.16	4138.82	5197.58	192.50	48.13	20.69

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
168	31561	8205.89	3528.53	4431.18	164.12	41.03	17.64
169	33945	8825.78	3795.08	4765.92	176.52	44.13	18.98
170	198463	51600.36	22188.15	27864.19	1032.01	258.00	110.94
171	94942	24684.90	10614.51	13329.85	493.70	123.42	53.07
172	50929	13241.46	5693.83	7150.39	264.83	66.21	28.47
173	39051	10153.27	4365.90	5482.76	203.07	50.77	21.83
174	32853	8541.67	3672.92	4612.50	170.83	42.71	18.36
175	26815	6971.88	2997.91	3764.82	139.44	34.86	14.99
176	22993	5978.21	2570.63	3228.24	119.56	29.89	12.85
177	19170	4984.11	2143.17	2691.42	99.68	24.92	10.72
178	18544	4821.37	2073.19	2603.54	96.43	24.11	10.37
179	15763	4098.34	1762.28	2213.10	81.97	20.49	8.81
180	13554	3523.96	1515.30	1902.94	70.48	17.62	7.58
181	11645	3027.69	1301.91	1634.95	60.55	15.14	6.51
182	10063	2616.36	1125.03	1412.83	52.33	13.08	5.63
183	9293	2416.27	1038.99	1304.78	48.33	12.08	5.19
184	11733	3050.49	1311.71	1647.26	61.01	15.25	6.56
185	10912	2837.01	1219.91	1531.99	56.74	14.19	6.10
186	9428	2451.17	1054.00	1323.63	49.02	12.26	5.27
187	7946	2065.95	888.36	1115.61	41.32	10.33	4.44
188	7435	1932.99	831.19	1043.82	38.66	9.66	4.16
189	5748	1494.57	642.67	807.07	29.89	7.47	3.21
190	5362	1394.12	599.47	752.83	27.88	6.97	3.00
191	4931	1282.09	551.30	692.33	25.64	6.41	2.76
192	4472	1162.65	499.94	627.83	23.25	5.81	2.50
193	3845	999.58	429.82	539.77	19.99	5.00	2.15
194	3477	904.02	388.73	488.17	18.08	4.52	1.94
195	2918	758.80	326.28	409.75	15.18	3.79	1.63
196	3170	824.25	354.43	445.09	16.48	4.12	1.77
197	2896	752.91	323.75	406.57	15.06	3.76	1.62
198	2700	701.90	301.82	379.03	14.04	3.51	1.51
199	2268	589.77	253.60	318.48	11.80	2.95	1.27
200	2467	641.34	275.78	346.32	12.83	3.21	1.38
201	2194	570.37	245.26	308.00	11.41	2.85	1.23
202	2010	522.54	224.69	282.17	10.45	2.61	1.12
203	1860	483.65	207.97	261.17	9.67	2.42	1.04
204	1952	507.46	218.21	274.03	10.15	2.54	1.09
205	1733	450.49	193.71	243.27	9.01	2.25	0.97
206	1476	383.71	164.99	207.20	7.67	1.92	0.82
207	1450	376.99	162.10	203.57	7.54	1.88	0.81
208	1320	343.15	147.55	185.30	6.86	1.72	0.74
209	1420	369.11	158.72	199.32	7.38	1.85	0.79

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
210	1201	312.22	134.25	168.60	6.24	1.56	0.67
211	1198	311.40	133.90	168.16	6.23	1.56	0.67
212	1231	320.13	137.65	172.87	6.40	1.60	0.69
213	1199	311.61	133.99	168.27	6.23	1.56	0.67
214	1228	319.21	137.26	172.37	6.38	1.60	0.69
215	1254	326.09	140.22	176.09	6.52	1.63	0.70
216	1187	308.52	132.66	166.60	6.17	1.54	0.66
217	1264	328.72	141.35	177.51	6.57	1.64	0.71
218	1189	309.12	132.92	166.92	6.18	1.55	0.66
219	1377	358.09	153.98	193.37	7.16	1.79	0.77
220	1483	385.68	165.84	208.27	7.71	1.93	0.83
221	1391	361.66	155.51	195.30	7.23	1.81	0.78
222	1286	334.46	143.82	180.61	6.69	1.67	0.72
223	1149	298.64	128.42	161.27	5.97	1.49	0.64
224	1614	419.52	180.39	226.54	8.39	2.10	0.90
225	1311	340.79	146.54	184.03	6.82	1.70	0.73
226	1150	298.94	128.55	161.43	5.98	1.49	0.64
227	1050	272.91	117.35	147.37	5.46	1.36	0.59
228	957	248.72	106.95	134.31	4.97	1.24	0.53
229	1037	269.54	115.90	145.55	5.39	1.35	0.58
230	927	241.15	103.69	130.22	4.82	1.21	0.52
231	905	235.24	101.15	127.03	4.70	1.18	0.51
232	864	224.56	96.56	121.26	4.49	1.12	0.48
233	842	218.86	94.11	118.19	4.38	1.09	0.47
234	870	226.30	97.31	122.20	4.53	1.13	0.49
235	1304	339.01	145.77	183.07	6.78	1.70	0.73
236	1490	387.37	166.57	209.18	7.75	1.94	0.83
237	1557	404.89	174.10	218.64	8.10	2.02	0.87
238	1491	387.64	166.68	209.32	7.75	1.94	0.83
239	1312	341.25	146.74	184.27	6.82	1.71	0.73
240	1301	338.29	145.47	182.68	6.77	1.69	0.73
241	1132	294.40	126.59	158.97	5.89	1.47	0.63
242	1152	299.48	128.77	161.72	5.99	1.50	0.64
243	1052	273.40	117.56	147.64	5.47	1.37	0.59
244	1014	263.54	113.32	142.31	5.27	1.32	0.57
245	953	247.79	106.55	133.80	4.96	1.24	0.53
246	952	247.52	106.43	133.66	4.95	1.24	0.53
247	981	255.02	109.66	137.71	5.10	1.28	0.55
248	1147	298.12	128.19	160.98	5.96	1.49	0.64
249	1374	357.29	153.63	192.94	7.15	1.79	0.77
250	1443	375.19	161.33	202.60	7.50	1.88	0.81
251	1443	375.25	161.36	202.64	7.51	1.88	0.81

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
252	1336	347.31	149.34	187.55	6.95	1.74	0.75
253	1284	333.74	143.51	180.22	6.67	1.67	0.72
254	1391	361.68	155.52	195.31	7.23	1.81	0.78
255	1573	408.86	175.81	220.79	8.18	2.04	0.88
256	1669	433.87	186.56	234.29	8.68	2.17	0.93
257	1561	405.77	174.48	219.12	8.12	2.03	0.87
258	1377	358.09	153.98	193.37	7.16	1.79	0.77
259	1384	359.88	154.75	194.34	7.20	1.80	0.77
260	1286	334.31	143.75	180.53	6.69	1.67	0.72
261	1249	324.75	139.64	175.36	6.49	1.62	0.70
262	1229	319.66	137.45	172.62	6.39	1.60	0.69
263	1465	380.92	163.80	205.70	7.62	1.90	0.82
264	1518	394.66	169.70	213.12	7.89	1.97	0.85
265	1404	365.16	157.02	197.19	7.30	1.83	0.79
266	1302	338.54	145.57	182.81	6.77	1.69	0.73
267	1105	287.33	123.55	155.16	5.75	1.44	0.62
268	1017	264.44	113.71	142.80	5.29	1.32	0.57
269	1065	276.88	119.06	149.52	5.54	1.38	0.60
270	963	250.45	107.69	135.24	5.01	1.25	0.54
271	978	254.33	109.36	137.34	5.09	1.27	0.55
272	920	239.24	102.87	129.19	4.78	1.20	0.51
273	807	209.79	90.21	113.28	4.20	1.05	0.45
274	1300	338.02	145.35	182.53	6.76	1.69	0.73
275	1376	357.78	153.85	193.20	7.16	1.79	0.77
276	1337	347.61	149.47	187.71	6.95	1.74	0.75
277	1227	319.07	137.20	172.30	6.38	1.60	0.69
278	1056	274.59	118.08	148.28	5.49	1.37	0.59
279	987	256.71	110.39	138.62	5.13	1.28	0.55
280	961	249.79	107.41	134.89	5.00	1.25	0.54
281	874	227.37	97.77	122.78	4.55	1.14	0.49
282	877	228.05	98.06	123.15	4.56	1.14	0.49
283	811	210.93	90.70	113.90	4.22	1.05	0.45
284	920	239.13	102.83	129.13	4.78	1.20	0.51
285	1127	293.13	126.05	158.29	5.86	1.47	0.63
286	1495	388.68	167.13	209.89	7.77	1.94	0.84
287	1612	419.17	180.24	226.35	8.38	2.10	0.90
288	1472	382.68	164.55	206.65	7.65	1.91	0.82
289	1668	433.72	186.50	234.21	8.67	2.17	0.93
290	1622	421.71	181.33	227.72	8.43	2.11	0.91
291	1530	397.74	171.03	214.78	7.95	1.99	0.86
292	1655	430.42	185.08	232.43	8.61	2.15	0.93
293	1582	411.19	176.81	222.04	8.22	2.06	0.88

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
294	1611	418.82	180.09	226.16	8.38	2.09	0.90
295	1789	465.12	200.00	251.17	9.30	2.33	1.00
296	1645	427.78	183.95	231.00	8.56	2.14	0.92
297	1381	359.15	154.44	193.94	7.18	1.80	0.77
298	1399	363.87	156.46	196.49	7.28	1.82	0.78
299	1268	329.63	141.74	178.00	6.59	1.65	0.71
300	1244	323.50	139.11	174.69	6.47	1.62	0.70
301	1613	419.33	180.31	226.44	8.39	2.10	0.90
302	1781	463.14	199.15	250.09	9.26	2.32	1.00
303	1850	480.94	206.80	259.71	9.62	2.40	1.03
304	1909	496.35	213.43	268.03	9.93	2.48	1.07
305	1555	404.38	173.88	218.36	8.09	2.02	0.87
306	1424	370.18	159.18	199.90	7.40	1.85	0.80
307	1321	343.42	147.67	185.45	6.87	1.72	0.74
308	1216	316.08	135.91	170.68	6.32	1.58	0.68
309	997	259.28	111.49	140.01	5.19	1.30	0.56
310	1060	275.48	118.46	148.76	5.51	1.38	0.59
311	918	238.63	102.61	128.86	4.77	1.19	0.51
312	831	216.02	92.89	116.65	4.32	1.08	0.46
313	707	183.69	78.99	99.19	3.67	0.92	0.39
314	714	185.74	79.87	100.30	3.71	0.93	0.40
315	655	170.23	73.20	91.93	3.40	0.85	0.37
316	587	152.64	65.64	82.43	3.05	0.76	0.33
317	508	132.05	56.78	71.31	2.64	0.66	0.28
318	474	123.11	52.94	66.48	2.46	0.62	0.26
319	456	118.66	51.02	64.07	2.37	0.59	0.26
320	420	109.24	46.97	58.99	2.18	0.55	0.23
321	407	105.71	45.46	57.08	2.11	0.53	0.23
322	366	95.27	40.96	51.44	1.91	0.48	0.20
323	330	85.78	36.88	46.32	1.72	0.43	0.18
324	300	77.94	33.51	42.09	1.56	0.39	0.17
325	301	78.35	33.69	42.31	1.57	0.39	0.17
326	282	73.20	31.48	39.53	1.46	0.37	0.16
327	322	83.76	36.01	45.23	1.68	0.42	0.18
328	372	96.60	41.54	52.16	1.93	0.48	0.21
329	318	82.63	35.53	44.62	1.65	0.41	0.18
330	305	79.37	34.13	42.86	1.59	0.40	0.17
331	269	69.95	30.08	37.77	1.40	0.35	0.15
332	271	70.49	30.31	38.07	1.41	0.35	0.15
333	248	64.40	27.69	34.78	1.29	0.32	0.14
334	230	59.74	25.69	32.26	1.19	0.30	0.13
335	215	56.01	24.08	30.25	1.12	0.28	0.12

Table E-1. Daily Allocation of Sediment Load Reductions for Upper Nevada Creek by Land Use Categories

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Placer Mining (lbs/day)
336	204	52.91	22.75	28.57	1.06	0.26	0.11
337	193	50.23	21.60	27.12	1.00	0.25	0.11
338	199	51.78	22.26	27.96	1.04	0.26	0.11
339	220	57.24	24.61	30.91	1.14	0.29	0.12
340	210	54.54	23.45	29.45	1.09	0.27	0.12
341	201	52.16	22.43	28.17	1.04	0.26	0.11
342	192	49.99	21.50	27.00	1.00	0.25	0.11
343	185	48.05	20.66	25.95	0.96	0.24	0.10
344	178	46.27	19.90	24.98	0.93	0.23	0.10
345	172	44.68	19.21	24.13	0.89	0.22	0.10
346	166	43.13	18.55	23.29	0.86	0.22	0.09
347	161	41.81	17.98	22.58	0.84	0.21	0.09
348	156	40.51	17.42	21.88	0.81	0.20	0.09
349	151	39.37	16.93	21.26	0.79	0.20	0.08
350	147	38.31	16.47	20.69	0.77	0.19	0.08
351	159	41.37	17.79	22.34	0.83	0.21	0.09
352	155	40.33	17.34	21.78	0.81	0.20	0.09
353	151	39.29	16.89	21.22	0.79	0.20	0.08
354	148	38.38	16.50	20.73	0.77	0.19	0.08
355	145	37.68	16.20	20.35	0.75	0.19	0.08
356	142	36.88	15.86	19.91	0.74	0.18	0.08
357	138	36.00	15.48	19.44	0.72	0.18	0.08
358	135	35.20	15.14	19.01	0.70	0.18	0.08
359	133	34.46	14.82	18.61	0.69	0.17	0.07
360	130	33.76	14.52	18.23	0.68	0.17	0.07
361	127	33.15	14.25	17.90	0.66	0.17	0.07
362	125	32.53	13.99	17.57	0.65	0.16	0.07
363	123	31.99	13.76	17.27	0.64	0.16	0.07
364	121	31.39	13.50	16.95	0.63	0.16	0.07
365	119	30.88	13.28	16.68	0.62	0.15	0.07
Total (lbs/yr)	**7001997**	**1820519**	**782823**	**983080**	**36410**	**9103**	**3914**
Total (tons/yr)	**3501**	**910**	**391**	**492**	**18**	**5**	**2**

Table E-2. Sediment TMDLs and Allocations by Listed Segment for Mid-Winter, Peak Runoff and Mid-Summer Dates

Stream Name	TMDLs (lbs/day) Mid-Winter Peak Runoff Mid-Summer	Land Use Allocations as Allowable Loading (lbs/day)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Erosion	Rural Residential
Nevada Creek							
Upper Washington	0.04	0.018	0.001	0.007	0.011	0.003	
	26861	12356	698	4432	7226	2149	
	0.01	0.005	0.000	0.002	0.003	0.001	
Lower Washington	14	5.5	8.1			0.5	
	43237	17040	24861			1440	
	123	48.5	70.7			4.1	
Upper Jefferson	0.015	0.006		0.003	0.006	0.001	
	59885	22996		11498	22996	2515	
	0.015	0.006		0.003	0.006	0.001	
Lower Jefferson	0.20					0.20	
	1012					1012	
	1.76					1.76	
Gallagher	0.01	0.007	0.002			0.001	
	24143	15935	5794	927		1449	
	0.01	0.007	0.002			0.001	
Buffalo Gulch	0.01	0.0041	0.0005	0.0038	0.0002	0.0014	
	28297	11602	1500	10753	509	3962	
	131	54	7	50	2	18	
Braziel	0.01	0.0052		0.0031		0.0018	
	46807	24340		14510		8425	
	0.03	0.016		0.009		0.005	
Black Bear	0.022	0.017		0.000		0.005	
	34015	26192		340		7143	
	0.022	0.017		0.000		0.005	
Murray	0.01	0.0031	0.0005	0.0001		0.006	
	337699	104687	15872	3377		214439	
	3266	1012	154	33		2074	
Upper Douglas	48	21	15			12	
	130339	57115	41988			31296	
	237	104	76			57	
Cottonwood	0.007	0.0034	0.0033			0.0003	
	374540	183525	177907			14982	
	0.007	0.0034	0.0033			0.0003	
Lower Douglas	79	54	19			6	
	358992	244067	86141			28714	
	314	214	75			25	
Nevada Spring	0.21	0.11	0.01			0.09	
	16824	8547	942			7335	
	0.48	0.24	0.03			0.21	

Table E-2. Sediment TMDLs and Allocations by Listed Segment for Mid-Winter, Peak Runoff and Mid-Summer Dates

Stream Name	TMDLs (lbs/day) Mid-Winter Peak Runoff Mid-Summer	Land Use Allocations as Allowable Loading (lbs/day)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Erosion	Rural Residential
McElwain	0.01	0.005	0.004			0.001	
	70714	33943	28286			8486	
	0.01	0.005	0.004			0.001	
Lower Nevada	56	49	5			2	
	210761	185470	18968			6323	
	542	477	49			16	
Middle Blackfoot							
Yourname	0.0012	0.001	0.000	0.000	0.000	0.000	0.000
	48893	35203	489	196	196	12712	196
	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Wales	0.02	0.01	0.01				
	30260	18156	9986			2118	
	0.03	0.02	0.01				
Frazier	0.001	0.000				0.001	
	3882	1591				2290	
	0.003	0.001				0.002	
Ward	0.007	0.003		0.001		0.003	
	11321	5207		1811		4302	
	0.008	0.004		0.001		0.003	
Kleinschmidt	0.001	0.000	0.000			0.001	
	1533	77	15			1441	
	0.001	0.000	0.000			0.001	
Rock	0.001	0.001		0.000		0.000	
	143567	96190		41635		5743	
	0.001	0.001		0.000		0.000	
Warren	0.003	0.000	0.000			0.003	
	27343	3555	273			23515	
	2541	330	25			2185	
Monture	0.003	0.000		0.001		0.002	
	86161	9478		36188		40496	
	0.25	0.03		0.10		0.12	
BFR (Nev to Mont)	37	16	13	7		1	
	578885	254709	196821	115777		11578	
	1176	517	400	235		24	
Cottonwood	0.014	0.002	0.001	0.006		0.005	
	212035	33926	12722	86934		78453	
	0.014	0.002	0.001	0.006		0.005	
Richmond	0.001			0.000		0.001	
	979			59		920	
	0.000016			0.000001		0.000015	

Table E-2. Sediment TMDLs and Allocations by Listed Segment for Mid-Winter, Peak Runoff and Mid-Summer Dates

Stream Name	TMDLs (lbs/day) Mid-Winter Peak Runoff Mid-Summer	Land Use Allocations as Allowable Loading (lbs/day)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Erosion	Rural Residential
West Fork Clearwater	0.08			0.04		0.04	
	52652			27379		25273	
	0.0008			0.0004		0.0004	
Deer	0.73			0.35		0.038	
	54219			26025		28194	
	195			94		102	
Blanchard	0.00088	0.00012		0.00004		0.00071	
	29779	4169		1489		24121	
	0.0040	0.0006		0.0002		0.0032	
BFR (Mont to Clrwtr)	18	9	1			5	2
	257586	128793	18031			77276	33486
	298	149	21			89	39

APPENDIX F
WATER QUALITY ANALYSIS RESULTS FOR FIELD PARAMETERS AND TRACE METALS

Waterbody	Sample Site Name	Sample site Description	Sample Date	Flow (cfs)	pH	Hardness (mg/L as CaCO3)	Total Suspended Solids (mg/L)	Al - Dissolved (mg/L)	As - Total Recoverable (mg/L)	Cd - Total Recoverable (mg/L)	Cu - Total Recoverable (mg/L)	Fe - Total Recoverable (mg/L)	Hg - Total Recoverable (mg/L)	Pb - Total Recoverable (mg/L)
Douglas Creek	CO3DOUGC10	Douglas Creek 150 yds upstream from second reservoir	9/27/2003	9.0	7.82	150	7.8		0.011	<0.0001	<0.001	0.18		<0.001
Douglas Creek	DCSW-2	Douglas Creek upstream of confluence with Sturgeon Creek	5/11/2005	4.38	7.64	232	<10	<0.05	<0.005	NM	0.001	0.25		<0.003
Douglas Creek	DCSW-2	Douglas Creek upstream of confluence with Sturgeon Creek	8/25/2005	3.42	8.17	181	11		<0.005	NM	<0.001	0.37		<0.003
Douglas Creek	CO3DOUGC20	Douglas Creek 0.25 mi upstream of Murray Cr confluence	9/27/2003	1.0	7.67	312	16.2		0.025	<0.0001	0.001	0.48		<0.001
Douglas Creek	DCSW-1	Douglas Creek upstream of road crossing west of Helmville (STORET 4124DO01)	6/12/2003	2.91	8.21	246		0.07	0.005	<0.0001	<0.001	0.23		<0.001
Douglas Creek	DCSW-1	Douglas Creek upstream of road crossing west of Helmville (STORET 4124DO01)	10/1/2003	0.76	8.35	294	13.6	<0.01	0.021	<0.0001	<0.001	0.13		<0.001
Douglas Creek	DCSW-1	Douglas Creek upstream of road crossing west of Helmville (STORET 4124DO01)	5/11/2005	15.9	7.51	183	43	<0.05	<0.005	NM	0.002	1.41		<0.003
Douglas Creek	DCSW-1	Douglas Creek upstream of road crossing west of Helmville (STORET 4124DO01)	8/25/2005	2.69	7.30	169	11		<0.005	NM	<0.001	0.58		<0.003
Jefferson Creek	JCSW-2	Jefferson Creek upstream of confluence with Madison Gulch	10/1/2003	0.56	8.28	100	4.3	<0.01	0.008	<0.0001	<0.001	0.08		<0.001
Jefferson Creek	JCSW-1	Jefferson Creek upstream of Dalton Mountain Road crossing	6/12/2003	2.05	7.66	75		0.27	0.002	<0.0001	<0.001	0.22		0.001
Jefferson Creek	JCSW-1	Jefferson Creek upstream of Dalton Mountain Road crossing	10/1/2003	0.67	8.15	96	25	<0.01	0.009	<0.0001	<0.001	0.51		<0.001
Jefferson Creek	JCSW-1	Jefferson Creek upstream of Dalton Mountain Road crossing	5/11/2005	4.15	8.30	66	27	<0.05				2.06	<0.0001	
Kleinschmidt Creek	KLSW-2	Kleinschmidt Creek at upstream Highway 200 crossing	5/12/2005	0.92	7.89	190	<10		<0.005		0.001	0.32		
Kleinschmidt Creek	KLSW-2	Kleinschmidt Creek at upstream Highway 200 crossing	8/24/2005	0.1	7.81	200	<10		<0.005		<0.001	0.19		
Kleinschmidt Creek	KLSW-1	Kleinschmidt Creek at downstream Highway 200 crossing	5/12/2005	1.26	7.75	220	<10	<0.05	<0.005		0.001	0.35		
Kleinschmidt Creek	KLSW-1	Kleinschmidt Creek at downstream Highway 200 crossing	8/24/2005	0.056	7.44	228	<10		<0.005		<0.001	0.34		
Kleinschmidt Creek	C03KLSMC01	Kleinschmidt Creek 200 yds upstream of confluence with Rock Cr	9/11/2003	16.32	7.46				0.022	<0.0001	<0.001	0.03		<0.001
Kleinschmidt Creek	C03KLSMC01	Kleinschmidt Creek 200 yds upstream of confluence with Rock Cr	5/12/2005	8.62	7.18	140	<10	<0.05	<0.005		<0.001	0.004		
Kleinschmidt Creek	C03KLSMC01	Kleinschmidt Creek 200 yds upstream of confluence with Rock Cr	8/24/2005	11.2	7.02	138	<10		<0.005		<0.001	0.002		
Murray Creek	C03MURYC10	Murray Creek 100 yds upstream from highest road crossing	9/26/2003	4.0	6.91	81			0.005	<0.0001	<0.001	0.09		<0.001
Murray Creek	C03MURYC20	Murray Creek 100 yds upstream of lowest road crossing	9/26/2003	0.2	7.49	238			0.016	<0.0001	<0.001	0.25		<0.001

Waterbody	Sample Site Name	Sample site Description	Sample Date	Flow (cfs)	pH	Hardness (mg/L as CaCO3)	Total Suspended Solids (mg/L)	Al - Dissolved (mg/L)	As - Total Recoverable (mg/L)	Cd - Total Recoverable (mg/L)	Cu - Total Recoverable (mg/L)	Fe - Total Recoverable (mg/L)	Hg - Total Recoverable (mg/L)	Pb - Total Recoverable (mg/L)
Nevada Creek (Upper)	NCSW-1	Nevada Creek upstream of Highway 141 crossing (STORET 4026NE03)	6/12/2003	30.6	8.24	90		0.04	0.003	<0.0001	<0.001	0.24		<0.001
Nevada Creek (Upper)	NCSW-1	Nevada Creek upstream of Highway 141 crossing (STORET 4026NE03)	10/1/2003	4.75	7.76	120	7.0	<0.01	0.010	<0.0001	<0.001	0.34		<0.001
Nevada Creek (Upper)	NCSW-1	Nevada Creek upstream of Highway 141 crossing (STORET 4026NE03)	5/11/2005	103	8.13	65	97	<0.05				2.62	<0.0001	
Nevada Creek (Upper)	NCSW-1	Nevada Creek upstream of Highway 141 crossing (STORET 4026NE03)	8/25/2005	3.61	8.13	109	<10		<0.005		<0.001	0.29		<0.003
Nevada Creek (Upper)	NCSW-2	Nevada Creek upstream of confluence with Gallagher Creek	8/25/2005	8.21	8.01	131	<10		<0.005		0.004	0.29		<0.003
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	6/10/1980	182	7.7	99	24	0.03	0.005		0.030	0.76	0.0004	
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	7/8/1980	63	8.1	120	6	0.02	0.006		0.010	0.29	0.0001	
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	5/14/2003	52	8.5	127	11		0.003	<0.0002	0.0019	0.30		0.00023
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	5/29/2003	189										
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	6/3/2003	126										
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	6/6/2003	81	8.2	105	16		0.003	<0.0002	0.0016	0.37		0.00031
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	7/11/2003	19										
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	7/23/2003	11	8.2	141	5		0.005	<0.00004	0.0012	0.18		0.00009
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	8/13/2003	11	8.2	123	5		0.005	<0.00004	0.0012	0.04		0.00018
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	8/27/2003	8.0										
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	12/2/2003	11	7.7		9							
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	3/10/2004	146	7.4	37	44	0.008	0.005	0.00002	0.0028	0.77		0.00069
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	4/13/2004	29	8.3	110	7		0.004	<0.00004	0.0011	0.31		0.00012
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	5/27/2004	51	8.4	120	8	0.002	0.004	<0.00004	0.0019	0.27		0.00018
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	7/14/2004	13	8.5	142	7		0.005	<0.00004	0.0011	0.29		0.00013
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	8/25/2004	8.4	8.5	142	4	<0.002	0.006	<0.00004	0.001	0.26		0.00007
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	5/11/2005	142	8.2	84	304				0.010	7.27	0.0000156	0.006
Nevada Creek (Upper)	12335500	Nevada Cr above Reservoir, near Helmville, MT (USGS gaging station)	8/25/2005	7.8	8.0	129	<10		<0.005		<0.001	0.27		<0.003
Washington Creek	WASW-2	Washington Creek upstream of confluence with Cow Gulch	10/1/2003	0.72	7.83	119	<1.0	<0.01	0.006	<0.0001	<0.001	0.02		<0.001
Washington Creek	WASW-1	Washington Creek upstream of Highway 141 crossing(STORET 4026WA01)	6/12/2003	3.11	8.03	106		0.05	0.004	<0.0001	<0.001	0.97		<0.001

Waterbody	Sample Site Name	Sample site Description	Sample Date	Flow (cfs)	pH	Hardness (mg/L as CaCO3)	Total Suspended Solids (mg/L)	Al - Dissolved (mg/L)	As - Total Recoverable (mg/L)	Cd - Total Recoverable (mg/L)	Cu - Total Recoverable (mg/L)	Fe - Total Recoverable (mg/L)	Hg - Total Recoverable (mg/L)	Pb - Total Recoverable (mg/L)
Washington Creek	WASW-1	Washington Creek upstream of Highway 141 crossing(STORET 4026WA01)	10/1/2003	0.024	7.72	149	6.0	<0.01	0.013	<0.0001	<0.001	1.38		<0.001
Washington Creek	WASW-1	Washington Creek upstream of Highway 141 crossing(STORET 4026WA01)	5/11/2005	17.1	8.11	80	63	<0.05				2.45	<0.0001	

SEDIMENT

Waterbody	Sample Site Name	Sample Site Description	Sample Date	Aluminum (µg/g)	Antimony (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Selenium (µg/g)	Silver (µg/g)	Thallium (µg/g)	Zinc (µg/g)
Douglas Creek	CO3DOUGC10	Douglas Creek 150 yds upstream from second reservoir	9/27/2003	9870	<1	6.6	206	<1	<1	27.7	14.1	9470	7.7	387	26.6	<1	<1	<1	34.3
Douglas Creek	CO3DOUGC20	Douglas Creek 0.25 mi upstream of Murray Cr confluence	9/27/2003	9550	<1	9.5	372	<1	<1	13.3	20.6	11500	9.1	1930	21.7	<1	<1	<1	43.2
Douglas Creek	DCSW-1	Douglas Creek upstream of road crossing west of Helmville (STORET 4124DO01)	10/1/2003	9740	<1	13.1	445	<1	<1	17.9	22.5	13400	10.7	827	25.9	<1	<1	<1	42.4
Jefferson Creek	JCSW-2	Jefferson Creek upstream of confluence with Madison Gulch	10/1/2003	12200	0.4	13.9	285	<1	<1	11.9	20.7	14000	17	522	14	<1	<1	<1	42.5
Jefferson Creek	JCSW-1	Jefferson Creek upstream of Dalton Mountain Road crossing	10/1/2003	9120	0.4	15.3	368	<1	<1	15.5	20.5	14500	12.5	600	22.2	<1	<1	<1	46.2
Kleinschmidt Creek	C03KLSMC01	Kleinschmidt Creek 200 yds upstream of confluence with Rock Cr	9/11/2003	11400	0.3	19.6	414	<1	<1	13.2	59.1	16000	18	839	9.5	1.3	<1	<1	84.1
Nevada Creek (Upper)	NCSW-1	Nevada Creek upstream of Highway 141 crossing (STORET 4026NE03)	10/1/2003	11200	0.4	30.7	484	<1	<1	10.7	26.1	17400	15.9	1110	18.9	<1	<1	<1	47
Ward Creek	C03WARDC01	Ward Creek 3.0 mi above Hwy 200 turnoff	6/20/2001	11600	<1	25	649	<1	<1	16	19	15800	15	395	18	<1	<1	<1	75
Ward Creek	C03WARDC02	Ward Creek First Stream crossing above Browns Lake	6/20/2001	12600	<1	18	489	<1	<1	10	34	18100	16	547	12	<1	<1	<1	75
Washington Creek	WASW-2	Washington Creek upstream of confluence with Cow Gulch	10/1/2003	13600	0.5	16	472	<1	<1	18.2	28.9	21300	18.1	493	24.3	1.6	<1	<1	57.4
Washington Creek	WASW-1	Washington Creek upstream of Highway 141 crossing(STORET 4026WA01)	10/1/2003	11700	0.4	52.3	1040	<1	<1	13	17.5	40300	13.8	8290	22	<1	<1	<1	61
Wilson Creek	WCSW-1	Wilson Creek upstream of hwy 141 rd xing	10/1/2003	15200	0.5	21.7	315	<1	<1	17.9	29.2	25100	16	3270	28.5	<1	<1	<1	50.7
Yourname Creek	C03YRNMC20	Yourname Creek 300 yds downstream from bridge	9/12/2003	15400	<1	7.2	245	<1	<1	31.5	31.9	13600	9.9	434	21.6	1	<1	<1	55.1
		Freshwater Sediment Toxicity Benchmark Values (Jones et al., 1997)																	
		Assessment and Remediation of Contaminated Sediments Program																	

Waterbody	**Sample Site Name**	**Sample Site Description**	**Sample Date**	**Aluminum (µg/g)**	**Antimony (µg/g)**	**Arsenic (µg/g)**	**Barium (µg/g)**	**Beryllium (µg/g)**	**Cadmium (µg/g)**	**Chromium (µg/g)**	**Copper (µg/g)**	**Iron (µg/g)**	**Lead (µg/g)**	**Manganese (µg/g)**	**Nickel (µg/g)**	**Selenium (µg/g)**	**Silver (µg/g)**	**Thallium (µg/g)**	**Zinc (µg/g)**
		(EPA, 1996a)																	
		Threshold Effect Concentration (TEC)				12.1			0.592	56	28		34.2	1673	39.6				159
		Probable Effect Concentration (PEC)		58030		57			11.7	159	77.7		396	1081	38.5				1532
		High No Effect Concentration (NEC)				92.9			41.1	312	54.8		68.7	819	37.9				541
		Ontario Ministry of Environment (Canada)																	
		Low (5th percentile of screening level concentration)				6			0.6	26	16	20000	31	460	16				120
		Severe (95th percentile of screening level concentration)				33			10	110	110	40000	250	1110	75				820
		EPA Region IV 1995 Ecological Screening Values for Sediment			12	7.24			1	52.3	18.7		30.2		15.9		2		124
		EPA Office of Solid Waste and Emergency Response Ecotox Thresholds (1996b)				8.2			1.2	81	34		47		21				150

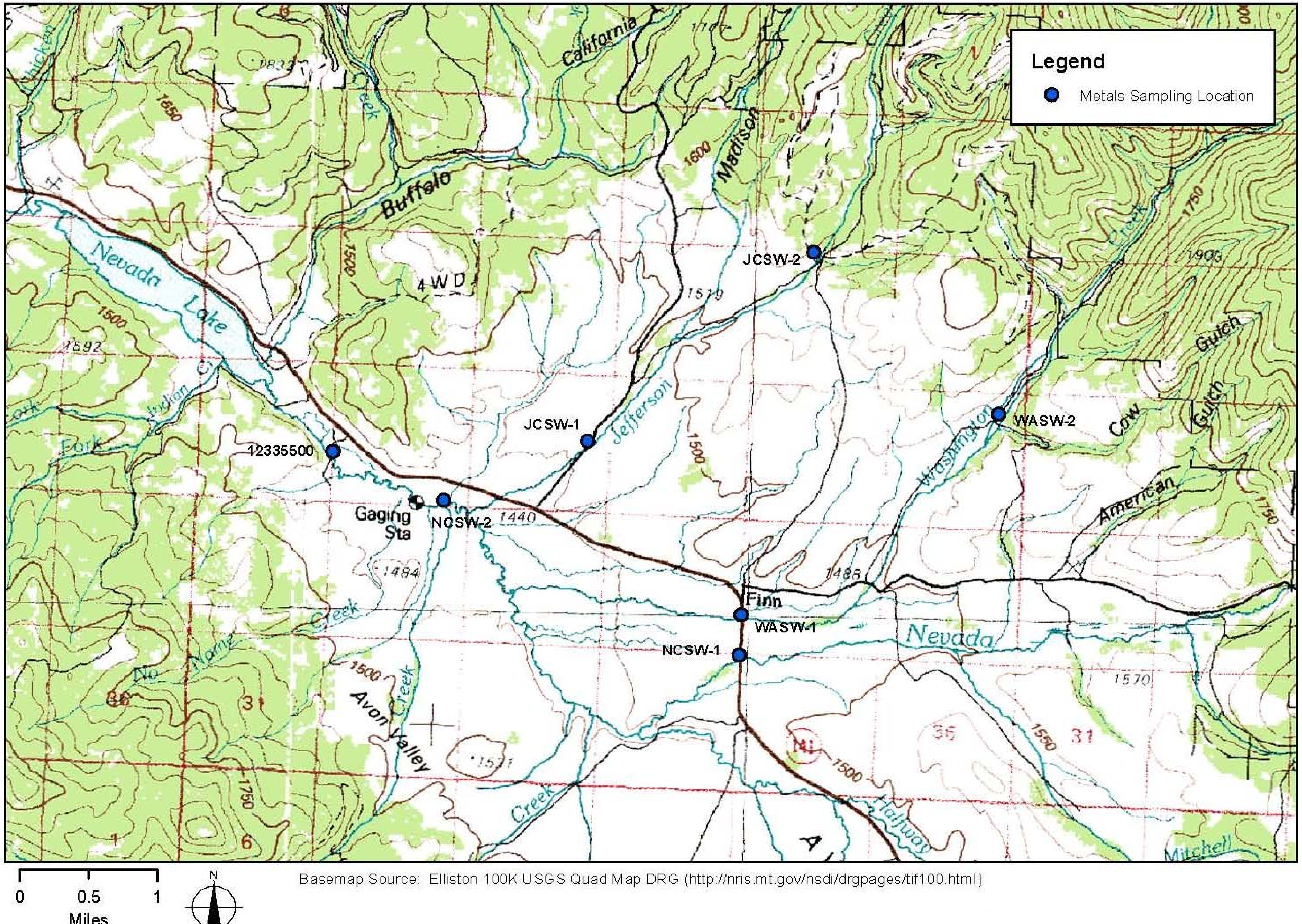

Figure F-1. Upper Nevada Creek Metals Sampling Locations

APPENDIX G
REPRESENTATIVE REFERENCE SHADE CONDITIONS AND DAILY TEMPERATURE LOADING

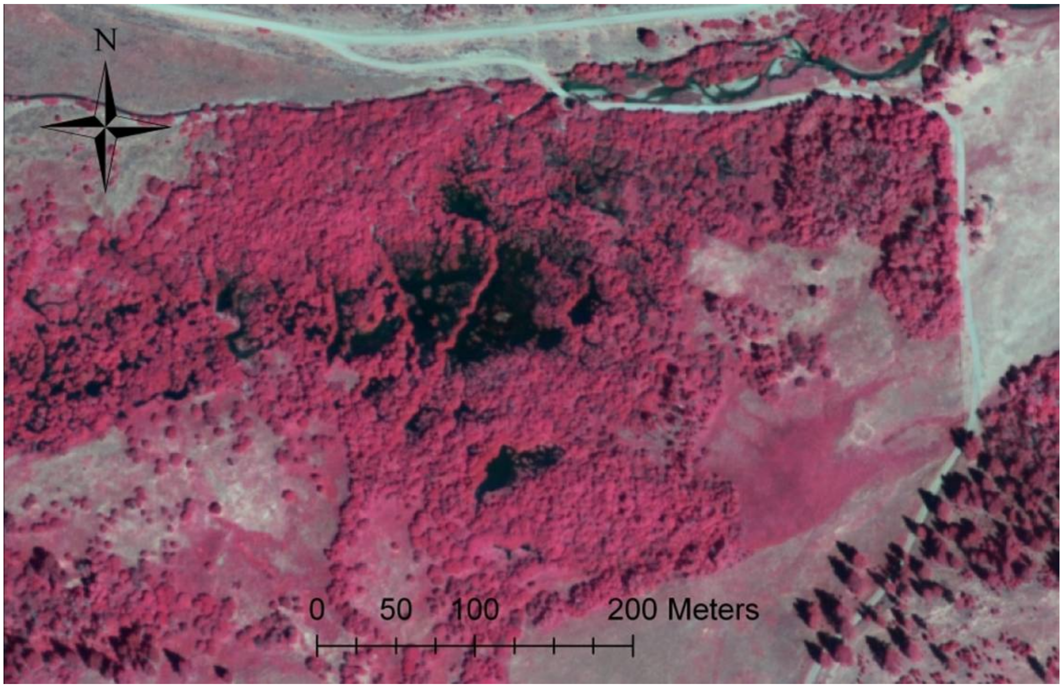

Figure G-1. Reference Shade Condition S ½ Sections 29 and 30, Township 12 North, Range 8 West, Upper Nevada Creek

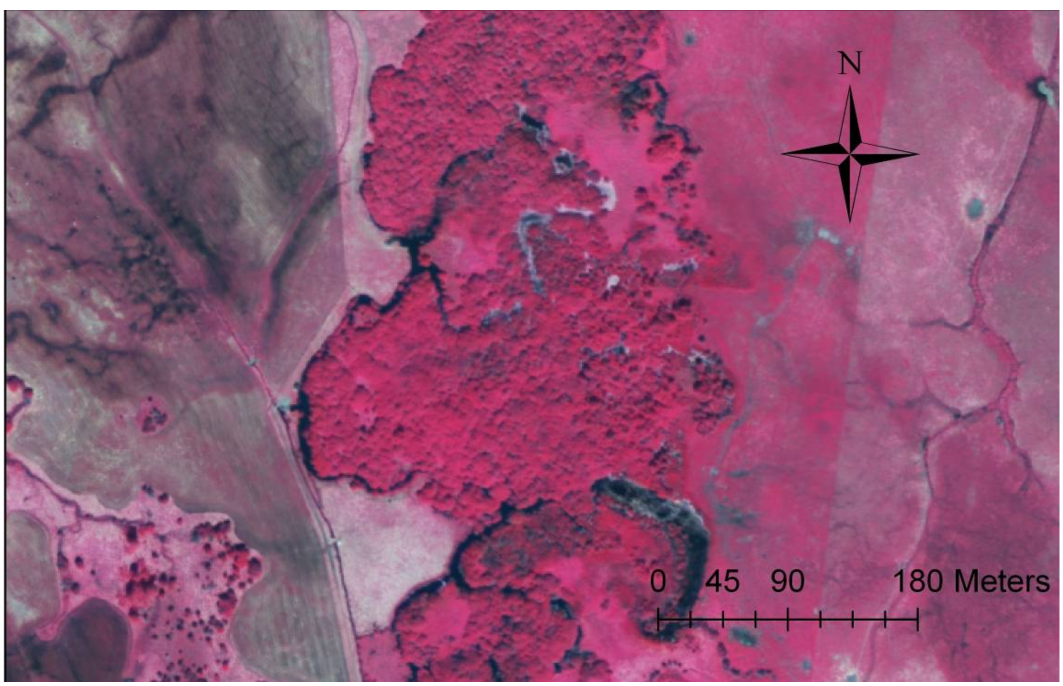

Figure G-2. Reference Shade Condition SW ¼ Section 24, Township 13 North, Range 11 West, Lower Nevada Creek

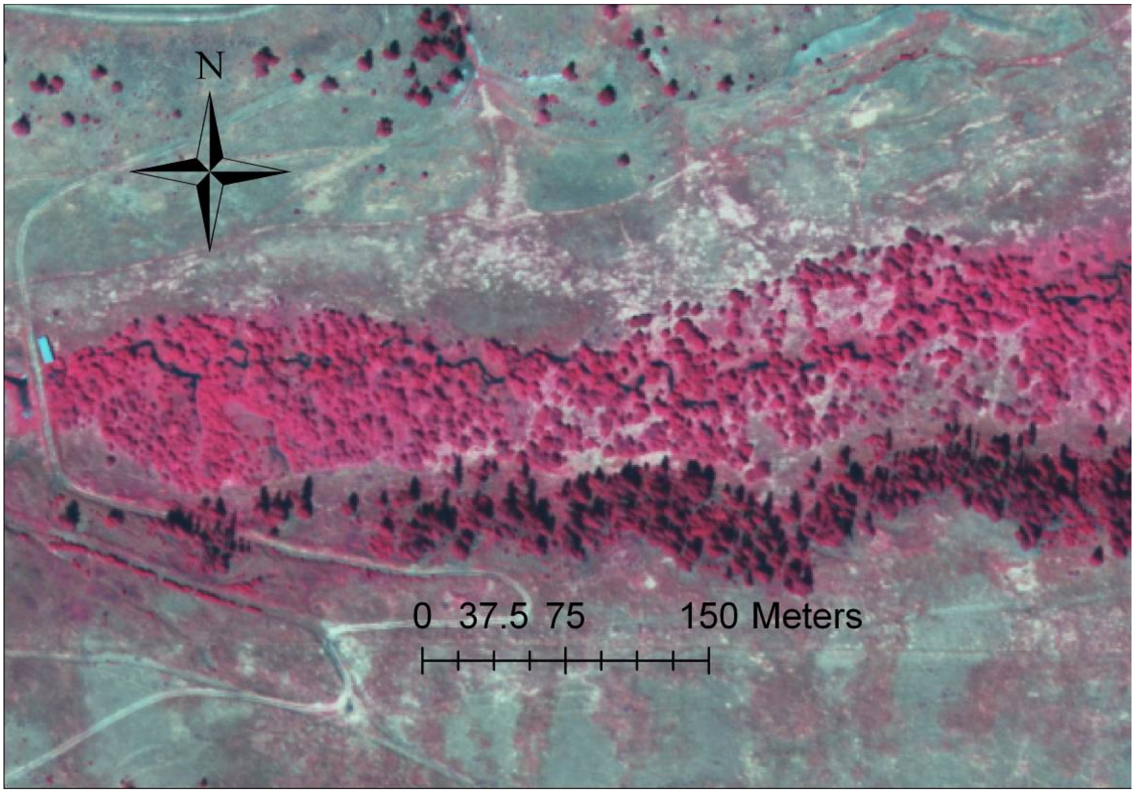

Figure G-3. Reference Shade Condition W ½ Section 20, Township 12 North, Range 12 West, Upper Douglas Creek

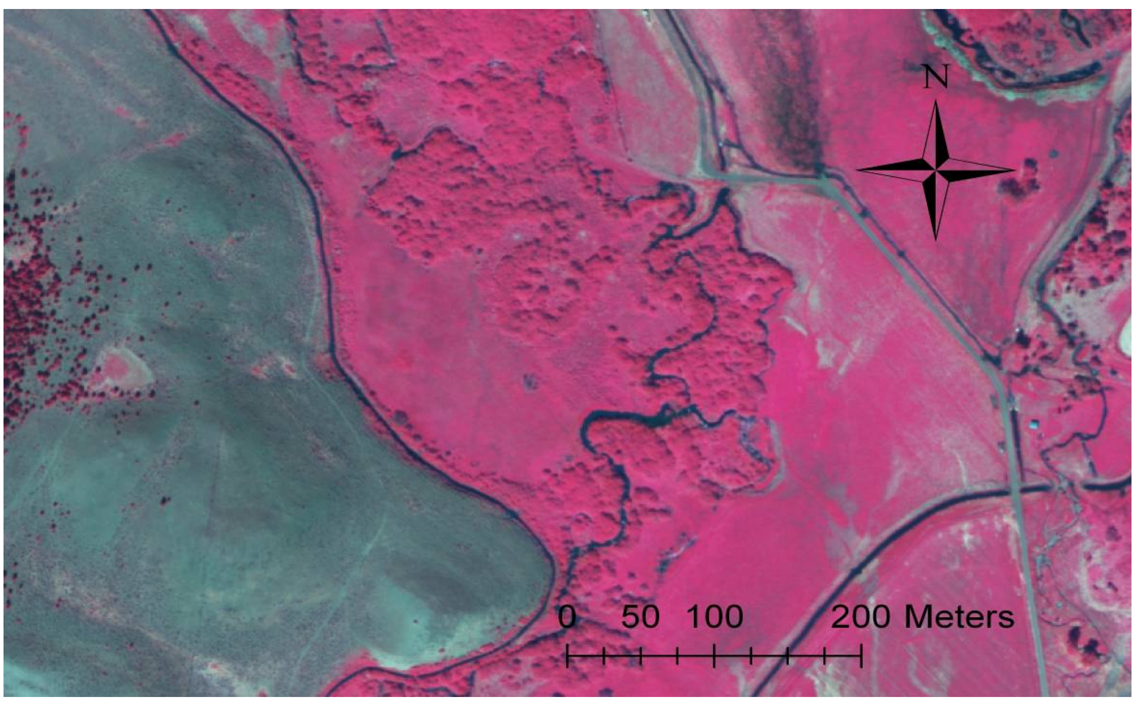

Figure G-4. Reference Shade Condition NW ¼ Section 33, Township 13 North, Range 11 West, Lower Douglas Creek

Daily Temperature Loading Example

A TMDL is the sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (**Equation G-1**). 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.

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

Where:

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

Total maximum daily loads are based on the loading of a pollutant to a water body. Federal Codes indicate that for each thermally listed water body the total maximum daily thermal load cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. Such estimates shall take into account the water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters. The following approach for setting numeric temperature TMDLs considers all of the factors listed above.

The numeric daily temperature TMDLs presented in this appendix apply to all the temperature impaired waters in the Middle Blackfoot-Nevada Creek planning area including:
- Upper Nevada Creek
- Lower Nevada Creek
- Murray Creek
- Cottonwood Creek
- Upper DouglasCreek
- Lower Douglas Creek
- Kleinschmidt Creek

All waters in the Middle Blackfoot-Nevada Creek planning area are classified as B1. Montana's temperature standard for B1 classified waters is depicted in **Figure G-5**. An example of the temperature TMDL and instantaneous temperature load (ITL) application to a water body is provided at the end of this appendix.

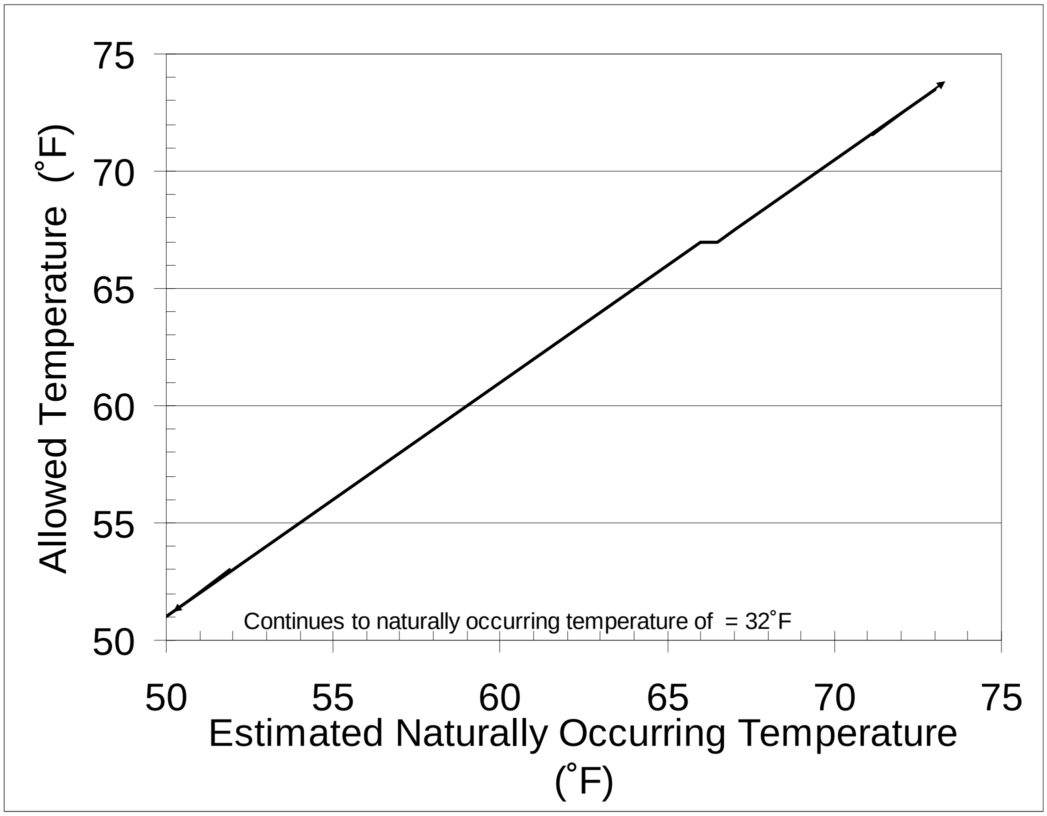

Figure G-5. In-Stream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

Daily Thermal Load

The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure G-5**) and using a modeled or estimated naturally occurring daily average daily temperature. The daily average total maximum load at any location in the water body is provided by **Equation G-2**. The daily allowable loading is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kilocalorie 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 G-5**.

Equation G-2

$(\Delta-32)*(Q)*(1.36 \text{ X } 10^6) = \text{TMDL}$

Where:

Δ = allowed temperatures from **Figure G-5** using any daily temperature condition
Q = average daily discharge in cubic feet per second (CFS)
TMDL = daily TMDL in Calories (kilocalories) per day above waters melting point
Conversion Factor = $1.36 \text{ X } 10^6$

There are no point sources, and therefore, no wasteload allocations in the Middle Blackfoot-Nevada Creek planning area. The TMDL load allocation for each stream is a combination of the 1°F allowable loading shared between the human caused sources identified in the stream in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The daily TMDL allocation is equal to the load allocation shared by all human-caused sources plus the load allocated to naturally occurring temperatures as shown in **Equation G-3**.

Equation G-3

Load Allocation= Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios -32)*(Discharge (CFS))*(1.36 X 10^6)

Allowable Human Sources = (1°F)*(1.36 X 10^6)*(Discharge (CFS))

Instantaneous Thermal Load

Because of the dynamic temperature conditions during the course of a day, an instantaneous load is also provided for temperature. For temperature, the daily average thermal conditions are not always an effective indicator of impairment to fisheries. The heat of the day is the usually the most stressful timeframe for salmonids and char. Also, in high altitudes, thermal impacts that heat during the day may produce advanced cooling conditions during the night so that the daily temperature fluctuations increase greatly with potentially significant negative impacts to fish without much impact on daily average temperature conditions. Therefore, Montana provides an instantaneous thermal load to protect during the hottest timeframes in mid to late afternoon when temperatures are most stressful to the fishery, which is the most sensitive use in reference to thermal conditions.

The instantaneous load is computed by the second. The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure G-5**) and using a modeled or estimated naturally occurring instantaneous temperature. The instantaneous total maximum load (per second) at any location in the water body is provided **Equation G-4**. 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 G-5**.

Equation G-4

$(\Delta-32)*(Q)*(15.7)$ = Instantaneous Thermal Load (ITL)

Where:

Δ = allowed temperatures from **Figure G-5** using daily temperature condition
Q = instantaneous discharge in CFS
ITL = Allowed thermal load per second in kilocalories per day above waters melting point
Conversion factor = 15.7

There are no point sources that increase water temperatures, and therefore, no wasteload allocations in the Middle Blackfoot-Nevada Creek planning area. The ITL load allocation for each stream is a combination of the 1°F allowable loading shared between the human caused sources identified in the stream in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The ITL allocation is equal to the load allocation shared by all human caused sources plus the load allocated to naturally occurring temperatures as shown in **Equation G-5**.

Equation G-5

Load Allocation= Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios -32)*(Discharge (CFS))*(15.7)

Allowable Human Sources = (1°F)*(15.7)*(Discharge (CFS))

Margins of Safety, Seasonal Variations and Future Sources

See **Section 9.5** of the main document for this discussion.

Example Numeric TMDL Application for Kleinschmidt Creek

Kleinschmidt Creek Daily Thermal Load Example Application

A calibrated SNTEMP thermal loading modeling was constructed for Kleinschmidt Creek. A model scenario used reference riparian shade conditions along the entire length of the stream to estimate naturally occurring temperatures. The monitoring and modeling effort is described **Section 8.2.2.1**. Naturally occurring average daily temperature at the first Highway 200 crossing of Kleinscmidt Creek was estimated at 62.5°F. This temperature is used to determine the allowable temperature according to **Figure G-5**, Montana's temperature standard. The allowable mean daily temperature is estimated at 63.5°F. **Equation G-2** from above is used to calculate Kleinschmidt Creek TMDL.

$(\Delta\text{-}32)*(Q)*(1.36x10^6) = \text{TMDL}$

Where:

Δ = allowed temperatures from **Figure G-1** using daily temperature condition = 63.5°F
Q = average daily discharge in cubic feet per second (CFS) = 2.5cfs
TMDL = daily TMDL in Calories (kilocalories) per day above water's
melting point = $1.07x10^7$ kilocal/day.

This load represents that from natural background sources, plus human caused sources where all reasonable land, soil, and water conservation practices area applied, plus the additional loading allowed by the 1°F increase. The portion of the Kleinschmidt Creek TMDL represented by the 1°F allowable increase alone is:

(1°F) (2.5 cfs) $(1.36x10^6) = 1.7 \text{ x } 10^6$ kilocalories per day

This portion of the TMDL is appropriated to the human caused sources combined that are identified in **Section 9.4.6** of the main document. The remainder of the TMDL is appropriated to naturally occurring thermal load that includes human sources with reasonable land, soil, and water conservation practices applied. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the TMDL is apportioned to naturally occurring thermal loading. Currently the daily total maximum daily load is not being met because the current temperature exceeds the naturally occurring temperature by more than 1°F.

The mean daily temperature of the site was 65.1°F, which equates to a thermal load of $1.12x10^7$ kilocal/day and exceeds standard and the TMDL when a daily averaged timeframe is considered. Because this site on Kleinschmidt Creek is not meeting Montana's temperature standard during an average daily condition, it exceeds the average daily TMDL. Montana's temperature standard is applied to any timeframe because no duration is provided in the standard. Therefore, we can also investigate the instantaneous thermal load. The instantaneous load will consider heating during the warm summer afternoons when the fishery is the most stressed.

Kleinschmidt Creek Instantaneous Thermal Load
The instantaneous thermal load (ITL) is described as the heat passing a monitoring location per second. The most sensitive timeframe for the fishery occurs during the heat of the day for the hottest period of the year. The same modeling described in this appendix was used to model daily maximum temperatures. The naturally occurring daily maximum temperature at the first highway 200 crossing on Kleinschmidt Creek was estimated at 65.8°F using a SNTEMP model.

This temperature is used to determine the allowable temperature according to **Figure G-5**, Montana's temperature standard. Therefore, the allowable maximum temperature during this timeframe is estimated at 66.8°F (73°F plus an additional 0.5°F for this temperature range).

Equation G-4 from above is used to calculate the Kleinschmidt Creek ITL.

(Δ-32)*(Q)*(15.7`) = Instantaneous Thermal Load (ITL)

Where:
Δ = allowed temperatures from **Figure G-1** using daily temperature condition = 66.8°F
Q = average daily discharge in cubic feet per second (CFS) = 2.5cfs
ITL = Allowed thermal load per second in kilocalories per day above water's melting point = 1366 kilocal/second

This load represents that from natural background sources, plus human caused sources where all reasonable land, soil, and water conservation practices area applied, plus the additional loading allowed by the 1°F increase. The portion of the Kleinschmidt Creek TMDL represented by the 1°F allowable increase alone is:

(1°F) (2.5 cfs) (15.7) = 39 kilocal/second

The Kleinschmidt Creek load allocation for the ITL is 1366 kilocalories per second and is appropriated to all human caused sources combined that are identified in **Section 9.4.6** of the main document. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the load allocation for the ITL is apportioned to naturally occurring thermal loading.

The hottest temperature estimated for current conditions at this site was 73.0°F, which equates to a thermal load of 1609 kilocal/sec. The temperature is above the State's temperature standard and the thermal load is above the allowable instantaneous load when considered during a one second timeframe. Because this site on Kleinschmidt Creek is not meeting Montana's temperature standard during a one second timeframe, the thermal load during a one second timeframe is also above the ITL. This scenario would also hold true for an hourly time step. This indicates that Montana's temperature standard at this site is not being met during an important timeframe for the most sensitive use.

A similar analysis could be completed for the remaining seven temperature impaired, stream segments, but for the sake of brevity is not provided since it is easy to figure if the TMDL and ITL are met by looking at measured temperatures and comparing them to Montana's temperatures standard instead of caloric loads.

APPENDIX H
RESTORATION PLAN

The information presented in this appendix is intended to supplement the Restoration and Monitoring Plan for the Middle Blackfoot and Nevada Creek TMDL planning areas (**Section 10.0**).

Conservation Practices/BMPS

The following is a list and description of conservation practices presented by Best Management Practice (BMP) category. These BMP categories correspond to the management recommendations and applicable treatments presented in **Section 10.2**. The majority of conservation practices come directly from the Natural Resource Conservation Service (NRCS) Field Office Technical Guide for Powell County and referenced by the NRCS practice standard number. Others sources of information are cited by name.

There are seven different BMP categories: Stream BMPs, Riparian Area BMPs, Upland BMPs, Grazing BMPs, Water Conservation BMPs, Forestry BMPs, and Road BMPs. Each BMP category is described in terms of water quality impairments they are intended to address and how and where they can be applied. Each BMP category contains a list of several different conservation practices giving landowners and land managers numerous options for implementation.

Implementation of conservation practices should be determined on a site specific basis. Water quality restoration objectives as well as landowner or land manager objectives should be evaluated prior to implementation. The conservation practices have been categorized to assist in this evaluation. Multiple practices from multiple categories may be needed to meet management objectives. Additional practices not listed in this Appendix may also be applicable. NRCS practice standards, specifications, job sheets, and other information sources should be consulted prior to implementation to achieve maximum effectiveness.

For private landowners, cost-share and technical assistance resources for implementation of conservation practices are often available. A “resource guide” is included in this appendix following the discussion of the BMP categories. For public land managers, partnerships with local watershed groups, Conservation Districts, and other pubic agencies have proven to be an effective tool in implementing desired conservation practices.

Stream BMPs – These conservation practices/BMPs have the primary purpose of affecting sediment, habitat, and metals impairments. Nutrients attached to sediment, primarily phosphorous, and temperature impairments are also addressed by this group of practices. Stream BMPs focus specifically on the stream channel and address impairments caused by alteration of the stream channel through active channel restoration or manipulation. When applied these practices are intended to have the following effects:

1. Reduction in sediment (as well as sediment bound metals and nutrients) from bank erosion through restoration, protection, or stabilization of streambanks

2. Improved or restored in-stream fish and aquatic habitat through the installation or restoration of habitat structures and features
3. Reduction in water temperatures through improved or restored channel form (width to depth ratio)
4. Improvement or restoration of channel form and function
5. Improved capacity for sediment and flow conveyance

Stream BMPs include the following:

- **Open Channel (582) –** Constructing, improving, re-creating, or restoring a channel in which water flows with a free surface. This practice may be applied to support the re-establishment or improvement of a channel to accommodate flows; provide for riparian vegetation establishment and growth on the flood plain; reduce bed and bank erosion; improve flood plain function and stability; modify sediment transport; provide improved water quality and habitat for aquatic species and improved riparian habitat for upland species.
- **Stream Crossing (578) –** A stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. This practice applies to all land uses where an intermittent or perennial watercourse exists and a ford, bridge, or culvert type crossing is desired for livestock, people, and/or equipment. The purpose of this practice is to improve water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream; reduce streambank and streambed erosion; providing for flood flows; reducing risk of washout and subsequent delivery of fill material; facilitating aquatic life passage; and provide crossing for access to another land unit.
- **Stream Habitat Improvement and Management (395) –** Maintain, improve, or restore physical, chemical, and biological functions of a stream. This practice applies to streams where habitat deficiencies limit survival, growth, reproduction, and/or diversity of aquatic species in relation to the potential of the stream. The purpose of this practice is to provide suitable habitat for desired aquatic species and diverse aquatic communities; provide channel morphology and associated riparian characteristics important to desired aquatic species; and provide aesthetic values and recreation opportunities associated with stream habitats such as angling and fish viewing.
- **Fish Passage (396) –** Modification or removal of barriers that restrict or impede movement or migration or fish or other aquatic organisms. The purpose of this practice is to improve or provide upstream or downstream passage for desirable fish and aquatic organisms.
- **Streambank and Shoreline Protection (580) –** Treatments used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries. This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion where the problem can be solved with relatively simple structural measures (vegetation or upland erosion control practices). The purpose of this practice is to maintain the flow or storage capacity of the water body or to reduce the offsite or downstream effects of excessive sediment resulting from bank erosion; improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, recreation; and to prevent, control, or minimize the loss of land or damage to land uses, or other facilities adjacent to the banks

including the protection of known historical, archeological, and traditional cultural properties.

- **Channel Stabilization (584) –** Measures used to stabilize the bed or bottom of a channel in the beds of existing or newly constructed channels, alluvial or non-alluvial, undergoing damaging aggradation or degradation that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, by the installation of bank protection, or by the installation of upstream water control measures. The purpose of this practice is to maintain or alter channel bed elevation or gradient; modify sediment transport or deposition; and to manage surface water and groundwater levels in floodplains, riparian areas, and wetlands.
- **Grade Stabilization Structure (410) –** A structure used to stabilize the grade and control erosion in natural or artificial channels; prevent the formation or advance of gullies; and enhance environmental quality and reduce pollution hazards in areas where the concentration and flow velocity of water requires stabilization. Special attention shall be given to maintaining or improving habitat for fish and wildlife when applied.
- To maximize the efficacy of any Stream BMP, the concurrent implementation of one or several **Riparian Area BMPs** is recommended. Similarly, where Stream BMPs have been implemented in areas where either grazing or timber harvesting occurs, **Grazing BMPs** and **Forestry BMPs** are recommended.

Riparian Area BMPs – These conservation practices/BMPs have the primary purpose of affecting sediment, habitat, and temperature impairments. Nutrient impairments are indirectly addressed through implementation of these practices as are metals. Riparian Area BMPs focus on those areas adjacent to the stream channel and involve restoring vegetation communities. These practices are a more passive approach to restoration allowing the riparian areas and stream channel to recover over a period of time. Implementation is strongly encouraged in conjunction with Stream BMPs. Implementation of these practices is intended to have the following effects:

1. Reduction in sediment delivery (as well as sediment bound metals and nutrients) from bank erosion through stabilization or protection of streambanks
2. Reduction in sediment yield (as well as sediment bound nutrients and metals) from upland sources through increased filtering and infiltration capacity
3. Reduction in water temperatures through increased shading capabilities and reduction in water surface area
4. Improved or restored in-stream fish and aquatic habitat through the recruitment and retention of large woody debris
5. Improvement or restoration of channel form and function through streambank stabilization

Riparian Area BMPs include the following:

- **Channel Bank Vegetation (322) –** The purpose and definition of this practice is establishing and maintaining vegetative cover on channel banks, berms, spoils, and associated areas. The purpose of this practice is to stabilize channel banks and adjacent areas and reduce erosion and sedimentation; and to maintain or enhance the quality of the environment, including fish and wildlife habitat.

- **Fence (382) –** A constructed barrier to animals or people. This practice is applied on any area where management of animal or people movement is needed. This practice can also be used to facilitate the application of other conservation practices as a means to control movement of animals and people.
- **Use Exclusion (472) –** The temporary or permanent exclusion of animals, people, or vehicles from an area. This practice can be applied on all land uses and can also be used to facilitate the application of other conservation practices. The purpose of this practice is to prevent, restrict, or control access to an area; maintain or improve the quantity and quality of natural resources; and minimize liability and human health concerns.
- **Riparian Forest Buffer (391) –** An area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies. Riparian forest buffers are applied on areas adjacent to permanent or intermittent streams, lakes, ponds, and wetlands. They are not applied to stabilize streambanks or shorelines. The purpose of this practice is to create shade to lower or maintain water temperatures to improve habitat for aquatic organisms; create or improve riparian habitat and provide a source of detritus and large woody debris; reduce excess amounts of sediment, organic material, nutrients, and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow groundwater flow; reduce pesticide drift entering the water body; restore riparian plant communities; increase carbon storage in plant biomass and soils.
- **Riparian Herbaceous Cover (390) –** Grasses, grass-like plants and forbs that are tolerant of intermittent flooding or saturated soils and that are established or managed in the transitional zones between terrestrial and aquatic habitats. This practice is applicable in areas adjacent to perennial and intermittent watercourses or water bodies where the natural plant community is dominated by herbaceous vegetation; where riparian areas have been altered and the potential natural plant community has changed or converted to cropland, pastureland, rangeland, or other commercial/agricultural uses; and where channel and streambank stability is adequate to support this practice. Related purposes of this practice include improving and protecting water quality by reducing the amount of sediment and other pollutants, such as pesticides, organic materials, and nutrients in surface runoff as well as nutrients and chemicals in shallow groundwater flow; help stabilize streambanks and shorelines; provision of food, shelter, shading, substrate, access to adjacent habitats, nursery habitat and pathways for movement by resident and nonresident aquatic, semi-aquatic, and terrestrial organisms.
- **The Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA) –** see discussion under Forestry BMPs.
- When Riparian Area BMPs have been applied in areas where grazing and timber harvesting occur, it is strongly recommended that **Grazing BMPs** and **Forestry BMPs** are implemented to maximize the efficacy of riparian area conservation measures.

Upland BMPs – These conservation practices have the primary purpose of affecting nutrient and sediment impairments. These practices focus on upland areas which for the purposes of this document are defined as the area within 350 feet of streams and waterbodies. The practices emphasize improving vegetation conditions in these upland areas. While most of these practices are tied to agricultural land uses, many can be applied to other land uses. Implementation of these practices is intended to have the following effects:

1. Reduced delivery of sediment, sediment bound nutrients, and sediment bound metals; and nutrients from upland soil erosion sources through improved upland vegetation conditions and increased filtering and infiltration capacity.

Upland BMPs include the following:

- **Conservation Cover (327) –** Establishing and maintaining permanent vegetative cover to protect soil and water resources and applies on land to be retired from agricultural production requiring permanent protective cover, and other lands needing permanent protective cover. The purpose of this practice is to reduce soil erosion and sedimentation; improve water quality; enhance wildlife habitat.
- **Critical Area Planting (342) –** Establishment of permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal practices and if left untreated could be severely damaged by erosion or sedimentation or could cause significant off-site damage. The purpose of this practice is to stabilize areas with existing or expected high rates of soil erosion by water or wind; restore degraded sites that cannot be stabilized through normal methods.
- **Filter Strip (393) –** A strip or area of herbaceous vegetation situated between cropland, grazing land, animal confinement areas, or disturbed land (including forest land) and environmentally sensitive areas such as streams or riparian areas. The purpose of this practice is to reduce sediment, particulate organics, and sediment absorbed contaminant loadings in runoff; to reduce dissolved contaminant loadings in runoff; to reduce sediment, particulate organics, and sediment absorbed contaminant loadings in surface irrigation tailwater; restore, create, or enhance herbaceous habitat for wildlife and beneficial insects; maintain or enhance watershed functions and values; utilize excess nutrients found in runoff water and groundwater; manage bacteria in runoff from livestock confinement areas
- **Forage Harvest Management (511) –** The timely cutting and removal of forages from the field as hay, green-chop or ensilage on all land uses where machine harvested forage is grown. The purpose of this practice is to optimize yield and quality of forage at the desired level; promote vigorous plant re-growth; maintain stand life; manage for the desired species composition; use forage plant biomass as a soil nutrient uptake tool; control insects, diseases, and weeds; maintain and/or improve wildlife habitat.
- **Grazing Land Mechanical Treatment (548) –** Modifying physical soil and/or plant conditions with mechanical tools by treatments such as pitting, contour furrowing, and ripping or sub-soiling. This practices may be applied on pasturelands, rangeland, grazed forest, and native pastures where slopes are less than 15% for the purposes of fracturing compacted soil layers and improve soil permeability; reduce water runoff and increase infiltration; renovate and stimulate plant community for greater productivity yield.
- **Heavy Use Area Protection (561) –** The stabilization of areas frequently and intensively used by people, animals, or vehicles by establishing vegetative cover, by surfacing with suitable materials, and/or by installing needed structures in agricultural, recreational, urban, or other frequently and intensively used areas requiring treatment to address one or more resource concerns. The purpose of this practice is to reduce soil erosion;

improve water quantity and quality; improve livestock health; improve air quality; improve aesthetics.

- **Nutrient Management (590) –** Managing the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments where applied. The purpose of this practice is to budget and supply nutrients for plant production; properly utilize manure or organic by-products as a plant nutrient source; minimize agricultural nonpoint source pollution of surface and groundwater resources; maintain or improve the physical, chemical, and biological condition of soil; and protect air quality by reducing nitrogen emissions and the formation of atmospheric particulates.
- **Pasture and Hay Planting (512) –** Establishing native or introduced forage species where forage production and/or conservation are needed and feasible. The purpose of this practice is to establish adapted and compatible species, varieties, or cultivars for forage production; improve or maintain livestock nutrition and/or health; balance forage supply and demand during periods of low forage production; reduce soil erosion and improve water quality; provide food and cover for wildlife; improve soil quality/health; and increase carbon sequestration.
- **Range Planting (550) –** Establishment of adapted perennial vegetation such as grasses, forbs, legumes, shrubs, and trees on rangeland, native or naturalized pasture, grazed forest, or other suitable locations where the principal method of vegetation management will be herbivores and where desirable vegetation is below the acceptable level for natural reseeding or grazing management is unsatisfactory. The purpose of this practice is to restore a plant community similar to its historic climax or the desired plant community; provide or improve forages for livestock; provide or improve forage, browse, or cover for wildlife; reduce erosion by wind and/or water; improve water quality and quantity; and increase carbon sequestration.
- **Upland Wildlife Habitat Management (645) –** Provide and manage upland habitats and connectivity within the landscape for wildlife. Treating upland wildlife habitat concerns identified during the conservation planning process that enable movement, or provide shelter, cover, food in proper amounts, locations and times to sustain wild animals that inhabit uplands during a portion of their life cycle.
- **Wetland Restoration (657) –** The rehabilitation of a degraded wetland or the re-establishment of a wetland so that soils, hydrology, vegetative community and habitat are in close approximation of the original natural condition that existed prior to modification to the extent practicable. The purpose of this practice is to restore wetland function, value, habitat diversity, and capacity by restoring hydric soils, restoring hydrology (depth duration and season of inundation, and/or duration and season of soil saturation), and restoring vegetation (including the removal of undesired species, and/or seeding or planting of desired species).
- **Integrated Weed Management –** The control of noxious and invasive weed species of foreign origin that directly or indirectly adversely impact agriculture, navigation, fish and wildlife, or public health. Integrated weed management involves the use of several control techniques in a well planned, coordinated, and organized strategy to reduce the impacts of weeds. Strategies include chemical, biological, and cultural control methods (Blackfoot Challenge, Draft 2006). **Pest Management (595)** is also applicable to weed management.

Grazing BMPs – These conservation practices have the primary purpose of affecting sediment, habitat, nutrient, and temperature impairments. Where livestock are present, Grazing BMPs can be implemented to reduce impacts to resources and sensitive areas while improving forage conditions for livestock. Where grazing occurs (i.e. irrigated or dry pastures, upland areas, or forests) implementation of these BMPs is highly recommended. Implementation of Grazing BMPs is strongly encouraged in areas where other conservation practices/BMPs (**Stream BMPs, Riparian Area BMPs, Upland BMPs**) have been implemented and where grazing occurs. Implementation of these practices is intended to have the following effects:

1. Reduction in sediment delivery (as well as sediment bound metals and nutrients) from bank erosion through controlling the timing, intensity, duration, and frequency of grazing in sensitive areas
2. Improved in-stream fish and aquatic habitat through controlling the timing, intensity, duration, and frequency of grazing in sensitive areas
3. Improvement of channel form and function through controlling the timing, intensity, duration, and frequency of grazing in sensitive areas
4. Reduction in sediment (and sediment bound nutrients and metals) and nutrient yield from upland sources through improved upland and riparian vegetation conditions, increased filtering and infiltration capacity; and uniform utilization of upland and riparian vegetation by livestock
5. Reduction in water temperatures through improved riparian vegetation conditions and increased shading capabilities

Grazing BMPs include the following:

- **Prescribed Grazing (528) –** Managing the controlled harvest of vegetation with grazing animals on all lands where grazing animals are managed. The purpose of this practice is to improve or maintain the health and vigor of plant communities; improve or maintain quantity and quality of forage for livestock health and productivity; improve or maintain water quality and quantity; reduce accelerated erosion, and maintain or improve soil condition; improve or maintain the quantity and quality of food and/or cover available for wildlife; promote economic stability through grazing land sustainability. Specific activities associated with prescribed grazing include:
- Design a grazing management plan and determine the intensity, frequency, duration, and season of grazing to promote desirable plant communities and productivity of key forage species. Maintain adequate vegetative cover to prevent accelerated soil erosion, protect stream banks and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants. No grazing unit should be grazed for more than half the growing season of key species. (**Best Management Practices for Grazing in Montana, MT DNRC 1999**; NRCS 2002)
    - Create riparian buffer exclosures (**Use Exclusion – 472**) through fencing (**Fence – 382**) or develop riparian pastures to be managed as a separate unit through fencing. Fencing should be incorporated only where necessary. Water gaps can be included in riparian fencing. (MT DNRC 1999)
    - Ensure adequate residual vegetative cover and regrowth and rest periods. Periodically rest or defer riparian pastures during the critical growth period of plant species. (MT DNRC 1999, Mosley et. al. 1997)

- Distribute livestock to promote dispersion and decomposition of manure and to prevent the delivery of manure to water sources. (MT DNRC 1999)
- Provide off-site high quality water sources (MT DNRC 1999). **Watering Facility (614) –** A trough or tank installed to provide livestock watering facilities supplied from spring, reservoir, well, or other sources where there is a need for new or improved watering places to permit the desired level of grassland management, to reduce health hazards for livestock and to reduce livestock waste in streams. The purpose of this practice is to protect vegetative cover through proper distribution of grazing or through better grassland management for erosion control; reduce or eliminate the need for livestock to be in streams, which reduces livestock waste there. **Pipeline (516), Spring Development (574),** and **Water Well (642)** are also applicable practices for off-site water sources.
- Periodically rotate feed and mineral sites. Place salt and minerals in uplands, away from water sources (ideally ¼ mile from water to encourage upland grazing). Keep salt in troughs and locate salt and minerals in areas where soils are less susceptible to wind or water erosion. (MT DNRC 1999, Mosley et. al. 1997)
- Create hardened stream crossings for livestock to reduce the number of crossing areas and reduce erosion at crossings. (MT DNRC 1999)
- Encourage the growth of woody species (willow, alder, etc.) along the stream bank, which will limit animal access to the stream and provide root support to the bank. (MT DNRC 1999)
- Alternate season of use from year to year in a given allotment or pasture. Time grazing to reduce impacts based on limiting factors for system recovery. For example, early spring use can cause trampling and compaction damage when soils and stream banks are wet. Fall and early winter grazing can encourage excessive browse on willows. (MT DNRC 1999, NRCS 2002).
- **Animal Trails and Walkways (575) –** A travel facility for livestock and/or wildlife to provide movement through difficult or ecologically sensitive terrain such as steep rough terrain, across rock outcrops, through dense timber or brush, over lava beds, on marsh rangelands, and grazing lands susceptible to overflow by water. The purpose of this practice is to provide or improve access to forage, water, and/or shelter; improve grazing efficiency and distribution; and divert travel away from ecologically sensitive and/or erosive sites.
- Monitor livestock forage use and adjust strategy accordingly. (MT DNRC 1999)
- **Range Planting (550) –** Establishment of adapted perennial vegetation such as grasses, forbs, legumes, shrubs, and trees on rangeland, native or naturalized pasture, grazed forest, or other suitable locations where the principal method of vegetation management will be herbivores and where desirable vegetation is below the acceptable level for natural reseeding or grazing management is unsatisfactory. The purpose of this practice is to restore a plant community similar to its historic climax or the desired plant community; provide or improve forages for livestock; provide or improve

forage, browse, or cover for wildlife; reduce erosion by wind and/or water; improve water quality and quantity; and increase carbon sequestration.

Water Conservation BMPs – These conservation practices/BMPs have the primary purpose of affecting temperature, flow, and habitat impairments. Nutrient and sediment impairments are also addressed through these practices but to a lesser extent. These practices promote water conservation and improving water use efficiency to meet in-stream flow needs of water quality beneficial uses while providing sufficient water for agricultural and industrial production. Implementation of these BMPs in intended to have the following effects:

1. Reduction in water temperatures through increased in-stream flows
2. Improved capacity for sediment and flow conveyance
3. Improved in-stream fish and aquatic habitat through maintenance of in-stream flows
4. Improved migration capabilities of fish and other aquatic species through the maintenance of in-stream flows
5. Reduction in water temperature through reduced tailwater/return flows through increased efficiency in water application
6. Reduced delivery of sediment, sediment bound nutrients, and nutrients from overland flow through increased efficiency in water application

Water Conservation BMPs include the following:

- **Water Banking (Blackfoot Challenge 2003) –** A water bank is simply an administrative mechanism by which water users may trade water among themselves in a given drainage. Water banks transfer water, not water rights. The "Temporary Change in Appropriation Right" provisions (85-2-407 MCA 2001) were developed in response to drought conditions in 1989. Again, relying upon the concept and criteria found in the Change of Appropriation Water Right section, this allows a water right holder to move his right temporarily to a new use, new user or new place of use and automatically revert to its original operation at the end of the temporary use. Although this section cannot be utilized to provide for instream flow it may be an effective water conservation and water efficiency tool, especially as linked to low water planning.
- **Leasing Water Rights and/or Converting Water Rights to In-Stream Flows (Blackfoot Challenge 2003) –** Sections 85-2-407 MCA, 85-2-408, MCA, 85-2-436, MCA and 85-2-439, MCA all allow for the temporary transfer of water rights. The last three of these provide for the transfer of water rights from a consumptive use to instream flows to protect the fishery resource. An appropriator may make a temporary change by simply changing the purpose and place of use, or by leasing the water right to another party. The instream leasing programs are all statutes operating under a sunset provision. Also, temporary changes can only be granted for a term not exceeding ten years or thirty years, if water is made available by a storage or conservation project. Water leasing/conversion are affect tools for supplementing and maintaining in-stream flows. Channel restoration and in-stream habitat improvements (**Stream BMPs**) used in conjunction with water leasing/conversion can greatly enhance results.
- **Irrigation Water Management (449) –** determining and controlling the volume, frequency, and application of water in a planned, efficient manner to manage soil moisture to promote desired crop response; optimize use of available water supplies;

minimize irrigation induces soil erosion; decrease non-point source pollution of surface and groundwater resources; manage salts in the crop root zone; and manage air, soil, or plant micro-climate. Irrigation Land Leveling (464) and Land Smoothing (466) which involve reshaping land surface can also be used to increase water application efficiency.

- **Irrigation Water Conveyance (Blackfoot Challenge 2003, NRCS 2007) –** Ditches and canals serve as integral parts of irrigation water distribution or conveyance systems. Ditches and canals can be lined with a variety of materials including Flexible Membrane (428B), Nonreinforced Concrete (428A), fabrics, polymers (Anionic Polyacrylamide: PAM (450)), chemicals or clay to improve management of irrigation water, prevent waterlogging of land; maintain water quality; prevent erosion; and reduce water loss. Clearing and Snagging (326) or removal of snags, drifts, or other obstructions can increase flow capacity of a ditch or canal as well. Pipelines (430AA, 430BB, 430CC, 430DD, 430EE, 430FF, 430GG, 430HH) are also used in irrigation water conveyance to prevent erosion or loss of water quality or damage to land; make possible proper water use; and reduce water conveyance losses.
- **Irrigation System Efficiency (Blackfoot Challenge 2003, NRCS 2007) –** Improving irrigation system efficiency is intended to efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment. Irrigation water management (449) can improve water use efficiency. In some cases however, improvements to infrastructure is also necessary. The most common change in irrigation infrastructure is conversion of flood or wheel-line irrigation systems to low pressure center pivot or sprinkler systems (442). Where these systems already exist, regular maintenance and replacement of worn equipment can maintain the intended system efficiency. Where center pivot or sprinkler systems are not feasible, additional surface and subsurface water-control structures can be installed for the efficient distribution of water (443 and 587).

Forestry BMPs – The Montana Department of Natural Resources and Conservation (MT DNRC) is charged with providing landowners and operators in Montana with information on BMPs that have been adopted to minimize non-point source water pollution from forest practices such as timber harvesting through preventing erosion and reducing delivery of sediment to streams. MT DNRC is also charged with monitoring the application and effectiveness of those BMPs. Two documents guide Forestry BMPs in Montana:

- **The Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA) –** prohibits certain timber harvest activities within at least 50 feet of any stream, lake, or other water body including broadcast burning; operating wheeled are tracked vehicles except on established roads; clear cutting; constructing roads in the SMZ except when necessary to cross a stream or wetland; handling, storing, applying, or disposing of hazardous or toxic material in a manner that pollutes streams, lakes, or wetlands or that may cause damage or injury to humans, land, animals, or plants; casting road material into a stream, wetland, or watercourse; depositing slash in streams or other water bodies. This law must be followed for all commercial timber harvest activities. MT DNRC must approve any exceptions to these prohibited activities. While the law is intended to guide commercial timber harvesting activities in streamside areas, the principles behind the law (riparian area protection) can be applied to numerous land management activities (i.e. timber harvest for personal use, agriculture, development). This plan promotes the use of SMZ practices across all land ownerships and streamside management activities.

- **Best Management Practices for Forestry in Montana** (MT DNRC/MT BMP Work Group – January 2006) – are a voluntary set of practices recommended for timber harvest activities outside of SMZs. These BMPs cover timber harvesting and site preparation, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. The Montana Logging Association and MT DNRC offer regular Forestry BMP training sessions for private landowners and contract loggers. **Water Quality BMPs for Montana Forests** (MSU, 2001) is another excellent resource for information on forestry related BMPs.

In addition to these guiding documents, forestry related conservation practices described by NRCS include:

- **Prescribed Forestry (490) –** Managed forested areas for health, wood, and/or fiber, recreation, water, aesthetics, wildlife, habitat, and plant biodiversity. The purpose of this practice is to maintain or improve forest health, protect soil quality and condition, maintain or enhance water quality and quantity; maintain or improve forest productivity; maintain or improve plant diversity; improve aesthetic and recreational values; improve wildlife habitat; and achieve or maintain a desired understory plant community for forest products, grazing, and browsing. Prescribed Burning (338) can also be used as part of a forest management plan.

Road BMPs – Road BMP guidance is contained in the **Best Management Practices for Forestry in Montana** (MT DNRC/ MT BMP Work Group – January 2006). These BMPs are voluntary and are related to road construction and maintenance for timber harvesting activities but can generally be applied to all roads. Road related BMPs covered include planning and location, design, road drainage, construction, maintenance, stream crossings, and road construction and harvesting considerations. These BMPs were designed to limit sediment delivery from roads to streams, limit impacts of roads on stream habitat and water temperatures, and to maintain fish passage and migration corridors. Road construction is also addressed in the **Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA)** which prohibits constructing roads in the SMZ except when necessary to cross streams or wetlands. **Water Quality BMPs for Montana Forests** (MSU, 2001) contains additional road related BMP information.

Other Land Uses and Best Management Practices – Grazing, Forestry, Water Conservation, and Road BMPs described in this Appendix cover the primary land uses in the Middle Blackfoot and Nevada Creek planning areas affecting water quality. Mining and residential/commercial development are less prevalent in these planning areas but still warrant some discussion.

- **Mining –** Historically mining played a larger role in the development and economy of the Blackfoot watershed. Current mining activities are fairly minimal (although many residual effects still linger), however, the potential for new mining activities is always present. All new mining activities must be approved through a permit authorized by the Montana Department of Environmental Quality. The standards and requirements set by these permits provide protection or mitigation of water quality degradation as a result of new mining activities.

- **Residential/Commercial Development –** On a whole the Blackfoot watershed remains largely rural and undeveloped. Development has and will continue to increase over time and left unguided can significantly impact water quality. The Montana Non Point Source Management Plan (2007) speaks to controlling nonpoint source pollution from development. While the recommended BMPs focus more on an urban setting, the practices described (floodplain buffers, setbacks, conservation easements, etc) can generally be applied to all development activities and should be considered especially when sensitive areas and/or water quality are of concern.

Resource Guide

The following is a list of resource contacts for private landowners. These organizations can provide assistance to landowners interested in conservation planning or conservation practice implementation.

Blackfoot Challenge
Contact: Brian McDonald
Phone: (406) 793-3900
Email: brian@blackfootchallenge.org
Web: www.blackfootchallenge.org

Big Blackfoot Chapter of Trout Unlimited (BBCTU)
Contact: Ryen Aashiem
Phone: (406) 543-6454
Email: ryen@montanatu.org

Montana Fish, Wildlife, and Parks
Contact: Ron Pierce
Phone: (406) 542-5532
Email: rpierce@mt.gov
Web: www.fwp.mt.gov

North Powell Conservation District
Contact: Brad Weltzien
Phone: (406) 244-4420
Email: weltzienb@yahoo.com

Missoula County Conservation District
Contact: Tara Comfort
Phone: (406) 829-3395 Ext. 113
Email: tara.comfort@mt.nacdnet.net

U.S. Fish & Wildlife Service
Contact: Greg Neudecker

Phone: (406) 793-7400
Email: greg_neudecker@fws.gov
Web: http://ecos.fws.gov/partners/viewContent.do?viewPage=home

Natural Resources Conservation Service – Deerlodge
Contact: Glen Green
Phone: (406) 846-1703 Ext. 304
Email: glen.green@mt.usda.gov
Web: www.mt.nrcs.usda.gov

Natural Resources Conservation Service – Missoula
Contact: Kris Berg
Phone: (406) 829-3395 Ext. 121
Email: Kris.Berg@mt.usda.gov
Web: www.mt.nrcs.usda.gov

APPENDIX I
STREAMFLOW, SEDIMENT, AND NUTRIENT SIMULATION ON THE BLACKFOOT WATERSHED USING SWAT

By Michael Van Liew and Kyle Flynn

Model Description

The SWAT model was originally developed by the USDA ARS to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large ungaged basins (Arnold et al., 1998). SWAT incorporates features of several ARS models and is a direct outgrowth of the SWRRB model (Simulator for Water Resources in Rural Basins) (Williams et al, 1985). Specific models that contributed to the development of SWAT include CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems) (Knisel, 1980), GLEAMS (Groundwater Loading Effects on Agricultural Management Systems) (Leonard et al., 1987), and EPIC (Erosion-Productivity Impact Calculator) (Williams et al., 1984). The SCS runoff curve number is used to estimate surface runoff from daily precipitation (USDA SCS, 1986). The curve number is adjusted according to moisture conditions in the watershed (Arnold et al, 1993). SWAT can also be run on a sub-daily time step basis using the Green and Ampt (Green and Ampt, 1911) infiltration method. Other hydrologic processes simulated by the model include evapotranspiration; infiltration; percolation losses; channel transmission losses; channel routing; and surface, lateral, shallow aquifer, and deep aquifer flow (Arnold and Allen, 1996). The runoff curve number option (Neitsch et al, 2002) is adopted in this study. Evapotranspiration (ET) in SWAT is computed using the Priestly Taylor (Priestly and Taylor, 1972), Penman-Monteith (Allen et al., 1989) or Hargreaves (1975) method. For this study, the Hargreaves (1975) method was used to estimate potential ET, since extraterrestrial radiation and air temperature were the only two measured variables required for computing daily potential ET values with this method. Channel routing in SWAT is accomplished by either the variable storage or Muskingum routing methods. For this study, the variable storage method was used to route flows in SWAT.

SWAT is a distributed parameter model that partitions a watershed into a number of subbasins. Each subbasin delineated within the model is simulated as a homogeneous area in terms of climatic conditions, but with additional subdivisions within each subbasin to represent various soils and land use types. Each of these subdivisions is referred to as a hydrologic response unit (HRU) and is assumed to be spatially uniform in terms of soils, land use, topographic, and climatic data.

AVSWAT 2003 was the version of the model used in this study, which incorporates an ArcView GIS interface for expediting model input and output (Di Luzio et al., 2002). The ArcView GIS raster based system consists of a modular structure that contains a tool for optimizing the definition and segmentation of a watershed and network based on topography. It also consists of a tool for defining the HRUs over the watershed and an integrated user-friendly interface. The GIS interface not only allows users to segment a watershed, but to import and format the supporting data necessary for the specific application and calibration of the model.

AVSWAT 2003 also includes a multi-objective, automated calibration procedure that was developed by Van Griensven and Bauwens (2003). The calibration procedure is based on a shuffled complex evolution algorithm (SCE-UA; Duan et al., 1992) and a single objective function. In a first step, the SCE-UA selects an initial population of parameters by random sampling throughout the feasible parameter space for "p" parameters to be optimized, based on given parameter ranges. The population is partitioned into several communities, each consisting of "2p+1" points. Each community is made to evolve based on a statistical "reproduction process" that uses the simplex method, an algorithm that evaluates the objective function in a systematic way with regard to the progress of the search in previous iterations (Nelder and Mead, 1965). At periodic stages in the evolution, the entire population is shuffled and points are reassigned to communities to ensure information sharing. As the search progresses, the entire population tends to converge toward the neighborhood of global optimization, provided the initial population size is sufficiently large (Duan et al., 1992). The SCE-UA has been widely used in watershed model calibration and other areas of hydrology such as soil erosion, subsurface hydrology, remote sensing, and land surface modeling and has generally been found to be robust, effective, and efficient (Duan, 2003).

In the optimization scheme developed for SWAT 2003, parameters in the model that affect hydrology or water quality can be changed in either a lumped (over the entire watershed) or distributed (for selected subbasins or hydrologic response units (HRUs)) way. In addition, the parameters can be modified by replacement, by addition of an absolute change or by a multiplication of a relative change. In addition to weight assignments for output variables that can be made in multi-objective calibrations (e.g., 50% streamflow, 30% sediment, 20% nutrients), the user can specify a particular objective function that is minimized. The objective function is an indicator of the deviation between a measured and a simulated series (Van Griensven and Bauwens, 2003). An approach often selected as an objective function is the sum of squares of residuals method:

$$SSQ = (1/n) \sum_{i=1,n}^{n} (Qi,obs - Qi, sim)2 \qquad (1)$$

where

SSQ = the sum of squares of the residuals
n = the number of pairs of measured and simulated variables
$Q_{i, obs}$ = observed variable at a daily time scale
$Q_{i,sim}$ = simulated variable at a daily time scale

Equation (1) represents the classical mean square error method that aims at matching a simulated time series to a measured series.

Erosion and sediment yield are estimated for each HRU in SWAT using the Modified Universal Soil Loss Equation (MUSLE) (Williams, 1975), an enhancement of the USLE (Borah et al., 2006). Sediment is routed through the stream channel considering deposition and degradation processes and using a simplified equation based on stream power. SWAT comprehensively models transfers and internal cycling of the major forms of nitrogen and phosphorus. The model monitors two pools of inorganic and three pools of organic forms of nitrogen. SWAT also monitors three pools of inorganic and three pools of organic forms of phosphorus. SWAT incorporates instream nutrient dynamics using kinetic routines from the instream water quality model referred to as QUAL2E (Brown and Barnwell, 1987). Other in-stream variables that are simulated include temperature, dissolved oxygen, bacteria, and pesticides.

Model documentation is well formulated in SWAT, with considerable detail that is provided regarding model structure, algorithms, data input, and viewing of test results. SWAT documentation can be accessed through the theoretical documentation and user's manuals (Neitsch et al., 2002).

Watershed Delineation within AVSWAT 2003

Elevation, land use, and soil characteristics were obtained from GIS data layers for the Blackfoot Watershed. The elevation layer was developed from a 30 m DEM obtained from the Shuttle Radar Topography Mission (Rabus et al., 2003), and the soils layer was obtained from available STATSGO data. The land use layer was obtained from the 1992 USGS National Land Cover Database and was modified by including data from Landsat satellite imagery and historic county water resource surveys to better describe the presence of irrigated pasture on the watershed.

For this investigation, 65 subbasins were delineated in the Blackfoot to account for climatic variations based on the spatial distribution of precipitation and temperature gages within the watershed and to account for hydrologic differences among impaired subwatersheds within the watershed. Five reservoir files were also created to consider the effects of storage and release of water from the larger dams within the watershed. The number of HRUs in the delineation of the respective watersheds was constrained by a threshold based on a land use and soil type covering an area of at least 10% and 10%, respectively, within any given subbasin. At this threshold level, a total of 633 HRUs were delineated within the Blackfoot. The original delineation of the watershed considered five land cover types that included forest, irrigated pasture with cattle grazing, range-grass, range-brush, and wetlands. This delineation was later modified to include four additional land cover/management types that consisted of urban development, residential development, forest harvest, and forest roads. Cattle grazing within the watershed was also expanded to include seasonal variations among the pasture, range, and forest cover types within a given subbasin.

Default values of the runoff curve number in SWAT were assigned to the various land cover types that were originally delineated in the Blackfoot project. Curve numbers were estimated for the urban development, residential development, forest harvest, and forest roads based on information available from published data by SCS (1986) and our understanding of existing field conditions on the watershed.

Table I-1 presents a listing of the respective land cover types, percent of watershed areas, representative curve number values, and USLE C factors for each land cover type delineated in the Blackfoot project. USLE C factor values shown in **Table I-1** represent values that yield average annual erosion rates that are similar to those reported in the literature for various land cover conditions present in Montana.

Table I-1. A Listing of the Representative Land Cover Types, Percent of Watershed Areas, Representative Curve Numbers, and USLE C Factors Delineated In the Blackfoot Project

Land Use/Management	Percent of Watershed Area	Representative Curve Number	USLE C Factor
Pasture	3.5	49	0.018
Range brush	6.6	41	0.04
Range grass	15.5	49	0.045
Wetlands	0.2	46	0.0085
Forest	71	35	0.004
Forest harvest	0.7	39	0.01
Forest roads	0.2	80	0.85
Urban	0.3	72	0.1
Residential	2	49	0.045

Urban and Residential Septic Systems

HRUs within SWAT were modified to estimate the impact of on-site septic systems within the Blackfoot Watershed. Urban and residential septic systems were represented on 16 of the 65 subbasins based on estimates of population density within the watershed. Nitrogen and phosphorus were applied at equivalent rates of 60 and 10 mg per liter, respectively. Septic discharge was assumed to be 165 liters per person per day times an average household occupancy of 2.5 persons. The resultant N and P application rates were therefore 2.48 and 0.41 kg per ha per day, respectively. These nutrients were input into SWAT as fertilizer beneath the land surface on a daily basis throughout the year.

Forest Roads

HRUs within SWAT were also modified to estimate the impact of unpaved forest roads within the watershed. These roads were represented on 8 of the 65 subbasins, and were assumed to have a slope steepness of 7% and a slope length of 5 m.

Miscellaneous Land Cover Types

Fertilizer 28-47-7 was assumed to be applied each year on April 15th at a rate of 282 Kg/ha on the pasture land cover type. If a given subbasin within the delineated project contained pasture as one of the cover types, it was assumed that livestock would be rotated among pasture, range grass, and forest cover types within that subbasin according the schedule presented in **Table I-2**. Livestock density on pasture, range grass, and forest lands was assumed to be 1.2, 0.35, and 0.067 animals per ha, respectively.

Table I-2. Yearly Simulated Rates of Total Nitrogen and Total Phosphorus from Fertilizer or Livestock Sources

Source	Land Cover	Time of Application	Annual Total N (Kg/ha)	Annual Total P (Kg/ha)
Fertilizer	Pasture	April 15th	79	56
Livestock	Pasture	Daily: Nov 1st to April 14th	17.2	4.7
Livestock	Range grass	Daily: April 15th to June 14th	1.6	0.45
Livestock	Forest	Daily: June 15th to Oct. 31st	0.78	0.22
Fertilizer*	Residential	Daily	905	150
Fertilizer*	Urban	Daily	905	150

*applied fertilizer used to mimic on site septic systems

Hydrologic Calibration and Validation

Based on available climatic and streamflow data within the watershed, model parameters in SWAT were calibrated for a period of record from 2002 to 2004 at four streamgaging locations. To account for spatial variability in topographic, soil, and land use factors among subwatersheds within the Blackfoot, parameters governing streamflow response in SWAT were calibrated in a distributed fashion using the automated calibration procedure, where observed and simulated outputs were compared at the same outlet points on the watershed. Therefore, with the completion of the optimization run, a set of calibrated parameters was computed for the Blackfoot River above Nevada Creek, Nevada Creek below the reservoir, the North Fork of the Blackfoot River, and the Blackfoot River near Bonner. With a decision that was made sometime following the streamflow autocalibration, two additional gaging stations were added as calibration points within the watershed. These two additional calibration points included the Nevada Creek above the reservoir and Clearwater Creek subwatersheds within the Blackfoot. Since streamflow data were not available for Clearwater Creek during the 2002 to 2004 period, the average annual ratio of streamflow for Clearwater Creek to Blackfoot River at Bonner based on the 1975 to 1992 available period of record for these two gages was used to estimate parameter values for the Clearwater subwatershed. Manual adjustments were then implemented at the six locations to fine tune the autocalibration. Available streamflow data at Nevada Creek above the reservoir, the North Fork of the Blackfoot River, and the Blackfoot River near Bonner from 1998 to 2001 were used for model validation. A description of parameters calibrated in the model is as follows.

Description of Calibration Parameters

For this investigation, fourteen parameters that govern hydrologic processes in SWAT were selected for calibration on the Blackfoot Watershed. Although the runoff curve number (CN2) could have also been calibrated, default values input during project delineation were assumed to be valid for model simulations. This assumption in turn facilitated the selection of appropriate curve number values for proposed changes in land management and cover associated with various simulation scenarios. The 14 hydrologic model parameters were grouped into three categories (**Table I-3**), which were considered to predominantly govern surface, subsurface, and basin response.

Following calibration of the hydrologic response of the model, 15 parameters governing sediment and nutrient response on the Bitterroot Watershed were calibrated. These 15 parameters are presented in **Table I-3**. The following is a brief description of parameters governing hydrologic, sediment and nutrient response in SWAT.

Parameters Governing Surface Response

Calibration parameters governing the surface water response in SWAT include the soil evaporation compensation factor and the available soil water capacity. The soil evaporation compensation factor (ESCO) adjusts the depth distribution for evaporation from the soil to account for the effect of capillary action, crusting, and cracks. The available soil water capacity (SOL_AWC) is the volume of water that is available to plants if the soil was at field capacity. It is estimated by determining the amount of water released between in situ field capacity and the permanent wilting point.

Parameters Governing Subsurface Response

Six calibration parameters govern the subsurface water response in SWAT. One of these parameters is referred to as the ground water "revap" coefficient (GW_REVAP), which controls the amount of water that will move from the shallow aquifer to the root zone as a result of soil moisture depletion and the amount of direct ground water uptake from deep-rooted trees and shrubs. Another parameter that governs the subsurface response is the threshold depth of water in the shallow aquifer for "revap" to occur (REVAPMN). Movement of water from the shallow aquifer to the root zone or to plants is allowed only if the depth of water in the shallow aquifer is equal to or greater than the minimum "revap." A third parameter is the threshold depth of water in the shallow aquifer required for return flow to occur to the stream (GWQMN). Two other parameters that govern watershed response include the baseflow alpha factor and ground water delay. The baseflow alpha factor (ALPHA_BF), or recession constant, characterizes the ground water recession curve. This factor approaches one for flat recessions and approaches zero for steep recessions. The ground water delay (GW_DELAY) is the time required for water leaving the bottom of the root zone to reach the shallow aquifer. A sixth factor is the deep aquifer percolation fraction which governs the fraction of percolation from the root zone to the deep aquifer (RCHRG_DP).

Parameters Governing Basin Response

Seven parameters that govern basin response in SWAT were calibrated in this study. Two of these parameters included channel hydraulic conductivity (CH_K2) that governs the movement of water from the streambed to the subsurface and the surface runoff lag time (SURLAG) that accounts for the storage of runoff in the model for a given subbasin. Five other basin parameters govern snowfall and snowmelt in SWAT. One parameter is the snowfall temperature (SFTMP) which is the mean air temperature at which precipitation is equally likely to be rain as snow or freezing rain. A second parameter is the snowmelt base temperature (SMTMP) that defines the snow pack temperature above which snowmelt will occur. SMFMX and SMFMN are melt factors for snow on June 21 and December 21, respectively, in the Northern Hemisphere that allow the rate of snowmelt to vary through the year as a function of snow pack density. A fifth parameter is the snow pack temperature lag factor (TIMP) that controls the impact of the current day's air temperature on the snow pack temperature.

Parameters Governing Sediment Response

Four parameters in SWAT must be calibrated to simulate processes of erosion and sedimentation in the model. One of these parameters is the channel erodibility factor (CH_EROD) which is conceptually similar to the soil erodibility factor in the universal soil loss equation. A second parameter is the channel cover factor (CH_COV) which is defined as the ratio of degradation from a specified vegetative cover to the corresponding degradation from a channel with no vegetative cover. The third and fourth sediment parameters that must be calibrated in SWAT are the coefficient and exponent parameters that are used to calculate the maximum amount of sediment that can be reentrained during channel sediment routing. These two parameters are referred to respectively as SPCON and SPEXP.

Parameters Governing Nutrient Response

Several parameters govern the movement and transformation of various constituents of nitrogen and phosphorus in SWAT. Five parameters govern nitrogen fate and transport on the landscape. One of these parameters in SWAT is referred to as the nitrogen uptake distribution parameter (N_UPDIS) which controls the amount of nitrogen removed from the different soil layers by the plant. A second parameter is the rate factor for humus mineralization of active organic nitrogen (CMN). A third parameter is referred to as the nitrogen percolation coefficient (NPERCO). This parameter controls the amount of mineral N removed from the surface layer in runoff relative to the amount removed via percolation. The fourth and fifth parameters are SOL_NO3 and SOL_ORGN which represent the initial nitrate and organic N concentrations in the respective soil layers.

Six parameters control phosphorus rate and transport on the landscape. One of these parameters governing phosphorus response in the model is referred to as the phosphorus percolation coefficient (PPERCO). Like NPERCO for nitrogen, PPERCO controls the ratio of the amount of soluble P removed from the surface layer in runoff relative to the amount of soluble P removed via percolation. A second parameter is the phosphorus soil partitioning coefficient (PHOSKD), which represents the ratio of phosphorus attached to sediment to phosphorus dissolved in soil water. A third parameter describes the phosphorus uptake distribution (P_UPDIS) which governs the plant uptake of phosphorus from the different soil horizons in the same way that N_UPDIS controls nitrogen uptake. Yet a fourth parameter is the phosphorus sorption coefficient (PSP). This parameter represents the fraction of mineral phosphorus remaining in the labile pool after initial rapid sorption to the soil. The fifth and sixth parameters are SOL_LABP and SOL_ORGP which represent the initial soluble P and organic P concentrations in the respective soil layers.

Table I-3. A Listing of Parameters, Their Description, and Units That Were Calibrated In SWAT

Parameter	Description	Units
Parameters governing surface water response		
ESCO	soil evaporation compensation factor	none
SOL_AWC	available soil water capacity	mm/mm
Parameters governing subsurface water response		
ESCO	soil evaporation compensation factor	none
SOL_AWC	available soil water capacity	mm/mm
Parameters governing subsurface water response		
GW_REVAP	ground water "revap" coefficient	none
REVAPMN	threshold depth of water in the shallow aquifer for "revap to occur"	mm
GWQMN	threshold depth of water in the shallow aquifer required for return flow to occur	mm
GW_DELAY	ground water delay	days
ALPHA_BF	baseflow alpha factor, or recession constant	days
RCHRG_DP	deep aquifer percolation fraction	fraction
Parameters governing basin response		
SFTMP	snowfall temperature	degrees C
SMTMP	snowmelt temperature	degrees C
SMFMX	melt factor for snow on June 21	mm/deg C day
SMFMN	melt factor for snow on December 21	mm/deg C day
TIMP	snow pack temperature lag factor	none
SURLAG	surface runoff lag time	days
Parameters governing sediment response		
CH_EROD	channel erodibility factor	none
CH_COV	channel cover factor	cm/hour-Pa
SPCON	coefficient for sediment reentrainment function	none
SPEXP	exponent for sediment reentrainment function	none
Parameters governing nutrient response		
N_UPDIS	nitrogen uptake distribution factor	none
CMN	humus mineralization of active organic nitrogen factor	none
NPERCO	nitrogen percolation coefficient	10 m**3/Mg
SOL_NO3	initial nitrate concentration in soil layer	mg/kg
SOL_ORGN	initial organic nitrogen concentration in soil layer	mg/kg
PPERCO	phosphorus percolation coefficient	10 m**3/Mg
PHOSKD	phosphorus soil partitioning coefficient	none
P_UPDIS	phosphorus uptake distribution factor	none
PSP	phosphorus sorption coefficient	none
SOL_LABP	initial soluble phosphorus concentration in soil layer	mg/kg
SOL_ORGP	initial organic phosphorus concentration in soil layer	mg/kg

Evaluation Criteria

Four evaluation criteria were used to assess monthly and daily streamflow simulated by SWAT. The first evaluation criterion used was the percent bias (PBIAS), which is a measure of the average tendency of the simulated flows to be larger or smaller than their observed values. The optimal PBIAS value is 0.0; a positive value indicates a model bias toward underestimation, whereas a negative value indicates a bias toward overestimation (Gupta et al., 1999). PBIAS may be expressed as

$$PBIAS = \sum_{k=1,n} (Q_{k\ obs} - Q_{k\ sim}) (100) / \sum_{k=1,n} (Q_{k\ obs}) \quad (2)$$

where

PBIAS = deviation of streamflow discharge, expressed as a percent
$Q_{k\ obs}$ = observed streamflow in $m^3\ s^{-1}$ (cms)
$Q_{k\ sim}$ = simulated streamflow (cms)

Donigian et al. (1983) considered HSPF model performance "very good" if the absolute percent error is <10%, "good" if the error is between 10% and <15%, and "fair" if the error is between 15% and <25% for calibration and validation. Measurement errors associated with streamflow as recommended by Harmel et al. (2006) follow the same standard. This standard was therefore adopted for the PBIAS evaluation criterion used in this study, with PBIAS values >25% considered as unsatisfactory.

The second evaluation criterion was the model coefficient of efficiency (NSE; Nash and Sutcliffe, 1970), which Sevat and Dezetter (1991) found to be the best objective function for reflecting the overall fit of a hydrograph. NSE expresses the fraction of the measured streamflow variance that is reproduced by the model.

$$NSE = 1 - \left[\sum_{k=1,n}^{n} (Q_{k\ obs} - Q_{k\ sim})^2 / \sum_{k=1,n}^{n} (Q_{k\ obs} - Q_{mean})^2\right] \quad (3)$$

where

NSE = Nash Sutcliffe coefficient of efficiency
Q_{mean} = mean observed streamflow during the evaluation period (cms)

NSE values were computed for both monthly and daily streamflow. Simulation results were considered to be good for values of NSE >0.75, while for values of NSE between 0.75 and 0.36, the simulation results are considered to be satisfactory. (Motovilov et al., 1999). For this study NSE values <0.36 were considered to be unsatisfactory.

The third evaluation criterion compared simulated daily and monthly hydrographs to observed values. At the daily time scale, particular attention was given to the timing and magnitude of peak flows and the shape of the recession curves. The fourth criterion compared average monthly measured versus simulated streamflow for the calibration period.

Results of Streamflow Calibration

Average annual values of precipitation as well as measured and simulated streamflow for five of the watershed measurement points are presented in **Table I-4**. Especially noteworthy in the table is the differences in average annual precipitation and discharge for the Nevada Creek subwatershed as compared to either the Blackfoot River above Nevada Creek or the North Fork of the Blackfoot River subwatersheds. For the calibration period for example, the Nevada Creek below the reservoir subwatershed average annual precipitation of 445 mm is about half of the 848 mm measured for the Blackfoot River above Nevada Creek subwatershed. For this time series the measured average annual discharge for Nevada Creek below the reservoir was 64 mm, or about 20% of the measured value of 316 mm for the Blackfoot River above Nevada Creek.

Table I-4. Drainage Area, Average Annual Precipitation, and Measured Versus Simulated Average Annual Discharge for the Blackfoot Streamgaging Locations

Measurement Point and Simulation Type	Drainage Area (Km^2)	Average Annual Precipitation (mm)	Measured Average Annual Discharge (mm)	Simulated Average Annual Discharge (mm)
Blackfoot abv Nevada-c*	1294	848	316	318
Nevada Cr abv res-c	310	471	70	67
Nevada Cr abv res v*	310	486	80	66
Nevada Cr bel res-c	885	445	64	66
North Fk Blackfoot-c	824	941	409	406
North Fk Blackfoot-v	824	919	377	333
Blackfoot nr Bonner-c	5958	819	203	204
Blackfoot nr Bonner-v	5958	809	194	192

c* = calibration v* = validation

Percent bias and the Nash Sutcliffe (1970) coefficient of efficiency values are presented in **Table I-5** for the calibration and validation periods on the Blackfoot Watershed. A comparison of measured versus simulated daily hydrographs shows good agreement for the Blackfoot River above Nevada Creek, the North Fork of the Blackfoot River, and the Blackfoot River at Bonner subwatersheds (**Figures I.1-I.3**). Based on the calibration period from 2002 to 2004, daily NSE values were 0.68, 0.81, and 0.77 for these three subwatersheds, respectively. A comparison of measured versus simulated daily hydrographs was considered poor for the calibration period for Nevada Creek above the reservoir (NSE = 0.08) and Nevada Creek below the reservoir (-0.26) (**Figures I-4 and I-5**), and adequate for the validation period for Nevada Creek above the reservoir (0.46). The difficulties encountered in calibrating the Nevada Creek subwatershed were attributed in part to an inadequate precipitation signal based on the available climatological stations on or near the watershed and the fair to poor measured streamflow records collected by the USGS which are due to the numerous irrigation diversions in the subwatershed.

Table I-5. Percent Bias and Nash Sutcliffe Coefficient of Efficiency Statistics for Streamflow during the Calibration (2002-2004) and Validation (1998-2001) Periods on the Blackfoot Watershed

Measurement Point	Time Series	Percent Bias	Monthly NSE	Daily NSE

Table I-5. Percent Bias and Nash Sutcliffe Coefficient of Efficiency Statistics for Streamflow during the Calibration (2002-2004) and Validation (1998-2001) Periods on the Blackfoot Watershed

Measurement Point	Time Series	Percent Bias	Monthly NSE	Daily NSE
BFT abv Nevada	Calibration	-5.9%	0.78	0.68
Nevada Cr. abv res	Calibration	6.9%	0.27	0.08
Nevada Cr. abv res	Validation	19.30%	0.6	0.46
Nevada Cr. bel res	Calibration	-2.70%	-0.17	-0.26
North Fk BFT	Calibration	-1.60%	0.91	0.81
North Fk BFT	Validation	13.90%	0.9	0.82
BFT nr Bonner	Calibration	-10.00%	0.81	0.77
BFT nr Bonner	Validation	-0.70%	0.84	0.81

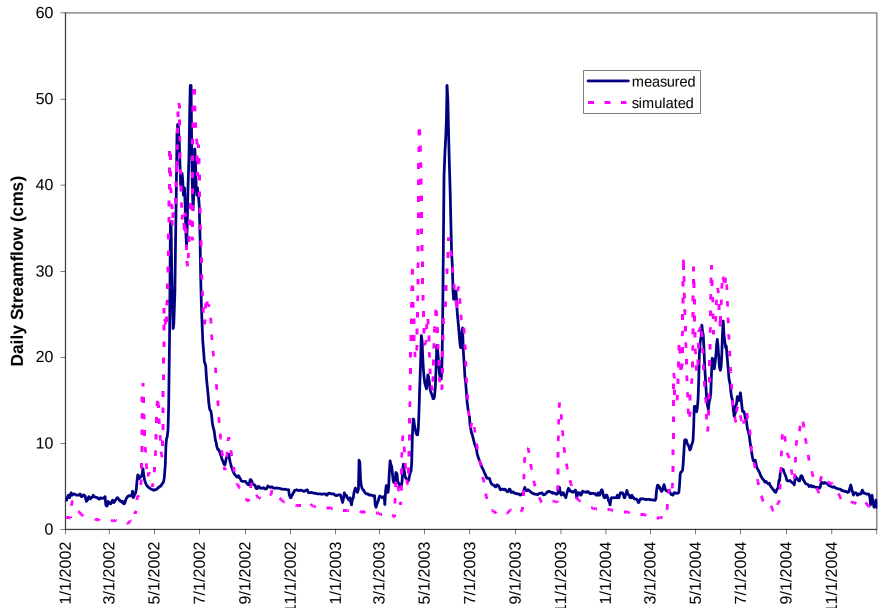

Figure I-1. Comparison of Measured Versus Simulated Daily Discharge for the Blackfoot River above Nevada Creek during The 2002 To 2004 Calibration Period

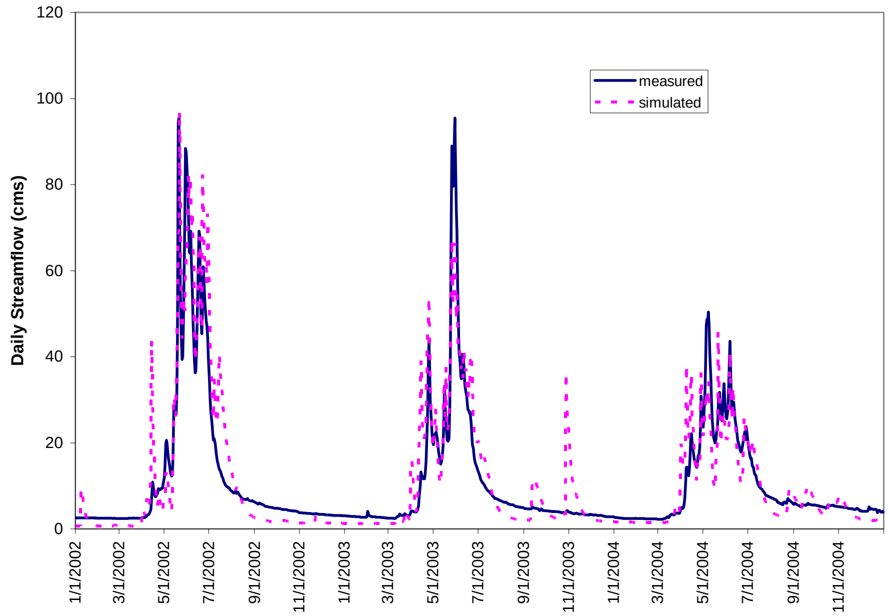

Figure I-2. Comparison of Measured Versus Simulated Daily Discharge for the North Fork of the Blackfoot River during The 2002 To 2004 Calibration Period

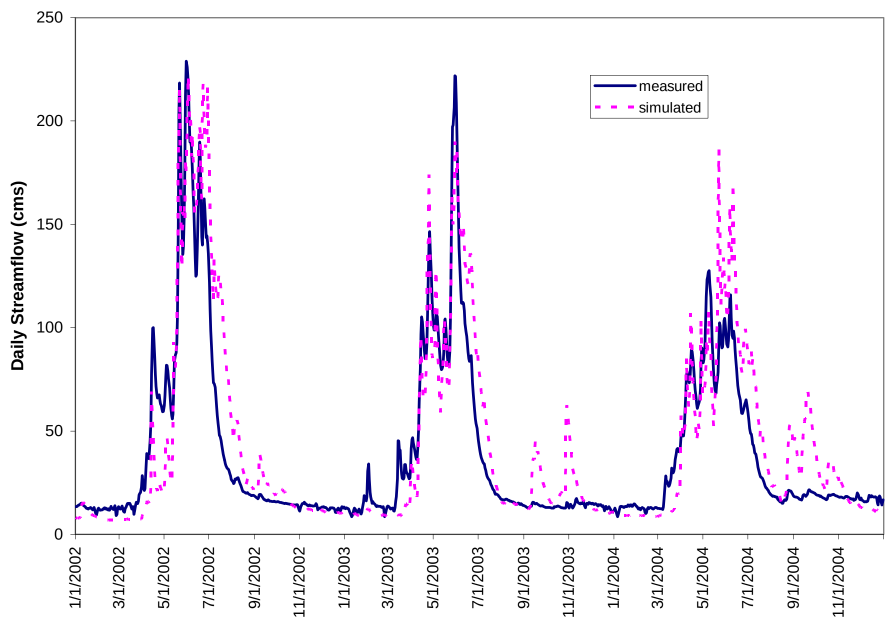

Figure I-3. Comparison of Measured Versus Simulated Daily Discharge for the Blackfoot River at Bonner during The 2002 To 2004 Calibration Period

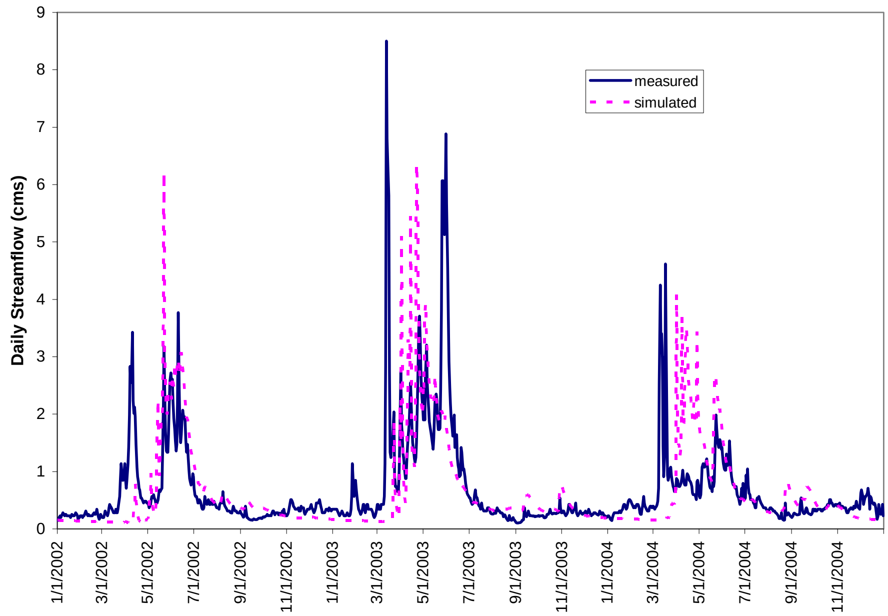

Figure I-4. Comparison of Measured Versus Simulated Daily Discharge for Nevada Creek above the Reservoir during The 2002 To 2004 Calibration Period

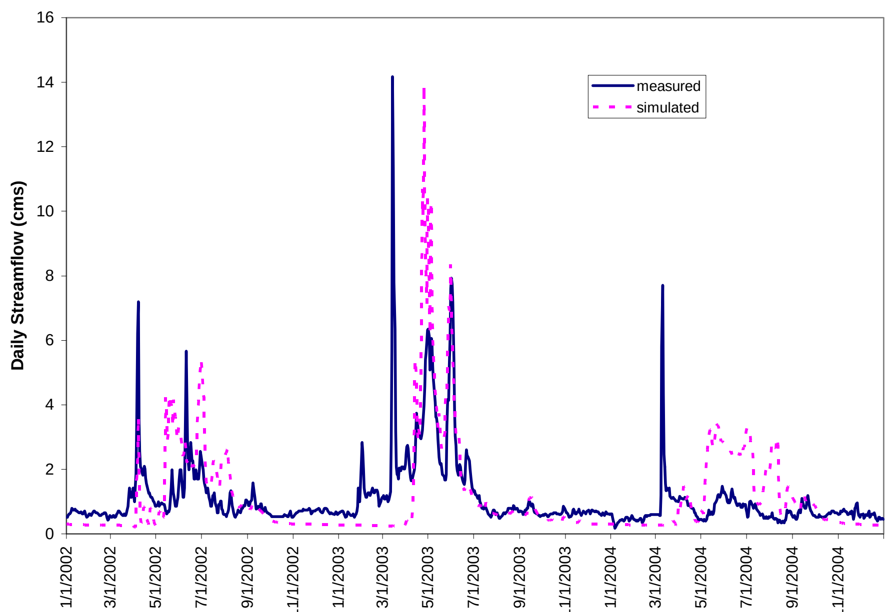

Figure I-5. Comparison of Measured Versus Simulated Daily Discharge for Nevada Creek below the Reservoir during The 2002 To 2004 Calibration Period

With the exception of the Nevada Creek subwatershed (**Figure I-6**), very good agreement was obtained in the comparison of measured versus simulated monthly hydrographs as illustrated in **Figures I-7 and I-8** for the North Fork of the Blackfoot River and the Blackfoot River at Bonner, respectively. Examination of the average monthly measured versus simulated hydrographs shows that SWAT tended to somewhat underestimate flows during the winter and late fall months (**Figures I-9 through I-11**). A suitable explanation could not be found to account for SWAT's tendency to substantially underestimate flows during the month of March for Nevada Creek above the reservoir.

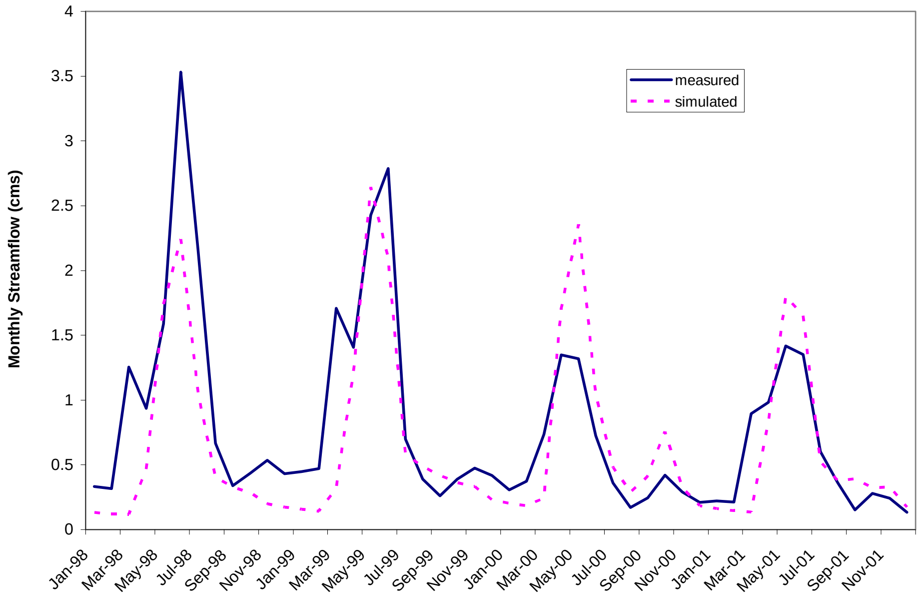

Figure I-6. Comparison of Measured Versus Simulated Monthly Discharge for Nevada Creek above the Reservoir during the 1998 To 2001 Validation Period

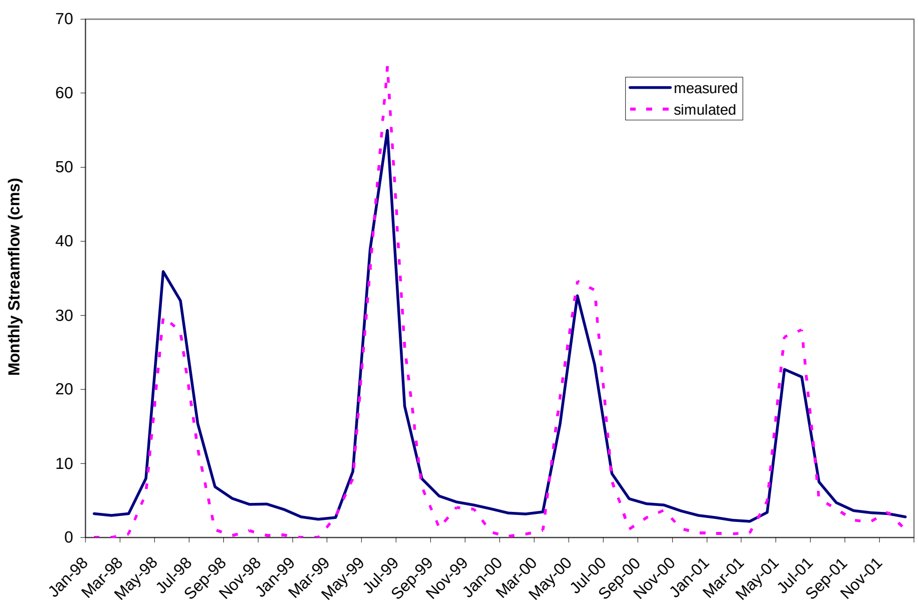

Figure I-7. Comparison of Measured Versus Simulated Monthly Discharge for the North Fork of the Blackfoot River during the 1998 To 2001 Validation Period

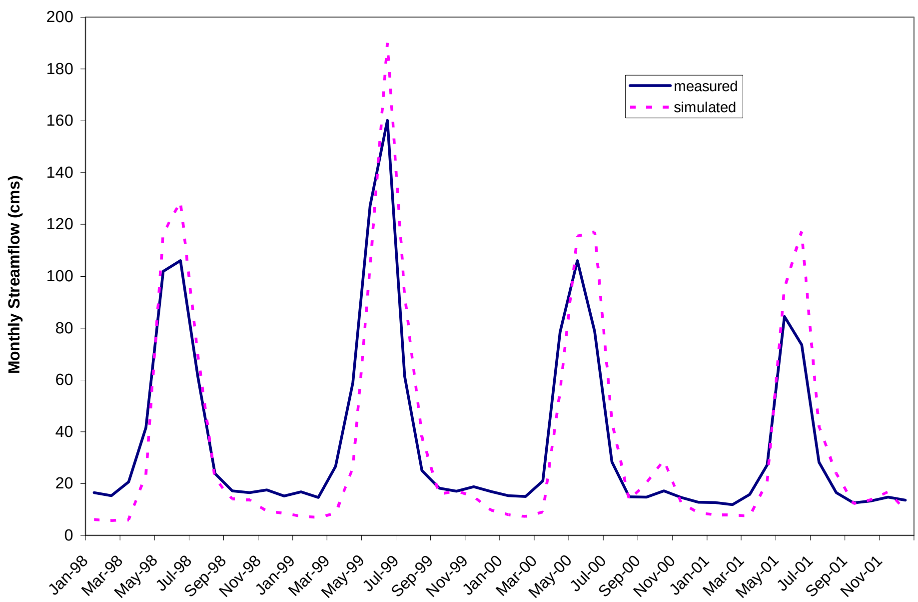

Figure I-8. Comparison of Measured Versus Simulated Monthly Discharge for the Blackfoot River at Bonner during the 1998 To 2001 Validation Period

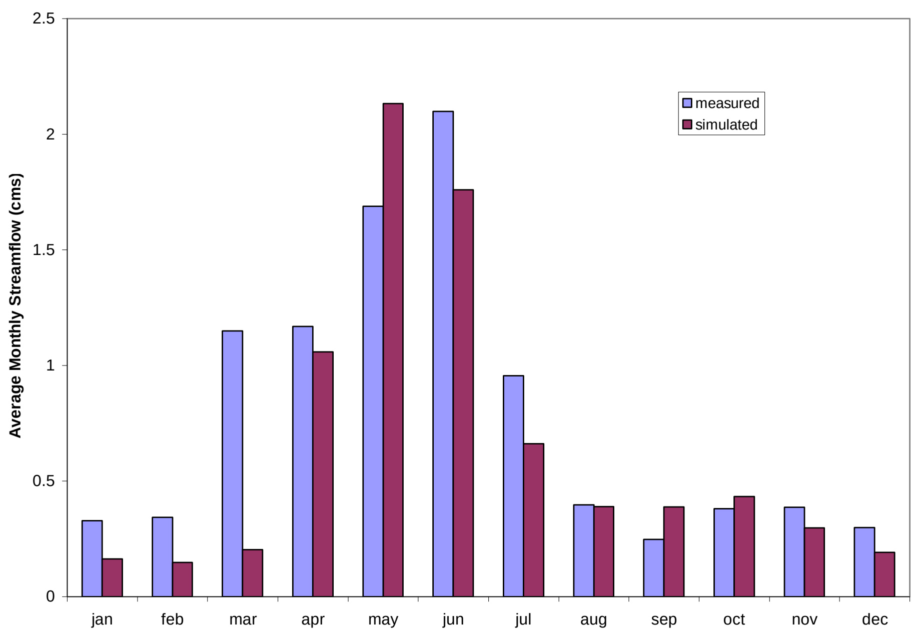

Figure I-9. Comparison of Measured Versus Simulated Average Monthly Discharge for Nevada Creek above the Reservoir during the 1998 To 2001 Validation Period

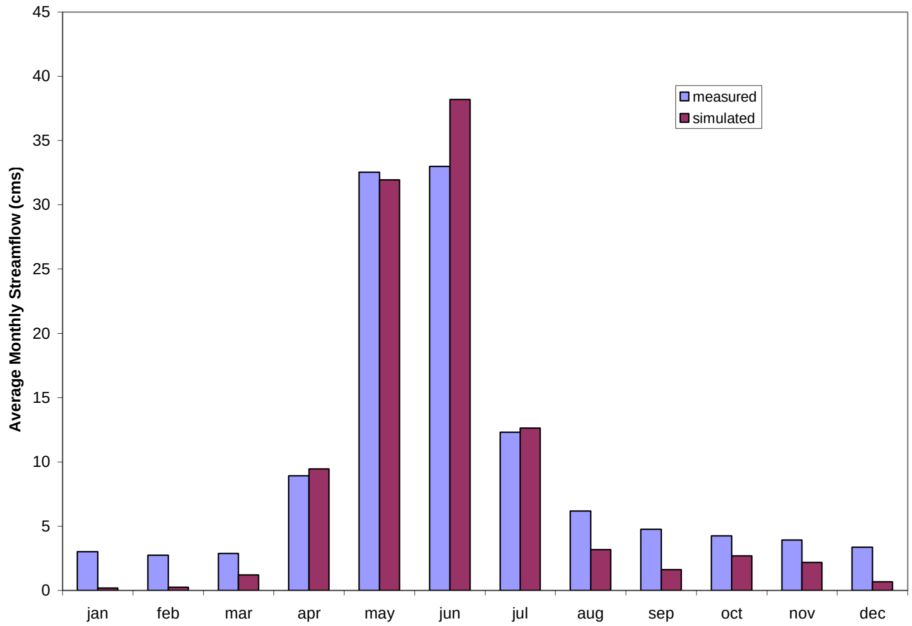

Figure I-10. Comparison of Measured Versus Simulated Average Monthly Discharge for the North Fork of the Blackfoot River during the 1998 To 2001 Validation Period

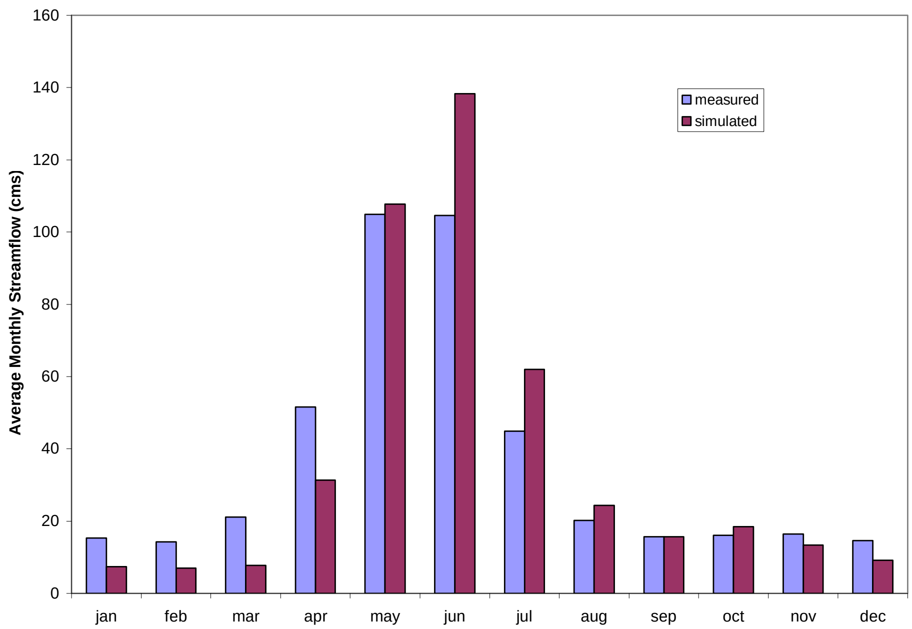

Figure I-11. Comparison of Measured Versus Simulated Average Monthly Discharge for the Blackfoot River at Bonner during the 1998 To 2001 Validation Period

Cursory testing with SWAT revealed that improvements in streamflow on the Blackfoot Watershed could be achieved in at least two ways. First of all, a single set of parameters was used to describe snow accumulation and melt processes across the basin. The utilization of regional sets of calibration parameters to account for these processes in the model would better represent spatial and temporal variations that take place across the watershed. Second, the hydrologic calibration did not include a consumptive use term to account for various losses associated with irrigation of pasture lands on the watershed. Recalibration of the model by adjusting the deep aquifer recharge parameter and including monthly consumptive use losses during the summer and early fall months would result in better matches between measured and simulated streamflow for the winter and summer months.

Calibration of Water Quality Parameters

Very limited data were available to calibrate sediment, total nitrogen, and total phosphorus for the Blackfoot Watershed. For these three water quality constituents, only 5 to 16 measured instantaneous values were used for calibration at any given streamgaging location. Sites selected for model calibration included the Blackfoot River above Nevada Creek, Nevada Creek above the reservoir, Nevada Creek below the reservoir, the North Fork of the Blackfoot River, and the Blackfoot River near Bonner locations. Model calibrations were performed by comparing graphical results of measured versus simulated constituent concentrations. A comparison of average measured versus simulated daily sediment, total nitrogen, and total phosphorus concentration for the calibration period at the five measurements points in the watershed is presented in **Table I-6**.

Table I-6. Comparison of Average Measured Versus Simulated Daily Sediment, Total Nitrogen, and Total Phosphors Concentration for the Calibration Period (2002-2004) At the Five Measurements Points on the Blackfoot Watershed

USGS Gage Location	Constituent	Number of Measured Points	Avg. Measured Concentration (mg/L)	Number of Simulated Points	Avg. Conc. On day of Measurement (mg/L)	Number of Simulated Points	Avg. Simulated Conc. For Calibration Period
Bk abv Nevada	Sediment	14	28.6	14	41.3	1096	17.6
Bk abv Nevada	Total N	6	0.1	6	0.152	1096	0.104
Bk abv Nevada	Total P	14	0.0253	14	0.0136	1096	0.009
Nevada abv Res	Sediment	10	11.6	10	12.6	1096	6.2
Nevada abv Res	Total N	6	0.463	6	0.13	1096	0.467
Nevada abv Res	Total P	10	0.0783	10	0.129	1096	0.512
Nevada bel Res	Sediment	16	45.3	16	7.3	1096	3.4
Nevada bel Res	Total N	6	1.05	6	0.573	1096	0.302
Nevada bel Res	Total P	13	0.21	13	0.688	1096	0.227
North Fk Bk	Sediment	5	3.2	5	55	1096	28.5
North Fk Bk	Total N	5	0.13	5	0.148	1096	0.202

Table I-6. Comparison of Average Measured Versus Simulated Daily Sediment, Total Nitrogen, and Total Phosphors Concentration for the Calibration Period (2002-2004) At the Five Measurements Points on the Blackfoot Watershed

USGS Gage Location	Constituent	Number of Measured Points	Avg. Measured Concentration (mg/L)	Number of Simulated Points	Avg. Conc. On day of Measurement (mg/L)	Number of Simulated Points	Avg. Simulated Conc. For Calibration Period
North Fk Bk	Total P	5	0.0052	5	0.0128	1096	0.0086
Bk near Bonner	Sediment	16	25.5	16	35.7	1096	15.7
Bk near Bonner	Total N	6	0.117	6	0.182	1096	0.132
Bk near Bonner	Total P	13	0.0323	13	0.0265	1096	0.0171

The calibration of sediment loading with SWAT proved to be a very daunting task for the Blackfoot Watershed. Adjusting the four parameters that govern sediment transport and bank erosion within the model did not provide consistent results when compared to measured data for the five calibration points. **Figures I-12 through I-16** illustrate the comparison of measured versus simulated sediment concentration for the five measurements points on the watershed. Results show reasonably good agreement for Nevada Creek above the reservoir, the Blackfoot River above Nevada Creek, and the Blackfoot River at Bonner, but poor agreement for the other two measurement points. Because the sediment calibration consisted of a parameter set with very high values of CH_EROD and CH_COV for the Nevada Creek subwatersheds and very low values for the other three Blackfoot gages, the contribution of sediment from bank erosion sources to total sediment sources was unrealistically low throughout the Blackfoot River reaches. Two improvements could be made in the project to better reflect processes of erosion and sedimentation. First of all, a delineation of the GIS data for the watershed with the option to specify the slope steepness of the various land cover types within a given subbasin would represent a significant improvement in erosion prediction with MULSE across the landscape. Second, the use of regional sets of the SPCON and SPEXP parameters in SWAT instead of a single set for the entire basin would provide the flexibility that is needed to consider spatial variability in sediment transport processes that exist on the watershed.

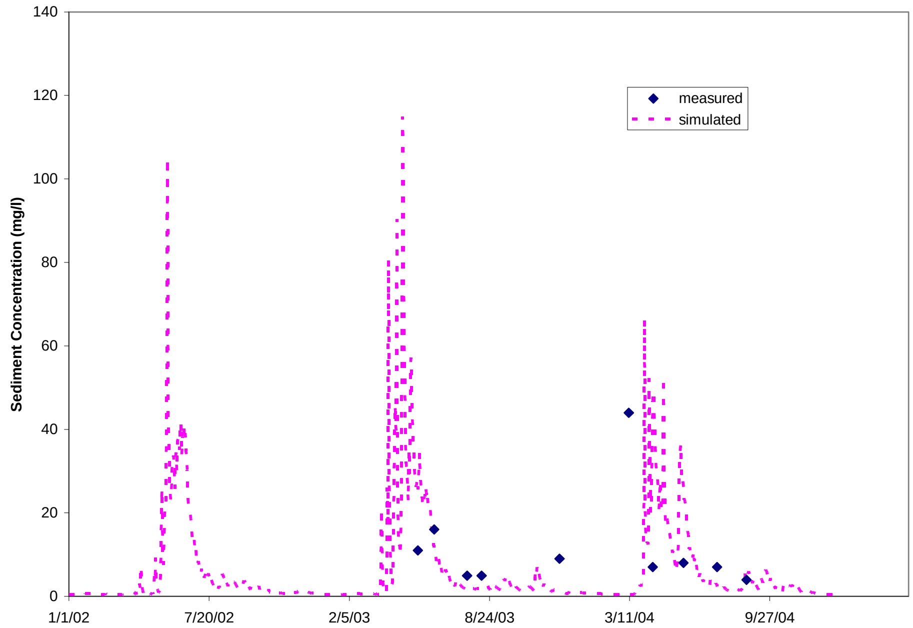

Figure I-12. Comparison of Measured Versus Simulated Sediment Concentration for Nevada Creek above the Reservoir during the 2002 To 2004 Calibration Period

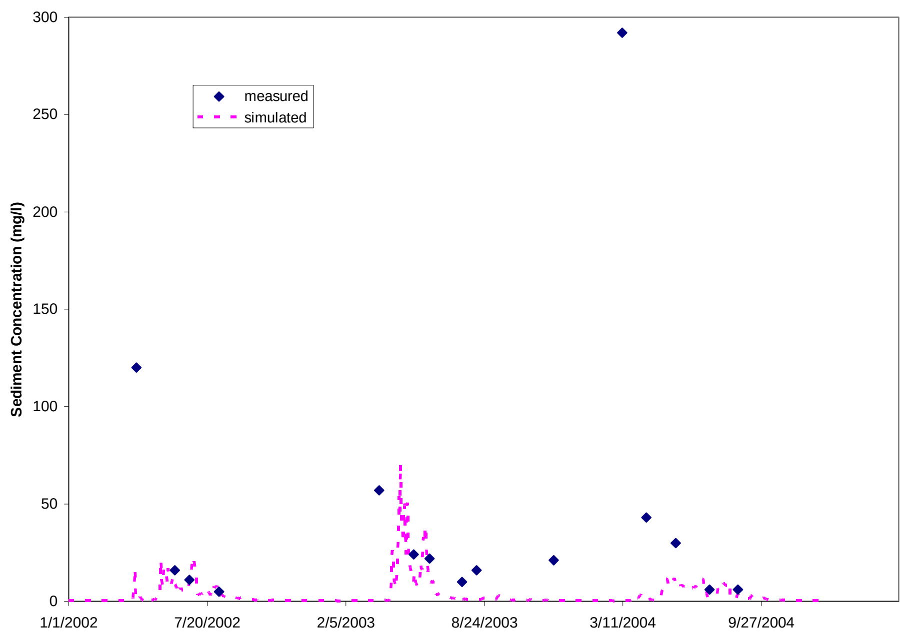

Figure I-13. Comparison of Measured Versus Simulated Sediment Concentration for Nevada Creek below the Reservoir during the 2002 To 2004 Calibration Period

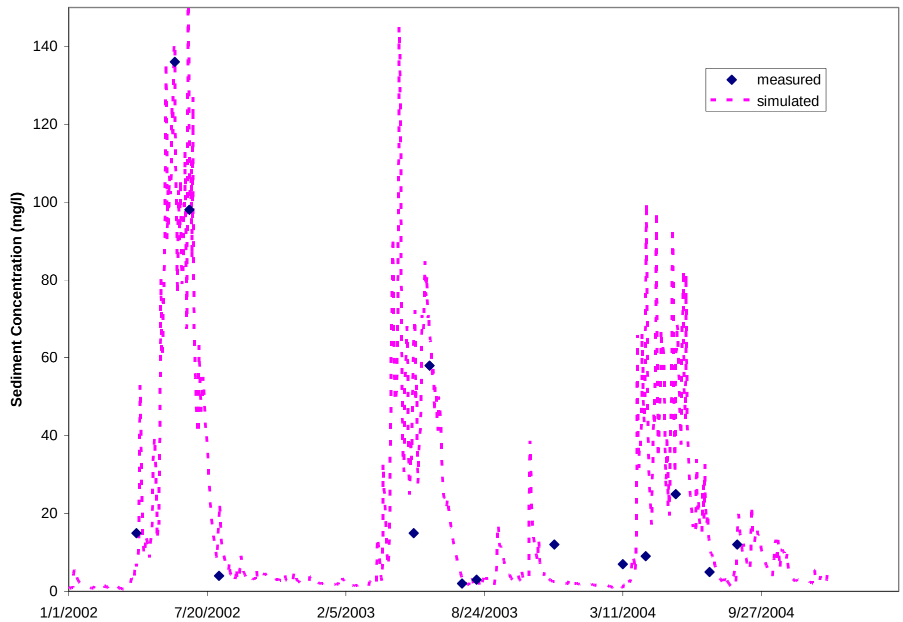

Figure I-14. Comparison of Measured Versus Simulated Sediment Concentration for the Blackfoot River above Nevada Creek during the 2002 To 2004 Calibration Period

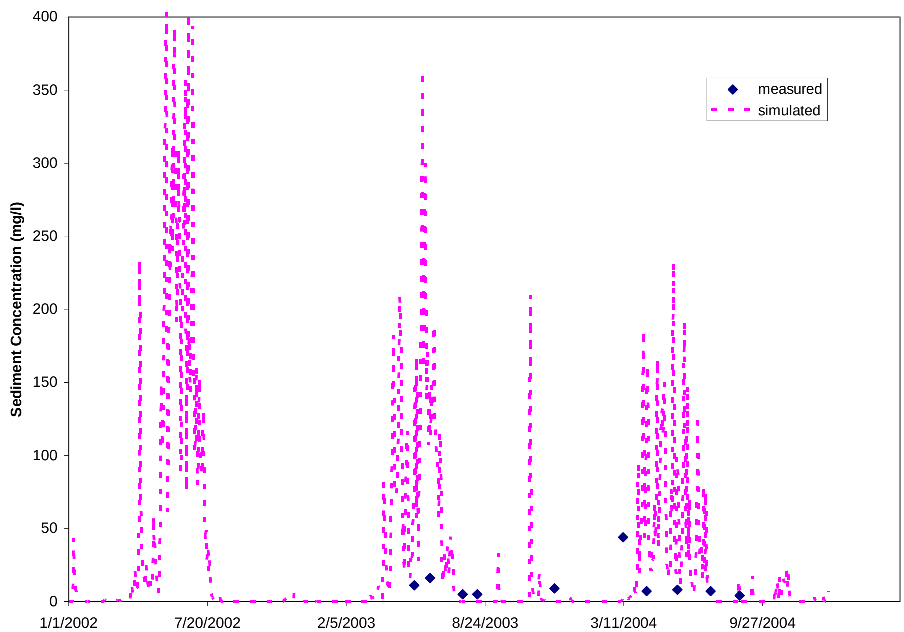

Figure I-15. Comparison of Measured Versus Simulated Sediment Concentration for the North Fork of the Blackfoot River during the 2002 To 2004 Calibration Period

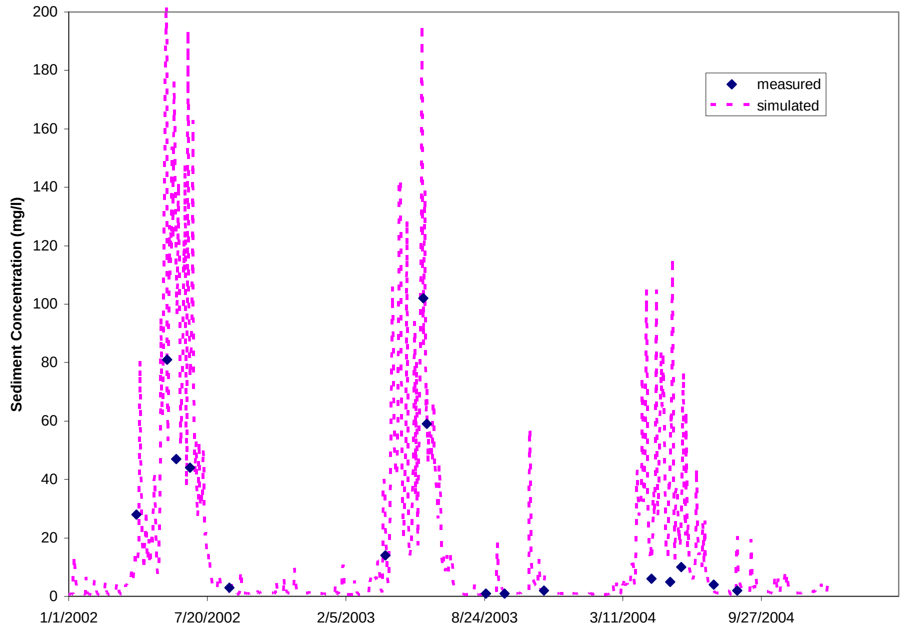

Figure I-16. Comparison of Measured Versus Simulated Sediment Concentration for the Blackfoot River at Bonner during the 2002 To 2004 Calibration Period

Although SWAT simulates the fate and transport of constituent forms of nitrogen and phosphorous, only total N and P were compared with measured data in this study. This is because of the very limited measured data set that was available for model calibration, and because of an apparent model deficiency that exists within SWAT for simulating nitrogen constituents on watersheds like the Blackfoot that primarily consist of snowfed forested areas with steep slopes. Of the available measured nitrogen record collected for the Blackfoot, the data indicate that the organic N and inorganic N generally account for about 80% and 20% of the total N concentrations, respectively. SWAT simulations showed that these N constituents were more or less the opposite as those from the measured record. In spite of attempts to remedy this problem in the model, no successful solutions were realized. Steps have been taken to request that USDA ARS in Temple, TX, determine a feasible solution to remedy in this deficiency in the model.

Although a number of different approaches were implemented for calibrating nitrogen and phosphorous on the Blackfoot Watershed, none proved to be adequately successful. Results of the model simulations show inconsistencies in simulating total N for the two Nevada Creek subwatersheds (**Table I-6**). This is further illustrated in **Figures I-17 and I-18**. For the other three measurement points, SWAT appeared to do an adequate job simulating total nitrogen (**Figures I-19 through I-21**).

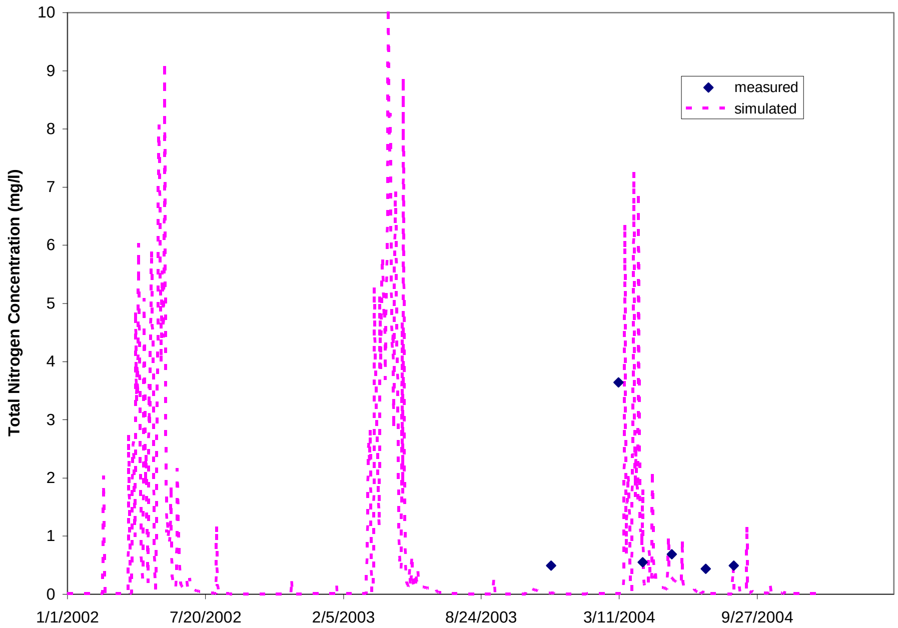

Figure I-17. Comparison of Measured Versus Simulated Total Nitrogen Concentration for Nevada Creek above the Reservoir during the 2002 To 2004 Calibration Period

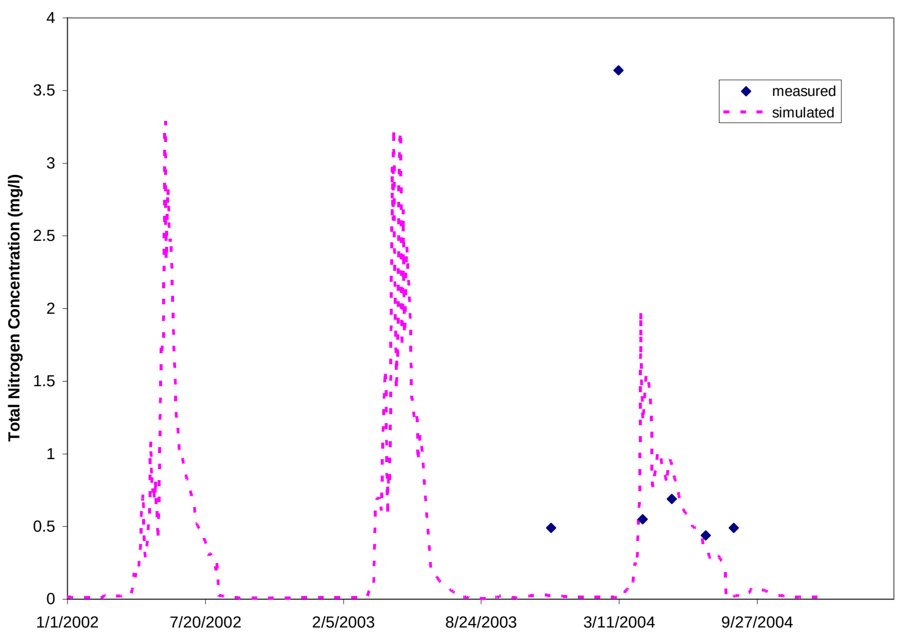

Figure I-18. Comparison of Measured Versus Simulated Total Nitrogen Concentration for Nevada Creek below the Reservoir during the 2002 To 2004 Calibration Period

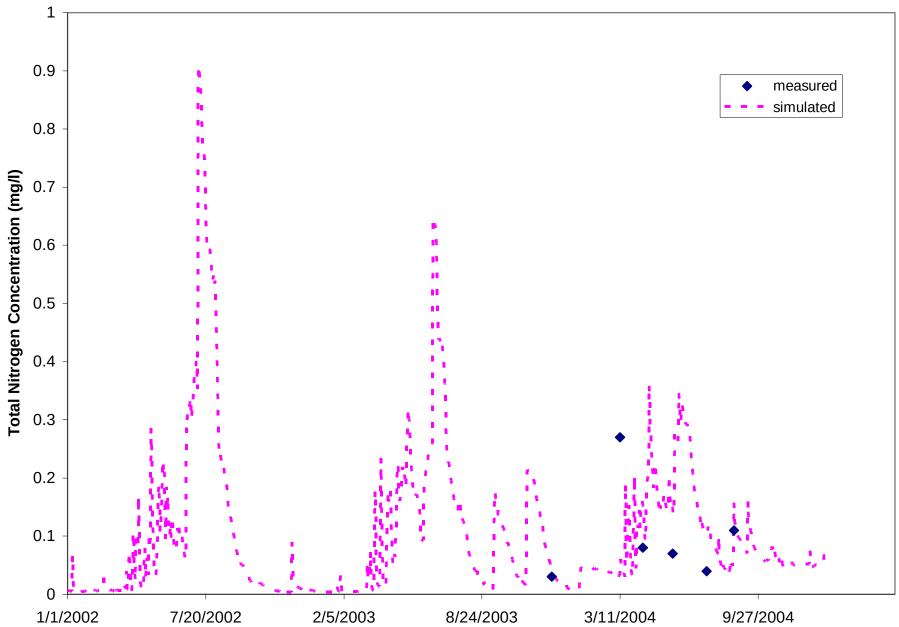

Figure I-19. Comparison of Measured Versus Simulated Total Nitrogen Concentration for the Blackfoot River above Nevada Creek during the 2002 To 2004 Calibration Period

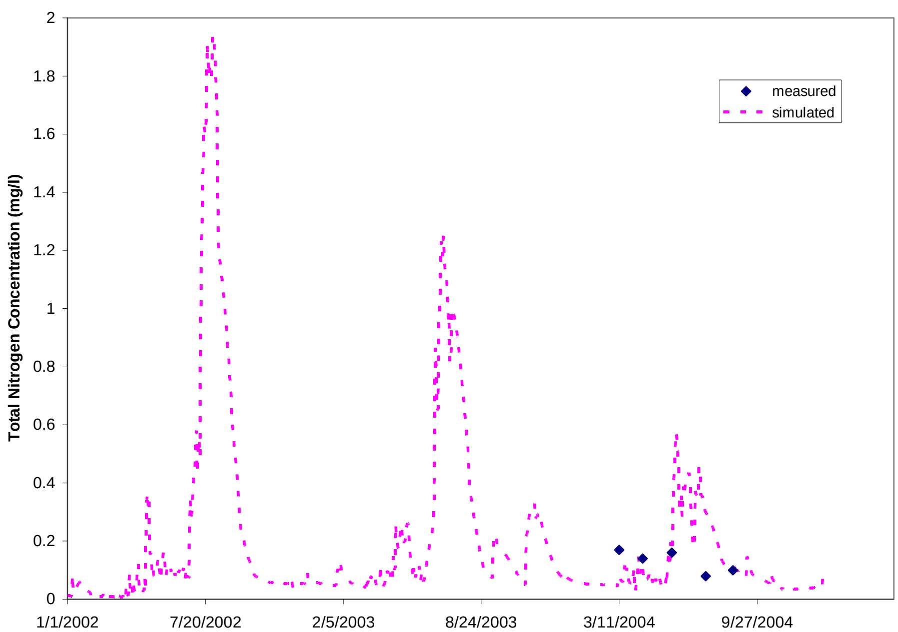

Figure I-20. Comparison of Measured Versus Simulated Total Nitrogen Concentration for the North Fork of the Blackfoot River during the 2002 To 2004 Calibration Period

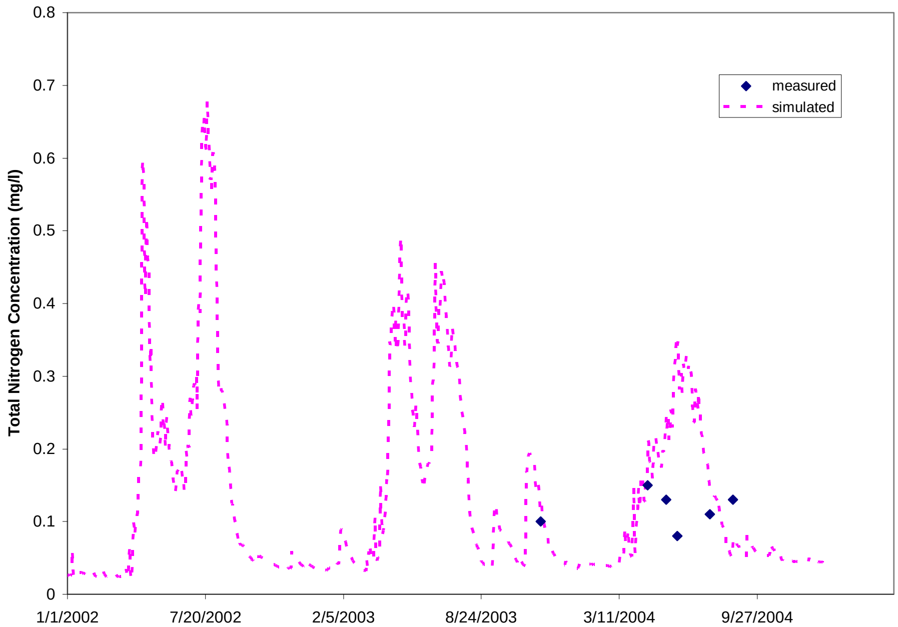

Figure I-21. Comparison of Measured Versus Simulated Total Nitrogen Concentration for the Blackfoot River at Bonner during the 2002 To 2004 Calibration Period

Figures I-22 and I-23 illustrate the inherent difficulties in calibrating total phosphorus in the Nevada Creek subwatershed. For the upper measurement point, SWAT overestimated total P, while for the lower point, the model underestimated total P. Satisfactory agreement was obtained for the Blackfoot above Nevada Creek, the North Fork of the Blackfoot River, and the Blackfoot River at Bonner.

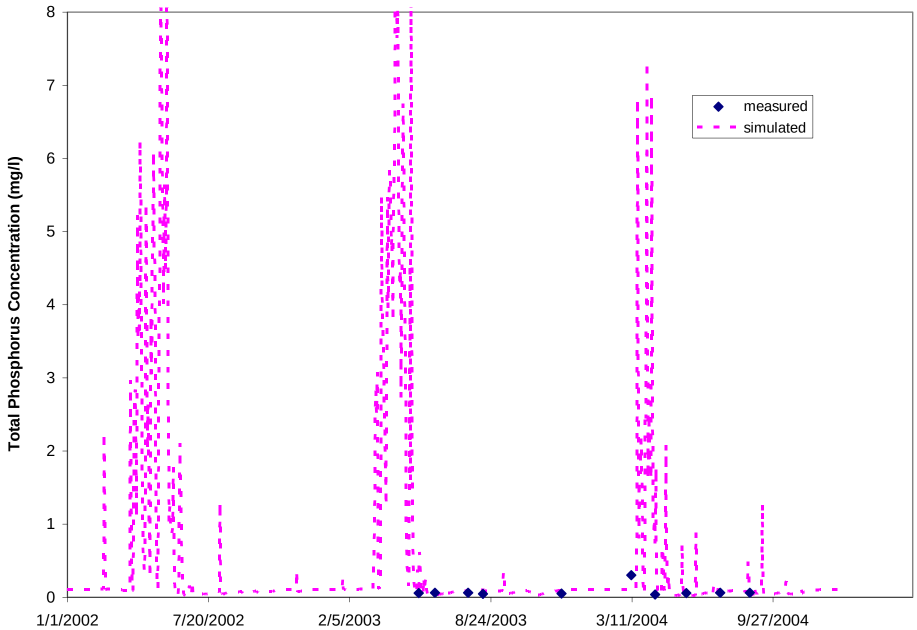

Figure I-22. Comparison of Measured Versus Simulated Total Phosphorus Concentration for Nevada Creek above the Reservoir during the 2002 To 2004 Calibration Period

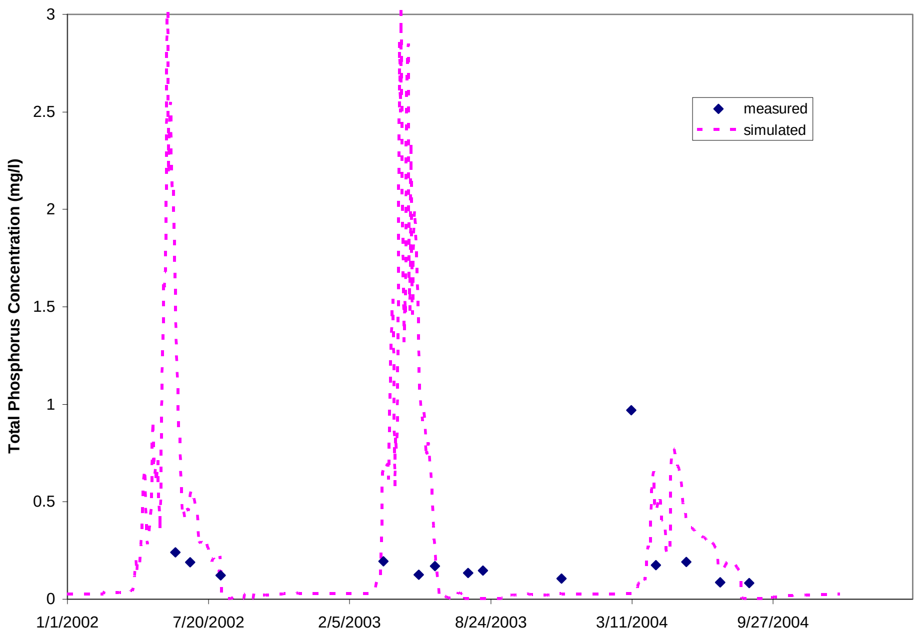

Figure I-23. Comparison of Measured Versus Simulated Total Phosphorus Concentration for Nevada Creek below the Reservoir during the 2002 To 2004 Calibration Period

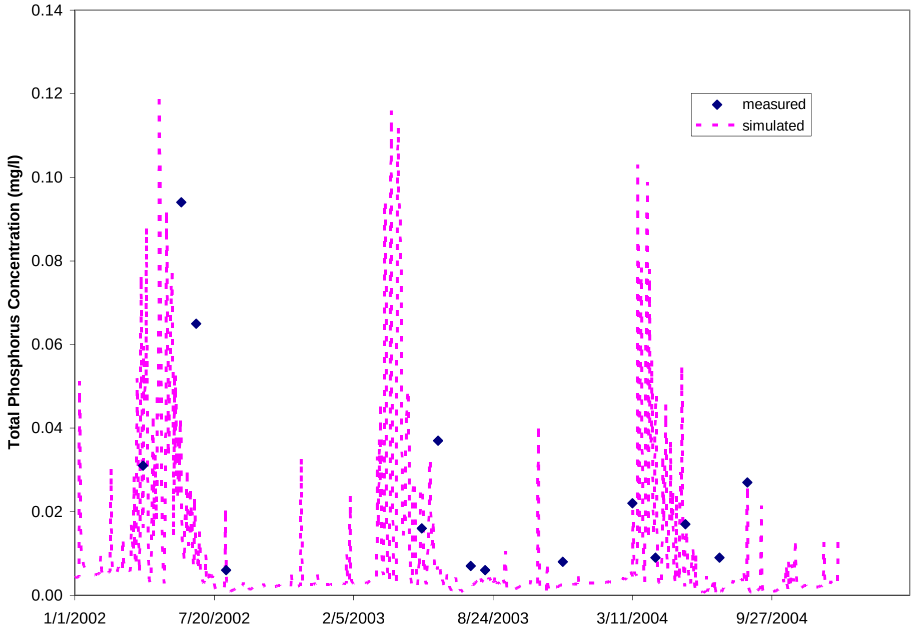

Figure I-24. Comparison of Measured Versus Simulated Total Phosphorus Concentration for the Blackfoot River above Nevada Creek during the 2002 To 2004 Calibration Period

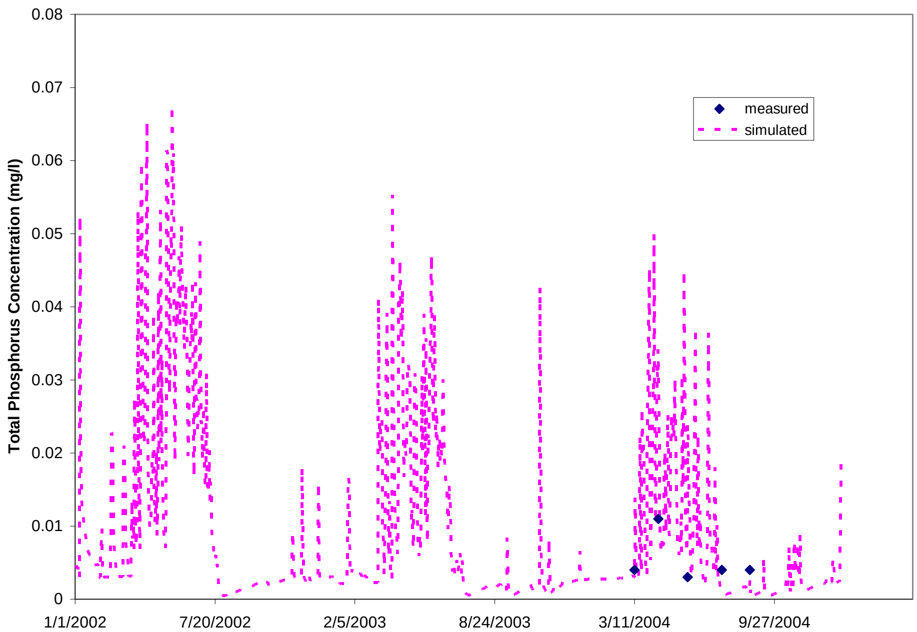

Figure I-25. Comparison of Measured Versus Simulated Total Phosphorus Concentration for the North Fork of the Blackfoot River during dhe 2002 To 2004 Calibration Period

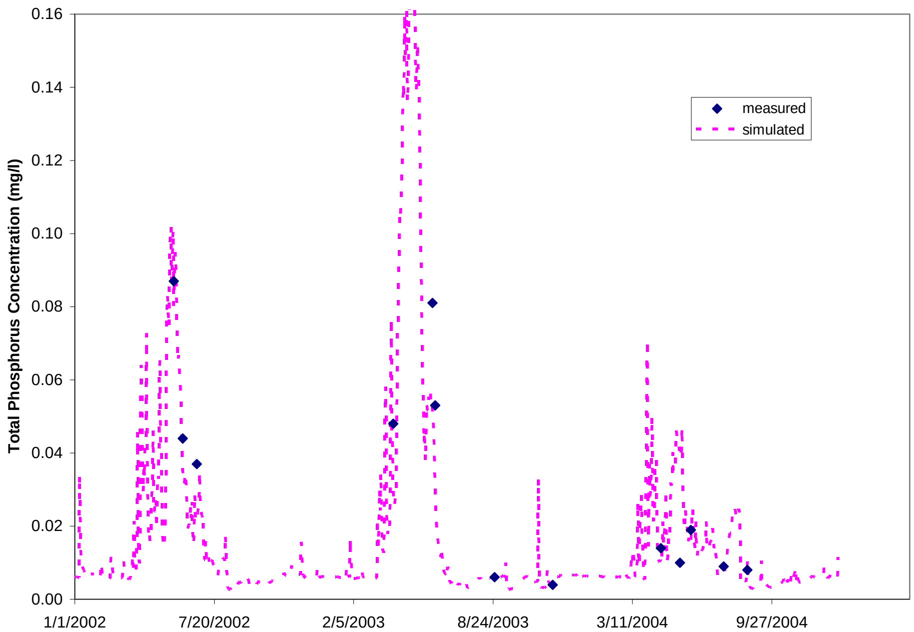

Figure I-26. Comparison of Measured Versus Simulated Total Phosphorus Concentration for the Blackfoot River at Bonner during the 2002 To 2004 Calibration Period

Shortcomings associated with nutrient calibration on the watershed were due to the limited available record, the previously described model deficiency in simulating organic versus inorganic N, and the fact that point source nutrient loading due to cattle grazing in or very near the stream was not accounted for in the model. Moderate improvement in nutrient simulation could also be achieved if regional sets of the parameters that govern nutrient transformation and movement in SWAT were utilized instead of a single set for the entire basin.

Simulation of Baseline Water Quality Conditions

Following calibration of the streamflow and water quality parameters in SWAT, a baseline period was selected for performing model simulations to represent current water quantity and quality conditions on the watershed. Simulations performed for this period not only provided estimates of sediment, total N and total P concentrations, and loadings for each of the 65 subbasins within the watershed, but also estimates of the source allocation by land cover/management type. Using available climatic and streamflow data, a 9-year period of record from 1996 to 2004 (preceded by a 5-year warm up period) was selected as the baseline condition for the Blackfoot. For this period, the annual mean, daily low flow and daily high flow are 44.1, 7.08, and 448 cms, respectively for the Blackfoot River near Bonner gage. These values compare to 44.5, 5.67, and 510 cms, respectively, for the long term record at the gage.

Daily and average annual values of water yield, sediment, total N and total P were simulated for selected stream reaches within the Blackfoot Watershed. Because output from the autocal or reach files in SWAT is not specific to particular land cover and management conditions, it was therefore necessary to use output from the HRU file in conjunction with the reach file to estimate the source allocation of water quality constituents. This was accomplished in the following manner. First, reach and HRU files were retrieved from the 9-year baseline condition. Second, SWAT was rerun without simulating the effect of channel bank and bed erosion and the reach and HRU files were again retrieved. The assumption was made that the relative proportions of sediment, total nitrogen, and total phosphorus that were simulated from the landscape for each land cover/management type would be the same as those present in the stream reaches. The estimated respective constituent fraction for a given land cover/management type assumed to be present in the stream reach was then computed by multiplying that particular simulated amount obtained from the landscape times the ratio of the total constituent reach load to the total constituent landscape load. This approach therefore provided a means for allocating a simulated load to bank/bed erosion and the various land cover/management types for a given channel reach. Results of this analysis are illustrated in **Figures I-27 through I-29**, for respective percentages of modeled sediment, total nitrogen, and total phosphorus for the Nevada Creek below the reservoir subwatershed.

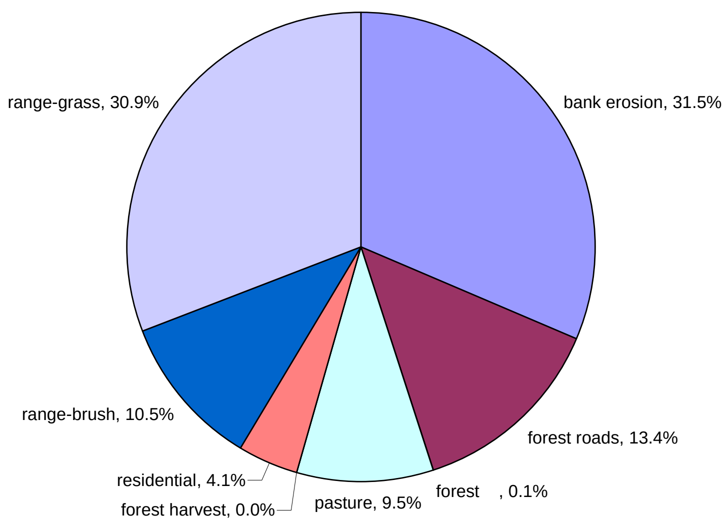

Figure I-27. Modeled Sources of Sediment for the Nevada Creek below the Reservoir Subwatershed

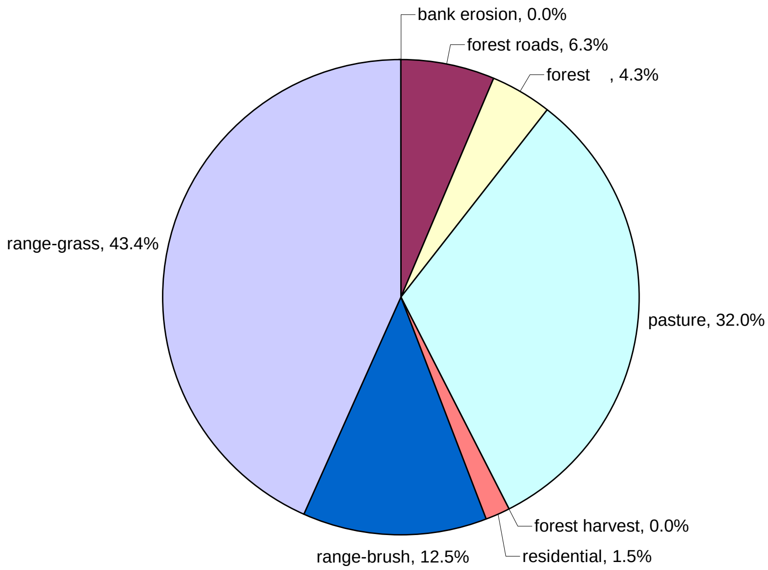

Figure I-28. Modeled Sources of Total Nitrogen for the Nevada Creek below the Reservoir Subwatershed

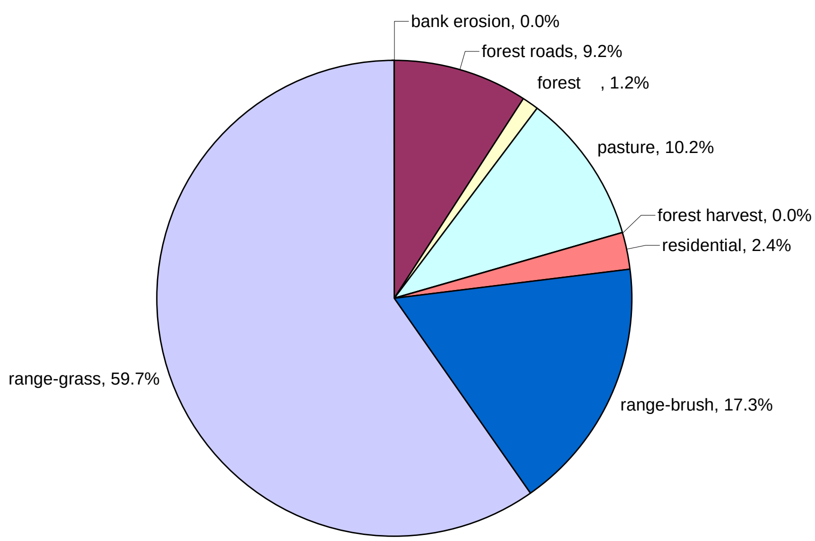

Figure I-29. Modeled Sources of Total Phosphorus for the Nevada Creek below the Reservoir Subwatershed

REFERENCES

Allen, R.G., M.E. Jensen, J.L. Wright, and R.D. Burman. (1989). "Operational estimates of evaportranspiration." Agronomy J. 81(4),650-662.

Arnold, J.G., P.M. Allen, and G. Bernhardt. (1993). "A comprehensive surface-groundwater flow model." J. Hydrology 142,47-69.

Arnold, J.G. and P.M. Allen. (1996). "Estimating hydrologic budgets for three Illinois watersheds." J. Hydrology 176,57-77.

Arnold, J.G., R. Srinivasan, R.S. Muttiah, and J.R. Williams. (1998). "Large area hydrologic modeling and assessment, part I: model development." J. American Water Resources Assoc. 34(1),73-89.

Borah, D.K. and M. Bera. (2003). "Watershed-scale hydrologic and nonpoint-source pollution models: review of mathematical bases." Trans. ASAE 46(6),1553-1566.

Brown, L.C. and T.O. Barnwell. 1987. The enhanced water quality models: QUAL2E and QAL2E_UNCAS documentation and user manual. EPA/600/3-87/007, USEPA, Athens, GA.

Di Luzio, M., R. Srinivasan, and J.G. Arnold. (2002). "Integration of Watershed Tools and SWAT model into BASINS." J. American Water Resources Assoc. 38(4),1127-1141.

Donigian, A.S., J.C. Imhoff, and B.R. Bicknell. (1983). Predicting Water Quality Resulting from Agricultural Nonpoint Source Pollution via Simulation – HSPF. In Agricultural Management and Water Quality,200-249. Ames, Iowa: Iowa State University Press.

Duan, Q.D. (2003). "Global optimization for watershed model calibration." In: Calibration of Watershed Models, Water Sci. Appl. Ser., Vol 6, edited by Q. Duan et al., AGU, Washington, D.C. 89-104.

Duan, Q., V.K.Gupta, and S. Sorooshian. (1992). "Effective and efficient global optimization for conceptual rainfall-runoff models." Water Resources Research 28, 1015-1031.

Green, W.H. and G.A. Ampt. (1911). "Studies on soil physics, 1. The flow of air and water through soils." J. Agricultural Sciences 4,11-24.

Gupta, H.V., S. Sorooshian, and P.O. Yapo. (1999). "Status of automatic calibration for hydrologic models: comparison with multilevel expert calibration." J. Hydrologic Engineering. 4(2),135-143.

Hargreaves, G.H. (1975). "Moisture availability and crop production." Trans. ASAE 18:980-984.

Harmel, R.D., R. J. Cooper, R.M. Slade, R.L. Haney, and J. G. Arnold. (2006). Error propagation in measured streamflow and water quality data for small rural watersheds. Trans. Of the ASABE In press.

Knisel, W.G. (1980). CREAMS, a field scale model for chemicals, runoff and erosion from agricultural managment systems. USDA Conservation Research Report No. 26.

Leonard, R.A., W.G. Knisel, and D.A. Still. (1987). "GLEAMS: Groundwater loading effects on agricultural management systems." Trans. ASAE 30(5),1403-1428.

Motovilov, Y.G., L. Gottschalk, K. Engeland, and A. Rodhe. (1999). "Validation of distributed hydrological model against spatial observations." Agricultural and Forest Meteorology 98,257-277.

Nash, J.E. and J.V. Sutcliffe. (1970). "River flow forecasting through conceptual models, Part 1 - A discussion of principles." J. Hydrology 10(3),282-290.

Nelder, J.A. and R.A. Mead. (1965). "Simplex method for function minimization." Computer J. 7,308-313.

Neitsch, S.L., A.G.Arnold, J.R. Kiniry, J.R. Srinivasan, and J.R. Williams. (2002). Soil and Water Assessment Tool User's Manual: Version 2000. GSWRL Report 02-02, BRC Report 02-06, Published by Texas Water Resources Instititue TR-192, College Station, TX.

Rabus, B., M. Eineder, A. Roth, R. Bamler. 2003. The shuttle radar topography mission- a new class of digital elevation models acquired by spaceborne radar, Photogramm. Rem. Sens., v. 57, p. 241-262.

Priestly, C.H.B. and R.J. Taylor. (1972). "On the assessment of surface heat flux and evaporation using large-scale measurements." Mon. Weather Rev. 100(2),81-92.

Sevat, E. and A. Dezetter. (1991). "Selection of calibration of objective functions in the context of rainfall-runoff modeling in a Sudanese savannah area." Hydrological Sciences Journal 36,307-330.

USDA Soil Conservation Service. (1986). Urban hydrology for small watersheds. Technical Release No. 55 (TR-55). Washington, D.C.

Van Griensven, A. (2002). Developments towards integrated water quality modeling for river basins. Dept. of Hydrology and Hydraulic Engineering, Vrije Universiteit Brussel. Publication No. 40.

Van Griensven, A. and W. Bauwens. (2003). "Multiobjective autocalibration for semidistributed water quality models." Water Resources Research 39(12),1348.

Williams, J.R., A.D. Nicks, and J.G. Arnold. (1985). "Simulator for water resources in rural basins." Journal of Hydraulic Engineering 111(6),970-986.

Williams, J.R., C.A. Jones, and P.T. Dyke. (1984). "A modeling approach to determining the relationship between erosion and soil productivity." Trans. ASAE 27(1),129-144.

APPENDIX J
SEDIMENT LOADING AND ALLOCATION ANALYSIS

This appendix summarizes the methods used to determine the sediment load estimates from hillslope and stream bank erosion and the allocation of those loads to land uses in the Middle Blackfoot-Nevada Creek planning area. Hillslope erosion loading was estimated using the Soil Water Assessment Tool (SWAT) model to obtain an initial estimate of loading by listed segment. A description of the SWAT model, its setup, calibration, and validation for use in the planning area is contained in **Appendix I**.

Stream bank erosion was estimated for sediment impaired stream segments using field data collected from selected assessment sites within each segment. The field assessment method was a modification of the Bank Erosion Hazard Index (BEHI) method of Rosgen (2000). The details of the methodology and procedures for extrapolation from surveyed sites to non-surveyed stream reaches are described in a separate document by DTM and AGI (2005).

Hillslope Erosion Loading Estimates and Adjustments

Sediment loading from hillslope erosion was estimated through use of the SWAT model. Model output included the number of tons of hillslope sediment delivered annually from each of 65 planning area subbasins. Due to large differences between subbasin land surface slope and stream channel slope, the channel transport capacity algorithms of the model allowed only a fraction of delivered hillslope sediment to be transported by channel processes. This sediment "bottle-necking" effect is due to the large slope variability within each subbasin and the model's assignment of a single subbasin slope value that, in most cases, is an order of magnitude greater than the channel slope. Steep, uniform slopes exaggerate sediment routing to the channel. Because of the coarse SWAT characterization of slope, sediment delivery could not be calibrated with channel sediment transport. At this point, SWAT model output for mean annual sediment loading from each hydrologic response unit or HRU (an HRU is a landcover-soil unit combination) becomes more narrowly a tool for estimating loads rather than simulating a sediment budget for the watershed. Because high average subbasin slopes exaggerate sediment yields, adjustments were needed to better quantify loading from sheet erosion directly entering the channel. Therefore, the SWAT estimates were adjusted downward to reflect the fractional area of sediment contributing HRUs that is likely to deliver sediment to the channel network of listed streams and their tributaries.

The surface erosion component of SWAT uses MUSLE to quantify sediment transported by overland flow as sheet erosion. Overland flow is water moving down slope as an irregular sheet prior to concentration in defined channels. Though estimates vary, the slope length over which overland flow occurs is usually less than 400 feet (McCuen 1998). A distance criterion of 350 feet and a slope criterion of greater than 3% were used in this analysis to obtain the fraction of each subbasin area likely to contribute sediment through sheet erosion to channels. GIS tools were used to define a 350-foot buffer and classify slopes greater than 3% on sediment impaired streams and their tributaries. The fraction, calculated by dividing the area of sediment contributing HRUs within the buffer by the total area of those HRUs in the subbasin, was used to adjust the SWAT subbasin sediment yields. These values are labeled as adjusted sheetflow area yields and given by listed stream segment in **Table J-1**. These adjusted yields were next apportioned into naturally occurring and controllable components.

The naturally occurring load was assumed to be that delivered with adequate vegetative filter conditions in place on contributing land cover types (HRUs). The SWAT buffering tool was used to apply this filtering condition to sediment contributing HRUs. The USDA filter strip practice standard for Powell County (USDA 2004) recommends a 35-foot filter width on moderate (4-7%) slopes to minimize sediment, particulate organics, and sediment-adsorbed contaminants. A filter width of 35 feet (11 m) was selected to represent adequate application of a sediment reducing management practice. Application of the filter through the SWAT model estimated a uniform loading reduction of 25%.

This 25% reduction is significantly lower than those reported in the literature. Sediment removal efficiency relationships developed by Castelle and Johnson (2000) estimated near 80% sediment removal and 65% particulate organic matter removal across a comparable buffer width. Research on buffers in southwest Montana by Hook (2003) reported greater than 90% removal of coarse textured sediment with a six meter buffer on bunchgrass uplands. A sediment reduction efficiency of 75% was assumed to represent naturally occurring loading conditions for this analysis. This value better reflects those reported in the literature and is closer to results reported for Montana settings while allowing for some hillslope loading from developed land. With 75% removal, 25% of the adjusted hillslope sediment yield is the assumed naturally occurring load representing the annual maximum loads from hillslope erosion in **Table J-1**. The remaining 75% of the adjusted hillslope load is assumed to be controllable by land management activities.

The initial SWAT hillslope sediment yields and the adjusted sheetflow area loads for each stream segment in **Table J-1** are displayed discretely. The discrete listing illustrates the degree of yield adjustment according to the fraction of total sediment contributing HRU area in the subbasin that is within the sheetflow area. After the sheetflow area adjustment, values for sheetflow area yield, naturally occurring loads and controllable loads are added cumulatively in **Table J-1** from the headwaters to the downstream outlets of listed segments. The cumulative naturally occurring load is the portion of the cumulative sheetflow area yield that is delivered to the stream channel from background hillslope erosion processes and from erosion processes on developed land with assumed application of all reasonable land, soil, and water conservation practices.

Using the lower Washington Creek values as an example, the SWAT model estimated loads of 407 tons/yr in upper Washington Creek and 22 tons/yr in lower Washington Creek are reduced by their respective sheetflow area fractions of 0.150 and 0.247. The respective loads from the sheetflow areas of the two segments are then 61 tons and five tons per year. The value of 67 tons per year for cumulative sheetflow area load in lower Washington Creek in **Table J-1** is the sum of 61 tons from upper Washington Creek and five tons from lower Washington Creek, rounded upward to the nearest whole number. The cumulative naturally occurring load of 17 tons per year in lower Washington Creek is the sum of 15.25 naturally occurring tons (61 tons times 0.25) contributed from upper Washington Creek, plus 1.25 tons (5 tons times 0.25) contributed from the lower Washington Creek segment, rounded to the nearest whole number. The cumulative controllable load of 50 tons/yr in lower Washington Creek is the sum of the upper Washington sheetflow area load of 61 tons multiplied by 0.75 (46 tons) and the lower Washington sheetflow area load of five tons multiplied by 0.75 (4 tons). The 0.75 multiplier is the value used to define the fraction of loading that can be removed by an effective vegetative buffer.

Table J-1. Hillslope Sediment Yield Adjustment and Partitioning into Naturally Occurring and Potential Human-Caused Components

Stream Name	Initial SWAT Sediment Load Estimate (tons/yr)	Sheetflow Source Area Fraction	Adjusted Sheetflow Area Load (tons/yr)	Cumulative Sheetflow Area Load (tons/yr)	Cumulative Naturally Occurring Load (tons/yr)	Cumulative Controllable Load (tons/yr)
Nevada Creek Planning Area						
Upper Washington Creek	407	0.150	61	61	15	46
Lower Washington Creek	22	0.247	5	67	17	50
Upper Jefferson Creek	482	0.654	315	315	79	236
Lower Jefferson Creek	2	0.000	0	315	79	236
Gallagher Creek	459	0.541	248	248	62	186
Buffalo Gulch	1,002	0.366	366	366	92	275
Upper Nevada Creek	2,125	0.859	1,826	2,822	705	2,116
Braziel Creek	182	0.392	71	71	18	53
Black Bear Creek	328	0.766	252	252	63	189
Murray Creek	6,486	0.770	4,997	4,997	1,249	3,748
Upper Douglas Creek	2,934	0.310	908	6,159	1,539	4,618
Cottonwood Creek	8,319	0.479	3988	3,988	977	2,991
Lower Douglas Creek	2,989	0.626	1,871	12,018	3,004	9,013
Nevada Spring Creek	0	0.000	0	0	0	0
McElwain Creek	507	0.459	233	233	58	175
Lower Nevada Creek	631	0.481	303	15,444	3,861	11,584
Middle Blackfoot Planning Area						
Yourname Creek	732	0.344	252	252	63	189
Wales Creek	174	0.172	30	30	8	22
Frazier Creek	103	0.193	20	20	5	15
Ward Creek	176	0.269	47	47	12	36
Kleinschmidt Creek	29	0.056	2	49	12	37
Rock Creek	20,397	0.113	2,307	2,356	589	1,767
North Fork Blackfoot River	53,040	0.226	11,992	14,348	3,587	10,761
Warren Creek	270	0.088	24	24	6	18
Monture Creek	1,928	0.248	478	478	120	359
Blackfoot River (Nevada Cr. to Monture Cr.)	33	0.576	19	30,617	7655	22,962
Chamberlain Creek	1,081	0.263	285	285	71	214

Table J-1. Hillslope Sediment Yield Adjustment and Partitioning into Naturally Occurring and Potential Human-Caused Components

Stream Name	Initial SWAT Sediment Load Estimate (tons/yr)	Sheetflow Source Area Fraction	Adjusted Sheetflow Area Load (tons/yr)	Cumulative Sheetflow Area Load (tons/yr)	Cumulative Naturally Occurring Load (tons/yr)	Cumulative Controllable Load (tons/yr)
Cottonwood Creek	2,950	0.449	1,325	1,325	331	994
Richmond	91	0.020	2	2	0.5	1.4
West Fork Clearwater	1392	0.133	186	186	46	139
Deer Creek	2,770	0.418	1,157	1,157	289	868
Buck Creek	225	0.028	6	6	2	4
Blanchard Creek	410	0.130	53	53	13	40
Unimpaired Clearwater	25,198	0.215	5,405	5,405	1,351	4,054
Blackfoot River (Monture Cr. to Clearwater R.)	1,432	0.491	703	39,738	9,935	29,803

With the adjustments, the total SWAT subbasin yield of 26,875 tons/yr (**Table 5-51**) for the Nevada Creek planning area was reduced by 42% to 15,444 tons/yr; the corresponding reduction for the Middle Blackfoot planning area was 78% from 112,430 to 24,292 tons/yr. The low discrete values for adjusted sheetflow yield for Lower Jefferson Creek, Nevada Spring Creek, and Kleinschmidt Creek are due to low hillslope yields in these subbasins. A similar situation occurs for Richmond Creek and Buck Creek in the Clearwater drainage.

Hillslope loading from sediment impaired streams in the Clearwater River drainage is included in **Table J-1** as estimates for Richmond Creek, West Fork of the Clearwater, Deer Creek, Buck Creek, and Blanchard Creek. These estimates were obtained by adjusting SWAT output for Clearwater subbasins according to the proportion of total subbasin area occurring within these impaired watersheds.

The estimated hillslope loading from the North Fork Blackfoot River, at 53,040 tons/yr, is an order of magnitude higher than that for any other stream. The overriding effects of precipitation and slope steepness on SWAT output account for the loading from this steep, high elevation watershed. About 60% of the drainage is within the Scapegoat Wilderness. Despite this large area with minimal human influence on sediment loading, the same multipliers of 0.25 and 0.75 identifying naturally occurring and controllable loading were applied to this and other unimpaired streams to quantifying total loading from the planning area. However, the "controllable" loads from unimpaired streams are assumed to result in minimal loading due to currently sufficient sediment filtering capacity. This assumption does not preclude consideration of future water quality improvement projects on these streams where specific improvements in field conditions can potentially reduce existing sediment loads.

Existing ground cover conditions within the sheet erosion source areas were assumed to have some sediment filtering capacity. Ground cover condition categories of "sparse," "moderate," or "dense" were assigned as part of the 2004 base parameter assessment (DTM and AGI 2005). With these ground cover conditions as guidance, 2005 aerial photography and ground photos taken during stream bank assessment work in 2004 were interpreted to estimate an existing filtering efficiency value for each stream. These values range from 0.50 to 0.85 and represent coarse estimates of the effect of current vegetation on sediment removal. When multiplied by the values for controllable load from each listed segment, the product is the controllable load reductions needed to reflect naturally occurring conditions from developed land. Since the sediment removal efficiency figures describe sediment filtering conditions adjacent to each listed stream segment, the reductions are applied to segment-specific loads in **Table J-2**. Reductions are not estimated for streams determined to be fully supporting.

Table J-2. Controllable Loads, Sediment Removal Efficiency and Hillslope Load Reductions For Listed Stream Segments in the Nevada Creek and Middle Blackfoot-Planning Areas

Stream Name	Controllable Load (tons/yr)	Existing Sediment Removal Efficiency	Needed Reductions to Controllable Load (tons/yr)
Nevada Creek Planning Area			
Upper Washington Creek	46	0.50	23
Lower Washington Creek	4	0.50	2
Upper Jefferson Creek	236	0.50	118
Lower Jefferson Creek	0.0	0.60	0.0
Gallagher Creek	186	0.55	84
Buffalo Gulch	275	0.55	124
Upper Nevada Creek	1369	0.60	548
Braziel Creek	54	0.50	27
Black Bear Creek	189	0.65	66
Murray Creek	3,748	0.65	1,312
Upper Douglas Creek	792	0.65	239
Cottonwood Creek	2,991	0.65	1,047
Lower Douglas Creek	1,403	0.60	561
Nevada Spring Creek	0	0.65	0
McElwain Creek	210	0.55	79
Lower Nevada Creek	227	0.65	80
Middle Blackfoot River Planning Area			
Yourname Creek	189	0.65	66
Wales Creek	22	0.60	9
Frazier Creek	15	0.55	7
Ward Creek	36	0.65	12
Kleinschmidt Creek	1.2	0.80	0.2
Rock Creek	1,730	0.60	692
Warren Creek	18	0.75	4
Monture Creek	359	0.85	54
Blackfoot River (Nevada Cr. to Monture Cr.)	14	0.75	4
Cottonwood Creek	994	0.70	298
Richmond Creek	1.4	0.75	0.3
West Fork Clearwater	139	0.85	21
Deer Creek	868	0.80	174
Blanchard Creek	40	0.60	16
Blackfoot River (Monture Cr. To Clearwater R.)	527	0.60	211

Considered cumulatively from upstream to downstream, existing sediment removal capacity in the Nevada Creek planning area reduces the controllable load by 63% from 11,584 to 4,308 tons per year. The corresponding reduction for the combined Middle Blackfoot-Nevada Creek planning areas is 69% from 29,803 to 9,186 tons per year.

The SWAT modeling framework included subbasin loading from the Blackfoot River headwaters planning area that extends upstream of the mouth of Nevada Creek. The model estimated the hillslope erosion yield in the Blackfoot River headwaters to be 25,182 ton/yr.

Adjusting this value by the 24% figure used in the Middle Blackfoot to account for the proportion the sediment yielding cover types that occur within the near stream sheetwash area, gives an adjusted headwaters hillslope yield of 6,044 tons per year for the headwaters. The assumed naturally occurring portion (25%) of this load is 1,511 tons, giving a controllable load value of 4,533 tons. Adjusting this value further to account for the estimated sediment removal efficiency of 0.65 provided by headwaters vegetation conditions gives a needed reduction in headwaters hillslope loading of 1,587 tons per year.

The SWAT model estimated loading from unlisted portions of the Clearwater drainage to be 25,198 tons per year. Approximately 21% of the unimpaired subbasin area is within the near-stream sediment contributing area, giving an adjusted sheetflow area load of 5,405 tons per year. The naturally occurring portion (25%) of this load equals 1,351 tons per year, leaving a controllable load of 4,054 tons. An assumed sediment removal efficiency of 0.75 attributable to current vegetation conditions further reduces the controllable load to 1,013 tons per year. **Table J-3** summarizes the total controllable, naturally occurring and needed reductions to hillslope erosion loading in the Middle Blackfoot-Nevada Creek TPA.

Table J-3. Summary of Estimated Controllable, Naturally Occurring and Needed Reductions to Hillslope Erosion Loading in the Middle Blackfoot-Nevada Creek Planning Area

Watershed Source Area	Controllable Load (tons/yr)	Naturally Occurring Load (tons/yr)	Needed Reduction (tons/yr)	Percent Needed Reduction in Controllable Load
Blackfoot Headwaters	4,533	1,511	1,587	35
Nevada Creek	11,584	3,861	4,308	37
Middle Blackfoot,	18,219	6,074	4878	27
Total	38,846	11,446	10,773	28

Stream Bank Erosion Loading

The base parameter and stream bank erosion inventory project undertaken in 2004 (DTM and AGI, 2005) included direct measurement of sediment from eroding banks on representative reaches of 303(d) Listed streams. **Section 5** of this document and **Appendix C** describe the assessment methodology and results. The Bank Erosion Hazard Index method of Rosgen (2000) was used to obtain measured values for reach specific stream bank erosion rates. Measurements of total bank erosion were partitioned into controllable and background components by assuming a degree of improvement in selected stream bank dimensional and condition parameters that would occur in the absence human influence. The difference between the measured rate and the rate reflecting no human influence defined the controllable load.

Impaired streams in the Clearwater River watershed that were not included in the 2004 reach assessment effort include Richmond Creek, the West Fork of the Clearwater River and Deer Creek. Stream bank sediment contributions from these streams were estimated by the modeled relationship between measured values and upstream precipitation. The controllable fraction of 31%, derived from both the Nevada Creek and Middle Blackfoot stream bank assessment effort was applied to the Clearwater River tributaries to define their background and controllable loads.

Table J-4 contains an upstream to downstream accounting of the total stream bank loads, controllable loads, and background loading for assessed reaches and listed segments of Nevada Creek planning area streams. The total, controllable, and background contributions from listed stream segments are entered cumulatively in the last three columns of the table. Values for individual listed streams with upstream loading can be obtained by subtracting the given upstream loads. **Table J-5** contains the stream bank loading for the Middle Blackfoot planning area. The estimated stream bank sediment load of 12,453 tons/yr from controllable sources in the combined Nevada Creek and Middle Blackfoot planning areas is 33% of the total annual stream bank load of 37,911 tons/yr.

Table J-4. Nevada Creek Planning Area Stream Bank Erosion Inventory and Sediment Loads

Stream Name	Reach Code	Reach Load (Tons/Yr)	Controllable Fraction	Controllable Reach Load (Tons/Yr)	Background Reach Load (Tons/Yr)	Cumulative Total Segment Load (Tons/Yr)	Cumulative Controllable Segment Load (Tons/Yr)	Cumulative Background Segment Load (Tons/Yr)
Upper Washington Creek	Wash1	16	0.26	4.2	11.8	296	119	177
	Wash2	280	0.41	114.6	165.0			
Lower Washington Creek	Wash3	754	0.31	233.8	520.3	1,050	353	697
Upper Jefferson Creek	Jeff1	536	0.41	219.6	315.9	535	220	315
Lower Jefferson Creek	Jeff2	537	0.30	220	316.8	537	220	317
Gallagher Creek	Gall1	10	0.26	2.6	7.4	100	27	73
	Gall2	90	0.27	24.2	65.3			
Buffalo Gulch	Buff1	8.1	0.26	2.1	6.0	158	50	109
	Buff2	82.7	0.30	24.8	57.9			
	Buff3	67.6	0.34	22.6	45.0			
Nevada Creek (upper)	Nev1	17.4	0.30	5.2	12.2	3,480	1,178	2,302
	Nev2	27.8	0.27	7.5	20.3			
	Nev3	232.4	0.38	88.3	144.1			
	Nev4	212.5	0.34	72.3	140.3			
	Nev5	741.8	0.30	222.5	519.3			
	Nev6	402.6	0.33	132.9	269.7			
Braziel Creek	Braz1	1	0.30	0.3	0.7	262	70	192
	Braz2	233.4	0.26	60.7	172.7			
	Braz3	27.4	0.34	9.2	18.2			
Black Bear Creek	BlkBr1	0.6	0.30	0.2	0.4	113	30	83
	BlkBr2	1	0.30	0.3	0.7			
	BlkBr3	15.8	0.28	4.4	11.4			
	BlkBr4	94.8	0.26	24.6	70.2			
Murray Creek	Murr1	1.7	0.30	0.5	1.2	615	224	391
	Murr2	128.5	0.27	34.2	94.3			
	Murr3	484.6	0.39	189.0	295.6			
Upper Douglas Creek	Doug1	1.9	0.30	0.6	1.3	996	356	641
	Doug2	3.2	0.30	1.0	2.2			
	Doug3	43.8	0.35	15.3	28.5			
	Doug4	220	0.39	84.7	135.3			

Table J-4. Nevada Creek Planning Area Stream Bank Erosion Inventory and Sediment Loads

Stream Name	Reach Code	Reach Load (Tons/Yr)	Controllable Fraction	Controllable Reach Load (Tons/Yr)	Background Reach Load (Tons/Yr)	Cumulative Total Segment Load (Tons/Yr)	Cumulative Controllable Segment Load (Tons/Yr)	Cumulative Background Segment Load (Tons/Yr)
Cottonwood Creek	CttnNv1	59.9	0.34	20.4	39.5	309	95	214
	CttnNv2	128.7	0.30	38.7	90.0			
	CttnNv3	120.7	0.30	36.3	84.4			
Lower Douglas Creek	Doug5	805.8	0.42	338.4	467.4	4,224	1,448	2,777
	Doug6	944.1	0.35	325.7	618.4			
	Doug7	902.7	0.27	243.7	659.0			
	Doug8	102.3	0.30	30.8	71.5			
	Doug9	163.8	0.36	58.3	105.5			
Nevada Spring Creek						25	8	17
McElwain Creek	McEl1	333	0.36	119.9	213.1	333	119.9	213.1
Nevada Creek (lower)	Nev7	402.6	0.34	265.7	515.7	10,687	3,502	7,185
	Nev8	781.4	0.26	101.7	289.3			
	Nev9	391	0.26	7.9	22.4			
	Nev10	30.3	0.27	7.8	21.0			
	Nev11	28.8	0.26	23.4	66.6			
	Nev12	90	0.28	5.2	13.5			
	Nev13	18.7	0.33	4.9	9.8			
	Nev14	14.7	0.26	262.4	747.0			

Table J-5. Middle Blackfoot Planning Area Stream Bank Erosion Inventory and Sediment Loads

Stream Name	Reach Code	Reach Load (Tons/Yr)	Controllable Fraction	Controllable Reach Load (Tons/Yr)	Background Reach Load (Tons/Yr)	Cumulative Segment Load (Tons/Yr)	Cumulative Controllable Segment Load (Tons/Yr)	Cumulative Background Segment Load (Tons/Yr)
Yourname Creek	Your1	17.4	0.30	5.2	12.2	274	95	179
	Your2	11.3	0.30	3.4	7.9			
	Your3	20.2	0.27	5.5	14.7			
	Your4	225	0.36	81.0	144.0			
Wales Creek	Wale1	266.7	0.36	96.0	170.7	267	96.0	171
Frazier Creek	Fraz1	0.04	0.30	0.0	0.0	0.3	0.1	0.2
	Fraz2	0.1	0.30	0.0	0.1			
	Fraz3	0.1	0.30	0.0	0.1			
Ward Creek	Ward1	0	0.30	0.0	0.0	77	23	54
	Ward2	0	0.30	0.0	0.0			
	Ward3	65.6	0.30	19.7	45.9			
	Ward4	0.2	0.30	0.1	0.1			
	Ward5	0.3	0.30	0.1	0.2			
	Ward6	0.1	0.30	0.0	0.1			
	Ward7	0.1	0.30	0.0	0.1			
	Ward8	10.6	0.27	2.9	7.7			
Kleinschmidt Creek	Klein1	0.3	0.30	0.1	0.2	80	24	56
	Klein2	1.1	0.39	0.4	0.7			
	Klein3	1.3	0.39	0.5	0.8			
Rock Creek	Rock1	0	0.30	0.0	0.0	227	62	163
	Rock2	0.1	0.30	0.0	0.1			
	Rock3	0.9	0.30	0.3	0.6			
	Rock4	79.9	0.26	20.8	59.1			
	Rock5	57.4	0.26	14.9	42.5			
	Rock6	7.3	0.26	1.9	5.4			
	Rock7	1.3	0.30	0.4	0.9			
North Fork Blackfoot River		6334	0.31	1964	4370	6,561	2,026	4535

Table J-5. Middle Blackfoot Planning Area Stream Bank Erosion Inventory and Sediment Loads

Stream Name	Reach Code	Reach Load (Tons/Yr)	Controllable Fraction	Controllable Reach Load (Tons/Yr)	Background Reach Load (Tons/Yr)	Cumulative Segment Load (Tons/Yr)	Cumulative Controllable Segment Load (Tons/Yr)	Cumulative Background Segment Load (Tons/Yr)
Warren Creek	Warr1	0.2	0.30	0.1	0.1	85	26	59
	Warr2	1.1	0.28	0.3	0.8			
	Warr3	15.1	0.26	3.9	11.2			
	Warr4	5	0.27	1.4	3.7			
	Warr5	7.4	0.28	2.1	5.3			
	Warr6	6.3	0.28	1.8	4.5			
	Warr7	6.7	0.28	1.9	4.8			
	Warr8	7.7	0.28	2.2	5.5			
	Warr9	0.1	0.30	0.0	0.1			
	Warr10	6.6	0.36	2.4	4.2			
	Warr11	13.3	0.36	4.8	8.5			
	Warr12	15.1	0.36	5.4	9.7			
Monture Creek	Mont1	1.3	0.30	0.4	0.9	770	209	561
	Mont2	0.6	0.30	0.2	0.4			
	Mont3	7.4	0.30	2.2	5.2			
	Mont4	118.6	0.29	34.4	84.2			
	Mont5	90.4	0.27	24.4	66.0			
	Mont6	120.4	0.27	32.5	87.9			
	Mont7	95.5	0.26	24.8	70.7			
	Mont8	43.2	0.26	11.2	32.0			
	Mont9	68	0.26	17.7	50.3			
	Mont10	94	0.26	24.4	69.6			
	Mont11	47.4	0.26	12.3	35.1			
	Mont12	44.85	0.30	13.5	31.4			
	Mont13	37.95	0.30	11.4	26.6			
Blackfoot River (Nevada Creek to Monture Creek)	Blkft1	1429.6	0.34	491.8	937.8	29,940	9,840	20,100
	Blkft2	2501.8	0.34	860.6	1641.2			
	Blkft3	2654.2	0.34	913.0	1741.2			
	Blkft4	165.6	0.34	57.0	108.6			
	Blkft5	2244.7	0.0	0.0	2244.7			
	Blkft6	906.9	0.34	312.0	594.9			
	Blkft7	508.2	0.0	0.0	508.2			
	Blkft8	884.5	0.34	304.3	580.2			

Table J-5. Middle Blackfoot Planning Area Stream Bank Erosion Inventory and Sediment Loads

Stream Name	Reach Code	Reach Load (Tons/Yr)	Controllable Fraction	Controllable Reach Load (Tons/Yr)	Background Reach Load (Tons/Yr)	Cumulative Segment Load (Tons/Yr)	Cumulative Controllable Segment Load (Tons/Yr)	Cumulative Background Segment Load (Tons/Yr)
Chamberlain Creek		240	0.31	74	166	240	74	166
Cottonwood Creek	CttnBlk0	104.6	0.39	40.8	63.8	296	106	190
	CttnBlk1	51.4	0.39	20.0	31.4			
	CttnBlk2	35.9	0.39	14.0	21.9			
	CttnBlk3	41.2	0.34	14.0	27.2			
	CttnBlk4	14.8	0.28	4.1	10.7			
	CttnBlk5	35.8	0.28	10.0	25.8			
	CttnBlk6	12	0.28	3.4	8.6			
Richmond Creek		3	0.31	1	2	3	1	2
West Fork Clearwater River		371	0.31	115	256	371	115	256
Deer Creek		124	0.31	38	86	124	38	86
Buck Creek		5	0	0	5	5	1.5	3.3
Blanchard Creek	Blan1	39.7	0.26	10.3	29.4	59	15	44
	Blan2	19.2	0.26	5.0	14.2			
Lower Clearwater River		2,871	0.31	890	1981	3,433	1,061	2,372
Blackfoot River (Monture Creek to Clearwater River)	Blkft9	2237.3	0.34	769.6	1467.7	4,002	1,377	2,625
	Blkft10	1040.6	0.34	358.0	682.6			
	Blkft11	723.8	0.34	249.0	474.8			
Middle Blackfoot-Nevada Creek TPA Totals						**37,911**	**12,453**	**25,458**

The analysis of how the bank erosion hazard index parameters would change in the absence human influence divides the stream bank load into a human-caused loading component and a background component without human influence. An estimate of the achievable reduction in human-caused loading is needed to quantify naturally occurring loading that includes human caused loading with the application of all reasonable land, soil, and water conservation practices.

The achievable reduction was estimated by reviewing the reach assessment database entries for land use, vegetation conditions, and bank stability ratings. Field notes of bank conditions, reach photographs of ground conditions, and aerial photography were also considered in estimating an achievable reduction in human-caused loading. The reductions ranged from 20% to 80%, with the lower percentages applying to more remote headwaters reaches having fewer human impacts and inherently more stable channel types. Larger deductions are more common on lower reaches where human influence is more extensive.

Tables J-6 and J-7 specify the achievable reduction to the human caused component of stream bank erosion for each assessment reach in the Nevada Creek and Middle Blackfoot planning areas. The shaded rows in the tables contain total loading figures for the corresponding stream segment. Reductions in human caused loading are not specified for the unlisted tributaries of North Fork Blackfoot River, Chamberlain Creek, and the Clearwater River; their human caused loads are assumed to occur with the application of all reasonable land, soil, land water conservation practices.

Table J-6. Nevada Creek Stream Bank Erosion Load Apportionment into Human Caused Loading, Background Loading and Achievable Reductions to Human Caused Loading

Listed Reach Name	Assessment Reach Name	Reach Load (tons/yr)	Load Reduction Percentage	Human Caused Load (tons/yr)	Background Load (tons/yr)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)
Upper Washington Creek	Wash1	16	26%	4	12	25%	1
Upper Washington Creek	Wash2	280	41%	114.6	165.0	50%	57
Upper Washington Creek Total		296	40%	119	177	33%	58
Lower Washington Creek	Wash3	754	31%	234	520	75%	175
Upper Jefferson Creek	Jeff1	536	41%	220	316	75%	165
Lower Jefferson Creek	Jeff2	1.3	30%	0.4	1	80%	0.3
Lower Jefferson Creek Total		537	41%	220	317	52%	165
Gallagher Creek	Gall1	10	26%	3	7	25%	0.1
Gallagher Creek	Gall2	90	27%	24	65	75%	18
Gallagher Creek Total		100	27%	27	73	70%	19
Buffalo Gulch	Buff1	8	26%	2	6	30%	0.1
Buffalo Gulch	Buff2	83	30%	25	58	70%	17
Buffalo Gulch	Buff3	68	34%	23	45	60%	14
Buffalo Gulch Total		159	31%	50	109	64%	32
Upper Nevada Creek	Nev1	17	30%	5	12	25%	1
Upper Nevada Creek	Nev2	28	27%	8	20	25%	2
Upper Nevada Creek	Nev3	232	38%	88	144	35%	31
Upper Nevada Creek	Nev4	213	34%	72	140	60%	43
Upper Nevada Creek	Nev5	742	30%	223	519	75%	167
Upper Nevada Creek	Nev6	403	33%	133	270	75%	100
Upper Nevada Creek Total		1635	32%	529	1106	65%	344
Braziel Creek	Braz1	1	30%	0.3	1	25%	0.1
Braziel Creek	Braz2	233	26%	61	173	60%	36
Braziel Creek	Braz3	27	34%	9	18	80%	7
Braziel Creek Total		262	27%	70	192	62%	44
Black Bear Creek	BlkBr1	1	30%	0.2	0.4	20%	0.0
Black Bear Creek	BlkBr2	1	30%	0.3	0.7	25%	0.1
Black Bear Creek	BlkBr3	16	28%	4	11	70%	3
Black Bear Creek	BlkBr4	95	26%	25	70	80%	20
Black Bear Creek Total		112	26%	30	83	78%	24
Murray Creek	Murr1	2	30%	1	1	20%	0.2
Murray Creek	Murr2	129	27%	34	94	60%	21

Table J-6. Nevada Creek Stream Bank Erosion Load Apportionment into Human Caused Loading, Background Loading and Achievable Reductions to Human Caused Loading

Listed Reach Name	Assessment Reach Name	Reach Load (tons/yr)	Load Reduction Percentage	Human Caused Load (tons/yr)	Background Load (tons/yr)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)
Murray Creek	Murr3	485	39%	189	296	75%	142
Murray Creek Total		615	36%	224	391	73%	162
Upper Douglas Creek	Doug1	2	30%	1	1	30%	0.2
Upper Douglas Creek	Doug2	3	30%	1	2	40%	0.4
Upper Douglas Creek	Doug3	44	35%	15	29	80%	12
Upper Douglas Creek	Doug4	220	39%	85	135	75%	64
Upper Douglas Creek Total		269	38%	102	167	75%	77
Cottonwood Creek	CttnNev1	60	34%	20	40	80%	16
Cottonwood Creek	CttnNev2	129	30%	39	90	80%	31
Cottonwood Creek	CttnNev3	121	30%	36	84	80%	29
Cottonwood Creek Total		310	31%	95	214	80%	76
Lower Douglas Creek	Doug5	806	42%	338	467	75%	72
Lower Douglas Creek	Doug6	944	35%	326	618	50%	163
Lower Douglas Creek	Doug7	903	27%	244	659	70%	171
Lower Douglas Creek	Doug8	102	30%	31	72	80%	25
Lower Douglas Creek	Doug9	164	36%	58	106	80%	47
Lower Douglas Creek Total		2919	34%	997	1922	48%	478
Nevada Spring Creek	NA	25	31%	8	17	75%	6
McElwain Creek	McEl1	333	36%	120	213	75%	90
Lower Nevada Creek	Nev7	781	34%	266	516	80%	213
Lower Nevada Creek	Nev8	391	26%	102	289	75%	76
Lower Nevada Creek	Nev9	30	26%	8	22	50%	4
Lower Nevada Creek	Nev10	29	27%	8	21	60%	5
Lower Nevada Creek	Nev11	90	26%	23	67	80%	19
Lower Nevada Creek	Nev12	19	28%	5	14	70%	4
Lower Nevada Creek	Nev13	15	33%	5	10	40%	2
Lower Nevada Creek	Nev14	1009	26%	262	747	75%	197
Lower Nevada Creek Total		2364.3	29%	679	1685		519

Table J-7. Middle Blackfoot Stream Bank Erosion Load Apportionment into Anthropogenic Loading, Background Loading and Achievable Anthropogenic Load Reductions

Listed Segment Name	Assessment Reach Name	Reach Load (tons/yr)	Load Reduction Percentage	Human Caused Load (tons/yr)	Background Load (tons/yr)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)
Yourname Creek	Your1	17	30%	5	12	25%	1
Yourname Creek	Your2	11	30%	3	8	30%	1
Yourname Creek	Your3	20	27%	5	15	75%	4
Yourname Creek	Your4	225	36%	81	144	75%	61
Yourname Creek Total		274	35%	95	179	71%	67
Wales Creek	Wale1	267	36%	96.0	171	75%	72
Frazier Creek	Fraz1	0.0	30%	0.0	0.0	25%	0.0
Frazier Creek	Fraz2	0.1	30%	0.0	0.1	25%	0.0
Frazier Creek	Fraz3	0.1	30%	0.0	0.1	25%	0.0
Frazier Creek Total		0.2	42%	0.1	0.2	25%	0.0
Ward Creek	Ward1	0	30%	0.0	0.0	25%	0.0
Ward Creek	Ward2	0	30%	0.0	0.0	25%	0.0
Ward Creek	Ward3	66	30%	20	46	80%	16
Ward Creek	Ward4	0.2	30%	0.1	0.1	80%	0.0
Ward Creek	Ward5	0.3	30%	0.1	0.2	75%	0.1
Ward Creek	Ward6	0.1	30%	0.0	0.1	25%	0.0
Ward Creek	Ward7	0.1	30%	0.0	0.1	40%	0.0
Ward Creek	Ward8	11	27%	3	8	75%	2
Ward Creek Total		779	30%	23	54	79%	18
Kleinschmidt Creek	Klein1	0	30%	0	0	80%	0
Kleinschmidt Creek	Klein2	1	39%	0	1	60%	0
Kleinschmidt Creek	Klein3	1	39%	1	1	70%	0
Kleinschmidt Creek Total		3	37%	1	2	70%	1
Rock Creek	Rock1	0	30%	0	0	20%	0
Rock Creek	Rock2	0	30%	0	0	60%	0
Rock Creek	Rock3	1	30%	0	1	75%	0
Rock Creek	Rock4	80	26%	21	59	75%	16
Rock Creek	Rock5	57	26%	15	42	80%	12
Rock Creek	Rock6	7	26%	2	5	80%	2
Rock Creek	Rock7	1	30%	0	1	75%	0
Rock Creek Total		147	26%	38	109	77%	30

Table J-7. Middle Blackfoot Stream Bank Erosion Load Apportionment into Anthropogenic Loading, Background Loading and Achievable Anthropogenic Load Reductions

Listed Segment Name	Assessment Reach Name	Reach Load (tons/yr)	Load Reduction Percentage	Human Caused Load (tons/yr)	Background Load (tons/yr)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)
North Fork Blackfoot River		6334	31%	1964	4370	0.0	0.0
Warren Creek	Warr1	0	30%	0	0	75%	0
Warren Creek	Warr10	7	30%	2	5	75%	1
Warren Creek	Warr11	13	36%	5	9	40%	2
Warren Creek	Warr12	15	36%	5	10	40%	2
Warren Creek	Warr2	1	28%	0	1	25%	0
Warren Creek	Warr3	15	26%	4	11	50%	2
Warren Creek	Warr4	5	27%	1	4	60%	1
Warren Creek	Warr5	7	28%	2	5	75%	2
Warren Creek	Warr6	6	28%	2	5	75%	1
Warren Creek	Warr7	7	28%	2	5	75%	1
Warren Creek	Warr8	8	28%	2	6	75%	2
Warren Creek	Warr9	0	30%	0	0	20%	0
Warren Creek Total		85	30%	26	59	56%	14
Monture Creek	Mont1	1	30%	0	1	20%	0
Monture Creek	Mont10	94	26%	24	70	65%	16
Monture Creek	Mont11	47	26%	12	35	75%	9
Monture Creek	Mont12	45	30%	13	31	60%	8
Monture Creek	Mont13	38	30%	11	27	70%	8
Monture Creek	Mont2	1	30%	0	0	20%	0
Monture Creek	Mont3	7	30%	2	5	20%	0
Monture Creek	Mont4	119	28%	33	85	60%	20
Monture Creek	Mont5	90	27%	24	66	60%	15
Monture Creek	Mont6	120	27%	33	88	60%	20
Monture Creek	Mont7	96	26%	25	71	60%	15
Monture Creek	Mont8	43	26%	11	32	60%	7
Monture Creek	Mont9	68	26%	18	50	60%	11
Monture Creek Total		770		208	561	61%	128
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft1	1430	34%	492	938	65%	320
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft2	2502	34%	861	1641	65%	559

Table J-7. Middle Blackfoot Stream Bank Erosion Load Apportionment into Anthropogenic Loading, Background Loading and Achievable Anthropogenic Load Reductions

Listed Segment Name	Assessment Reach Name	Reach Load (tons/yr)	Load Reduction Percentage	Human Caused Load (tons/yr)	Background Load (tons/yr)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft3	2654	34%	913	1741	65%	593
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft4	166	34%	57	109	65%	37
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft5	2245	34%	772	1473	60%	463
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft6	907	34%	312	595	65%	203
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft7	508	34%	175	333	65%	114
Blackfoot River (Nevada Cr. To Monture Cr.)	Blkft8	885	34%	304	580	70%	213
Blackfoot River (Nevada Cr. To Monture Cr.) Total		11295	34%	3886	7410	64%	2502
Chamberlain Creek		240	31%	74	166	0.0	0.0
Cottonwood Creek	CttnBlk0	105	39%	41	64	75%	31
Cottonwood Creek	CttnBlk1	51	39%	20	31	75%	15
Cottonwood Creek	CttnBlk2	36	39%	14	22	50%	7
Cottonwood Creek	CttnBlk3	41	34%	14	27	75%	11
Cottonwood Creek	CttnBlk4	15	28%	4	11	40%	2
Cottonwood Creek	CttnBlk5	36	28%	10	26	50%	5
Cottonwood Creek	CttnBlk6	12	28%	3	9	65%	2
Cottonwood Creek Total		296		106	189	68%	72
Richmond Creek		3	31%	1	2.	70%	1
West Fork Clearwater River		371	31%	115	256	60%	69
Deer Creek		124	31%	38	86	60%	23
Buck Creek		5	0%	1	4	60%	1
Blanchard Creek	Blan1	40	26%	10	29	75%	8
Blanchard Creek	Blan2	19	26%	5	14	75%	4
Blanchard Creek Total		59	26%	15	44	75%	11
Clearwater River		2871	31%	890	1981	0.0	0.0

Table J-7. Middle Blackfoot Stream Bank Erosion Load Apportionment into Anthropogenic Loading, Background Loading and Achievable Anthropogenic Load Reductions

Listed Segment Name	Assessment Reach Name	Reach Load (tons/yr)	Load Reduction Percentage	Human Caused Load (tons/yr)	Background Load (tons/yr)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)
Blackfoot River (Monture Cr. To Clearwater R.)	Blkft9	2237	34%	770	1468	45%	346
Blackfoot River (Monture Cr. To Clearwater R.)	Blkft10	1041	34%	358	683	60%	215
Blackfoot River (Monture Cr. To Clearwater R.)	Blkft11	724	34%	249	475	30%	75
Blackfoot River (Monture Cr. To Clearwater R.) Total		4002	34%	1377	2625	46%	636

Sediment Loading From Culvert Failure

Sediment contributions from road fill failure at crossings can occur from fill saturation by ponded water at the upstream inlet of undersized culverts or from overflow of ponded water onto the road with subsequent erosion of the fill. The estimation of sediment from roadways conducted in 2005 included an analysis of sediment from culvert failure. Seventy-three culverts were surveyed in the Middle Blackfoot-Nevada Creek planning area during the 2005 road sediment source assessment. The analysis associated risk of failure with the ratio of culvert width to bankfull channel width (constriction ratio) of less that one.

A total of 1,060 tons of fill from 17 sites in the Nevada Creek planning area and 4,393 tons of sediment from 38 surveyed sites in the middle Blackfoot River planning area were considered at risk from culvert failure. Per crossing means were 62.4 tons in Nevada Creek and 115.6 tons in the middle Blackfoot. These means were multiplied by number of crossings per listed segment to estimate per segment loading. Most of the Nevada Creek tonnage was surveyed at culverts that were 70% or less of the channel bankfull width; tonnage in the middle Blackfoot was mostly from culverts that were 40% or less of the channel bankfull width; (RDG 2006). Annual loads from culvert failure were based on an assumed one percent failure rate. Thus annual loading was 450 tons in the Nevada Creek planning area and 2,100 tons per year in the middle Blackfoot planning area. The annual load is partitioned into controllable versus naturally occurring components by applying a percent reduction derived from an alternative, discharge based culvert failure analysis used in other forested watersheds in Montana.

In these analyses, regression equations developed by the USGS (Omang 1992) were used to estimate peak discharge (Q) for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals at surveyed stream crossings based on drainage area (square miles) and mean annual precipitation (inches). Survey data was used to calculate a ratio of ponded headwater depth to culvert inlet depth (Hw:D) at each culvert. Culverts exceeding a Hw:D ratio of 1.4 were considered at risk for failure. The annual probability of modeled discharge, Hw:D ratio and road fill volume subject to erosion at failure were used to quantify annual loading from failure. The existing loading condition assumed that failed culverts were replaced with culverts of the same size. An appropriate reduction from the current loading condition was based on a scenario where failed culverts were upgraded to those passing the Q100 discharge. This scenario follows the guidance from the USFS INFISH recommendations which call for all culverts on USFS land to be able to pass the Q100 flow event. The sediment yields and reductions from the surveyed locations were extrapolated to unsurveyed culverts at the watershed scale. The Q100 replacement scenario resulted in annual loading reductions ranging from 70 to 80 percent. The Q100 replacement BMP and assumed loading reduction were applied to the annual loading estimates to define the controllable and naturally occurring loads. The culvert upgrade scenario was assumed to represent application of all reasonable land, soil, and water conservation practices addressing culvert failure. **Table J-8** below gives the details of loading from culvert failure by listed stream segment.

Table J-8. Annual Loading from Culvert Failure by Listed Segment

Stream Name	**Crossings**	**At Risk Mass (tons)**	**Annual Loading (tons/yr)**	**Controllable Load (tons/year)**	**Load Per Q100 Replacement (tons/yr)**
Nevada Creek Planning Area					
Upper Washington Creek	9	562	6	4	1
Lower Washington Creek	8	499	5	4	1
Upper Jefferson Creek	21	1,310	13	10	3
Lower Jefferson Creek	4	250	2	2	1
Gallagher Creek	7	437	4	3	1
Buffalo	39	2,434	24	19	6
Upper Nevada Creek	18	1,123	11	9	3
Braziel Creek	13	811	8	6	2
Black Bear Creek	12	749	7	6	2
Murray Creek	50	3,120	31	24	7
Upper Douglas Creek	111	6,926	69	53	16
Cottonwood Creek	69	4,306	43	33	10
Lower Douglas Creek	88	5,491	55	42	13
Nevada Spring Creek	5	312	3	2	1
McElwain Creek	24	1,498	15	12	3
Nevada Creek TPA Non-303(d) Listed Streams	201	12,542	125	97	29
Lower Nevada Creek	39	2,434	24	19	6
Sub Planning Area Totals	**718**	**44,803**	**448**	**345**	**103**
Middle Blackfoot Planning Area					
Yourname Creek	33	3,815	38	29	9
Wales Creek	4	462	5	4	1
Frazier Creek	8	925	9	7	2
Ward Creek	16	1,850	18	14	4
Kleinschmidt Creek	8	925	9	7	2
Rock Creek	29	3,352	34	26	8
North Fork Blackfoot River	79	9,132	91	70	21
Warren Creek	43	4,971	50	38	11
Monture Creek	121	13,988	140	108	32
Blackfoot River (Nevada Creek to Monture Creek)	39	4,508	45	35	10
Chamberlain Creek	109	12,600	126	97	29
Cottonwood Creek	177	20,461	205	158	47
Richmond Creek	11	1,272	13	10	3
West Fork Clearwater River	81	9,364	94	72	22
Deer Creek	68	7,861	79	61	18
Buck Creek	12	1,387	14	11	3
Blanchard Creek	97	11,213	112	86	26
Middle Blackfoot TPA, Non-303(d) Listed Streams	800	92,480	925	712	213

Table J-8. Annual Loading from Culvert Failure by Listed Segment

Stream Name	Crossings	At Risk Mass (tons)	Annual Loading (tons/yr)	Controllable Load (tons/year)	Load Per Q100 Replacement (tons/yr)
Blackfoot River (Monture Creek to Clearwater River)	83	9,595	96	74	22
Sub Planning Area Totals	**1,818**	**210,161**	**2,102**	**1,618**	**483**
Middle Blackfoot-Nevada Creek Totals	**2,536**	**254,964**	**2,550**	**1,963**	**586**

Allocations for Sediment Loading

The estimated annual load reductions are allocated to land uses within the watersheds of impaired streams. The allocation for each land use is expressed as a percentage of the needed annual reduction for the listed water body and converted to annual reductions in tons per year. The annual reduction allocations given in **Table 9.7** are a composite of those determined separately for hillslope, stream bank and road erosion.

Annual hillslope allocations are based partially upon the proportional loading from cover type categories that are linked to specific land uses. The size of the allocation to silviculture activities, for example, reflects the magnitude of modeled annual loading from forest landcover types. Allocations to livestock grazing are proportional to modeled loading from rangeland types. SWAT loading estimates by cover type are at the subbasin scale, allowing for broad land use allocations. The allocations were refined by considering the extent of cover types, and corresponding land uses, occurring within the sheetflow area defined by the 350-foot buffer extending from each stream bank.

Clipping the USGS 2001 landcover layer to the stream buffer layer allowed the calculation of landcover proportions within the sheetflow area. Examining the aerial imagery at the larger scale required to discern buffer zone land uses identified land use sources such as placer mining that are not accounted for in SWAT. Interpretation of the aerial imagery of the buffer zone and its landcover polygons also exposed noted differences between USGS landcover categories and actual ground conditions. Nearly the entire Rock Creek buffer area on Kleinschmidt Flats is classified as annually harvested cropland on the USGS landcover map. The aerial imagery indicates that seasonal grazing is the principal land use. In many cases, the 2005 aerial imagery and ground photos taken during the 2004 field assessment were used to adjust the allocations derived by strict adherence to USGS landcover category. **Table J-9** below lists the landcover types identified by SWAT as the hillslope loading sources and gives in parentheses the proportion of total loading attributable to each.

Table J-9 also contains values for land use extent expressed as a percentage of the sheetflow area adjacent to sediment impaired channels. These values frequently sum to greater than 100 percent due to the overlapping uses such as grazing within forest as well as rangeland types. Seasonal grazing on irrigated hay acreage is also a common practice within both planning areas.

Table J-9. SWAT Sediment Yield Percentages by Cover Type, Sheetflow Area Land Use Extent (%) and Hillslope Land Use Allocations (%) for Sediment Impaired Waters in the Nevada Creek and Middle Blackfoot Planning Areas

Impaired Segment Name	SWAT Landcover Types (Yield Percentage)	Sheetflow Area Land Use Percentage				Hillslope Land Use Allocation Percentage			
		Forestry	Placer Mining	Grazing	Irrigated Hay	Forestry	Placer Mining	Grazing	Irrigated Hay
Nevada Creek TPA									
Upper Washington	Grasslands (62) Shrublands (38)		50	50			40	50	10
Lower Washington	Grasslands (82) Shrublands (18)		30	70				100	
Upper Jefferson	Grasslands (62) Shrublands (38)	50	30	70	0	20	40	40	
Lower Jefferson	No Hillslope Yield		10	100	10				
Gallagher	Grasslands (84) Shrublands (16)			100	30	5		75	20
Buffalo Gulch	Forest Roads (70) Shrublands (10) Grasslands (20)	40		60	0.1	70		30	
Upper Nevada	Grasslands (73) Shrublands (16) Pasture (1)	20	10	70	40			55	45
Braziel	Grasslands (67) Shrublands (30) Forest (3)	10		80	10			100	
Black Bear	Grasslands (86) Shrublands (12) Pasture (2)	60		80				100	
Murray	Forest Roads (69) Shrublands (9) Grasslands (22)	40		80	25	70		30	
Upper Douglas	Grasslands (79) Shrublands (19) Pasture (2)	50		50	10			56	44
Cottonwood	Grasslands (38) Pasture (36) Shrublands (14) Rural Residential (12)			60	40			50	50

Table J-9. SWAT Sediment Yield Percentages by Cover Type, Sheetflow Area Land Use Extent (%) and Hillslope Land Use Allocations (%) for Sediment Impaired Waters in the Nevada Creek and Middle Blackfoot Planning Areas

Impaired Segment Name	SWAT Landcover Types (Yield Percentage)	Sheetflow Area Land Use Percentage				Hillslope Land Use Allocation Percentage			
		Forestry	Placer Mining	Grazing	Irrigated Hay	Forestry	Placer Mining	Grazing	Irrigated Hay
Lower Douglas	Grasslands (75) Shrublands (25)			90	10			100	
Nevada Spring	No Hillslope Yield			100	15				
McElwain	Grasslands (66) Shrublands (31) Pasture (3)			100	40			60	40
Lower Nevada	Grasslands (94) Shrublands (1) Pasture (5)			100	40			95	5
Middle Blackfoot TPA									
Yourname	Grasslands (72) Shrublands (27) Forest (1)			100				100	
Wales	Grasslands (67) Shrublands (32) Forest (1)			100				100	
Frazier	Grasslands (77) Shrublands (23)			100	10			100	
Ward	Grasslands (74) Shrublands (23) Forest (3)			100				100	
Kleinschmidt	Pasture (92) Grasslands (8)			40	50				
Rock	Pasture (96) Rural Residential (4)	10		90	10	30		70	
Warren	Forest Roads (81) Grasslands (16) Shrublands (3)	20		80	20	100			
Monture	Forest (80) Grasslands (17) Shrublands (3)	85		15		80		20	

Table J-9. SWAT Sediment Yield Percentages by Cover Type, Sheetflow Area Land Use Extent (%) and Hillslope Land Use Allocations (%) for Sediment Impaired Waters in the Nevada Creek and Middle Blackfoot Planning Areas

Impaired Segment Name	SWAT Landcover Types (Yield Percentage)	Sheetflow Area Land Use Percentage				Hillslope Land Use Allocation Percentage			
		Forestry	Placer Mining	Grazing	Irrigated Hay	Forestry	Placer Mining	Grazing	Irrigated Hay
Blackfoot River (Nevada Cr. to Monture Cr.)	Grasslands (85) Shrublands (15)			100				100	
Cottonwood	Grasslands (87) Shrublands (12) Forest (1)	10		90		10		90	
Richmond	Forest (100)	100				100			
West Fork Clearwater	Forest (99) Grasslands (1)	100				100			
Deer	Forest (84) Shrublands (14) Grasslands (2)	90		10		100			
Blanchard	Grasslands (87) Shrublands (12) Forest (1)			100				100	
Blackfoot River (Monture Cr. To Clearwater R.)	Forest Roads (84) Grasslands (13) Shrublands (3)	10		90		85		15	

Both SWAT landcover sediment yields and land use extent within the sheetflow area influenced the final land use allocation percentages for hillslope erosion. Hillslope allocations were weighted toward forestry land uses in SWAT subbasins such as Buffalo Gulch, Murray Creek, Warren Creek and the Blackfoot River below Monture Creek that have large yields from "forest roads". Among subbasins without the forest roads HRU, forestry land use allocations are significant only where the majority of the watershed is consists of forest cover. Examples include Richmond Creek, West Fork Clearwater and Deer Creek.

In the majority of the SWAT subbasins most the hillslope loading comes from rangeland cover types. This reflects the strong influences of canopy cover and surface litter accumulation on simulated hillslope erosion. Both the larger canopy density and thicker surface litter accumulation of forests suppress sediment mobility compared to the more open canopy and larger bare soil area characteristic of arid grasslands and shrub dominated rangelands.

As with the hillslope allocations, those for stream bank erosion reflect land use extent as recorded by the assessment field crews during the stream bank erosion inventory in 2004. Land uses were recorded and vegetation conditions evaluated and photographed within assessed reaches. Recorded reach attribute information included woody vegetation density and visible sources of sediment to channels (DTM and AGI 2004). These field observations and the interpretation of ground and aerial imagery identified the principal land uses affecting stream bank conditions and evaluated the degree of sediment loading from each. **Table J-10** gives the percent reduction allocations for land uses affecting stream bank erosion loading.

Table J-10. Land Use Allocations for Streambank Erosion Loading

Stream Name	Livestock Grazing	Irrigated Hay	Silviculture	Placer Mining	Rural Residential
Nevada Creek TPA					
Upper Washington Creek	50			50	
Lower Washington Creek	40	60			
Upper Jefferson Creek	50		20	30	
Lower Jefferson Creek	50	0	20	30	
Gallagher Creek	50	48	2	0	
Buffalo Gulch	40	26	23	11	
Upper Nevada Creek	33	63	2	2	
Braziel Creek	42		58		
Black Bear Creek	96		4		
Murray Creek	47	44	10		
Upper Douglas Creek	50	50			
Cottonwood Creek	58	42			
Lower Douglas Creek	91	9			
Nevada Spring Creek	90	10			
McElwain Creek	50	50			
Lower Nevada Creek	92	8			

Table J-10. Land Use Allocations for Streambank Erosion Loading

Stream Name	Livestock Grazing	Irrigated Hay	Silviculture	Placer Mining	Rural Residential
Middle Blackfoot TPA					
Yourname Creek	96	2	1	1	
Wales Creek	60	40			
Frazier Creek	29	13	58		
Ward Creek	56	0	44		
Kleinschmidt Creek	79	21			
Rock Creek	62	0	38		
Warren Creek	90	10	1		
Monture Creek	20		80		
Blackfoot River (Nevada Cr. To Monture Cr.)	43	34	23		
Cottonwood Creek	25	10	65		
Richmond Creek			100		
West Fork Clearwater River			100		
Deer Creek			100		
Blanchard Creek			100		
Blackfoot River (Monture Cr. To Clearwater R.)	73	5			22

There is fair agreement between the land use allocations for hillslope and stream bank erosion. Livestock grazing effects on woody vegetation condition and bank stability were common in both planning areas. Stream bank allocations to irrigated hay production are generally larger than those for hillslope erosion. This reflects the generally low hillslope loading from this cover type due mostly to the relatively level slopes of hay fields compared to rangeland slopes.

The reductions in road surface erosion and culvert failure are those possible with BMP implementation. A 30 percent reduction is allocated to sediment loading from road crossings. This is the reduction expected with full implementation of road construction and maintenance BMP. The reduction in loading from culvert failure is that achieved by implementing a culvert replacement BMP that calls for the replacement of failed culverts those sized to pass the 100 year storm event as described above under culvert failure loading. An evaluation of the Q100 replacement scenario found that annual reductions ranged from 70 to 80 percent.

The total sediment load reduction allocations by contributing land use category for the Nevada Creek and Middle Blackfoot planning areas are summarized in the **Figure 9-4**.

APPENDIX K: RESPONSE TO PUBLIC COMMENTS

Seven individuals/organizations submitted formal written comments. Their comments have been summarized/paraphrased and organized below by primary topic heading. Responses prepared by MDEQ follow each of the individual comments. The original comment letters are located in the project files at MDEQ and may be reviewed upon request. Where specific modifications to the document have been made in response to comments, they are noted in the responses.

In addition to the comments below, several general comments that mainly included grammatical errors and missing references were addressed by modifying the final document. These comments were addressed and are not summarized below.

1. Executive Summary, Regulatory Framework and Watershed Characterization (Sections 2.0 and 3.0)

Comment 1.1

The proposed removal of Seeley Lake and Salmon Lake from the 303(d) list of impaired waters appears premature and inaccurate based on recent human development activity around the water body, increases in recreational use, and observed water quality deficiencies which exceed Montana standards. The outlet arm of the lake regularly exceeds Montana standards for turbidity and TSS due to high volumes of speed boat and recreation traffic. As a result, visible increases in turbidity are evident in the Clearwater River from Seeley Lake to the Morrell Creek confluence. Missoula County photo documentation has also confirmed the gradual encroachment of infrastructure around the lakeshore and conversion of native riparian vegetation to manicured lawns along the lake perimeter and Clearwater River at the outlet (Missoula County Office of Planning and Grants, Missoula County Conservation District). The city of Seeley Lake is also experiencing rapid human population growth and is planning for modifications or upgrades to its septic treatment system near Morrell Creek. This stream is a direct tributary of the Clearwater River just upstream of Salmon Lake. Therefore, I would not recommend removing either lake from the list.

Response 1.1

> The development of TMDLs relies upon an assessment of the water quality data record for specific pollutants compared to water quality standards and the resulting impairment listing concluded by MDEQ's Monitoring and Assessment program. The assessment record for Seeley Lake cites studies from the early 1970's and the mid 1990's that reported that water quality for nutrients, dissolved oxygen, and Secchi depth appeared fairly constant during this period. The total phosphorus concentration reported in the more recent studies was lower than reported in the 1970's. This improving trend from the 1970s through the mid 1990s is stated in the assessment record as the reason for the current Seeley Lake listing of full support.

The impairment status of Seeley Lake was last updated by MDEQ in 1999. Water quality data has been collected on Seeley Lake since that time and, once reviewed by the staff of MDEQ's Monitoring and Assessment program, the future listing status could change. In addition, water quality monitoring and assessment protocols have evolved since 1999 and an updated assessment of Seeley Lake using updated methods could describe use support differently than in 1999

The assessment record from 1999 acknowledges that excessive nitrogen inputs from shoreline septic systems could alter the lake's water quality. A fish consumption advisory was issued for rainbow trout in Seeley Lake based on 1992 and 1993 data for PCB in fish tissue. A detected concentration of 0.06 parts per million (ppm) just exceeded the 0.05 ppm fish tissue threshold for PCB. Water quality concentrations of PCB that would result in this low level of accumulation are not likely to exceed acute or chronic water quality standards. Indeed, the water quality data record does not contain a result for PCB that exceeds the standards.

The 1996 listing of Salmon Lake for nutrients, organic enrichment, and siltation stemmed from fish surveys from the 1950s through the 1970s that indicated higher than normal numbers of non-game fish. Nutrient concentrations measured since the mid-1980s appear normal. Although summer algal blooms have observed in recent years and have apparently led to fish kills, cause and effect documentation is lacking.

The impairment status of Salmon Lake was last updated by MDEQ in 2005 and includes the interpretation of nutrient data collected in 2003 and 2004. Total nitrogen values averaged 0.177 mg/L from six sampling events; the samples had a mean total phosphorus concentration of 12 µg/L. These values do not represent elevated nutrients in the lake. The degree of shoreline human influence indicates some impairment but the suppressed fishery is thought to be more related to the illegal introduction of northern pike than excess sedimentation.

Although Seeley and Salmon lakes were not mentioned specifically in the adaptive management strategy for nutrients **(Section 9.3.5)**, the discussion acknowledges the shortfalls in the current understanding of nutrients in the Blackfoot River watershed, including the Clearwater River watershed, and recommends a strategy to address the data shortfalls.

Comment 1.2

Salmon Lake and Seeley Lake are considered fully functioning without adequate current data. Therefore, I request that the restoration plan include planning for a non-growing season nutrient evaluation and chemical contamination monitoring. Temperature evaluations also need to be included for these lakes. There are many public water supply system violations for sources in the Seeley Lake area. Lake monitoring should include the constituents named with these violations. MDEQ needs to examine these lakes for nutrients, organic enrichment, Coliform, HAA5, Arsenic, Mercury and Organochlorides. I suspect TMDLs will be needed in some of these categories. The restoration plan should include an expanded discussion that addresses planning for evaluations and monitoring in these lakes.

Tote Road Lake has a history of chemical spills and clean-up activities and subdivision development is planned in the near future. The lake does not appear on the list of impaired waters. I would like to see the TMDL document include plans for a review of water quality in Emerald Lake and the Fish Creek watershed.

Lower Clearwater River appears as a 303d stream on many of the maps and appears on several tables in **Section 5.0** and in some appendices. **Section 2.0** needs to include a preliminary discussion of this stream segment and **Section 10.0** needs to provide a TMDL calculation and long term planning for the Lower Clearwater River 303d segment erosion/sediment, nutrients and temperature parameters. In **Section 10.0**, it would be appropriate to include a plan to evaluate nutrients and organics during a non-growing season period, particularly in the lower reaches of this stream.

The entry for Blanchard Creek in **Table 2-1** of the report shows that the primary contact recreation is N, but the text in **Section 5.0** indicates that this classification is a P. This should be reviewed to insure **Sections 2.0 and 5.0** are consistent. In **Section 10.0**, please include a plan to evaluate nutrients and organics during a non-growing season period, particularly in the lower reaches of this stream.

Analysis of the combined potential impact of the recent (2007) fire, associated salvage logging, existing housing, and proposed housing (820 units being discussed by the community) in the Placid Creek watershed may make it necessary for MT DEQ to plan for additional sampling in the watershed, including Placid Lake.

Buck Creek was listed as impaired in 1996, and the current planning document implies this is no longer the case. There appears to be a lack of data or evidence of remediation to support a fully functioning classification. **Table 2-1** shows the status for Buck Creek, and indicates that there are not sufficient data. In **Section 2.0** it states that DEQ could not sample in 2004 due to dry channel conditions; for consistency, please include that statement on page J-9 in the next to the last paragraph. MT DEQ needs to obtain data before this stream can be considered fully functioning.

Seasonal dewatering of Owl Creek occurs. I request that DEQ include mention of the Owl Creek flow limitation in **Section 2.0** and propose the appropriate remediation planning in **Section 10.0**.

Deer Creek was classified as threatened in 1996 due to non-priority organics and sediment. No subsequent data are referenced. **Table 2-1** implies there are data available to make the change to fully and partially functioning calls in that table. However, there is a statement that Deer Creek was removed from subsequent lists due to a lack of sufficient data (SCD). There is a sediment TMDL proposed which may be based on modeling or other assumptions (footnotes should identify real and modeled data). **Section 5.0** talks about meeting targets, periphyton samples etc. Please clarify the real situation with the Deer Creek data. If data are available, please cite the sources. If they are not it would seem that some data collection would be an important step before there are changes in classifications of water quality status. In **Section 10.0**, should include a plan to evaluate nutrients and organics during a non-growing season period, particularly in the lower reaches of this stream.

The background information in **Section 2.0** indicates that Richmond Creek was listed as (threatened) for the cold water fishery in 1996; other issues were not considered due to a lack of data. **Section 10.0** identifies sources of erosion and possible remediation but claims no monitoring needs. Please include in **Section 10.0** any plan to evaluate nutrients and organics during a non-growing season period, particularly in the lower reaches of this stream.

The data summary for the West Fork Clearwater River presented in **Section 2.0** indicates that the cold water fishery is fully supported. I question this determination from my own experience and collaboration with Montana Fish Wildlife and Parks and the University of Montana in current studies. Montana Fish Wildlife and Parks has unpublished temperature data for the 2007 field season that shows summer temperatures were clearly marginal for bull trout. Ongoing graduate student research has documented very high bull trout spawner mortality for that area as well. I believe that in addition to the sediment TMDL proposed for the West Fork Clearwater River (**Section 9.0**), there may also be a need to examine water temperature and nutrients in this watershed. The classification of "Partial" in the Primary Contact Recreation category due to elevated Chl-*a* values implies the need to look at nutrients. Please include in **Section 10.0** a plan to evaluate nutrients and organics during a non-growing season period, particularly in the lower reaches of this stream. **Section 10.0** should include a monitoring or data collection component.

While the lower Clearwater River between Seeley and Salmon lakes has not been listed as a 303d stream in the past, this reach was very low during the summer of 2007. It is unlikely that this river segment was "fully supporting" because water temperatures. At least one bull trout redd was observed by MFWP biologists and me in this river segment during a period when water temperatures would have been lethal to embryos; this may warrant further investigation by MT DEQ. Sediment, discharge, and temperature issues may exist in this reach as well, particularly because of the reduced flows in this stream segment.

Response 1.2

The justifications for the removal of the 1996 impairment listings for Seeley and Salmon lakes can be obtained by examining the assessment record for these water bodies. This information is available to the public at the Clean Water Act Information Center located at the following link: http://deq.mt.gov/cwaic/. The information is summarized above in the response to Comment 1.1. Also see the response to Comment 1.1 above regarding the PCB fish consumption advisory.

Of the 28 public water supply violations listed in the comment, 26 violations were monitoring violations for "regular" or "major" parameters. Monitoring violations result from a failure to complete required monitoring for a specific constituent. They do not address intake water quality. The remaining two "MCL average" violations were due to exceeding a specific maximum contaminant level (MCL) for "5 haloacetic acid", referred to as "HAA5". This chemical is a disinfection byproduct that results from treatment with chlorine. The violation is not evidence of a standards violation for intake water. High source water levels of total organic carbon (TOC) can cause the MCL for HAA5 to be exceeded in treated water. Naturally occurring concentrations of TOC in surface waters often require settling or filtration in the treatment system prior to treatment with chlorine to reduce the concentrations of disinfection products such as haloacetic acid.

The Clean Water Act provides for periodic assessment of the nation's lakes and streams. The removal of the impairment listings for Seeley Lake is based upon a perceived long-term trend of static to improving lake water quality between the mid 1970s and the mid 1990s. The listing in 2006 is not based on the interpretation of lake assessment data collected by MDEQ in 2003 and 2004. A future interpretation of the most recent information and justifiable changes to levels of use support for Seeley Lake will be reflected in future assessment cycles. According to the assessment record for Salmon Lake, the delisting was based on a "good" set of nutrient data from the early 1980's, plus assessment data collected by MDEQ in 2003 and 2004.

The existing body of water quality data for the watershed is acknowledged as being sparse. The adaptive management strategy described in **Section 9.3.5.**1 specifically calls for collecting and compiling sufficient data to set up and calibrate a lake and stream response model for the entire watershed. This effort is intended to identify the location and relative importance of impairment causes, simulate water quality responses to existing and future conditions and plan for protective and remedial means to meet water quality standards. **Section 10.0** of the document has been edited to suggest monitoring for the Clearwater River Watershed.

Responses to Water Body-Specific Concerns in Comment 1.2

Lower Clearwater River - Assessment records have not been available for the lower Clearwater River for the listing cycles from 2000 through 2006. The current listing for the Clear water is "Not Assessed"; that is, sufficient credible data are not available to make a use support determination for the stream. This water body will be assessed by MDEQ's Monitoring and Assessment program during a future assessment cycle. The timing of the assessment is dependent upon workload, staffing level and funding.

The TMDL development process uses the current listing to identify the pollutant-water body combinations for which TMDLs are needed. Analysis of the water quality data to determine impairment status is a monitoring and assessment function that is outside the scope of TMDL development. If a water body is listed as "Not Assessed", it is assumed that sufficient, credible data are not available for an impairment listing and further data collection is needed. TMDLs will be developed in the future for the appropriate pollutants if impairment is concluded after collection and analysis of sufficient, credible data.

The figures in Appendix A depicting the Clearwater River as being impaired are incorrect and will be redrafted.

Blanchard Creek – **Section 5.0** wording has been revised to specify non-support (N) for contact recreation. **Section 10.0** has been revised to suggest the need for nutrient monitoring in lower Blanchard Creek.

Placid Creek – Placid Creek has not been listed as impaired on the 2006 303(d) list and so is not addressed in the document. Future assessments in the drainage would occur according to MDEQ's assessment schedule and available funding.

Buck Creek – The data for sediment target parameters collected from Buck Creek do not support development of a sediment TMDL on the stream. The impairment status of the stream and its degree of use support must await reevaluation of the data or collection of new data by MDEQ's monitoring and assessment program.

Owl Creek - Owl Creek has not been listed as impaired on the 2006 303(d) list and so is not addressed in the document. Future assessments in the drainage would occur according to MDEQ's assessment schedule and available funding.

Deer Creek – As a result of the 2006 listing for sediment, a sediment TMDL is developed for Deer Creek. The listing of partial support for contact recreation stems from the Chl-a concentrations measured in 2004. The current Chl-a target for primary contact recreation use support 100 mg/m^2) exceeds the values measured on Deer Creek (94.8 and 65.2 mg/m^2), implying that this use may not be impaired. The 2003 assessment by MDEQ concluded elevated fine sediment in channel substrate pebble counts and a sediment TMDL was developed. **Section 10.0** of the document has been edited to suggest monitoring of Deer Creek may be needed.

Richmond Creek - As a result of the current 2006 listing for sediment, a sediment TMDL is developed for Richmond Creek. The 1996 listing of Richmond Creek as "threatened" only indicates a possible negative trend in water quality. A "threatened" water body still provides support for beneficial use. **Section 10.0** of the document has been change to suggest monitoring of Richmond Creek may be needed.

West Fork Clearwater River - Data for the 2007 field season was not reviewed in the preparation of TMDLs for the West Fork or any other stream in the basin. This data will be incorporated in future assessment cycles. The review of additional data may result in additional impairment determinations for the West Fork of the Clearwater and other streams in the basin. **Section 10.0** of the document has been change to suggest that monitoring of the West Fork may be needed in the future.

Citations and references will be reviewed for consistency in the final document. Appendices C, D, E and J were available on line for databases relating to sediment. Though not listed for specific tributary streams, the entire nutrient data base is illustrated by points on load duration curves throughout **Section 9.3.** This approach was thought sufficient to show the general differences between target based loading and that based on the small amount of available nutrient data. Several report documents were referenced in developing TMDLS for sediment and temperature due to the large size of climate and hydrologic databases used for temperature modeling and calculating daily sediment loading. The cost of providing paper versions of these databases or providing a complete listings in the text prompted the use of these report references.

Comment 1.3

I am in favor of improving the general water quality standards for the Middle Blackfoot and Nevada Creek water shed. I will offer non scientific observations and comments about the Nevada Creek Reservoir as I am most familiar with this area and I believe it is underrepresented in the overall study.

I would like to draw attention to the potentially toxic Blue-green algae blooms (cyanobacteria) that occur seasonally from mid summer to late fall at the Nevada Creek Reservoir. The Montana Department of Environmental Quality warns that these algae blooms can occur in any lake, reservoir, stock pond or roadside ditch when conditions of warm water temperature, sunlight and nutrient loads are right. The Montana DEQ also warns that there is no easy way to determine if the water is toxic and that people should use common sense to avoid these areas when they have the unsightly algae blooms, as algae blooms can cause serious illness in humans and, more rarely, has killed pets, waterfowl, aquatic life, and other animals including livestock.

The draft (MB-NC WQRP) highlights some pollutants of concern at the Nevada Creek Reservoir as being sediment/siltation, dissolved oxygen, phosphorous, nitrogen and (seasonally) ammonia. The draft also points out that high water temperatures occur in upper portions of Nevada Creek and its tributaries just before reaching the reservoir. The unofficial campground, roadside pull-offs and general human recreation at Nevada Creek Reservoir also provide a quantifiable nutrient load not represented in the study in the form of solid and liquid human waste and bank erosion due to foot traffic and wave action from boats producing a wake.

It would seem that improving the water quality from harmful nutrients and warm temperatures both upstream and at the Nevada Creek Reservoir could potentially help reduce the annual algae bloom, thus reducing toxic health threats to humans, animals and invertebrates. I would recommend erecting signage at the unofficial boat ramp and the unofficial campground alerting people of the potential threats of Blue-green algae to themselves and their pets if there continues to be known human recreation at Nevada Creek Reservoir. It would also make sense to provide regulations on the recreational human impact in regard to camping and proper disposal of human waste and litter, and imposing a wake limit on boats to reduce the harmful effects of bank erosion and sedimentation/siltation of the reservoir due to wave action on such a small body of water.

Nevada Lake Reservoir is a unique and wonderful place for human recreation and wildlife to co-exist on into the future with minimal smart regulations. This area could benefit greatly from improved water quality; both for human safety and recreation, quality wildlife habitat and the general well being of the Middle Blackfoot-Nevada Creek watershed. I encourage your department to consider my comments and continue to collect more scientific data about this watershed to further enable wise decision making for the betterment of our collective area.

Response 1.3

Thank you for your concern and comment. The Department agrees that improving the water quality from harmful nutrients and warm temperatures both upstream and at the Nevada Creek Reservoir could reduce the algae concentrations and any associated health threat. Your suggestions for signage regarding waste and litter disposal will be forwarded to the Water Resources Division of the Montana Department of Natural Resources and Conservation, the operator of Nevada Lake.

Comment 1.4

The science behind this work is very inexact. I believe all assessments, impairments, allocations, targets, etc. should be interpreted very generally. As noted in the TMDL summary, much of the base line data for this report was based on only a few samplings. I know from personal experience in the valley that some of the streams listed on the 303D list are in no worse condition than other streams that are not listed on the 303D list. It would be a mistake to make judgments of one or two degrees here or a few parts per million there when the whole scientific approach is admittedly suspect. For example, the modeling work done with temperature was a very difficult to calibrate and apply. The DEQ personnel and consultants who did the work are the first to admit that in many cases the end conclusions are only a "best guess".

That said I feel that the general conclusions to come form this document are fair. It is fair to take a general look at this document to see what streams are compromised and what the major causes are. But it would be inaccurate to use this document to say to what degree any stream is compromised nor exactly how the problem should be allocated.

We can interpret this report in a general way to come to the conclusion that Nevada Creek is in need of improvement in several areas. Certainly metals, temperatures, nutrients and sediments are higher than they should be. We cannot say to what degree they are high nor point exactly to the cause. But we can interpret generally again and say, for example, that agriculture is a significant part of the pollution source and that better implementation of BMPs will help elevate the pollutions. For this reason the Restoration Action Plan portion of this document is a good start to improving the resources and habitat of this valley. If we can encourage producers to improve and maintain good shading and filter strips our stream will be in better shape. On the other hand treating this document as the "know all end all" to accurately identify and divide the blame would be very inaccurate and unproductive.

Response 1.4

MDEQ agrees with your assessment that the document should be interpreted generally. This approach is stated in the Executive Summary and other sections addressing the major pollutant categories.

Comment 1.5

What are the "liberal assumptions" used in determining the size of hillslope contributing area mentioned in the Executive Summary?

Response 1.5

> Literature values for the slope length over which sheet wash erosion occurs vary from 100 to 400 feet. The use of 350 feet in the hillslope erosion estimate is toward the higher end of this range. An alternative approach would have been to use a mean or median value.

Comment 1.6

There are several water bodies where DEQ's impairment decisions appear questionable, based on conflicting assessments and an apparent failure to follow standard procedures for beneficial use determinations. Richmond Creek, West Fork Clearwater River, and Deer Creek were initially identified by DEQ as fully supporting beneficial uses in the project QAPP (Dated November 2006), but were subsequently included on the 2006 Montana 303(d)/305(b) Integrated Report as requiring TMDLs. Because these streams were determined to be fully supporting their uses in the QAPP, no detailed phase II data were collected. Because of this, the TMDL assessments for these areas are relatively weak. Our review of the beneficial use determination assessment records for these waters, in the context of DEQ's standard operating procedures for making beneficial use determinations, suggests that these streams are in fact fully supporting their uses. We ask that DEQ review our detailed comments for each of these water bodies, re-examine the information, and if you concur that these streams are in fact fully supporting that the TMDL document be modified to reflect this.

Response 1.6

> The decision to re-list Deer and Richmond creeks was based upon the higher relative weight given the channel substrate conditions (as reflected in pebble count data) compared to the macroinvertebrate metric scores. The process for making such listing decisions is distinct from that for developing TMDLs. While public comments are welcome on any of MDEQ's watershed programs, its helpful to recognize that definitive impairment listing decisions are beyond the scope of TMDL development. Watershed stakeholders, advisory committee members, consultants and the MDEQ staff preparing the planning documents do not finalize impairment listings but can make recommendations for specific assessment reviews. Buck Creek remains on the 303(d) list as impaired for sediment despite having met all Type I targets, two of three Type II targets and all supplemental indicators. A sediment TMDL was not developed for Buck Creek because the target departures did not indicate the need for reductions in controllable loading. Although the West Fork Clearwater is listed as fully supporting on the 2006 303(d) List, the nature of the target departures were similar to those for Deer Creek and Richmond Creek. Therefore a sediment TMDL was prepared for the West

Fork. The listing status for Buck Creek and the other Clearwater streams will be reviewed and revised during future assessment cycles.

Comment 1.7

The draft TMDL is ambiguous as to the status of Buck Creek. **Section 5.3**.16 states *"…Buck Creek is not considered as impaired for sediment and no sediment TMDL is proposed in this document*." However, a TMDL is in fact proposed for Buck Creek in **Section 9.0**. We request that DEQ sort out the situation for Buck Creek, and update the document accordingly.

Response 1.7

As discussed in Response 1.6 above, the target departures for Buck Creek indicate that sediment does not appear to be limiting use support. However, the impairment listing will remain until modified in a future assessment cycle. The inclusions of Buck Creek in **Table 9-6** and **Figure 9-3** are mistaken and have been corrected in the document.

2. Sediment and Habitat Impairments (Section 5.0)

Comment 2.1

It is not clear in **Section 5.5.1**, page 149, whether any field calibration or verification of input data occurred for the SWAT model computations addressing hillslope erosion. Was site specific field data or field observations used to calibrate model inputs? Were model inputs and outputs validated in anyway?

Response 2.1

Model parameters used in SWAT were calibrated for a period of record from 2002 to 2004 at four stream gaging locations. The calibration and validation procedures are described in **Appendix I**. **Tables I-3 and I-6** list the calibration and validation parameters and locations. Both the hydrologic and water quality data used for model calibration were field measurements (stream discharge) or analytical results for water samples collected at specific locations in the watershed.

Comment 2.2

The road erosion assessment does not adequately consider recent research on erosion rates in soil types common in the planning area. As such, predicted sediment delivery from roads is likely a factor of 3-10 times too high. We request that the TMDL acknowledge the new information, and that the results are likely conservatively high. This could be another aspect of the implicit Margin of Safety in the TMDL as well.

Response 2.2

The text describing the margin of safety for sediment TMDLs has been edited to cite the research by Sugden and Woods (2007). The difference in base erosion rates suggested by this research and the 10 tons per acre use in the sediment loading analysis is included as an additional margin of safety.

Comment 2.3

The SWAT modeling was unable to accurately represent hillslope erosion and deposition processes, and model output required further manipulation to reflect some semblance of reality. However, we believe the predicted rates of sediment delivery from hillslope erosion are still unrealistically high in that they do not comport with results of forest BMP audits and empirical data on watershed erosion rates in the Blackfoot. This is particularly so for the Deer Creek watershed, where hillslope erosion rates are estimated to be 60 tons/mi2/yr, which is nearly 30 times higher than predictions for adjacent forested watersheds with similar characteristics. We ask that DEQ acknowledge in **Section 5.5** that model outputs are highly suspect. We also ask DEQ to investigate (and as appropriate explain) why Deer Creek predictions are so different from nearby watersheds.

Response 2.3

It is acknowledged throughout the document that considerable uncertainty exists in the pollutant load estimates. A general statement describing the degree of uncertainty in loading estimates is contained in paragraph three of the Executive Summary. Appendix J explains that the hillslope estimates are not a realistic attempt at sediment budgeting. The high sediment estimates for Clearwater River basin streams are explicitly mentioned in the sediment TMDL margin of safety discussion. SWAT hillslope erosion estimates for Deer Creek and other Clearwater drainages are affected by the inclusion of a "forest roads" HRU in the model and the high delivery rates for this HRU.

The process of adaptive management that applies to all pollutant types provides a means of incorporating new information into future adjustments to TMDLs. Revisions to the SWAT watershed model or selection and calibration of an entirely different model for estimating pollutant loads and defining allocations are possibilities as new modeling tools become available and our understanding of loading processes improves.

Comment 2.4

The second paragraph of **Section 5.0** states that *"…Salmon Lake has been listed as impaired due to siltation since 1996*". We believe this statement is incorrect. In **Section 2.0**, Salmon Lake is listed as fully supporting beneficial uses on the 2006 Integrated Report.

Response 2.4

The sentence has been edited to state that both Nevada Lake and Salmon Lake have been listed as impaired due to siltation.

Comment 2.5

The TMDL document needs to better document the fact that the SWAT model yielded unsatisfactory results (this noted in Appendices I and J but not in **Section 5.0**), and predictions are likely to be grossly inaccurate.

Response 2.5

The limitations of the SWAT model have been given sufficient mention in the document. The model output and its modifications are not represented in the document as predictions. They are estimates made in an atmosphere of sparse analytical data, are acknowledged as such and are open to adjustment if necessary. Little would be gained by further delaying the final document with additional revisions to the estimates.

Comment 2.6

Road sediment delivery in the Deer Creek watershed was not summarized by RDG (2006). Plum Creek Timber Company (PCTC) conducted a complete inventory of all road sediment delivery locations in the Deer Creek watershed in 2002 (total of 46 locations), and assuming the DEQ's conservatively high base erosion rate of 10 tons/ac/yr, the predicted watershed wide sediment loading would be 30.5 tons/yr. As such, it is unclear how the 176 ton/yr estimated load for Deer Creek in **Table 5-55** was derived. This would imply average loading of 2.6 tons/crossing/yr, which is unrealistic and not consistent with the extrapolation averages in RDG (2006) Table IR-22. If sediment load allocation is made for Deer Creek, we ask that DEQ re-evaluate and correct the calculation for Deer Creek.

Response 2.6

The original calculation for Deer Creek mistakenly applied a mean per crossing loading value for geologic materials other than quaternary alluvial and glacial deposits that was higher than that specified by RDG in Table IR-22. The road sediment loads were recalculated for Deer Creek using the proper per crossing mean. The results are in the following table for 68 crossings in the Deer Creek watershed.

Ownership	Geology	Annual Precipitation (inches)	Per Crossing Load (tons/yr)	Number of Crossings	Loading (tons/yr)
U.S.F.S.	Erosive	≤ 26	2.0	3	6
U.S.F.S.	Erosive	>26	0.7	1	0.7
PCTC	Erosive	≤ 26	0.6	5	3.0
PCTC	Erosive	> 26	0.4	48	19.2
PCTC	Non-erosive	> 26	0.8	10	8
Other Private	Erosive	≤ 26	1.6	1	1.6
			Total	68	38.5

The resulting load total of 38.5 tons per year from road crossings in Deer Creek is a significantly lower estimate than the 176 tons given for Deer Creek in the document and the appropriate tables have been adjusted to reflect this recalculation.

Comment 2.7

It does not seem like streams which DEQ has determined to be fully supporting their uses should be included in **Sections 5.0 and 9.0**.

Response 2.7

The inclusion of unlisted streams and unlisted portions of the planning area into the loading discussions in **Sections 5.0 and 9.0** are intended to show that while beneficial uses are supported, there may be opportunities to further reduce loads in these areas that would improve use support in listed segments that are downstream. This is consistent with a watershed approach to TMDL development. The goal is to reduce loading throughout the impaired stream's watershed.

Comment 2.8

Sediment contribution from culvert failure is a legitimate source of sediment. However, the potential sediment risk from culvert failure analysis portrays sediment AT RISK rather than a known annual contribution. Culvert failures are episodic events and should not be accounted for in the same way as actual annual sediment contributions from sediment sources such as road surface erosion and highway sanding. Many culverts out there are undersized and have been in place for years and years and yet have never failed. The culvert failure analysis is better used to help prioritize culverts for removal and/or upgrade. A similar analysis was used in the Upper Lolo TMDL as a prioritization mechanism, but was, appropriately, not used to determine an annual load from culvert failures.

Response 2.8

EPA sediment TMDL development guidance for source assessment states that the basic source assessment procedure includes compiling an inventory of all sources of sediment to the waterbody and using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (EPA 1999, page 5-1). 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(I)). The analysis in this document uses a gross estimate approach to equate the load at risk to a yearly load making estimates of failure rate and failure amount when a given storm event exceeds a basic culvert design criteria. We acknowledge that the average yearly culvert failure loading values are gross estimates and can also be viewed as a load at risk. Using a load at risk approach would make it difficult to compare the relative contribution of culvert failures to other sediment sources and would make development of daily allowable loads a difficult task.

The vast majority of sediment loading, whether from roads or hillslope erosion, is derived and delivered to streams during episodic events. Models used for hillslope and road erosion loading use time step periods with loading, averaged over the time step period, weighted more heavily for some years than others. In fact, it is likely that many roads included within the source assessment would not contribute sediment loading to the stream during a typical year, but only deliver a sediment load during episodic events. This time step approach is consistent with EPA guidance (EPA 1999). Furthermore, the modeling and inclusion of average yearly loads from episodic events such as mass wasting is routinely incorporated into sediment TMDLs developed by or approved by EPA, including the Grave Creek TMDL in Montana (MDEQ 2005), the Lower Clark Fork River Subasin TMDLs in Idaho (IDEQ 2007), and the Garcia River sediment TMDL developed by EPA in California (USEPA 1998).

The MDEQ is constantly improving TMDL development methods, including source assessments, and will look at improving their methods for addressing source loading from culverts to ensure that the basic goals of TMDL source assessments, defined at the very beginning of this response to comments, are satisfied. Wording has been added to the discussion in **Section 9.1.4** to clarify the "at risk" nature of this potential loading source.

Comment 2.9

A key assumption in the culvert failure analysis is that on average, 1% of culverts fail annually. No basis for the 1% value is provided. We ask that the TMDL either provide justification for the 1% or note the value as an educated estimate in the document.

Response 2.9

Lacking detailed analysis of failure rates, the one percent value is an estimated point of departure for the purpose of calculating loads. The document text has been edited to clarify this assumption.

Comment 2.10

It is inappropriate to define culvert replacement with a structure sized to accommodate the Q100 as a "natural" rate of loading. Montana forestry BMPs require that culverts be sized to accommodate at least the 25-year flood. We do not believe that a federal standard (INFISH) is appropriate for other landowners. It has simply not been demonstrated that designing culverts to accommodate 25-year flood events will fail to protect beneficial uses. The Q100 is not considered a established reasonable practice by Montana's private landowners.

Response 2.10

Immediate replacement of all culverts not capable of passing the Q100 discharge is not anticipated. Upgrades will occur over time. A more reasonable approach may be to upgrade all culverts incapable of passing the most frequent flows or to replace those undersized culverts with the greatest amount of road fill at risk. The BMP recommends a minimum culvert capacity of 25-year. In addition, the BMP recommends designing crossings that have a minimum impact on water quality. Much of the forested portion of the planning area has high road densities. Water quality may be better protected in these areas by providing for more than the minimum design recommendation. The Q100 replacement is a road crossing BMP being implemented on some forest roads in Montana and it provides for a significant margin of safety for a source with a characteristically high degree of uncertainty. Although we do not cite a quantitative demonstration that the minimum culvert size criterion fails to protect beneficial uses, we are suggesting that more than the minimum BMP recommendation may be appropriate where sediment impairment is common and forest road crossing are numerous. In the context of adaptive management that applies to all of the TMDLs proposed in the document, the reduction estimated for this practice is open to future adjustment when data on loading from actual culvert failures is available for the Blackfoot River watershed.

Comment 2.11

The pools per mile target is not a good Type I target because it is influenced by more than simply sediment supply. Pools are highly variable among channel types, and in many cases the presence of Large Woody Debris (LWD). With certain channel types, pools may be sparse because of low LWD levels, which may be the result of a variety of reasons, both natural (floods, ice jams, shrub riparian types) and man-made (e.g., timber harvest, historic channel clearing for fish enhancement, etc.).

Response 2.11

The pools per mile target is a useful general indicator of sediment transport function. The targets have been stratified by both channel type and stream size (channel top width) to remove some of the variability due to these factors. The parameter will remain in the document as a Type I target. Future target adjustments are an option through adaptive management.

Comment 2.12

There is no adaptive management or monitoring section contained in the TMDL. This is traditionally a section in the TMDL. If one is included, the watershed stakeholders should have an opportunity to comment on it before being submitted to EPA.

Response 2.12

Adaptive management is addressed specifically in the margin of safety discussion for each pollutant category. Adaptive management is an important contribution to margin of safety. Describing it for specific to pollutant categories avoids a broader description less useful for those developing pollutant specific strategies for load reductions. Elements of Adaptive Management have also been integrated into the existing Evaluating Success Section (**10.4**)

3. Pollutant Loads and Allocations (Section 9.0)

Comment 3.1

The reductions in loads under the TMDL may not be possible everywhere. This is the case where significant road improvements have already been made over the past decade. We request that the TMDL acknowledge that the reductions may not be attainable everywhere, especially where road improvements have already been made.

Response 3.1

It is reasonable to expect that current BMP implementation is adequate in some locations and wording to this effect has been inserted into the sediment margin of safety discussion.

Comment 3.2

In **Section 9.1.7**, the explanation for allocating total modeled sediment loads simply says that it was done by land use. Please provide more details. What land use classification was used? If 86% of a watershed was in forestry/silviculture land use was 86% of the total modeled load for that watershed contributed to silviculture? (See comment below for **Section 10.0**).

Response 3.2

Section 9.1.7 further explains that for hillslope erosion, loading from land uses were assumed for specific cover types described by the 2001 USGS Landcover Dataset. The extent of these types in the watershed guided the hillslope allocations to land use. Field descriptions of vegetation conditions and the associated land uses were recorded during the stream bank erosion assessment and this information, in addition to ground and aerial photo interpretation, guided allocations of stream bank erosion to existing land use. The allocations are not based on a universally applied formula but reflected the extent and degree of land use effects on a stream by stream basis. Road erosion allocations were based upon expected improvements with BMP implementation.

Comment 3.3
PCTC

The naturally-occurring load for culvert failure is that load expected for culverts that are sized to pass the 100-year flood. It is unclear in Appendix J how this replacement scenario leads to a 70-80% reduction in annual loading. Please describe how this reduction is derived.

Response 3.3

Appendix J explains the basis for calculating culvert failure loading used in other studies of forested watersheds. An example is the analysis used for Prospect Creek in northwestern Montana. The analysis period for this example is 100 years, using a time step approach for source assessment consistent with EPA sediment TMDL guidance (EPA 1999). The road fill volume at risk with an event of a certain magnitude includes the volume at risk for all smaller events. In 100 years, a Q2 or greater flow event is likely to occur every two years or 50% of the time; a Q5 or greater event is likely to occur every 5 years or 20% of those 100 years; and a Q10 or greater event every 10 years or 10% of the time, and so on. The mass of fill (calculated from survey data) entering the channel for each event is multiplied by the probability of that event. The volume of fill at risk of failure over 100 years is calculated by adding the product values calculated for each recurrence interval. Culvert failure from storm events below the upgrade condition is assumed to occur once before the culvert is replaced. Failure at culverts less than the upgrade scenario is then assumed to occur once, plus one additional time where failure is likely to occur over 100 years. The load at risk associated with all culverts less than a Q100 is added to the total load at risk associated with Q100 failure. The difference in loading over a 100-year period between the same-size replacement scenario and the Q100 replacement scenario was a 77 percent reduction in this

Comment 3.4

The load reduction based on replacement of failed culverts with those capable of passing the Q100 event is in conflict with MCA 75-5-703 Paragraph 2, regarding consultation with local conservation districts and watershed advisory groups toward developing reasonable land, soil, and water conservation practices that specifically recognize established practices and programs for nonpoint sources.

Response 3.4

As noted in the response to Comment 3.3, the culvert design BMP includes minimizing impact to water quality. The approach does not represent a completely new practice given the fact that the forest industry upgrades many culverts above and beyond the 25 year event in bull trout watersheds. While consultation on load reductions for this source did not include input from all technical advisory committee members at the initial drafting, all advisory group members, as well as the public, have had the opportunity for input during the public comment period.

4. Water Quality Restoration Implementation and Monitoring Plan (Section 10)

Comment 4.1

The current package of Forestry BMPs in Montana, referenced on page 335, are not the product of voluntary practices (forestry management practices) developed by the 2006 BMP working group as stated in the document. In the text it states that: "The continued implementation of forestry management practices such as Streamside Management Zone (SMZ) practices, as well as the voluntary practices developed by the 2006 BMP working group should be applied in any existing or proposed silvicultural activities". Montana's Forestry BMPs were originally developed by the Cumulative Watershed Effects Cooperative (CWEC) under the direction of the Montana Department of State Lands (Forestry BMP programs are now administer under DNRC). The Environmental Quality Council (EQC) established a Best management Practices Technical Committee which reviewed the CWEC BMP package and adopted the package with minor editorial changes in 1989. The EQC sanctioned BMP package was adopted by DHES Water Quality Bureau in the Nonpoint Source Management Plan in 1991. Over the subsequent years the BMPs have been periodically reviewed and slightly revised by the DNRC directed BMP Workgroup. The most recent minor revisions occurred in 2006. The changes made to the BMPs are not considered to be substantive.

Response 4.1

The reference to the source of the forestry BMPs has been removed from the paragraph.

Comment 4.2

How has timber harvesting, described on page 336 and 337, been directly linked to habitat degradation in Blanchard Creek? This has not been clearly demonstrated in the text. How have disturbances associated with timber harvesting mentioned on page 336 been determined to be the primary cause of stream bank erosion in the upper reaches of Blanchard Creek? The text of document states that "The primary land use in upper Blanchard Creek has been timber harvesting, and disturbances associated with this harvesting activity are believed to be the primary cause of stream bank erosion on upper reaches of Blanchard Creek". The document does not disclose the basis of this "belief". Are these assumptions or beliefs supported by field data or have clear cause and effect mechanisms been observed or evaluated?

How was the contribution of hillslope erosion as a sediment source determined in Blanchard Creek? The text states that: "Another source of fine sediment is hill slope erosion which accounts for approximately 45% of the total controllable sediment load. Vegetation removal and soil disturbances in upland areas from livestock grazing practices are suspected as the primary cause of hill slope erosion in Blanchard Creek (**Section 9.0**)." Is the 45% hill slope erosion estimated from the SWAT model?

Response 4.2

Timber harvesting has not been directly linked to habitat degradation in the referenced pages. The text states that "The primary land use in upper Blanchard Creek has been timber harvesting, and disturbances associated with this harvesting activity are believed to be the primary cause of stream bank erosion on upper reaches of Blanchard Creek." No direct linkage is made in the statement. Since timber harvesting is the primary land use in upper Blanchard Creek, some of the stream bank erosion in the upper watershed could reasonably be attributed to timber harvest. A clear demonstration of causes and effect is more appropriate for more intensive, small scale erosion assessments that are not feasible in the context of TMDL development for a planning area as large as the middle Blackfoot planning area.

The SWAT model, as modified for use in the Middle Blackfoot-Nevada Creek planning area, was used to estimate hillslope erosion for the project. Forty tons of controllable hillslope erosion was estimated for Blanchard Creek. This is 23 percent of the total controllable load. The reference to 45 percent has been removed from the text.

Comment 4.3

The assessment discussed on page 338 assumes that historic logging has resulted in sediment delivery from steep hillslopes above Blanchard Creek. Recommendations include conservation measures to reduce sediment sources from hillslopes through the application of upland BMPs to reduce sediment production from historic timber harvest activities. Any future logging-related land management should include Forestry BMPs. What is the basis of the determination that upland hillslopes are a contributing sediment source?

Response 4.3

Hillslope erosion is an acknowledged source of sediment to streams. The basis for this position is the large body of erosion control literature that describes hillslope erosion processes and their effects on water quality. Chapter 15 of Dunne and Leopold (1978) provides a good overview of this topic. As discussed in the response to Comment 1.4 above, the conclusions of the sediment source assessment should be considered as first approximations that can be described in more detail after further, basin-specific investigation.

Comment 4.4

The discussion on page 339 needs to integrate the effects of the 2007 Jacko Lakes Wildfire into the assessment and recommendation for Buck Creek. Is the 4.5 tons/year attributed to roads still relevant in the post-fire environment? Surface erosion tends to spike the first year following fire depending on weather and then decline. How will allocations be modified in the future to incorporate sedimentation from large wildfires?

Response 4.4

Because of the uncertainty in the sediment source assessment, the reference to 4.5 tons per year from road erosion in Buck Creek is more useful when compared to other sediment sources in the basin. Control of road erosion in Buck Creek will remain relevant. Planned adjustments for future applications of sediment loading models to reflect fire include:

- Dates specified for fire occurrence;
- Alternate USLE curve numbers will be applied to fire affected HRUs;
- Alternate cover factor values will be applied to burned acreage;
- Surface soil content of nitrogen and phosphorus will be altered to reflect changes with fire;
- Return to pre-fire conditions will be simulated by condition decay coefficients inserted into program operations files.

The loads and allocations established in the document are meant to apply under median conditions of natural background and natural disturbance. Under some natural conditions, such as large wildfires or extreme flow events, it may not be possible to satisfy all targets, loads and allocations. 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 excess loading during recovery from significant natural events. These goals to not require recalculation of loads and allocations with each fire.

Comment 4.5

The discussion on page 347 needs to be updated to include the effects of the 2007 Jacko Lakes Wildfires that provide short term pulses of sediment that can exceed current baseline levels of sediment allocations. The cause and effect mechanism described may be insignificant or irrelevant under the post fire existing conditions. In the statement "The removal of vegetation in upland and riparian areas as well as the landscaped disturbances caused by timber harvesting has reduced sediment trapping and storage capabilities and increased sediment delivery to the stream.", what landscaped disturbances are being described?

Response 4.5

See response to Comment 4.4 above regarding integrating fire effects. In the context of timber harvesting, associated landscape disturbances could include vegetation clearing, skid trail formation and road construction.

Comment 4.6

The Jocko Lakes Fires burned much of the Buck Creek and Deer Creek drainages. The effects of this fire may include increased sedimentations, nutrients and temperature and runoff. I could not find in the document reference to fires and effects of fires on water quality (other than North Fork of the Blackfoot). It would be a good idea to include some fire-related discussion especially with respect to natural variation.

Response 4.6

See response to Comments 4.4 and 4.5 above.

Comment 4.7

The most notable recent landscape level wildfire in the North Fork of the Blackfoot Drainage, referred to on page 359, was the Canyon Creek fire in 1988, not 1998 as stated in the text.

Response 4.7

The data has been changed in the text to 1988.

Comment 4.8

The implementation plan (**Section 10.0**) seems overly detailed and repeats much of the information presented earlier in the document. We have two specific suggestions relative to the implementation plan. **Section 10.0** should be much more general in nature and should discuss Montana's nonpoint source management plan, Plum Creek's NFHCP, the Lolo Forest Plan, and other Blackfoot Challenge restoration efforts being undertaken across the planning area. On a watershed-specific level, a table/matrix could be constructed which would identify the applicable practices to meet the TMDL in each watershed. For example, in Blanchard Creek, various actions that could be "checked" in the table include: Implementation of the Plum Creek NFHCP, grazing management practices, forestry BMPs, SMZ law, irrigation BMPs, channel restoration, and comment on anything specific. This suite of "checked" boxes would vary from watershed to watershed depending on the issues. I see the detailed implementation plan (current **Section 10.0**) being appropriate as an appendix to the TMDL, and would essentially be a standalone document. This detailed restoration plan could then be periodically updated as new information becomes available, as well as documenting restoration actions that are taken over time.

Response 4.8

While the desire to shorten **Section 10.0** is understood, the individual treatment given to each stream was the approach preferred by the Blackfoot Challenge to set the stage for future restoration proposals and applications for funding. The suggestion of a matrix approach to the section is a useful one and will be considered in future revisions to the document.

Comment 4.9

The implementation plan (**Section 10.0**) seems much more detailed than needed. A matrix configuration is more suitable.

Response 4.9

See response to Comment 4.8 above.

Comment 4.10

In **Section 10.2.1.5**, first paragraph under "Suspected Sources and Causes" for Cottonwood Creek, the following statement is made: "…results of the sediment source assessment indicate that upland areas are the largest contributors of sediment to the stream. Sediment from hillslope erosion accounts for 86% of the controllable sediment load. Timber harvesting in the uppermost reaches is believed to be the cause of most hillslope generated sediment. Sediment produced from livestock grazing practices and hay production in the valley reaches accounts for 35% of the hillslope sediment load."

While modeling in the source assessment indicates this, I would hesitate to actually attribute 86%, 35% or whatever % of sediment supply to any source in particular for any one tributary.

Response 4.10

The TMDL process required that actual daily loads be calculated for each impaired segment and the percentages referred to in various **Section 10.0** discussions were likely part of those stream specific calculations. The uncertainty in the calculations is acknowledged in the discussion of the margin of safety for sediment TMDLs and the process of adaptive management is described as part of that margin. The acknowledgement of the uncertainty in all loading estimates throughout the document should prompt the reader toward a proper interpretation of any percentages mentioned in the section. The commenter's suggestion that caution should be used in referring to specific loading values and percentages figures in any single water body is valid considering the acknowledged amount of uncertainty in the loading estimates.

Comment 4.11

Add the following to the Lolo National Forest Section: "The Lolo National Forest is also committed to improving water quality in a variety of ways. Road BMPs are implemented for most all projects and through other general road improvements. Undersized stream crossings are being upgraded to better accommodate aquatic organisms, sediment, and debris and to reduce sedimentation. With each new project, existing roads are evaluated and unneeded roads may be scheduled for decommissioning. In the Middle Blackfoot the Lolo National Forest was a major partner for the Dunham Creek restoration project and is also helping to develop several other stream restoration projects with partners in the valley. Recently a new grazing management plan was completed for the Monture Creek grazing allotment. Forestry BMPs used by the Lolo National Forest on timber harvest and road projects are typically more stringent than the State of Montana's recommended forestry BMPs and required SMZ laws."

Response 4.11

The requested excerpt has been added to the discussion in **Section 10.3.2**.

REFERENCES

Idaho Department of Environmental Quality. 2007. Lower Clark Fork River Subbasin Assessment and Total Maximum Daily Loads. Coeur d'Alene Regional Office 2110 Ironwood Parkway Coeur d'Alene, Idaho 83814.

Montana Department of Environmental Quality. 2005. Grave Creek Watershed Water Quality and Habitat Restoration Plan and Sediment Total Maximum Daily Loads.

United States Environmental Protection Agency. 1998. Garcia River Sediment Total Maximum Daily Load. USEPA Region IX, March 16, 1998.

United States Environmental Protection Agency. 1999. Protocol for Developing Sediment TMDLs, First Edition. EPA 841-B-99-004.