Boise-Mores Creek Watershed Subbasin Assessment and Total Maximum Daily Loads

Final

Department of Environmental Quality

June 2009

Revised December 2009

Boise-Mores Creek Subbasin Assessment and TMDL

June 2009

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This document was completed and reviewed with the help of the Boise-Mores Creek Watershed Advisory Group.

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Abbreviations, Acronyms, and Symbols

§303(d) Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section

µ micro, one-one thousandth

§ Section (usually a section of federal or state rules or statutes)

ADB assessment database

AU assessment unit

AWS agricultural water supply

BAG Basin Advisory Group

BLM United States Bureau of Land Management

BMP best management practice

BOD biochemical oxygen demand

BOR United States Bureau of Reclamation

Btu British thermal unit

BURP Beneficial Use Reconnaissance Program

C Celsius

CFR Code of Federal Regulations (refers to citations in the federal administrative rules)

cfs cubic feet per second

cm centimeters

CWA Clean Water Act

CWAL cold water aquatic life

CWE cumulative watershed effects

DEQ Department of Environmental Quality

DO dissolved oxygen

DOI U.S. Department of the Interior

DWS domestic water supply

EMAP Environmental Monitoring and Assessment Program

EPA United States Environmental Protection Agency

ESA Endangered Species Act

F Fahrenheit

FPA Idaho Forest Practices Act

FWS U.S. Fish and Wildlife Service
GIS Geographical Information Systems

HUC Hydrologic Unit Code

I.C. Idaho Code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDL Idaho Department of Lands

IDWR Idaho Department of Water Resources

INFISH the federal Inland Native Fish Strategy

IRIS Integrated Risk Information System

km kilometer

km^2 square kilometer

LA load allocation

LC load capacity

m meter

m^3 cubic meter

max maximum

mi mile

mi^2 square miles

MBI Macroinvertebrate Biotic Index

mcl maximum contaminant level

MGD million gallons per day

mg/L milligrams per liter

mm millimeter

MOS margin of safety

MRCL multiresolution land cover

MWMT maximum weekly maximum temperature

n.a. not applicable

NA not assessed

NB natural background

nd no data (data not available)

NFS not fully supporting

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NTU nephelometric turbidity unit

ORV off-road vehicle

ORW Outstanding Resource Water

PACFISH the federal Pacific Anadromous Fish Strategy

PCR primary contact recreation

PFC proper functioning condition

ppm part(s) per million

QA quality assurance

QC quality control

RBP rapid bioassessment protocol

RDI DEQ's River Diatom Index

RFI DEQ's River Fish Index

RHCA riparian habitat conservation area

RMI DEQ's River Macroinvertebrate Index

RPI DEQ's River Physiochemical Index

SBA subbasin assessment

SCR secondary contact recreation

SEI Storm Erosion Index

SFI DEQ's Stream Fish Index

SHI DEQ's Stream Habitat Index

SMI DEQ's Stream Macroinvertebrate Index

SRP soluble reactive phosphorus

SS salmonid spawning

SSOC stream segment of concern

STATSGO State Soil Geographic Database

TDG total dissolved gas

TDS total dissolved solids

T&E threatened and/or endangered species

TIN total inorganic nitrogen

TKN total Kjeldahl nitrogen

TMDL total maximum daily load

TP total phosphorus

TS total solids

TSS total suspended solids

t/y tons per year

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USDI United States Department of the Interior

USFS United States Forest Service

USGS United States Geological Survey

WAG Watershed Advisory Group

WBAG *Water Body Assessment Guidance*

WBID water body identification number

WEPP Water Erosion Prediction Project

WET whole effluence toxicity

WLA wasteload allocation

WQLS water quality limited segment

WQMP water quality management plan

WQRP water quality restoration plan

WQS water quality standards

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Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

This document addresses the water bodies in the Boise-Mores Creek Subbasin that have been placed on Idaho's 2008 §303(d) list.

This subbasin assessment (SBA) and TMDL analysis have been developed to comply with Idaho's TMDL schedule. The assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the Boise-Mores Creek Subbasin, located in southwest Idaho.

The first part of this document, the SBA, is an important first step in leading to the TMDL. The starting point for this assessment was Idaho's current §303(d) list of water quality-limited water bodies. Eight stream segments in the Boise-Mores Creek Subbasin were placed on this list. The SBA examines the current status of §303(d) listed waters and defines the extent of impairment and causes of water quality limitation throughout the subbasin. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

Subbasin at a Glance

The subbasin is located in southwestern Idaho. This watershed includes Mores Creek, Grimes Creek, and all tributaries upstream to the headwaters as well as Lucky Peak and Arrowrock Reservoirs and the Middle Fork Boise River to the confluence of the North Fork Boise River (Figure A). The subbasin area is approximately 400,000 acres and it is situated about 7 miles east of Boise, Idaho. With the exception of 83,925 acres of private land and 53,039 acres of state land, the subbasin is federally owned and administered. The subbasin is located predominantly in Boise County with small parts in Ada County and Elmore County, Idaho. Idaho City and Placerville are the only recognized cities in the watershed; however, there are numerous sub-divided areas with second/summer/recreational homes located throughout the watershed. Extensive access is provided by many miles of roads maintained by the U.S. Forest Service and by roads owned or maintained by counties.

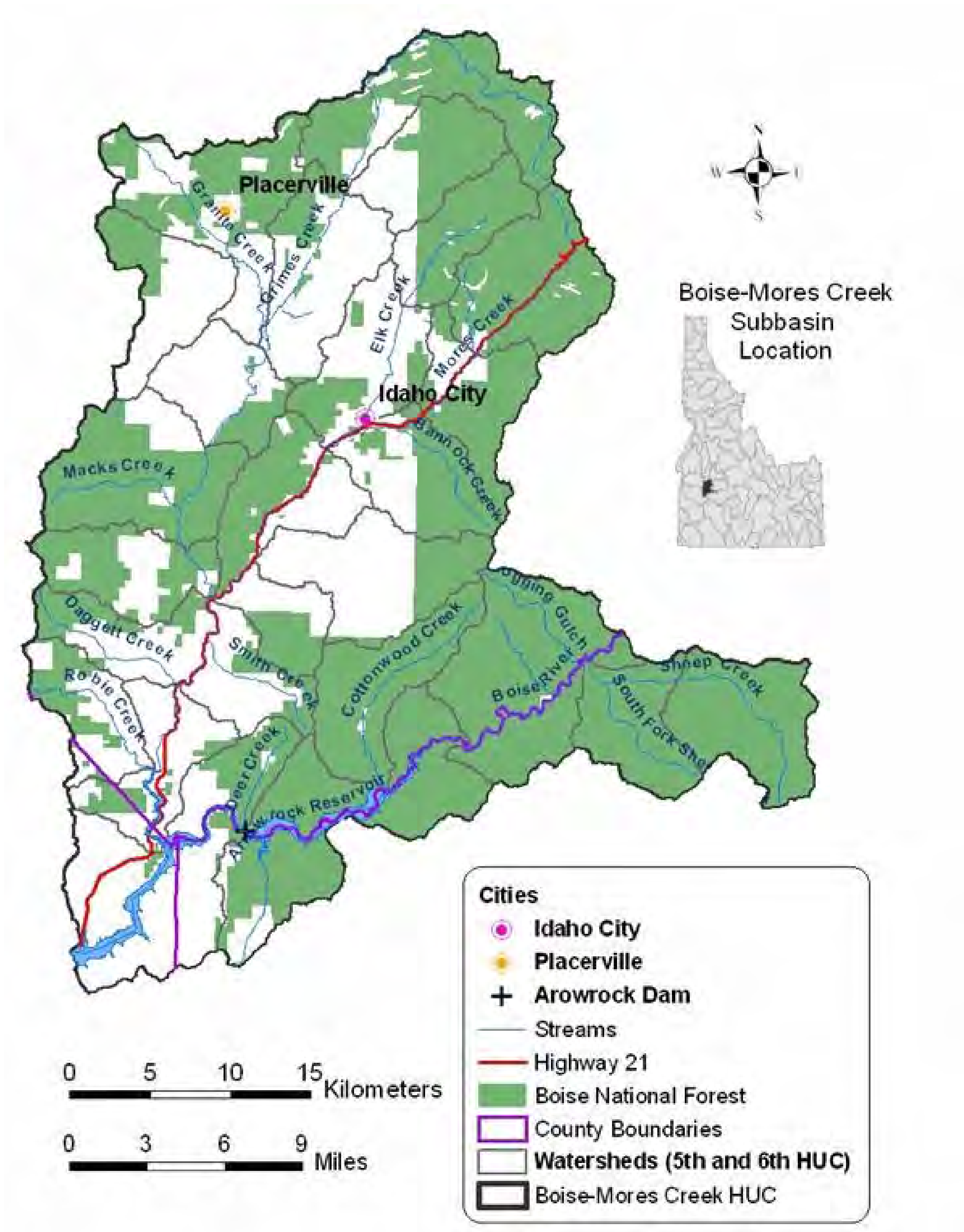

Figure A. Boise-Mores Creek subbasin

This watershed lies within Hydrologic Unit Code (HUC) 17050112. This subbasin contains 17 separate assessment units, some of which are described in Section 2 of this document. Because all the units are within HUC 17050112, only the last three digits plus two-digit extension will be used to identify them in this document (except in some cases in tables). For example, assessment unit (AU) 17050112SW009_02 will be abbreviated as AU 009_02. More information about water bodies and assessment units is in the section About Assessment Units on page 39.

Table A and Figure B show a summary of the 7 stream segments in the Boise-Mores Creek subbasin that are on the 2008 §303(d) list. Table B summarizes the beneficial uses of each listed segment. Water body assessment units 009_02, 009_03, 009_04, 009_06 and 013_04 were added by EPA to the 1998 revision of the §303(d) list, for temperature impairment. Mores Creek AU 009_02 and Grimes Creek AUs 013_02 and 013_05 were assessed by DEQ in 2002, determined impaired, and subsequently listed for an unknown pollutant. .

Table A. Description and pollutants of concern for 2008 §303(d)-listed water bodies in the Boise-Mores Creek subbasin.

Water Body Name	Assessment Unit ID Number	2008 §303(d) Boundaries	Pollutant
Mores Creek	ID17050112SW009_02	1st and 2nd order tributaries to Mores Creek	Unknown
Mores Creek	ID17050112SW009_03	3rd order Mores Creek	Temperature
Mores Creek	ID17050112SW009_04	4th order Mores Creek	Unknown
Mores Creek	ID17050112SW009_06	6th order Mores Creek	Temperature
Grimes Creek	ID17050112SW013_02	1st and 2nd order Grimes Creek	Unknown
Grimes Creek	ID17050112SW013_04	4th order Grimes Creek	Temperature
Grimes Creek	ID17050112SW013_05	5th order Grimes Creek	Unknown

Table B. Beneficial uses of §303(d)-listed streams in the Boise-Mores Creek subbasin.

Water Body	Assessment Unit ID#	Beneficial Use[a]	Type of Use
Mores Creek	ID17050112SW009_02 ID17050112SW009_03 ID17050112SW009_04 ID17050112SW009_06	CW, SS, PCR, DWS	Designated
Grimes Creek	ID17050112SW013_02 ID17050112SW013_04 ID17050112SW013_05	CW, PCR	Presumed
	ID17050112SW013_02	SS	Existing

[a] CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, DWS – domestic water supply

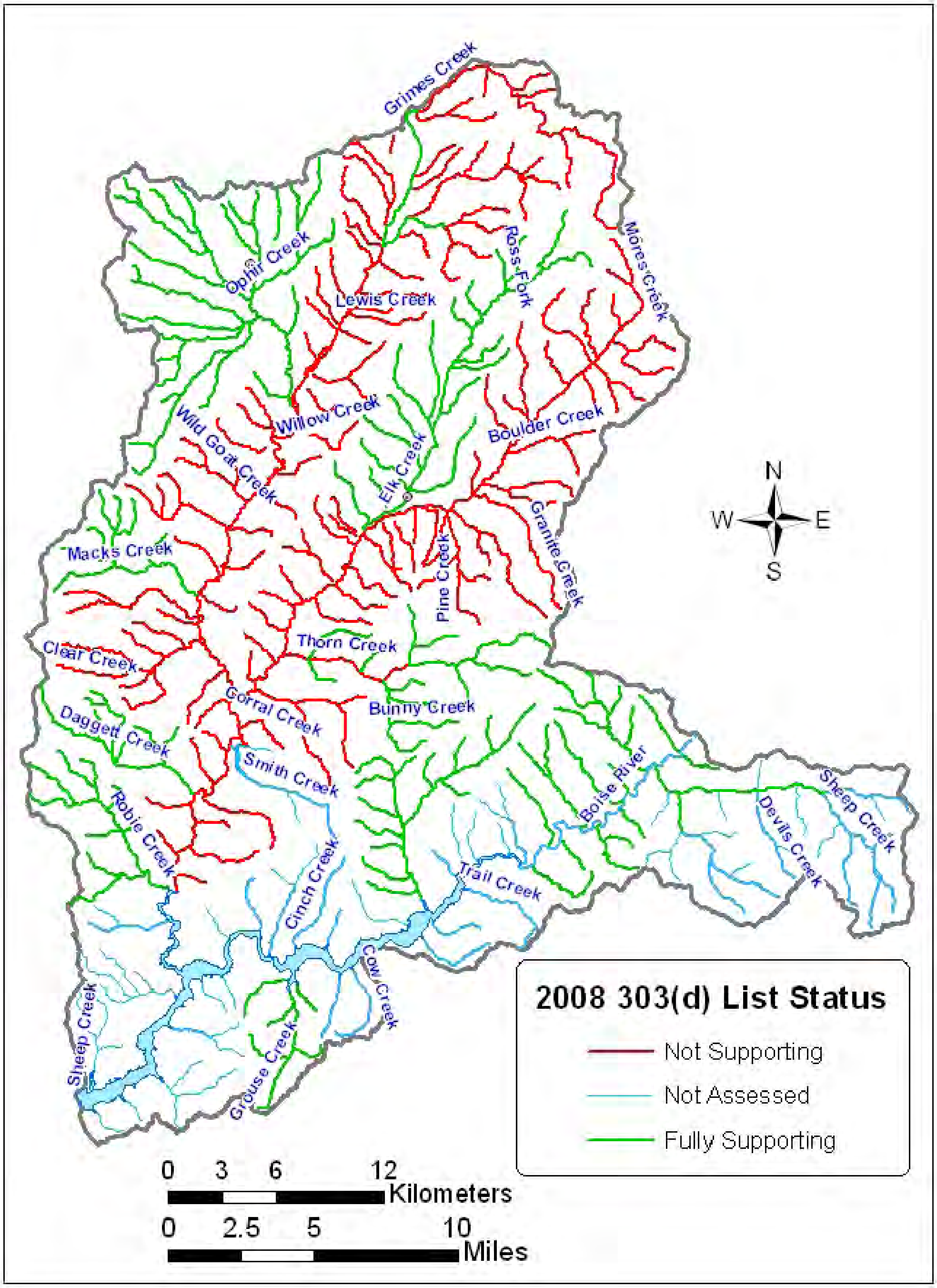

Figure B. 2008 §303(d)–listed Stream Reaches in the Boise-Mores Creek Subbasin.

Key Findings

TMDLs were developed for the two §303(d)-listed streams (Table A). A sediment TMDL has been developed for all AUs in Mores Creek and AUs 013_04 and 013_05 in Grimes Creek. Another TDML addresses temperature impairment of Mores Creek, 3rd order Thorn Creek and Macks Creek and thermal contributions of tributaries including Smiths Creek, Thorn Creek, Elk Creek, Grimes Creek, Granite Creek, Daggett Creek, and Robie Creek. Table C shows the streams and pollutants for which TMDLs were developed. Load allocations were included in the temperature TMDL for tributaries which contribute loads to these streams, but are not themselves impaired. Pollutant targets and load allocations described in the TMDLs apply throughout the assessment unit. Table D is the summary of assessment outcomes.

The Boise River AU 004_05 is recommended to be added to the §303(d) list due to temperature impairment. DEQ also proposes listing Mores Creek AUs 009_02, 009_03 and 009_04, Elk Creek AU 012_03, Grimes Creek AUs 013_03, 013_04 and 013_05, and Granite Creek AUs 014_02, 014_03 and 014_04 in Section 4c of the next Integrated Report for habitat alteration and flow alteration due to impacts from historic placer mining. No TMDLs were completed for habitat alteration or flow alteration in accordance with DEQ and EPA policy.

Detailed information regarding the streams in this watershed is provided in Section 2 of this document. Many of these streams were not on the §303(d) list of impaired waters and thus did not require a TMDL; however loads were assigned because they contribute to an impaired water body (Table C). Determination of beneficial use support is based on evaluation of BURP surveys and other data and is summarized at the end of each water body description in Section 2.

Table C. Streams and pollutants for which TMDLs were developed in the Boise-Mores Creek subbasin.

Water Body and AU	Pollutant(s)	Impairment Status
Lucky Peak Reservoir – Robie Creek Beach Area 17050112SW001L_0L	*E. coli* bacteria	Impaired
Mores Creek 17050112SW009_02	Temperature and Sediment	Impaired
Mores Creek 17050112SW009_03	Temperature and Sediment	Impaired
Mores Creek 17050112SW009_04	Temperature and Sediment	Impaired
Mores Creek 17050112SW009_06	Temperature and Sediment	Impaired
Thorn Creek 17050112SW011_03	Temperature	Impaired
Grimes Creek 17050112SW013_02	Temperature	Impaired
Grimes Creek 17050112SW013_03	Temperature	Impaired
Grimes Creek 17050112SW013_04	Temperature and Sediment	Impaired
Grimes Creek 17050112SW013_05	Temperature and Sediment	Impaired
Macks Creek 17050112SW015_02	Temperature	Impaired

Table D. Summary of assessment outcomes for the Boise-Mores Creek subbasin

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Lucky Peak Reservoir 17050112SW001L_0L Robie Creek Beach	Bacteria	Bacteria	Add to Section 4a of Integrated Report	Unlisted but data indicates *E. coli* bacteria impairment for PCR at Robie Creek Beach
Boise River Mainstem 17050112SW004_05	Temperature	None	Add to Section 5 of Integrated Report	Unlisted but data indicates temperature impairment for CWAL and SS
Mores Creek 17050112SW009_02	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for SS
	Sediment	Sediment	Change pollutant from unknown to sediment and move to Section 4a of Integrated Report	Data indicates sediment impairment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Mores Creek 17050112SW009_03	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but impaired by sediment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Mores Creek 17050112SW009_04	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but impaired by sediment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Mores Creek 17050112SW009_06	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but impaired by sediment
Smith Creek 17050112SW010_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Thorn Creek 17050112SW011_02	Temperature	Temperature	No impairment known	Contributes thermal load to 3rd order Thorn Creek and Mores Creek
Thorn Creek 17050112SW011_03	Temperature	Temperature	Add to Section 4a of Integrated Report	Unlisted but contributes thermal load to Mores Creek and BURP data indicates temperature impairment
Elk Creek 17050112SW012_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Elk Creek 17050112SW012_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Grimes Creek 17050112SW013_02	Temperature	Temperature	Change from unknown pollutant to temperature and move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
Grimes Creek 17050112SW013_03	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Grimes Creek 17050112SW013_03	Temperature	Temperature	Add to Section 4a of Integrated Report	Unlisted but data indicates temperature impairment for CWAL and SS
Grimes Creek 17050112SW013_04	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL
Grimes Creek 17050112SW013_04	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but data indicates sediment impairment
Grimes Creek 17050112SW013_04	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Grimes Creek 17050112SW013_05	Temperature	Temperature	Change from unknown pollutant to temperature and move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL
Grimes Creek 17050112SW013_05	Sediment	Sediment	Change pollutant from unknown to sediment and move to Section 4a of Integrated Report	Data indicates sediment impairment
Granite Creek 17050112SW014_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores and Grimes Creeks
Granite Creek 17050112SW014_02	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Granite Creek 17050112SW014_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores and Grimes Creeks
Granite Creek 17050112SW014_03	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Granite Creek 17050112SW014_04	Temperature	Temperature	No impairment known	Contributes thermal load to Mores and Grimes Creeks
Granite Creek 17050112SW014_04	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Macks Creek 17050112SW015_02	Temperature	Temperature	Add to Section 4a of Integrated Report	Unlisted but impaired by temperature
Daggett Creek 17050112SW016_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Daggett Creek 17050112SW016_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Robie Creek 17050112SW017_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Robie Creek 17050112SW017_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek

Public Participation

DEQ has complied with the Watershed Advisory Group (WAG) consultation requirements in conformance with Idaho Code §39-3615. A WAG was formed in November 2006 and recognized by the Southwest Basin Advisory Group (BAG) and DEQ in January 2007. DEQ provided the WAG with information concerning applicable water quality standards, water quality data, monitoring, assessments, reports, procedures, and schedules. The group met in Idaho City regularly over the course of the development of the TMDL. In 2006, the WAG met on November 2 and December 14, in 2007 on January 18, February 15, March 15, May 17, and October 18, and in 2008 on March 20 and August 21. The WAG also met on June 21, 2007 to take a watershed tour of potential sites for implementation activities to restore channel conditions and bank vegetation to background levels in areas that have been historically dredge-mined. A watershed web page was created on the DEQ internet site where meeting announcements and select agenda items are posted (http://www.deq.idaho.gov/about/regions/boise_mores_ck_wag/index.cfm).

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1. Subbasin Assessment – Watershed Characterization

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. (In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.)

This document addresses the water bodies in the Boise-Mores Creek subbasin that are on Idaho's 2008 §303(d) list.

The overall purpose of the subbasin assessment (SBA) is to characterize and document pollutant loads within the Boise-Mores Creek Subbasin. The first portion of this document, the SBA, is partitioned into four major sections: watershed characterization, water quality concerns and status, pollutant source inventory, and summary of past and present pollution control efforts (Sections 1 – 4). This information will then be used to develop a TMDL for each pollutant of concern for the Boise-Mores Creek subbasin (Section 5).

1.1 Introduction

In 1972, Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Water Environment Federation 1987, p. 9). The act and the programs it has generated have changed over the years, as experience and perceptions of water quality have changed.

The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to insure "swimmable and fishable" conditions. This goal, along with a 1972 goal to restore and maintain chemical, physical, and biological integrity, relates water quality with more than just chemistry.

Background

The federal government, through the U.S. Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. In Idaho, The Department of Environmental Quality (DEQ) implements the CWA, while the EPA oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Section 303 of the CWA requires DEQ to adopt water quality standards and to review those standards every three years (Idaho's water quality standards must be approved by EPA). Additionally, DEQ must monitor waters to identify those not meeting water quality standards. For those waters not meeting standards, DEQ must establish a TMDL for each pollutant impairing the waters. Further, the agency must set appropriate controls to restore water quality and allow the water bodies to meet their designated uses.

These requirements result in a list of impaired waters, called the "§303(d) list." This list describes water bodies not meeting water quality standards. Waters identified on this list require further analysis. An SBA and TMDL provide a summary of the water quality status and allowable TMDL for water bodies on the §303(d) list. *Boise-Mores Creek Watershed Subbasin Assessment and Total Maximum Daily Loads* provides this summary for the currently listed waters in the Boise-Mores Creek Subbasin.

The SBA section of this document (Sections 1 – 4) includes an evaluation and summary of the current water quality status, pollutant sources, and control actions in the Boise-Mores Creek Subbasin to date. While this assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up to date and accurate. The TMDL is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (Water quality planning and management, 40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

Some conditions that impair water quality do not receive TMDLs. The EPA does consider certain unnatural conditions, such as flow alteration, human-caused lack of flow, or habitat alteration, that are not the result of the discharge of a specific pollutant as "pollution." However, TMDLs are not required for water bodies impaired by pollution, but not by specific pollutants. A TMDL is only required when a pollutant can be identified and in some way quantified.

Idaho's Role

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The state may assign or designate beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho water quality standards and include the following:

- Aquatic life support–cold water, seasonal cold water, warm water, salmonid spawning, modified
- Contact recreation–primary (swimming), secondary (boating)
- Water supply–domestic, agricultural, industrial
- Wildlife habitats
- Aesthetics

The Idaho legislature designates uses for water bodies. Industrial water supply, wildlife habitats, and aesthetics are designated beneficial uses for all water bodies in the state. If a water body is unclassified, then cold water aquatic life and primary contact recreation are used as additional default designated uses when water bodies are assessed.

An SBA entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, and landscape data to address several objectives:

- Determine the degree of designated beneficial use support of the water body (i.e., is the water body attaining or not attaining water quality standards).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identity and location of pollutant sources.
- Determine the causes and extent of the impairment when water bodies are not attaining water quality standards.

1.2 Physical and Biological Characteristics

The Boise-Mores Creek Subbasin contains the US Geological Survey (USGS) Hydrologic Unit Code (HUC) 17050112. The watershed (Figure 1) contains the upper mainstem Boise River, Arrowrock Reservoir, Lucky Peak Reservoir, and Mores Creek, and their tributaries. Elevations range from 2,840 feet at the base of Lucky Peak Reservoir to 9,070 feet at the upper boundary of the Sheep Creek drainage. The Boise-Mores Creek subbasin covers 620.5 square miles in Boise, Ada, and Elmore Counties. The southwestern corner of the basin is in Ada County, and the southeastern section of the basin lies in Elmore County. Highway 21 parallels Mores Creek for most of its length. Forest Service Road 268 parallels the Boise River along Lucky Peak and Arrowrock Reservoirs and the mainstem Boise River throughout the segment included in this HUC.

The climate, geology, hydrology, and biological characteristics of the subbasin will be discussed in the following sections.

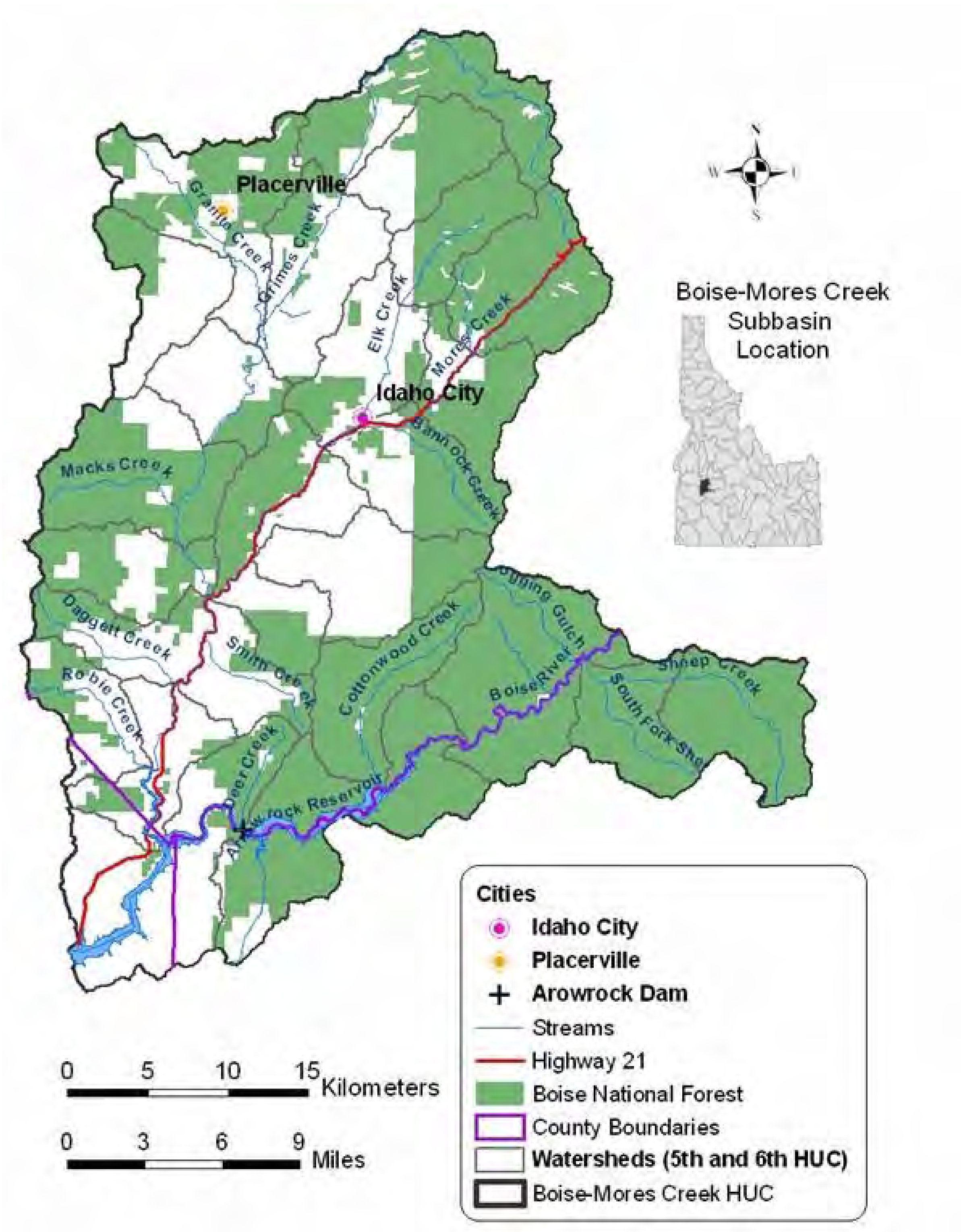

Figure 1. Boise-Mores Creek subbasin.

Climate

There are four Idaho climate monitoring stations within the Boise-Mores Creek watershed: Lucky Peak (Station #101018), Arrowrock (Station #100448), Idaho City (Station #104442), and Centerville (Station #101636). The Centerville station does not record air temperature. The Lucky Peak and Arrowrock stations reflect weather conditions in lower elevations, while Idaho City and Centerville reflect conditions in the middle and upper elevations. Table 1 shows the annual average climatic summary within the watershed. Figure 2 shows the averaged precipitation patterns.

Table 1. Climatological summary data (Western Regional Climate Center 2007).

Climate Factor	Lucky Peak Dam (Station #101018)	Arrowrock Dam (Station #100448)	Idaho City (Station #104442)	Centerville (Station #101636)
Dates of Record	1951 - 2006	1916 - 2006	1931 - 2006	1949 - 2006
Elevation (feet)	2840	3280	3970	4440
Average Annual Precipitation (inches)	13.7	18.7	25.3	27.9
Average Monthly Precipitation, June-September (inches)	0.6	0.5	0.8	1.0
Average Monthly Precipitation, November- February (inches)	1.6	2.7	3.2	3.8
Average Annual Snowfall (inches)	4.9	41.3	81.2	119.8
Average Monthly Precipitation, November - February (inches)	1.2	9.6	18.1	24.4
Maximum Average Temperature, June-September (°F)	85.8	84.3	82.4	n/a
Minimum Average Temperature, June - September (°F)	53.8	51.8	40.9	n/a
Highest Temperature (°F)	113	112	109	n/a
Maximum Average Temperature, November - February (°F)	42	38.3	39.1	n/a
Minimum Average Temperature, November - February (°F)	25.4	23.3	16	n/a
Lowest Temperature (°F)	-17	-20	-38	n/a

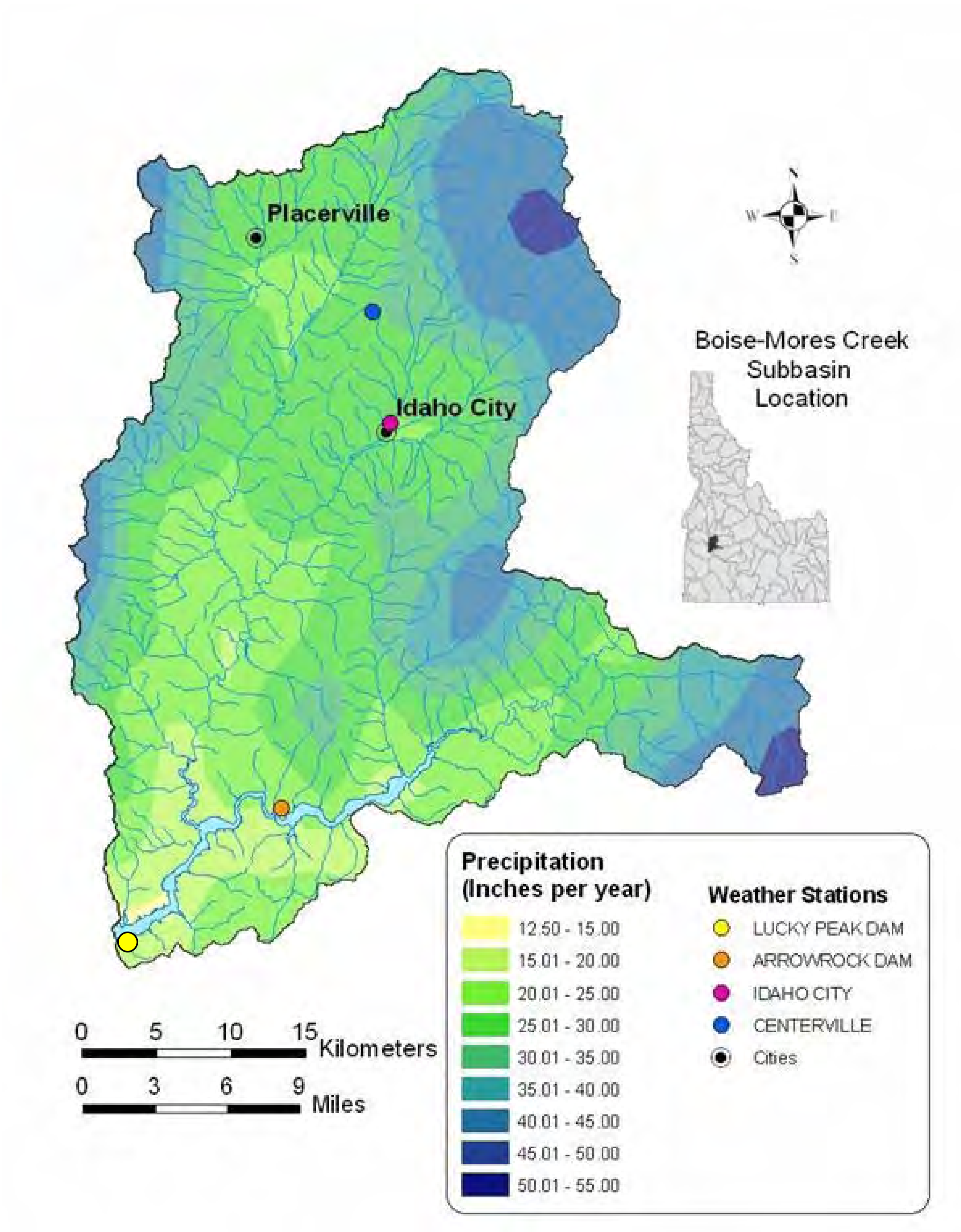

Figure 2. Boise-Mores Creek subbasin precipitation ranges.

The watershed lies within a dry climate region described generally by Trewartha (1957) as middle latitude steppe. The Boise-Mores Creek subbasin, like most of Idaho, receives relatively little precipitation in late summer. Weather stations in the subbasin report an average rainfall of one inch or less per month in July and August (Western Regional Climate Center 2007). The summer dry season in southern Idaho usually ends by October.

There is a dramatic difference in precipitation based on elevation in the watershed. The average annual precipitation in the subbasin ranges from 12 inches to an estimate of nearly 50 inches per year at the uppermost elevations of the subbasin. Idaho City and Centerville, located at nearly 4,000 and 4,500 feet elevation, receive twice the annual average precipitation of the weather station located at Lucky Peak Dam at 2,840 feet, the lowest elevation in the subbasin. Based on data from the Mores Creek Summit SNOWTEL (Snow Telemetry) station (Figure 3), at 6100 feet elevation, the average March snow depth would be approximately 35 inches SWE (Snow Water Equivalent). The average relative humidity for the subbasin in winter is 70-75% and in summer 25-30% (USDA 1990).

Temperature within the subbasin can fluctuate dramatically from month to month. Weather stations at Idaho City, Arrowrock Dam, and Lucky Peak Dam have recorded similar extremes as low as -38^{o}F (January) and as high as 113^{o}F (July). The mean monthly temperature in Idaho City for January is 24.1 ^{o} F (26.8^{o} at Arrowrock Dam and 28.8^{o} at Lucky Peak Dam) and for July is 66.5^{o} F (73.5^{o} at Arrowrock Dam and 74.6^{o} at Lucky Peak Dam) (Western Regional Climate Center 2007).

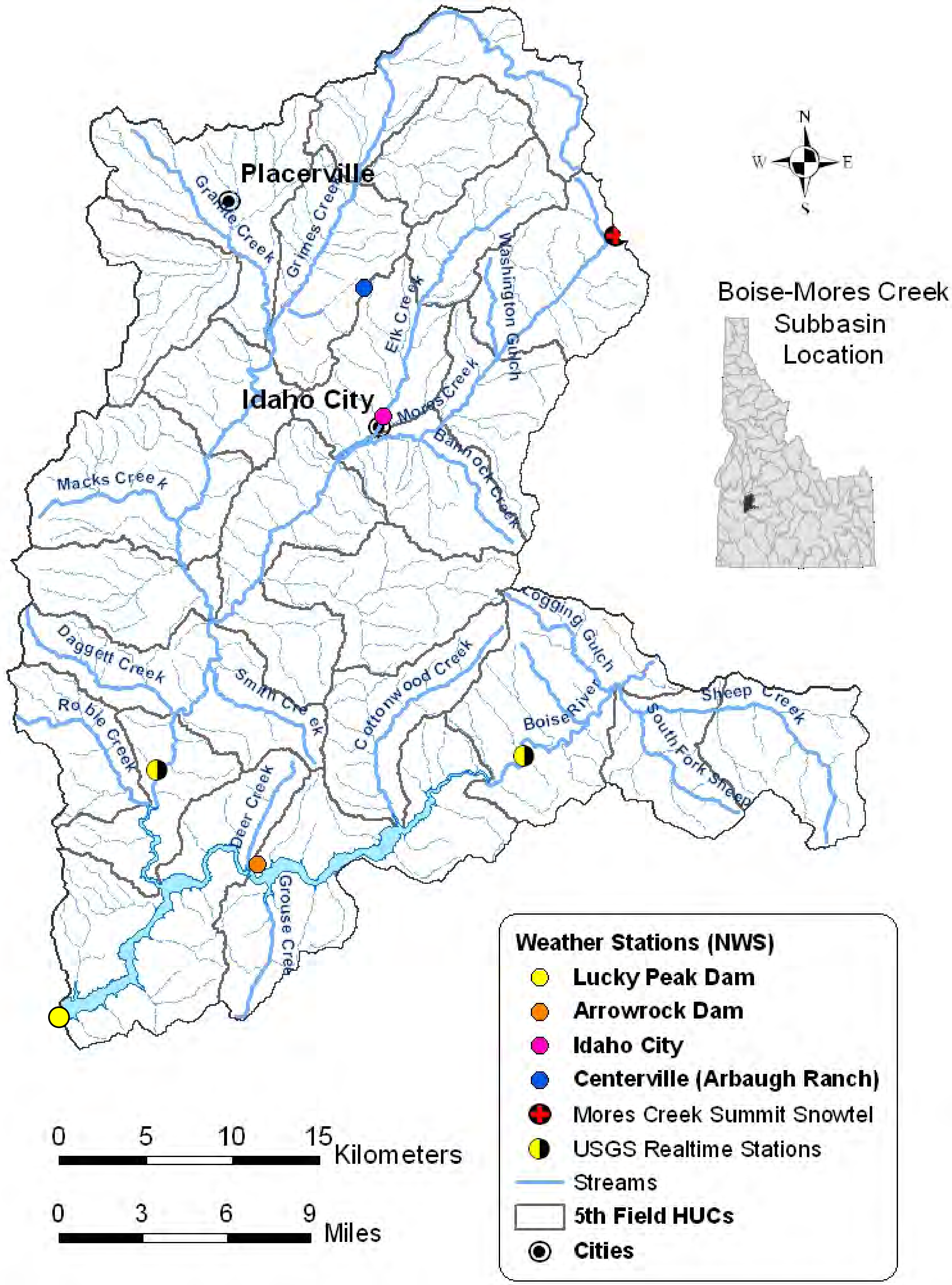

Figure 3. Boise-Mores Creek subbasin major water bodies and monitoring stations.

Figure 4 illustrates that the number of sunshine days per month at the nearest weather station, in Boise, ranges from 20% in winter to about 80% in summer (NOAA 2007)

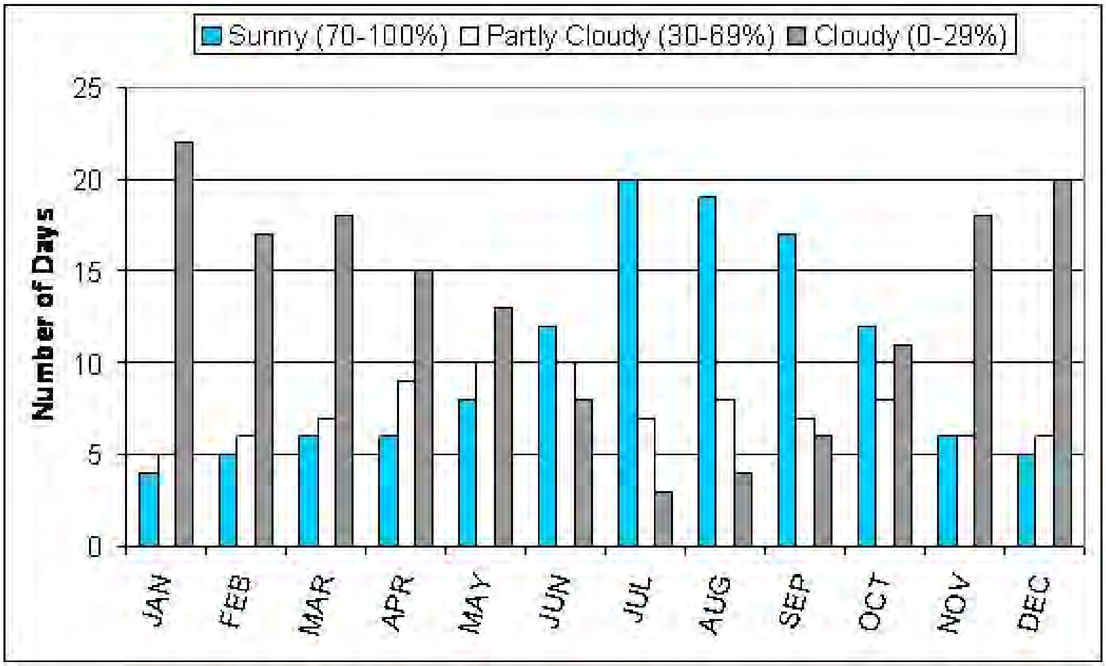

Figure 4. Percent sunshine as measured at the nearest weather station (Boise, ID), (NOAA National Data Center, http://ols.nndc.noaa.gov, 1949-2005).

Subbasin Characteristics

Hydrography

The general flow characteristics of the Boise-Mores watershed are from north, northeast to south. Major topographic features include the Boise Ridge to the west and Wilson and Pilot Peaks to the north, while the Boise and Danskin Mountains form the eastern and southern boundaries. Typical drainage systems in the subbasin consist of steep headwater streams leading into steep to moderately steep main channels. Stream energy is generally high in the upper stream reaches, with sediment readily transported downstream. These channels have abundant boulders, cobbles, and rubble contained in their beds and banks. As the streams progress into the lower elevations with lesser gradients, energy is reduced and sediment particles settle into the channel bottoms. The Boise-Mores Creek watershed is comprised of seventeen water body units (Figure 3). Lucky Peak Reservoir is the water body furthest downstream in this watershed.

Two USGS flow gauging stations are operated in the subbasin (Figure 3). One station, which records discharge and gauge height, is located on Mores Creek just upstream from Robie Creek and the slackwater at full pool volume of Lucky Peak Reservoir. A second gauging station, which records stream temperature and discharge, is located on the Boise River just upstream from the confluence with Willow Creek and the slackwater at full pool volume for Arrowrock Reservoir. Details regarding these gauging stations and the average annual discharge measured at each are listed in Table 2.

Table 2. Estimated average annual discharge.

Location	Elevation (ft)	Drainage Area (mi^2)	Estimated Average Annual Discharge (cfs)[1]
Boise River near Twin Springs	3,255	830	1,192
Mores Creek above Robie Creek	3,120	399	283

[1] Cubic feet per second

Natural stream flow in the subbasin is seasonally variable, but the majority of in-river flow is outflow from melting snow. The snowmelt-driven flow regimes result in low flows in fall and winter and high flows during spring and early summer (IDEQ and ODEQ 2001). In some areas and seasons, ground water discharge is a substantial source of flow. Stream hydrographs (runoff regimes) peak from late March to May because of snowmelt runoff. The timing of the runoff varies, with south-facing aspects at lower elevations (less than 4,500 feet [1,372 m]) warming early with resulting peak runoffs occurring as early as late March. High elevation lands with deeper snowpacks generate peak runoff beginning in late April and last until late May. Rain falling on snow in winter and spring can cause rapid increases in stream flows. These rain-on-snow events usually occur in the elevation band between 4,500 feet (1,372 m) and 5,000 feet (1,524 m). The peak runoff periods are followed by warm, dry summers, which greatly decrease stream flows. Seeps and springs provide perennial flows to streams in higher elevations, but smaller streams in the lower elevations tend to become dry before the end of summer. Periodic localized summer thunderstorms can result in flash floods within small drainages. The fall climate reduces transpiration in plants, and additional ground water results in slight increases in stream flows.

The stream flow regimes in the watershed have been dramatically altered from historical conditions. Two dams (Lucky Peak Reservoir Dam and Arrowrock Reservoir Dam) were built that isolate migrant fish populations in the subbasin. In addition, downstream dams on the Snake and Columbia River systems have blocked anadromous fish. Remaining migrant fish species have adapted from a fluvial existence to a fluvial/adfluvial lifestyle, generally wintering in reservoirs.

Geology

The Boise-Mores Creek subbasin is located within the Idaho Batholith, which is a coarse-grained granitic intrusion. The geologic processes of uplifting, faulting, glaciation, and fluvial action resulted in landscapes that are characterized by mixtures of steep canyon lands, steep slopes with strongly expressed drainages, gently rounded topography, and glacial and fluvial deposits such as river terraces. Figure 5 illustrates the distribution of different rock types in the subbasin. Batholith rocks in the subbasin are believed to have been formed in two distinct times. The older age rocks originate from about 70-85 million years ago (Cretaceous period), while the younger rocks are believed to be 40 million years old (Eocene epoch). A number of igneous rock dikes crosscut the granitic rocks, mostly from Eocene intrusions. Basalt flows approximately 15 million years old cover the granite in places and are interbedded with sedimentary rocks, which may be gold-bearing. Younger, canyon-filling basalt flows related to the Snake River plain inundated old drainages about half a million years ago. Columns of basalts are visible in the lower Mores Creek canyon and the shoreline of Lucky Peak Reservoir. Pleistocene age glacial deposits are found in some subbasin valleys. Gold mines and vein deposits like Gold Hill, near Placerville, may be related to the intrusive granite and igneous dikes.

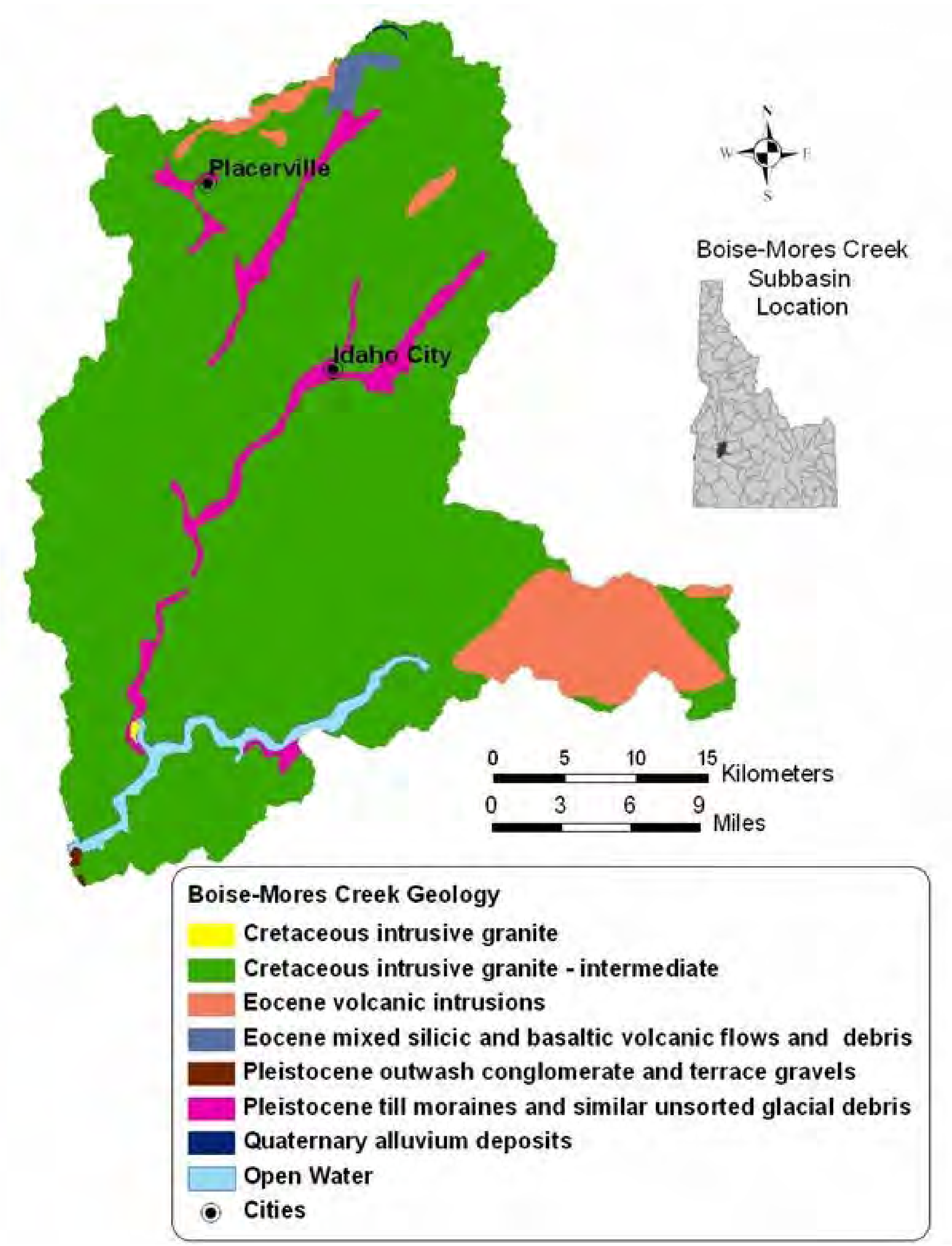

Figure 5. Boise-Mores Creek subbasin geology.

Geomorphologically speaking, the landforms within the subbasin indicate that the watershed is in an immature (relatively young) state. Most slopes are very steep, and meadows are limited in number and extent. Natural barriers in the form of waterfalls appear to be infrequent. Although the geology is complicated, most of the rocks are similar in composition. Rocks of similar composition erode at similar rates, therefore minimizing knickpoints and waterfalls. If falls develop as a result of some catastrophic event, they are soon (on the geologic timescale) eliminated.

The parent rock of the Boise-Mores Creek watershed, like others with similar geology, has limited water-holding capability. Water transfer through rock and water-holding capacity of weathered rock near the surface suggest that fractures play the dominant role in the low water-holding capacity. Intergranual porosity resulting from mineral grain weathering is very slow (Clayton 1992). Most of the rock materials with water-holding capacity are the sedimentary rocks and alluvial sand and gravels, located in the valley bottoms. This alluvium is critical in providing ground and surface water interaction, which dictates selection of salmonid spawning habitat (Baxter 1997).

The majority of the parent rock, Batholith, is principally composed of biotite granodiorite, a medium-grained igneous rock that disaggregates easily on steep slopes. Thus the subbasin is subject to rapid surface erosion and mass wasting (overland or instream debris flows). Geologic immaturity paired with an easily erodible granitic rock makes for naturally high erosion rates. Both forms of erosion provide soils and rock material that streams need for nutrients and structure. These rock-weathering processes also provide well-drained soils that make the watersheds productive for forest development. Mass wasting usually occurs in over-saturated soils on over-steepened slopes. Mass wasting frequently is highest in those areas that have had recent intense fires that result in hydrophobic soils. When excessive soil and rock materials are deposited in streams, it becomes difficult or impossible for the stream to assimilate them. This can cause impairment to the stream and impacts to salmonid species. Mass wasting rates in watersheds can be accelerated by anthropogenic activities. In areas with intense land management activities, erosion and mass wasting rates are often higher.

Soils

There are a wide variety of soils found throughout the subbasin. Surface soils are typically coarse sands weathered from granite. These sandy loams have little adhesion or cohesion, resulting in potential sources for sedimentation in the watershed.

The average soil slope provides a gauge of potential soil erosion, or erodability risk. The ArcGIS map of the subbasin (Figure 6) shows that slopes are low (0% - 9%) on the grassland/shrub communities in the southeast section of the watershed and along the sloping shorelines of Arrowrock and Lucky Peak Reservoirs. Slopes are moderately steeper in the areas forming the watersheds surrounding the reservoir basin (35% - 44%), and they increase appreciably as one approaches the bordering mountain ranges. In the mountain ranges, slopes are fairly steep, exceeding 45%. Table 3 shows how much of the subbasin is covered by slopes of varying degrees.

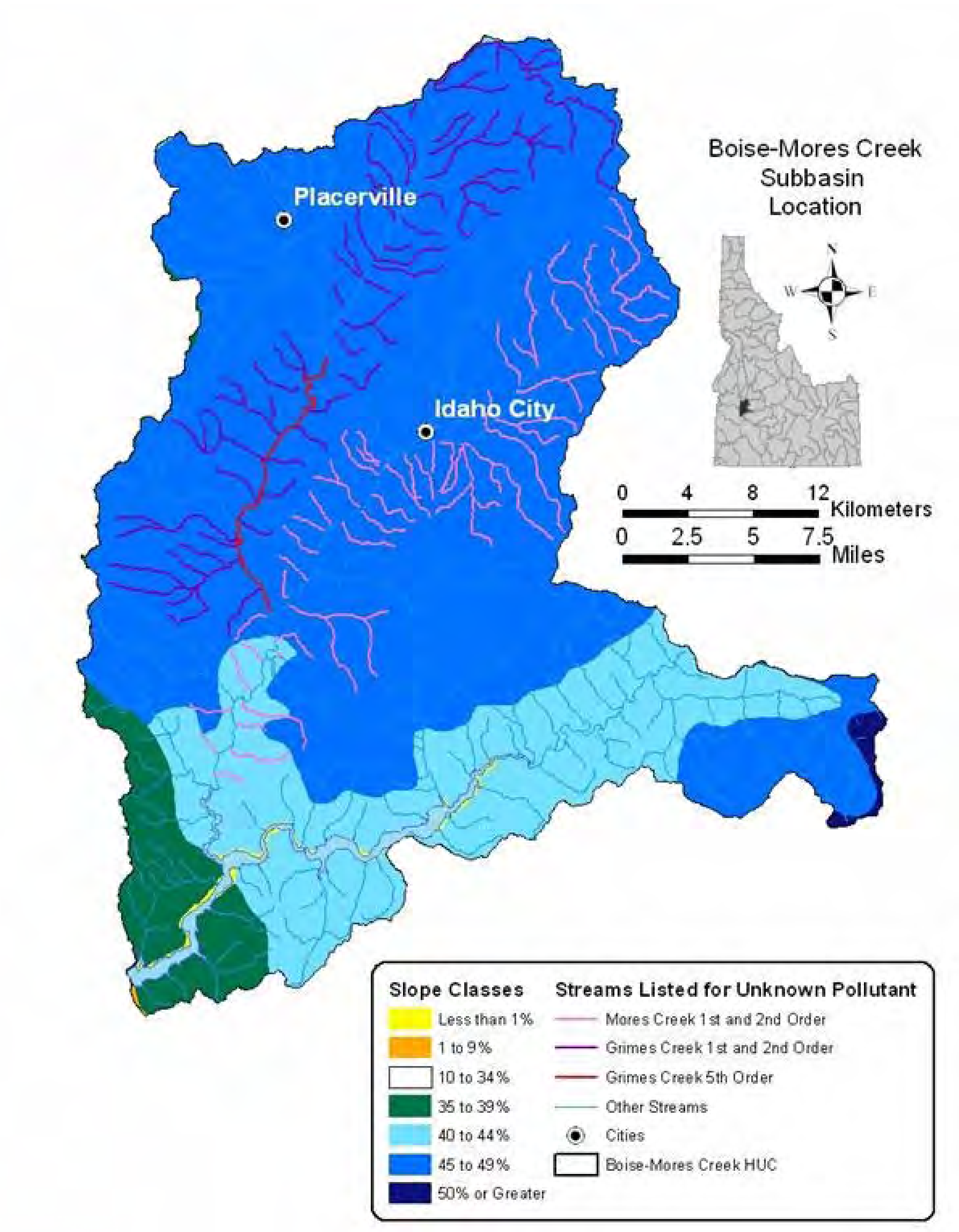

Figure 6. Slope classes of the Boise-Mores Creek subbasin.

Table 3. Slope classes of the Boise-Mores Creek subbasin.

Slope	Hectares	Square Miles	% of Area
Less than 1%	2101	8	1%
1 to 9%	50	<1	< 1%
10 to 34%	0	0	0%
35 to 39%	9271	36	6%
40 to 44%	31452	121	20%
45 to 49%	117061	452	73%
50% or greater	786	3	< 1%

The "K-factor" is the soil erodability factor in the Universal Soil Loss Equation (Wischmeier and Smith 1965). This factor is comprised of four soil properties: texture, organic matter content, soil structure, and permeability. K-factor values range from 1.0 (most erosive) to 0 (nearly non-erosive). K-factors for the Boise-Mores Creek subbasin, which were calculated from the USGS Water Resources Division soil information, range from 0.078 to 0.30. This indicates that the soils in the subbasin are relatively stable, with the highest K-factor less than one-third of the way up the scale toward highly erodible. See Table 4 and Figure 7 for details regarding K-factor ratings for specific areas in the subbasin. Soils on relatively flatter slopes of the grassland/shrub-dominated rangeland area surrounding small and mainly intermittent tributaries to Lucky Peak Reservoir have the most erodible soils, with K-factors at 0.3. The K-factors range from 0.20 to 0.29 on the soils in the majority of the subbasin. Many of the §303(d)-listed streams with unknown pollutants are found in the area with these lower K-factors, such as Grimes Creek 4th and 5th order segments and portions of Mores and Grimes Creeks 1st and 2nd order segments. The lowest K-factors, ranging from 0 - 0.09, are found in the highest elevation stream segments such as Upper Mores, Upper Grimes, and Sheep Creeks, and those with the steepest watersheds such as Sheep Creek, Cottonwood Creek, Thorn Creek, Browns Creek, and Smith Creek.

Table 4. Soil erosion index values of the Boise-Mores Creek subbasin.

K-Factor Classes	Hectares	Square Miles	% of Area
0 or less	50251	193.9	31.3%
0.01 to 0.09	786	3.0	0.5%
0.10 to 0.19	38	0.2	< 0.1%
0.20 to 0.29	100325	387.1	62.4%
3.0	777	35.9	5.8%

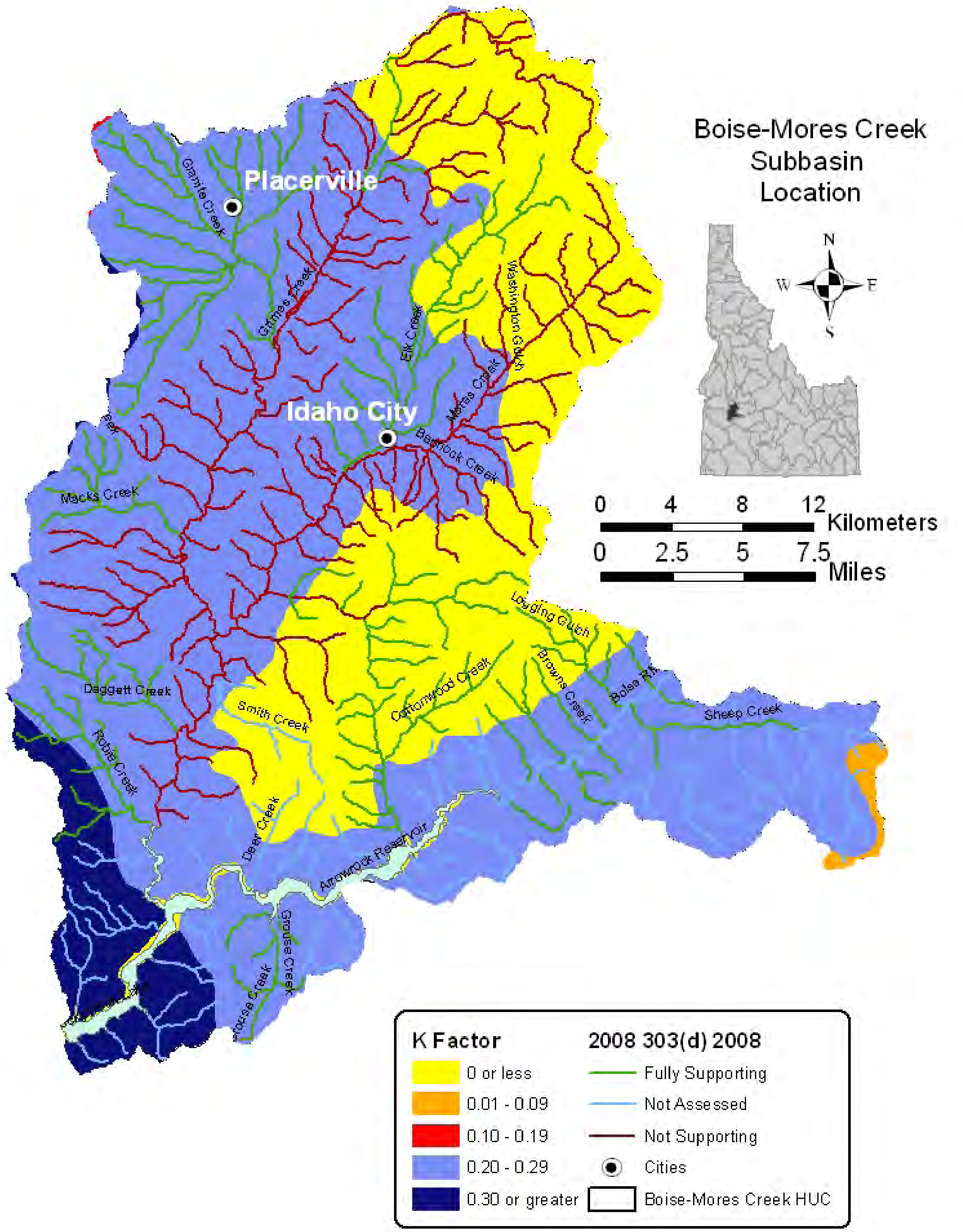

Figure 7. Soil erosion index and location of water quality limited streams within the subbasin.

Topography

Elevations in the watershed range from 2,840 feet at the base of Lucky Peak Dam to over 9,000 feet at the watershed boundary of Sheep Creek. The uplands portion of the watershed is characterized by steep, deeply incised slopes with gradients of 30% or more. Mid elevations are typically steep V-shaped drainages. The lower elevations of the watershed have lesser gradients and are more arid. Arrowrock and Lucky Peak Reservoirs are located in these sections.

Watershed slope is one of the major influences affecting runoff. Increased basin slopes result in greater percentages of precipitation or meltwater runoff. Areas with gradual slopes absorb more precipitation or meltwater into the soil or geological formations than areas with steeper slopes. The Boise-Mores Creek subbasin is dominated by deeply incised canyons with slopes greater than 30%. Table 5 shows topographical characteristics for the major streams in the subbasin, and Figure 8 illustrates major streams and topographical relief of the subbasin.

Table 5. Drainage area; minimum, maximum, and average elevation; and average drainage area slope for major streams in the subbasin.

Stream Name	Subbasin Drainage Area (Mi^2)	Minimum Elevation (ft)	Maximum Elevation (ft)	Mean Elevation (ft)	Average Basin Slope
Browns Creek	3.2	3390	7060	5050	50.5%
Cottonwood Creek	22.0	3220	7280	5160	40.2%
Daggett Creek	12.3	3190	6520	4770	37.8%
Deer Creek	2.7	3100	5860	4650	40.8%
Elk Creek	24.1	3980	8110	5620	31.7%
Granite Creek	51.3	4100	7280	5030	26.4%
Grimes Creek	196.0	3330	7950	5130	29.2%
Grouse Creek	8.42	3230	5400	4380	40.4%
Macks Creek	12.4	3540	7500	5110	42.0%
Mores Creek	397.0	3090	8110	5070	31.3%
Robie Creek	16.2	3080	6520	4670	39.7%
Sheep Creek	43.1	3520	9070	6250	49.4%
Smith Creek	6.92	3280	6330	4770	41.6%
Thorn Creek	27.2	3470	7470	5260	37.7%

Figure 8. Boise-Mores Creek subbasin topography.

Vegetation

The Boise-Mores Creek subbasin is split between three ecological regions as described by Omernick and Gallant (1986) and Omernick (1986). Eight percent of the subbasin is in the Blue Mountains, 43% in the Northern Rockies, and 49% in the Snake River Basin/High Desert ecoregion (Figure 9). The Blue Mountains ecoregion occurs on 27,380 mi^2 (70,914 km^2) in Idaho, Oregon, and Washington. The native vegetation includes sagebrush steppe and saltbrush-greasewood as well as deciduous and coniferous forest (McGrath et al. 2002; Idaho Gap Analysis Project 2004), with extensive areas of old-growth coniferous forest (DellaSalla et al. 2001) that include some of the largest stands of western juniper in the world (Oregon Progress Board 2000). The Snake River Plain ecoregion is a xeric intermontane basin and range area covering about 20,700 mi^2 (53,613 km^2) in Idaho and Oregon. Except for scattered barren lava fields, the ecoregion was dominated by sagebrush steppe vegetation that is now used for cattle grazing (McGrath et al. 2002). The Northern Rockies ecoregion encompasses about 31,600 mi^2 (81,844 km^2) in northern Idaho, northwestern Montana, and northeastern Washington. The high, rugged Northern Rockies ecoregion is mountainous, and, despite an inland position, its climate and vegetation are marine-influenced (EPA 2002). Douglas fir, subalpine fir, Englemann spruce, ponderosa pine, and Pacific indicators, such as western red cedar, western hemlock, and grand fir, are found in the ecoregion (McGrath et al. 2002).

The subbasin is dominated by forest and grassland (GAP II 2003). Land cover and vegetation types are shown in Figure 10. Timber species of ponderosa pine (*Pinus ponderosa*), Douglas fir (*Psuedotsuga menziesii*), subalpine fir (*Abies lasiocarpa*), grand fir (*Abies grandis*), lodgepole pine (*Pinus contorta*), and Engelmann spruce (*Picea engelmanii*) make up approximately 42% of the vegetation cover. At lower elevations, the forest transitions to ponderosa pine-dominated forests with mixed fir at higher elevations on north, west, and east aspects. At higher elevations, spruce/fir and lodgepole pine forests are common. Sagebrush and grassland communities are common at lower elevations or on south and southwest aspects. Shrub/steppe grassland communities make up approximately 42% of the vegetative cover and 12% of the land is vegetated by sagebrush (*Artemisia sp*.) and bitterbrush (*Purshia sp*.). Riparian vegetation species comprise the remaining 4% of vegetative cover in the subbasin. Most privately owned lands are within the sagebrush, shrub/grassland, or ponderosa pine vegetative areas of the watershed.

Many plant species in the basin are adapted to a frequent low intensity fire regime. Fire suppression has changed the frequency and intensity of wildfires in the subbasin as in many areas in the arid west. Much of the Boise-Mores Creek subbasin has burned at least once during the past 100 years (Figure 11). Recent fires, over the past 20 years, have burned very large areas, indicating changes in intensity or burn frequency. Areas burned by large, high intensity fires tend to generate higher sediment loads and take longer to recover stabilizing vegetative cover.

Figure 9. Ecoregions of the Boise-Mores Creek subbasin.

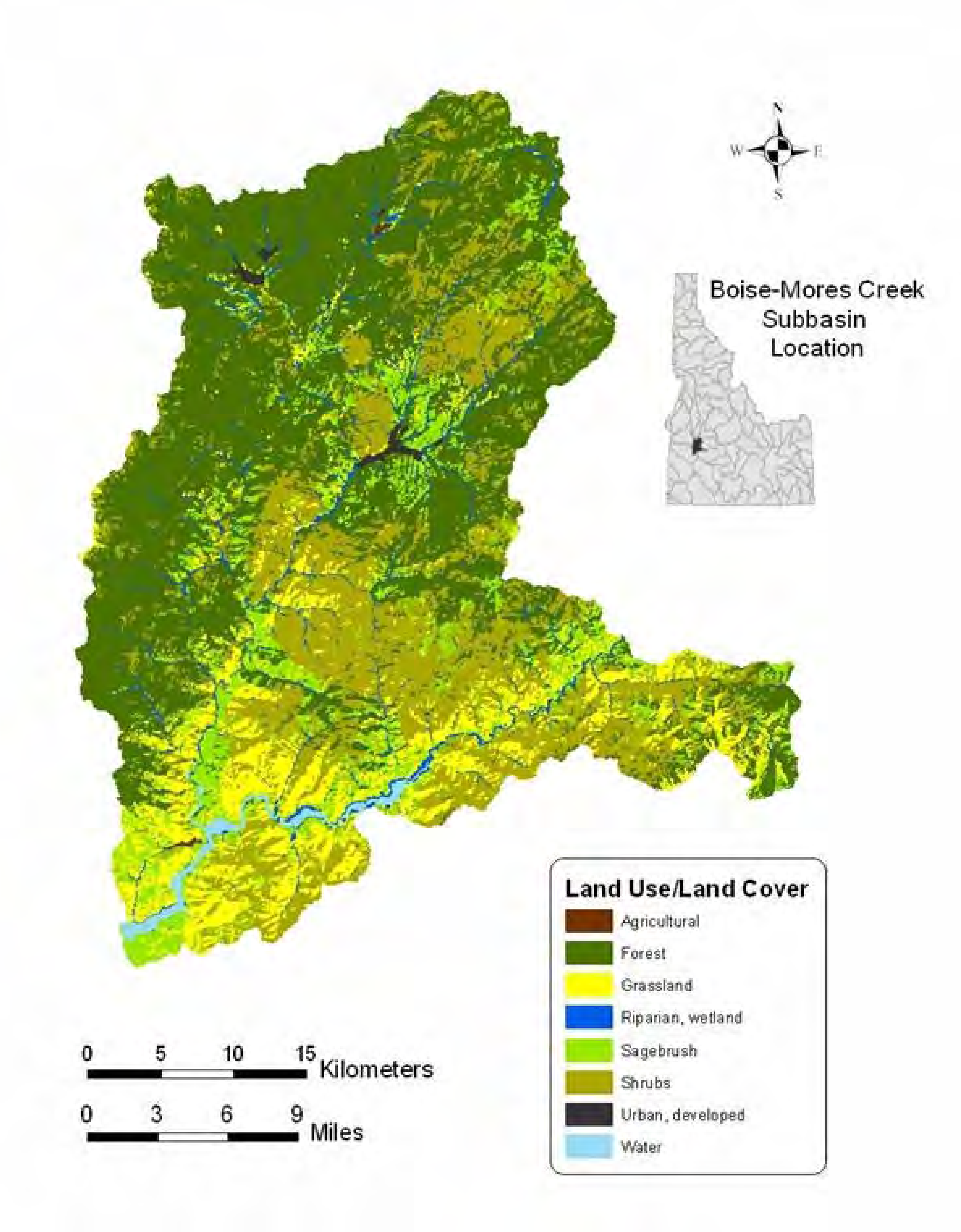

Figure 10. Boise-Mores Creek land use, land cover, and vegetation classification.

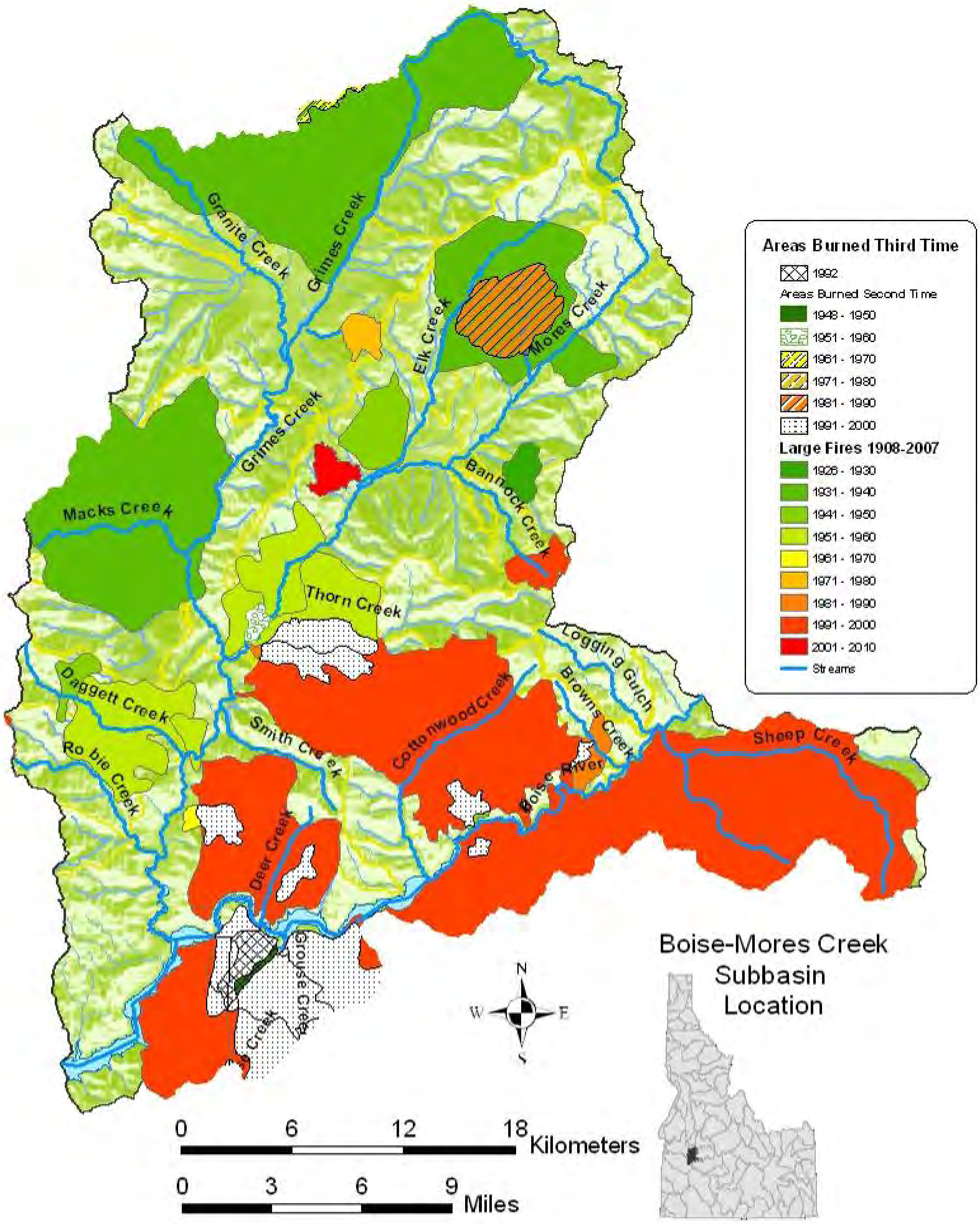

Figure 11. Large Fires (greater than 100 acres) in the Boise-Mores Creek subbasin.

Fisheries

In the Boise-Mores Creek subbasin, headwater drainages are generally populated by fish communities of low richness (i.e., few species). Headwater fish communities generally consist of bull trout (*Salvelinus confluentus*) or rainbow/redband trout (*Onchorynchus mykiss spp.*), or both, in addition to sculpin (*Cottus spp.*). Downstream fish communities (found in mainstem migration corridors or reservoir wintering areas) are more diverse and include native species such as mountain whitefish (*Prosopium williamsoni*), northern pike minnow (*Ptychocheilus oregonensis*), redside shiner (*Richardsonius balteatus*), several sucker species (*Catostomus spp*.), and dace (*Rhinichthys spp*.). Figure 12 shows documented salmonid species ranges in the watershed. A more complete list of fish species documented to inhabit the individual water body units of the Boise-Mores Creek subbasin can be found in Section 2.4.

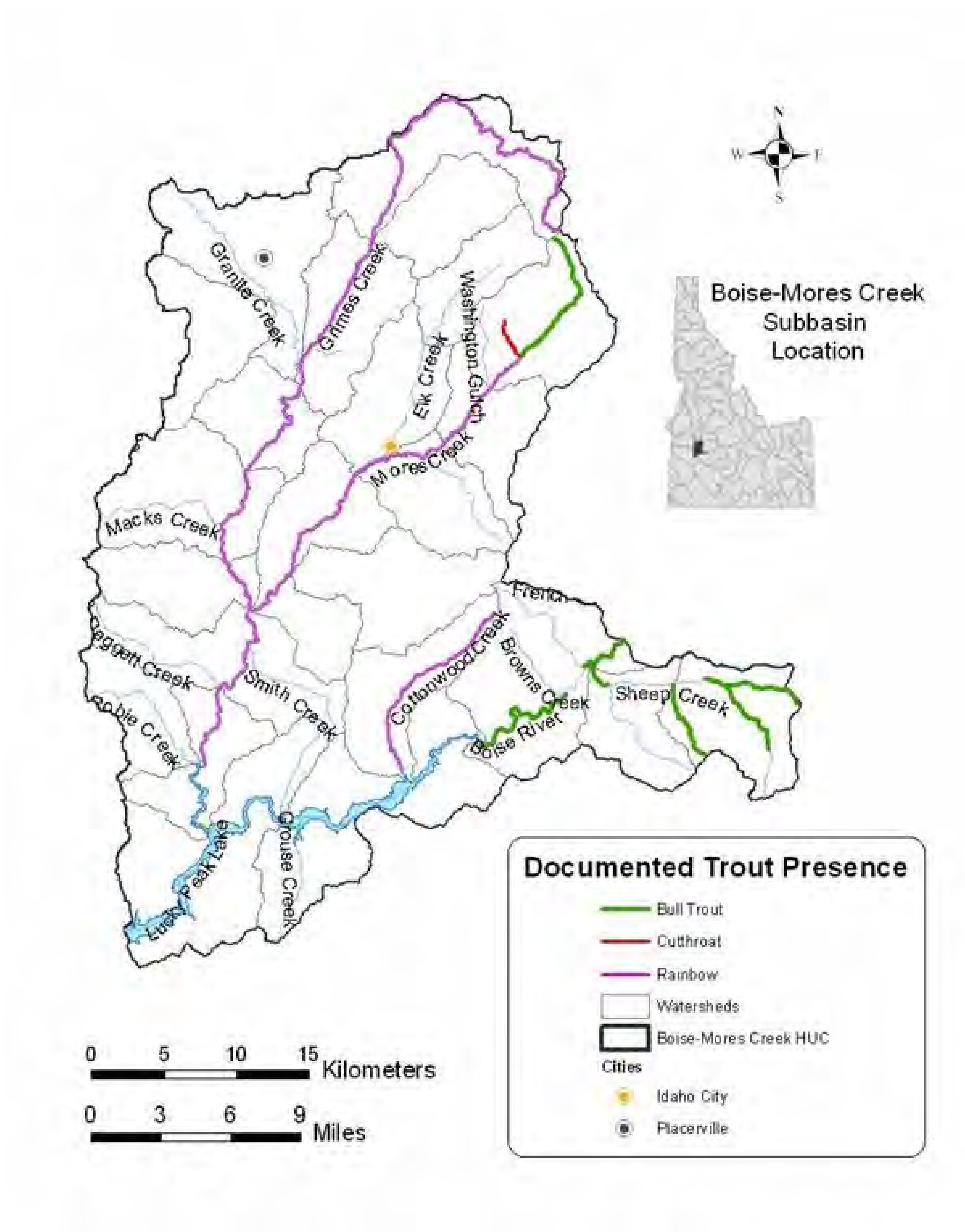

Figure 12. Documented salmonid species present (Idaho Fish and Game Conservation Data Center, 2004).

Important bull trout spawning and rearing streams include Sheep Creek, the Boise River, and Arrowrock Reservoir. Fluvial and adfluvial bull trout migrate out of the Upper Boise River tributaries and into the mainstem Boise River and Arrowrock Reservoir. Some fish are entrained from Arrowrock Reservoir into Lucky Peak Reservoir, especially during times of high reservoir discharge. There is no upstream fish passage from Lucky Peak Reservoir back to Arrowrock Reservoir. Entrained bull trout are restricted to Mores Creek as potential spawning and rearing habitat. In 2000-2001, several juvenile bull trout were observed in Upper Mores Creek by US Forest Service fisheries survey crews. In addition, adfluvial bull trout were tracked out of Lucky Peak migrating upstream to above Idaho City in Mores Creek by US Bureau of Reclamation (BOR) and Forest Service personnel. These fish returned to Lucky Peak during mid-summer, long before spawning season in September and October.

While bull trout are thought to be particularly sensitive to environmental change, their dispersal capabilities afford them the opportunity to potentially re-colonize these disturbed streams once conditions become suitable. However, stable bull trout populations require high quality habitat. Large rivers or lakes supporting migratory populations have the highest potential for supporting large, flourishing populations (Rieman and McIntyre 1993). Detailed discussions of general bull trout biology and life history can be found in Rieman and McIntyre (1993) and the State of Idaho’s Bull Trout Conservation Plan (Batt 1996). Specific to the Boise River Basin, bull trout have been reported throughout the Upper Boise subbasin and have also been found in several areas of the Boise-Mores Creek subbasin. Bull trout found in both subbasins exhibit both the migratory and resident life history forms. For more detailed life history studies on bull trout in the Boise River Basin, see Monnot 2008, Salow 2001, and Flatter 2000.

Bull trout have the capability to colonize all tributaries of the subbasin that do not contain impassable barriers. In almost all situations, bull trout were sympatric (coexisted) with anadromous fish species and were the predominant species group. In the absence of anadromous fish, bull trout have adapted to a fluvial/adfluvial existence. Findings of federal and state biologists indicate that most local populations of bull trout are strongly influenced by the resident form, though the migratory form is important. Migratory forms have been documented in Boise River Basin complexes. The first complex consists of Arrowrock Reservoir and the North Fork Boise River, Middle Fork Boise River, and lower South Fork Boise River. The second complex consists of Anderson Ranch Reservoir and the upper South Fork Boise River. It is notable that migratory forms were historically fluvial in nature but apparently have adapted to an adfluvial lifestyle following construction of both Arrowrock (1915) and Anderson Ranch (1950) dams. As previously mentioned, bull trout entrained into Lucky Peak Reservoir are using this reservoir habitat similarly. Adult bull trout captured in the early spring in Arrowrock and Lucky Peak Reservoirs have attained 28 inches (700 mm) in length (Salow 2001 and Flatter 2000).

Based on the Idaho Fish and Game (IDFG) and BOR research, upstream migration by adult bull trout out of Arrowrock Reservoir begins in early April through early July. These fish enter spawning streams in the Middle and North Forks of the Boise River in late July or August. Spawning commences in September and October when water temperatures decrease below 10^o C. Following spawning, adults reenter the main stems and migrate downstream to winter in Arrowrock Reservoir. Bull trout have patchy distribution within the watersheds of the Boise River Basin. While bull trout distributions are probably influenced by habitat loss, dams, diversions, and exotic species, juvenile bull trout also appear to be naturally restricted to cold stream temperature conditions (Rieman and McIntyre 1993). Suitable bull trout habitat was defined based on the observed relationship of fish distribution with elevation and watershed area (Rieman and McIntyre (1995). For the discussion in this document, an elevation of 5,000 feet (1,524 meters) is used as the necessary criterion for the first three life-history stages. Criteria for life history stages four and five (sub-adult migration post-spawning maintenance) are currently being developed.

Subwatershed Characteristics

The Boise-Mores Creek watershed consists of six subwatersheds defined by 5th field HUCs. Figure 13 shows the boundaries and Table 6 outlines characteristics of 5th field HUCs in the Boise-Mores Creek subbasin. These 5th field HUCs are further subdivided into 24 subwatersheds defined by 6th field HUCs (Figure 14)

Table 6. General characteristics of 5th field HUCs in the Boise-Mores Creek watershed.

5th Field HUC Water Body	Reach Boundaries	5th Field HUC Code	Total Acres
Boise River Arrowrock and Lucky Peak Reservoir	Arrowrock and Lucky Peak Reservoirs	1705011206	72,705
Middle Fork Boise River – Sheep Creek	Middle Fork Boise River from Arrowrock Reservoir to North Fork Boise River	1705011205	52,997
Lower Grimes Creek	Downstream of Granite Creek confluence	1705011202	44,062
Lower Mores Creek	Downstream of Elk Creek confluence	1705011204	79,638
Upper Grimes Creek	Upstream including Granite Creek	1705011201	81,374
Upper Mores Creek	Upstream including Elk Creek	1705011203	66,551

Stream Characteristics

This section describes Rosgen stream types (a widely-used classification method for streams), sinuosity, width-to-depth ratio, surface percent fines, the concept of stream order, and the general vegetation types that are seen in the areas around streams in the Boise-Mores Creek watershed.

Rosgen Stream Types

The Rosgen Stream Classification System (Rosgen 1996) is useful in describing general stream characteristics like channel shape, channel patterns (e.g., braided), valley types in which streams are found in, etc. Based on the geomorphologic characteristics of streams, the Rosgen classification scheme delineates expected ranges for width-to-depth ratios, entrenchment, substrate materials, sinuosity, and gradient. When dealing with streams impaired by sediment, the Rosgen Stream Classification System is an important tool in determining whether a stream is stable or not and whether that instability is leading to contribution of excess sediment to the stream.

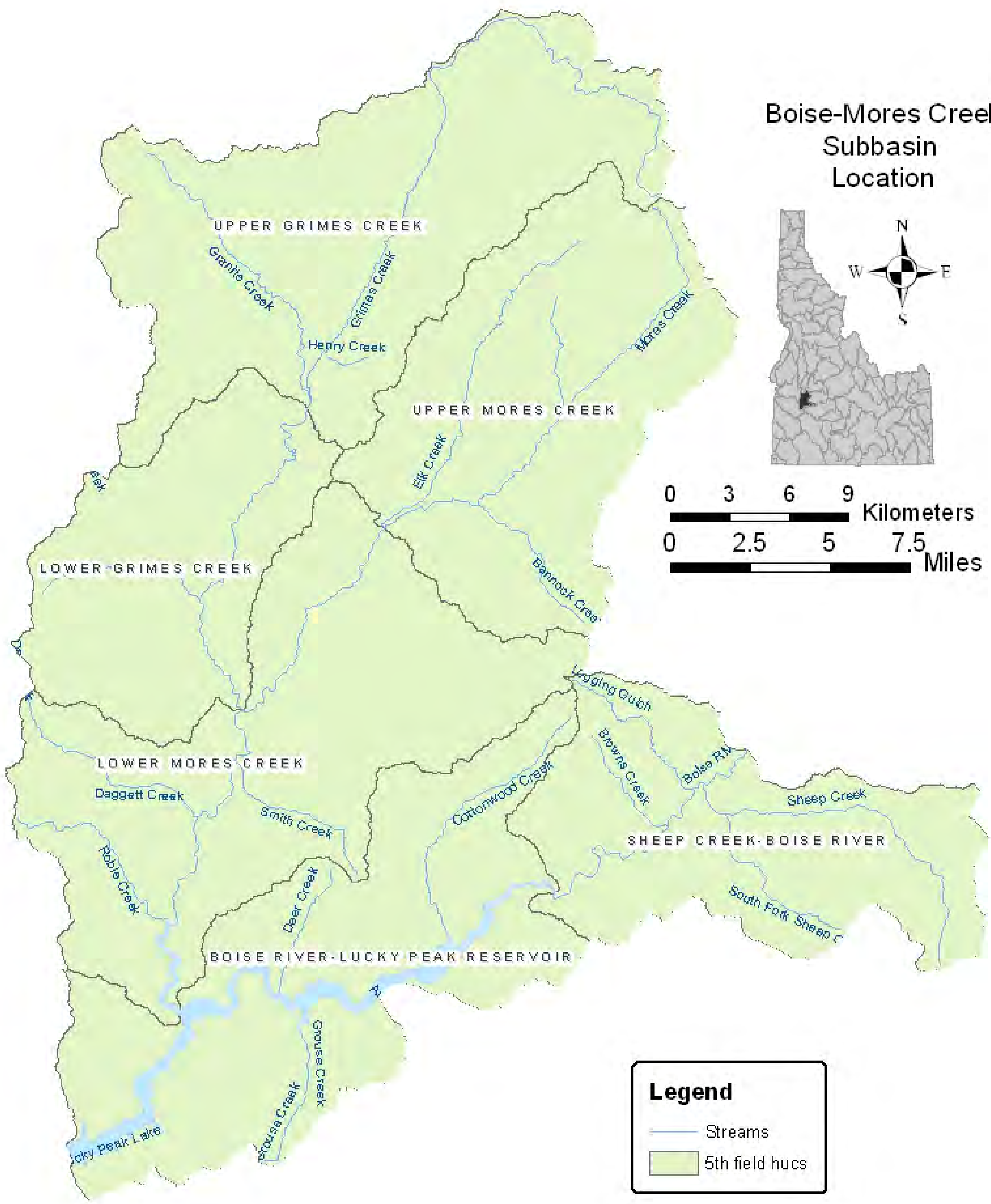

Figure 13. Boundaries of 5th field HUCs in the Boise-Mores Creek subbasin.

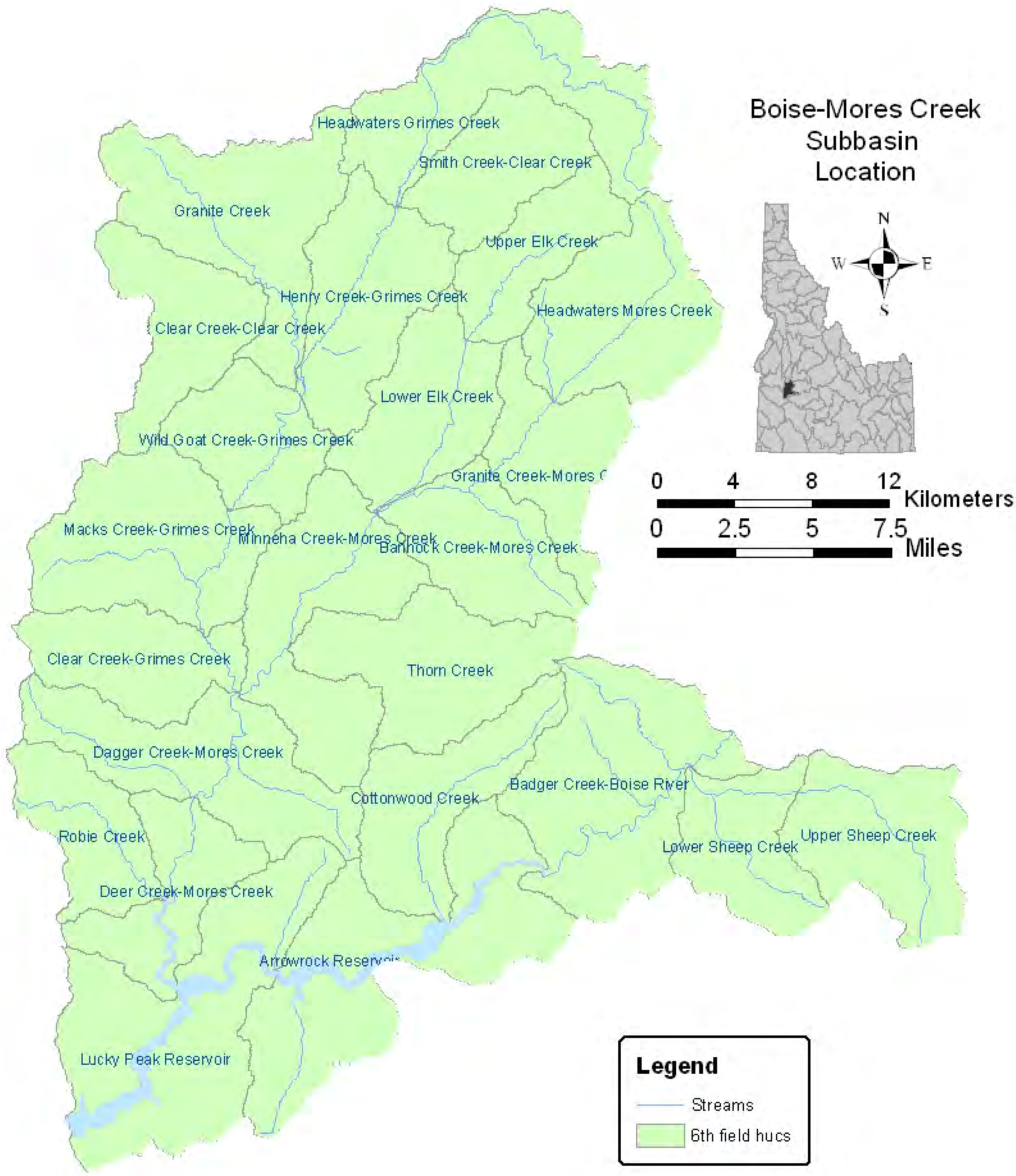

Figure 14. Boundaries of 6th field HUCs in the Boise-Mores Creek subbasin.

Tributary streams in the Boise-Mores Creek watershed originate in either granitic or basaltic parent material. Due to the different topographical attributes and parent material throughout the subbasin, stream channel characteristics are highly variable throughout the watershed. Headwater streams and smaller tributary streams are typically A-type channels (Rosgen 1996) because they course through steeper terrain. These are steep-gradient, low-sinuosity, confined channels with high sediment transport capacity. Channel gradients are greater than 4% and have a cascading, step/pool morphology. These streams have low width-to-depth ratios. B-type channels, which are moderate gradient and are moderately confined, are found downstream of these reaches in less steep areas. These streams usually have relatively stable channels and are also efficient at sediment transport.

Type B streams generally occupy stable channels with moderately stable banks. These streams tend to occur in narrow, gently sloping valleys in areas of moderate relief. They may be moderately entrenched in low-gradient channels. Channel gradients typically range from 2% - 4%, but may be lower or higher. Width-to-depth ratios are moderate, and bed forms are predominantly riffle with infrequently spaced pools. Moderate gradient and moderately- to well-confined type B channels are predominantly associated with mainstem and tributary reaches within moderate relief landforms.

Type C streams typically occupy low gradient (less than 2%) alluvial channels with broad, well-defined floodplains located in broad valleys. These streams are slightly entrenched within a well-defined meandering channel. Generally, they have a riffle-pool bed morphology with point bars typically developed at meander bends.

Sinuosity

Sinuosity is defined as the degree to which a stream curves from side to side. Sinuosity is important in developing fish habitat structure and reducing sediment transfer. Higher sinuosity is generally found in Rosgen B- and C-type channels.

Width-to-Depth Ratio

Width-to-depth ratio (W:D) provides a dimensionless index of channel morphology and can be an indicator of change in the relative balance between sediment load and sediment transport capacity. Large W:D ratios are often a result of lateral bank cutting due to increased peak flows, sedimentation, and eroding stream banks (Overton et al. 1995). Very high W: D ratios can cause reduced pool numbers, increased stream temperature, increased bank erosion, and excess sediment delivery. In the Idaho Batholith, W: D ratios less than 10 are not common, even in wilderness streams (Overton et al. 1995).

Surface Percent Fines

The particle size of the substrate directly affects the flow resistance of the channel, the stability of the streambed, and the amount of available aquatic habitat. If substrate is predominantly composed of fines, then the spaces between the particles are too small to provide refuge for most organisms. The highest biotic diversity is found in streams with a complex substrate of boulders, cobble, gravel, and sand. When small fines (less than 6.35mm) exceed 20 - 25% of the total substrate, embryo survival and emergence of fry is reduced by up to 50% (Bjorn and Reiser 1991).

Based on available Beneficial Use Reconnaissance Program (BURP) data, Table 7 lists averaged values of the following parameters for 6th field HUCs in the subbasin: Rosgen channel type, gradient, sinuosity, width-to-depth ratio, and percent fines.

Table 7. Averaged stream characteristics of 6th field HUCs in the Boise-Mores Creek watershed.

6th Field HUC Water Body	6th Field HUC Unit	Rosgen Channel Type	Gradient	Sinuosity	Width-to-Depth Ratio	Percent Fines
Browns Creek	SW6	A	5%	LOW	36	20%
Cottonwood Creek	SW7	B	2.5%	LOW	55	20%
Elk Creek	SW12	B	2%	MODERATE	10	5%
Granite Creek	SW14	C	1%	MODERATE	40	32%
Grimes Creek	SW13	A/B/C	2 %	MODERATE	44	9%
Grouse Creek	SW3	B	2%	MODERATE	3	5%
Macks Creek	SW15	B	3.5%	MODERATE	12	5%
Mores Creek	SW9	A/B/C	3%	MODERATE	30	6%
Robie Creek	SW17	B	2%	MODERATE	7	5%
Sheep Creek	SW5	A/B	3.5-11%	LOW	44	2%
Thorn Creek	SW11	B	2.5%	LOW	41	2%

Stream Order

Stream order is a hierarchical ordering of streams based on the degree of branching. A first order stream is an unforked or unbranched stream. Higher order streams result from the joining of two streams of the same order (Figure 15).

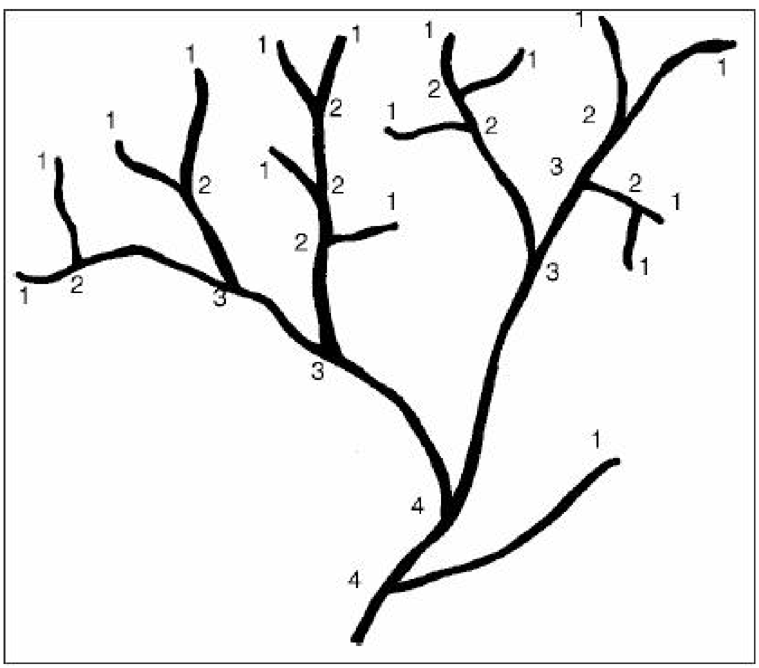

Figure 15. Stream order classification system (Rosgen, 1996).

Riparian Vegetation

The riparian vegetation in much of the Boise-Mores Creek subbasin has been highly disturbed by dredge mining practices. Conifer-forested areas of the subbasin are typically found in headwater reaches. The dominant species include grasses and sedges *(Carex* sp.), ponderosa pine, and Douglas and grand fir up to the stream edge. Conifer meadows and areas where conifers are further from the stream bank provide less shade, while small shrubs such as alder *(Alnus* sp.), willow (*Salix sp*.), huckleberry, rose, and elk brush dominate the streamside vegetation. A few areas in the upper portions of Grimes Creek have been classified as meadow due to the distance of conifer forests from the bank and the riparian cover consisting of grasses and low shrubs. Willow, alder, red-osier dogwood, (*Cornus stolonifera*) and/or hawthorn (*Crataegus sp.)* dominate areas in the middle elevations of the subbasin. In lower elevations, deciduous trees such as black cottonwood (*Populus trichocarpa*) and aspen are more prevalent along stream banks. The lower portion of Mores Creek is surrounded by high canyon walls with ponderosa pine on the slopes and tall shrubs such as willow and alder closer to the banks.

1.3 Cultural Characteristics

Gold was the principal factor in the establishment of many present day towns in the Boise-Mores Creek subbasin, including Idaho City. During the Civil War, the subbasin was the scene of the richest gold rush in American history. Mineral deposits of gold were discovered near Centerville in the Grimes Creek basin on August 2, 1862. There was a rapid influx of people into the area following this discovery. The majority of people were miners and prospectors whose main interest was to acquire the mineral wealth from the streams and soils of the area. Idaho City was founded near the confluence of Elk and Mores Creeks in December 1862. This area supported numerous mines and camps. As many as 20,000 miners came to the area of Mores and Grimes Creeks. By the middle of September, 1863, Idaho City had a population of 6,267. At that time, it was the largest city in the Northwest. Placerville previously had been the most populous. At this time, Boise had a population of nearly 1,000. At its peak, Idaho City's population numbered in the tens of thousands, but most departed once mining declined. The only current incorporated townships in the watershed are Idaho City and Placerville. The modern economy relies mainly on natural resources and tourism.

Water quality is influenced by both natural and human factors. Gold mining was accomplished through sluice operation and hydraulic mining of slopes. These practices drastically altered the hydrology and riparian habitat. This section provides an overview of the cultural characteristics that affect water quality. The economy, land use, infrastructure, and development history of an area can all affect water quality. The Boise-Mores Creek watershed has a long history of mining, followed by timber harvest, ranching, and recreation, all of which have influenced patterns of settlement and water resource use.

Land Use/Ownership

Land use was estimated using a 1971 USGS land use GIS coverage and a GIS coverage from the U.S. Census Bureau (2000). According to the 1971 land use information available from USGS (Table 8 and Figure 16), 81.5% of the subbasin is forested with conifers and occasional aspen stands. Seventeen percent of the subbasin is rangeland, most of which is ungrazed or lightly grazed. Figure 10 shows the vegetative cover of the watershed. Urban land acreage was taken from the U.S. Census Bureau data for Idaho City and Placerville. There are several large subdivisions and numerous single owner land parcels used for permanent residences in addition to the urban areas. These could not be readily estimated and thus were not included in the urban land use acreage estimate.

Table 8. Land use, total acres and percent of total acres in 1971.

Land Use Description	Acres	Percent of Total
Forest	323,510	81.5
Rangeland	69,249	17.4
Urban	1,107	0.3
Water	3,276	0.8

Figure 17 shows the road types present in the subbasin. Highway 21 (indicated in Figure 17 with a blue line) is the only state highway in the Boise-Mores Creek subbasin. In addition to the highway, there are 531 miles of local access roads that are mostly gravel surfaces (indicated with black lines). Roads are prohibited only in the Sheep Creek drainage, which is located in the blue-shaded eastern section of Figure 17. The tan-shaded sections of the subbasin are areas where motorized travel is restricted to improved roads. In the subbasin, highways and local roads crossing perennial streams have open arch bridges or culverts. Sixteen culverts that were inventoried in 2003 and 2004 by U.S. Forest Service (USFS) culvert survey crews were found to pose potential problems for fish passage. These culvert locations are marked with red circles in Figure 17. DEQ is not aware of any surveys to determine fish passage on state or private land, therefore potential problems for fish passage through road culverts may be underestimated in the basin.

Table 9 and Figure 18 show land ownership information for the subbasin. About 79% (313,208 acres) of the Boise-Mores Creek watershed is public land (Figure 18). Federal agencies manage approximately 260,000 acres, and state and local governments manage just over 53,000 acres. Private ownership, totaling nearly 84,000 acres, is clustered in areas with low topographical relief in the subbasin.

Table 9. Land ownership/management, acres, and percent total acres.[1]

Ownership/Management	Total Acres	Percent of Total Acres
USFS	245,685	61.9
Private	83,925	21.1
State	43,792	11.0
BLM	11,935	3.0
State of Idaho Department of Fish and Game	9,247	2.3
Military	2,549	0.6

[1]Data from BLM 2004

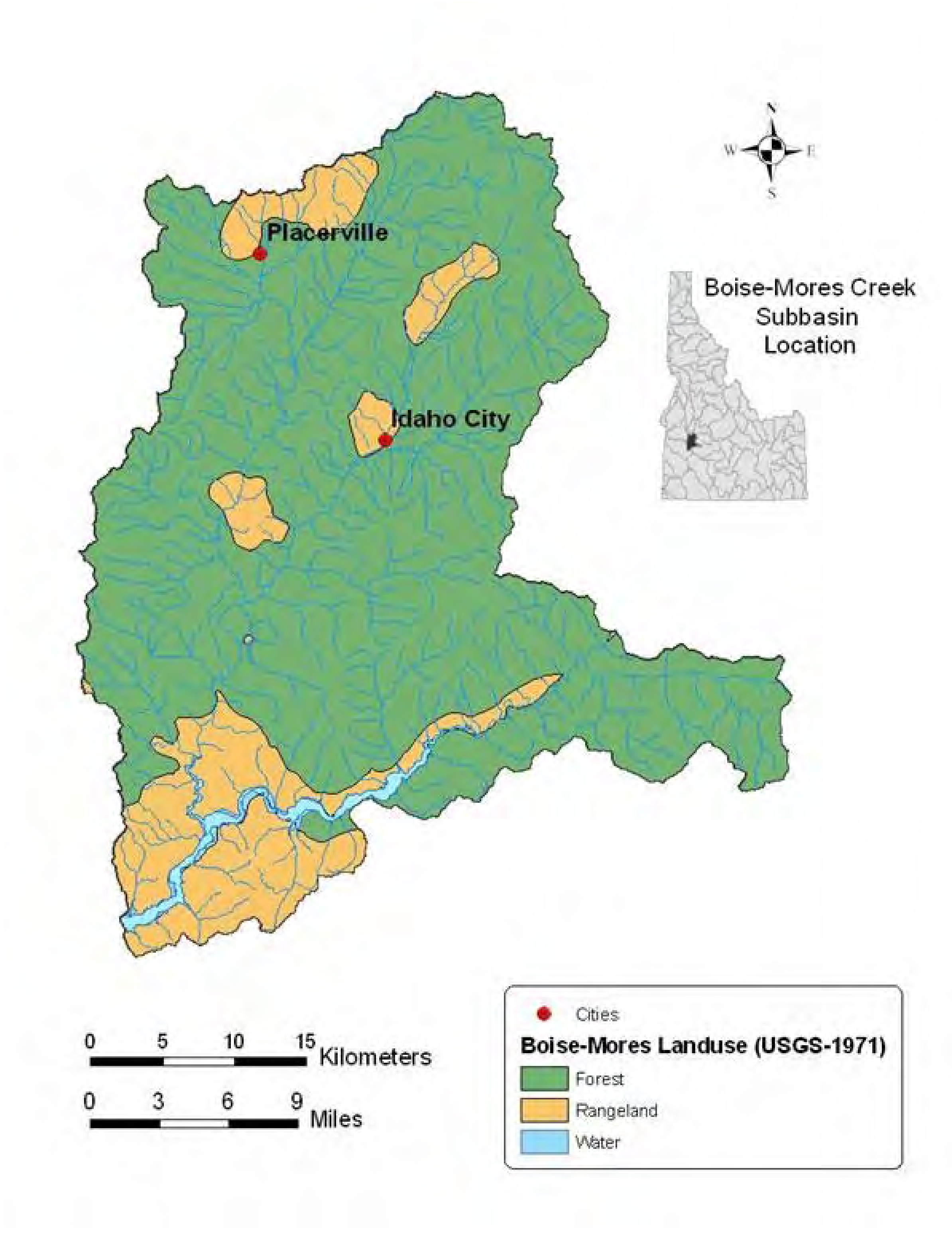

Figure 16. Boise-Mores Creek subbasin land use.

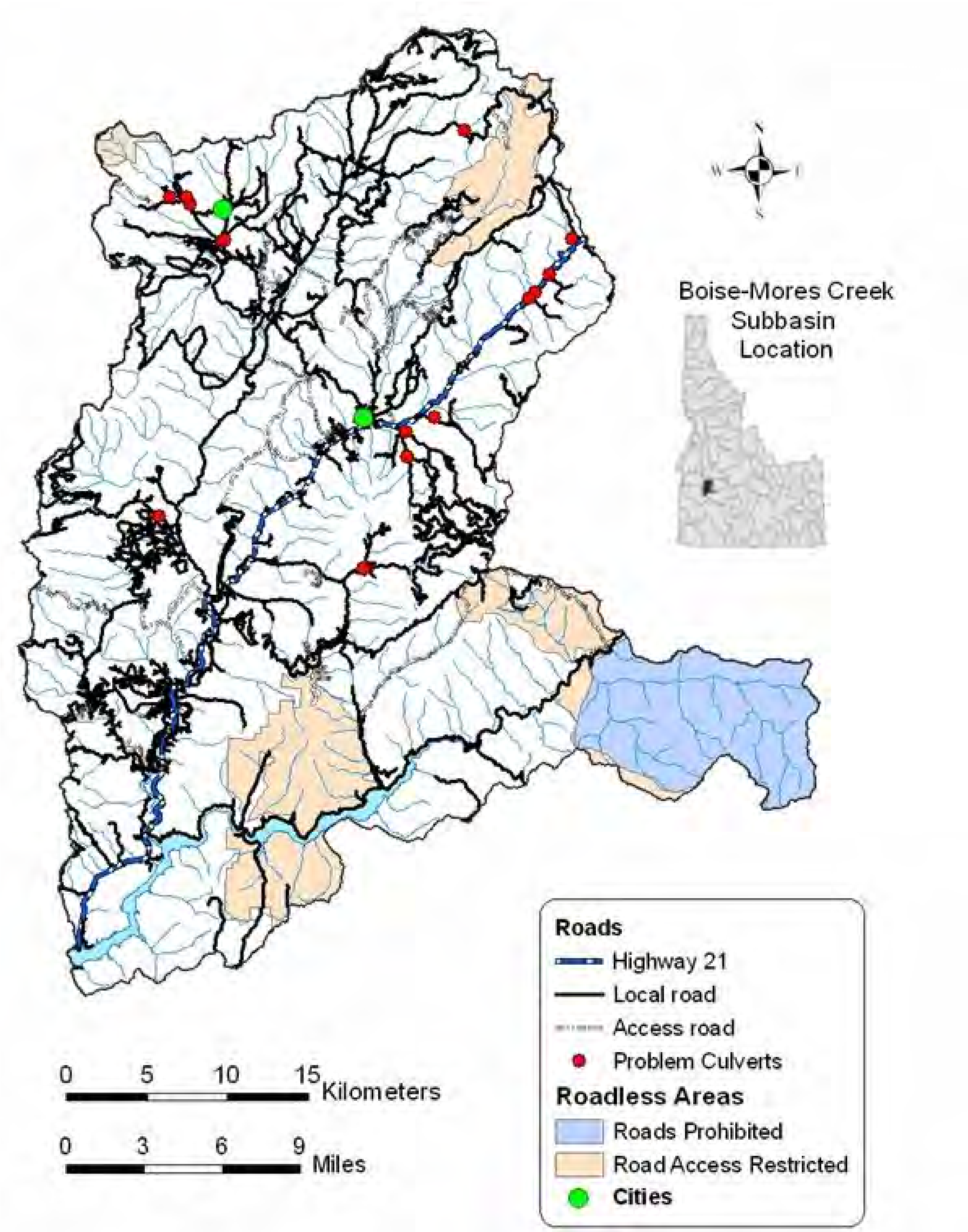

Figure 17. Road types, motorized vehicle restricted areas, and culverts potentially limiting fish passage on Boise National Forest land in the Boise-Mores Creek subbasin.

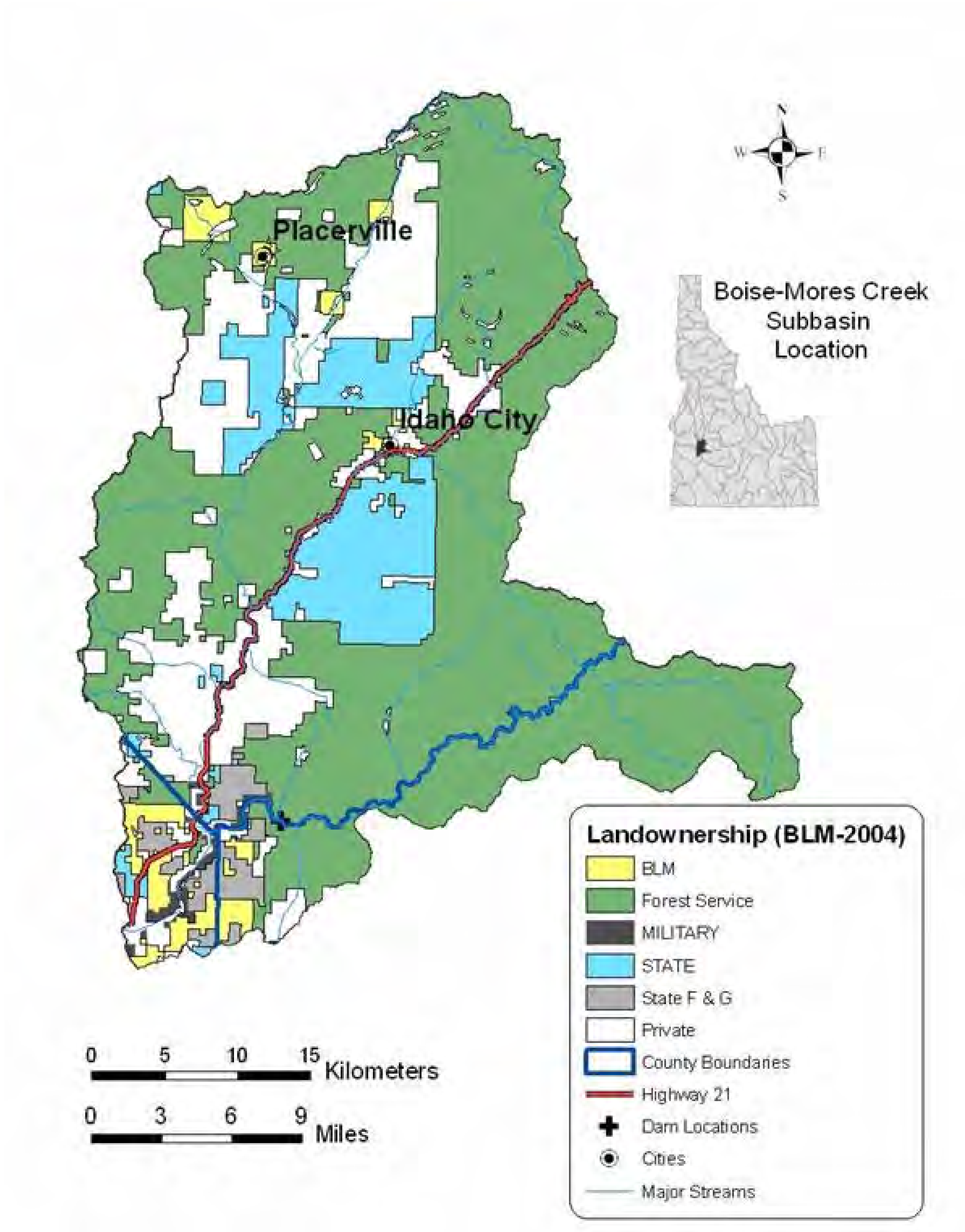

Figure 18. Land ownership in the Boise-Mores Creek subbasin.

The Boise-Mores Creek subbasin lies primarily within Boise County, with the majority of the County's population inside watershed boundaries. The extreme southwestern tip of the watershed is located in Ada County, and the southeastern side is in Elmore County. These portions of Ada and Elmore Counties are almost exclusively state or federally owned.

Within the watershed, there is a gradual shift of forest and rangeland starting to include more residential private property. As Idaho's population continues to increase, land use in the subbasin is beginning to shift toward urbanization. Figure 10 shows only a small percentage of land designated as urban land use. Since construction on the Wilderness Ranch subdivision began in the 1980s, other developments have begun construction along the canyon rims of Lucky Peak Reservoir and into the forested tributaries of Mores Creek. As the Treasure Valley grows, outlying areas, such as the Boise-Mores Creek watershed, which are within a reasonable commute of Boise, will likely continue to urbanize as well. Within the subbasin, probable areas of new residential construction include the privately owned sections near Lucky Peak Reservoir, Idaho City, and Placerville. The majority of new building construction permits in Boise County have been issued for construction in unincorporated areas (Figure 19). Population trends reviewed and identified in the Boise County Comprehensive Plan project a doubling of the population from 2000 to 2010. This increased number of residents will likely reside in unincorporated areas served by unimproved road surfaces. Sediment generation from these road surfaces will likely exacerbate current sediment issues in the subbasin,

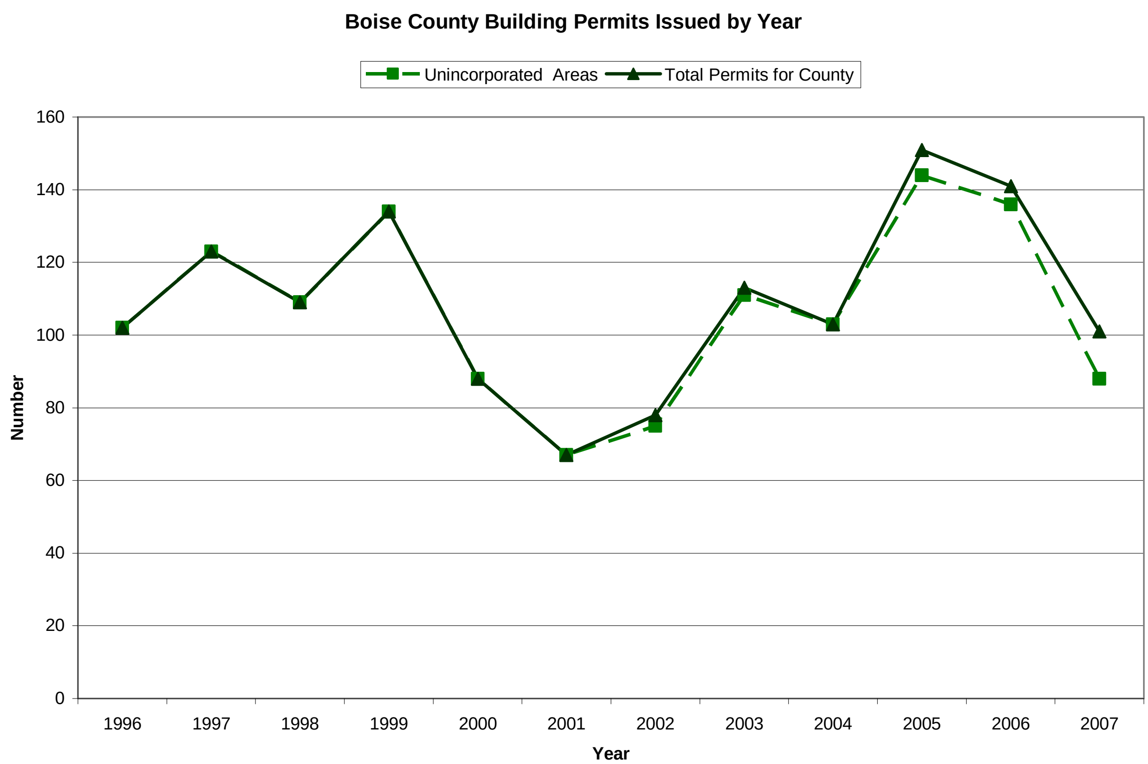

Figure 19. Building Permits Issued in Boise County from 1996 to 2007.

Population

Since the majority of the watershed lies within Boise County, statistics for this county will be used to describe the population and economics. Besides Idaho City and Placerville, other incorporated cites in the county include Horseshoe Bend, Crouch, Garden Valley, and Lowman. Horseshoe Bend is the largest city, with a population of 770 in the 2000 census. Idaho City is the next most populous, with a population of 458. Idaho City is the county seat. According to the US Census Bureau, the average commute time in the county is 37 minutes, indicating that many residents either commute outside the county to larger cities for work or live outside incorporated areas in the county. The area has experienced moderately sharp population growth in the last decade as shown in Figure 20. The population continues to expand, as the population from the 2006 census was 7,641. Boise County population grew by 14.6% between 2000 and 2006, compared to an increase of 13.3% in Idaho as a whole.

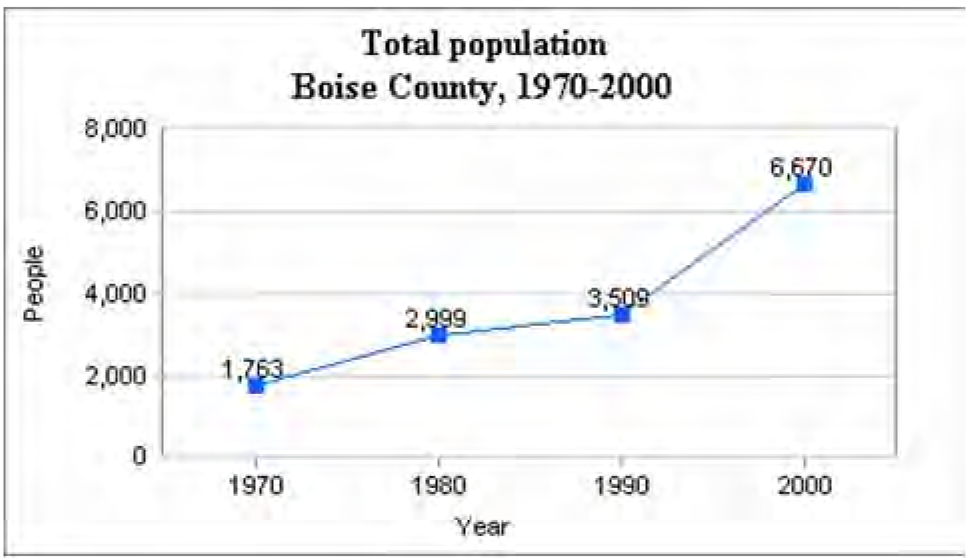

Figure 20. Boise County population from 1970 to 2000.

Economics

The Boise County economy is considered to be federal/state dependent, as determined by the US Department of Agriculture (USDA) Economic Research Service. Fifteen percent or more of the average annual labor earnings were derived from government during 1998-2000. Categories of employment for Boise County and their distribution are listed in Table 10. In 2003, the four US industries with the largest shares of employment nationwide were government (14.2%), retail trade (11.0%), health care and social assistance (9.9%), and manufacturing (9.0%). In Boise County, government accounted for 21.5% of employment, which is considerably higher than the national average for counties. Retail trade in Boise County accounted for 7.6% of employment, while health care and social assistance accounted for 3.7%, and manufacturing for 3.2%.

Table 10. Summary of employment by industry.[1]

Industry[1]	Percent of County Employment
Government	21.5%
Recreation	14.4%
Construction	8.8%
Accommodation and food services	8.0%
Retail trade	7.6%
Other services, except public administration	5.3%
Farm	3.7%
Manufacturing	3.2%
Other categories, each containing less than 2% of total employment.	27.5%

[1]US Department of Agriculture, Economic Research Service, 2004. County Typology Codes (http://www.ers.usda.gov/Briefing/Rurality/Typology/).

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2. Subbasin Assessment – Water Quality Concerns and Status

This section discusses water quality data and the relationship to beneficial use support in more detail for each assessment unit. Since assessment units often encompass several streams, individual streams and their associated watersheds may be discussed separately from the rest of the assessment unit. The uniform use of assessment units began in mid-2004 and further explanation of assessment units is provided below. Some individual streams or groups of streams of the same order are discussed in Section 2.4. Streams that are not on the §303(d) list are also discussed in this section even though they do not have impaired beneficial uses, for informational purposes. This report presents all information that DEQ was able to gather regarding water bodies in the watershed, because this information allows the reader to gain a good understanding of the whole watershed.

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

The Boise-Mores Creek watershed contains eight water quality-limited assessment units. Figure B shows the general location of §303(d)-listed listed stream assessment units, and they are summarized in Table 11. This section will discuss which stream segments are water quality-limited and the potential pollutants that are causing beneficial use impairment.

Section 303(d) of the Clean Water Act (CWA) states that waters that are unable to support their beneficial uses and that do not meet water quality standards must be listed as water quality-limited waters. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

About Assessment Units

Assessment units (AUs) now define all the waters of the state of Idaho. These units and the methodology used to describe them can be found in the WBAGII (Grafe et al 2002).

The 21 major river basins of the United States are subdivided into hydrologic units by region and assigned a 2-digit code (number). Each regional basin is then subdivided into smaller units (by sub-region, accounting unit, and then cataloging unit) by minor river or stream basins. Each sequential subdivision adds two numbers to the initial regional basin two-digit number. There are 2,264 cataloging units in the United States. Each numbered basin is referred to, or identified by, the corresponding 2- to 8-digit Hydrologic Unit Code (HUC) in hydrologic reports, maps, and documents (USGS 2007).

The Boise-Mores Creek subbasin is in region 17, sub-region 05, accounting unit 01, and cataloging unit 12. The resulting HUC for the Boise-Mores Creek subbasin is 17050112. In order to identify watersheds within cataloging units, HUCs can be subdivided into individual AUs. AUs are groups of similar streams that often have similar land use practices, ownership, or land management; however, stream order is the main basis for determining AUs — even if ownership and land use change significantly, an AU remains the same.

Using AUs to describe water bodies offers many benefits; primarily, that all the waters of the state are now defined consistently. In addition, using AUs fulfills the fundamental requirement of the 305(b) report, required by EPA under a component of the Clean Water Act whereby states report on the condition of all the waters of the state. Because AUs are extensions of water body identification numbers, there is now a direct tie to the water quality standards for each AU, so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

However, the new framework of using AUs for reporting and communicating needs to be reconciled with the legacy of §303(d) listed streams. Due to the nature of the court-ordered 1994 §303(d) listings, and the subsequent 1998 §303(d) list, all segments were added with boundaries from "headwater to mouth." In order to deal with the vague boundaries in the listings, and to complete TMDLs at a reasonable pace, DEQ set about writing TMDLs at the watershed scale (HUC), so that all the waters in the drainage are and have been considered for TMDL purposes since 1994.

The boundaries from the 1998 §303(d) listed segments have been transferred to the new AU framework, using an approach quite similar to how DEQ has been writing SBAs and TMDLs. All AUs contained in the listed segment were carried forward to the 2002 §303(d) listings that now make up Section 5 of the Integrated Report. AUs not wholly contained within a previously listed segment, but partially contained (even minimally), were also included on the §303(d) list. This was necessary to maintain the integrity of the 1998 §303(d) list and to maintain continuity with the TMDL program. These new AUs will lead to better assessment of the need for water quality listing and de-listing.

When new monitoring data indicate full support of beneficial uses, only the AU that the data represents will be removed (de-listed) from the §303(d) list (Section 5 of the Integrated Report).

Because all the units in the Boise-Mores Creek subbasin are within HUC 17050112SW, only the last three digits plus two-digit extension will be used to identify them in this document (except in some cases in tables). For example, assessment unit (AU) 17050112SW009_02 will be abbreviated as AU 009_02.

Listed Waters

Table 11 shows the pollutants listed and the basis for listing for each §303(d)-listed AU in the subbasin. Not all of the water bodies will require a TMDL, as will be discussed later. However, a thorough investigation using the available data was performed before this conclusion was made. This investigation, along with a presentation of the evidence of non-compliance with standards for several other tributaries, is contained in the following sections.

Table 11. §303(d)-listed segments in the Boise-Mores Creek subbasin.

Water Body Name	Assessment Unit ID Number	2008 §303(d) Boundaries	Pollutants	Listing Basis
Mores Creek	17050112SW009_02	1st and 2nd Order	Unknown	DEQ
Mores Creek	17050112SW009_03	3rd Order	Temperature	EPA
Mores Creek	17050112SW009_04	4th Order	Unknown	DEQ
Mores Creek	17050112SW009_06	6th Order	Temperature	EPA
Grimes Creek	17050112SW013_02	1st and 2nd Order	Unknown	DEQ
Grimes Creek	17050112SW013_04	4th Order	Temperature	DEQ
Grimes Creek	17050112SW013_05	5th Order	Unknown	DEQ

2.2 Applicable Water Quality Standards

Idaho adopts both narrative and numeric water quality standards to protect public health and welfare, enhance quality of water, and protect biological integrity. By designating the beneficial use or uses for water bodies, Idaho has created a mechanism for setting criteria necessary to protect those uses and prevent degradation of water quality through anti-degradation provisions. According to IDAPA 58.010.02.050 (02)a 'wherever attainable, surface waters of the state shall be protected for beneficial uses which includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic biota." Beneficial use support is determined by DEQ through its water body assessment process. For streams with no designated beneficial uses, cold water aquatic life and recreation are presumed to be beneficial uses. The following discussion focuses on beneficial uses and water quality criteria, both narrative and numeric, applicable to each of the listed water bodies. A more detailed explanation of the numeric water quality targets developed as an interpretation of the narrative standards for nutrients and sediment can be found later in this section.

Beneficial Uses

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described in the following paragraphs. The Water Body Assessment Guidance, second edition (WBAG II, Grafe et al. 2002) gives a more detailed description of beneficial use identification for use assessment purposes.

Existing Uses

Existing uses under the CWA are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards." The existing in-stream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.050.02, .02.051.01, and .02.053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a stream that could support salmonid spawning, but salmonid spawning is not occurring due to other factors, such as dams blocking migration.

Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing uses).

Presumed Uses

In Idaho, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. These undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric cold water criteria and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen, temperature). However, if for example, cold water aquatic life is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Of the listed streams in the Boise-Mores Creek subbasin, Mores Creek has four designated beneficial uses. They are: support of cold water aquatic life (CW), salmonid spawning (SS), use for primary contact recreation (PCR) and a domestic water supply (DWS). The beneficial uses of cold water aquatic life and primary or secondary contact recreation are presumed for Grimes Creek. Table 12 contains a list of the designated and presumed beneficial uses for each §303(d)-listed stream.

Table 12. Boise-Mores Creek subbasin beneficial uses of §303(d)-listed streams.

Water Body	Uses[a]	Type of Use
Mores Creek	CW, SS, PCR, DWS	Designated
Grimes Creek	CW, PCR or SCR	Presumed
	SS	Existing

[a] CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, DWS – domestic water supply

Table 13 contains a listing of the beneficial uses of water bodies that have been assessed but are not §303(d)-listed. Many of these water bodies have presumed uses rather than designated uses. Arrowrock and Lucky Peak Reservoirs have the same designated beneficial uses as Mores Creek, with the addition of being designated special resource waters (SRW). They are designated as SRW because they possess outstanding recreational and aesthetic qualities and the protection of water quality is of paramount interest to the people of the state of Idaho.

Table 13. Boise-Mores Creek subbasin beneficial uses of assessed, non-§303(d)-listed water bodies.

Water Body	Uses[a]	Type of Use
Lucky Peak Reservoir	CW, SS, PCR, DWS, SRW	Designated
Arrowrock Reservoir	CW, SS, PCR, DWS, SRW	Designated
Grouse Creek	CW, SCR	Presumed
Boise River (confluence of North and Middle Fork Boise River to Arrowrock Reservoir)	CW, SS, PCR, DWS, SRW	Designated
Sheep Creek	CW, SCR	Presumed
Brown Creek	CW, SCR	Presumed
Cottonwood Creek	CW, SCR	Presumed
Deer Creek	CW, SCR	Presumed
Smith Creek	CW, SCR	Presumed
Elk Creek	CW, SCR	Presumed
	DWS	Existing
Thorn Creek	CW, SCR	Presumed
Granite creek	CW, PCR	Designated
Macks Creek	CW, SS, PCR	Designated
Daggett Creek	CW, SCR	Presumed
Robie Creek	CW, SS, PCR	Designated

[a] CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, DWS – domestic water supply, SRW – special resource water

Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250) (Table 14).

Excess sediment is described by narrative criteria (IDAPA 58.01.02.200.08): "Sediment shall not exceed quantities specified in Sections 250 and 252 or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350."

Narrative criteria for excess nutrients are described in IDAPA 58.01.02.200.06, which states: "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses."

Narrative criteria for floating, suspended, or submerged matter are described in IDAPA 58.01.02.200.05, which states: "Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities."

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the WBAG II (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

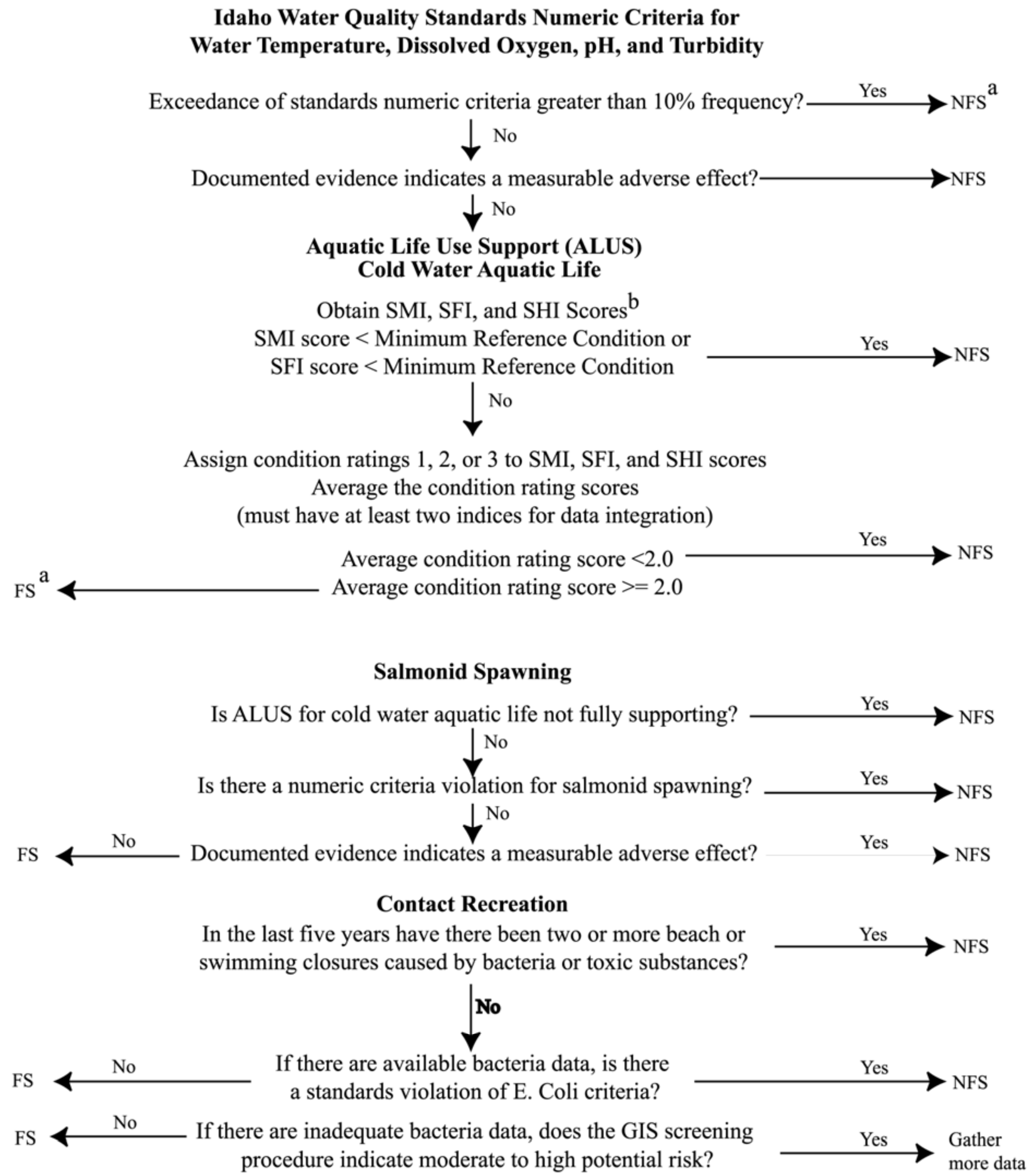
Table 14 is a summary of the water quality standards associated with the designated and assumed beneficial uses in this subbasin.

Figure 21 provides an outline of the stream assessment process for determining support status of the beneficial uses of contact recreation, cold water aquatic life, and salmonid spawning.

Table 14. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.

Designated and Existing Beneficial Uses				
Water Quality Parameter	**Primary Contact Recreation**	**Secondary Contact Recreation**	**Cold Water Aquatic Life**	**Salmonid Spawning (During Spawning and Incubation Periods for Inhabiting Species)**
Water Quality Standards: IDAPA 58.01.02.250				
Bacteria, pH, and Dissolved Oxygen	Less than 126 *E. coli*/100 ml[a] as a geometric mean of five samples over 30 days; no sample greater than 406 *E. coli* organisms/100 ml For public swim beaches: No single sample over 235 *E. coli*/100ml. Values above this should be used in considering beach closures	Less than 126 *E. coli*/100 ml as a geometric mean of five samples over 30 days; no sample greater than 576 *E. coli*/100 ml	pH between 6.5 and 9.0 DO[b] exceeds 6.0 mg/L[c]	pH between 6.5 and 9.5 Water Column DO: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater Intergravel DO: DO exceeds 5.0 mg/L for a one day minimum and exceeds 6.0 mg/L for a seven day average
Tempera-ture[d]			22 °C or less daily maximum; 19 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average Bull trout: not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June – August; not to exceed 9 °C daily average in September and October
Turbidity			Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days.	
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131				
Tempera-ture				7 day moving average of 10 °C or less maximum daily temperature for June - September

[a] *Escherichia coli* per 100 milliliters
[b] dissolved oxygen
[c] milligrams per liter
[d] Temperature Exemption - Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the seven-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.
[e] Nephelometric turbidity units



[a] FS = fully supporting, NFS = not fully supporting

[b] SMI = Stream Macroinvertebrate Index, SFI = Stream Fish Index, SHI = Stream Habitat Index

Figure 21. Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: *Water Body Assessment Guidance,* Second Addition (Grafe *et al*. 2002).

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses of streams are naturally-occurring stream characteristics that have been altered by humans. That is, streams naturally have sediment, nutrients, and the like, but when anthropogenic sources cause these to reach unnatural levels, they are considered “pollutants” and can impair the beneficial uses of a stream.

Temperature

Temperature is a water quality factor integral to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or cold water aquatic community is present. Many factors, natural and anthropogenic, affect stream temperatures. Natural factors include altitude, aspect, climate, weather, riparian vegetation (shade), and channel morphology (width and depth). Human-influenced factors include heated discharges (such as those from point sources), riparian alteration, channel alteration, and flow alteration.

Elevated steam temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low dissolved oxygen or poor food supply. Acceptable temperature ranges vary for different species of fish, with cold water species being the least tolerant of high water temperatures. Temperature as a chronic stressor to adult fish can result in reduced body weight, reduced oxygen exchange, increased susceptibility to disease, and reduced reproductive capacity. Acutely high temperatures can result in death if they persist for an extended length of time. Juvenile fish are even more sensitive to temperature variations than adult fish, and can experience negative impacts at a lower threshold value than the adults, manifesting in retarded growth rates. High temperatures also affect embryonic development of fish before they even emerge from the substrate. Similar kinds of affects may occur to aquatic invertebrates, amphibians, and mollusks, although less is known about them.

Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to stream purification. Dissolved oxygen (DO) is the concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. While air contains approximately 20.9% oxygen gas by volume, the proportion of oxygen dissolved in water is about 35%, because nitrogen (the remainder) is less soluble in water. Oxygen is considered to be moderately soluble in water. A complex set of physical conditions that include atmospheric and hydrostatic pressure; turbulence, temperature, and salinity affect the solubility.

Dissolved oxygen levels of 6 mg/L and above are considered optimal for aquatic life. When DO levels fall below 6 mg/L, organisms are stressed, and if DO levels fall below 3 mg/L for a prolonged period, these organisms may die; oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Dissolved oxygen levels below 1 mg/L are often referred to as hypoxic; anoxic conditions refer to those situations where there is no measurable DO.

Juvenile aquatic organisms are particularly susceptible to the effects of low DO due to their high metabolism and low mobility (they are unable to seek more oxygenated water). In addition, oxygen is necessary to help decompose organic matter in the water and bottom sediments. Dissolved oxygen reflects the health or the balance of the aquatic ecosystem.

Oxygen is produced during photosynthesis and consumed during plant and animal respiration and decomposition. Oxygen enters water from photosynthesis and from the atmosphere. Where water is more turbulent (e.g., riffles, cascades), the oxygen exchange is greater due to the greater surface area of water coming into contact with air. The process of oxygen entering the water is called aeration.

Water bodies with significant aquatic plant communities can have significant DO fluctuations throughout the day. Oxygen sags will typically occur once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. As flows decrease, the amount of aeration typically decreases and the in-stream temperature increases, resulting in decreased DO. Channels that have been altered to increase the effectiveness of conveying water often have fewer riffles and less aeration. Thus, these systems may show levels of DO that are depressed in comparison to levels before the alteration. Nutrient-enriched waters have a higher biochemical oxygen demand due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand results in lower in-stream DO levels.

Sediment

Both suspended (floating in the water column) and bedload (moving along the stream bottom) sediment can have negative effects on aquatic life communities. Many fish species can tolerate elevated suspended sediment levels for short periods of time, such as during natural spring runoff, but longer durations of exposure are detrimental. Elevated suspended sediment levels can interfere with feeding behavior (difficulty finding food due to visual impairment), damage gills, reduce growth rates, and in extreme cases can eventually lead to death.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on streams and estuaries. For rainbow trout, physiological stress, which includes reduced feeding rate, is evident at suspended sediment concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species, although the data sets are less reliable. Adverse effects on habitat, especially spawning and rearing habitat presumably from sediment deposition, were noted at similar concentrations of suspended sediment.

Organic suspended materials can also settle to the bottom and, due to their high carbon content, lead to low intergravel DO through decomposition. In addition to these direct effects on the habitat and spawning success of fish, detrimental changes to food sources may also occur. Aquatic insects, which serve as a primary food source for fish, are affected by excess sedimentation. Increased sedimentation leads to a macroinvertebrate community that is adapted to burrowing, thereby making the macroinvertebrates less available to fish. Community structure, specifically diversity, of the aquatic macroinvertebrate community is diminished due to the reduction of coarse substrate habitat.

Settleable solids are defined as the volume (milliliters [ml]) or weight (mg) of material that settles out of a liter of water in one hour (Franson et al. 1998). Settleable solids may consist of large silt, sand, and organic matter. Total suspended solids (TSS) are defined as the material collected by filtration through a 0.45 µm (micrometer) filter (Standard Methods 1975, 1995). Settleable solids and TSS both contain nutrients that are essential for aquatic plant growth. Settleable solids are not as nutrient-rich as the smaller TSS, but they do affect river depth and substrate nutrient availability for macrophytes. In low flow situations, settleable solids can accumulate on a stream bottom, thus decreasing water depth. This increases the area of substrate that is exposed to light, facilitating additional macrophyte growth.

Increased levels of turbidity dramatically reduce light penetration in both lakes and streams and are associated with decreased production and abundance of plant material (primary production), decreased abundance of food organisms (secondary production), decreased production and abundance of fish (Lloyd et al. 1987), decreased growth of fish (Sigler et al. 1984), and decreased predatory efficiency (Sweka and Hartman 2001). Benthic invertebrates tend to drift as turbidity increases (Runde and Hellenthal 2000, Shaw and Richardson 2001). Predatory salmonids also avoid highly turbid waters (Servizi and Martens 1992) and they do not benefit from increased drift associated with turbidity (Shaw and Richardson 2001) because sight distances and capture rates are reduced (Vogel and Beauchamp 1999). Servizi and Martens (1992) showed that coho salmon were relatively tolerant of low-turbidity suspended solids, but that behavioral responses match other studies when turbidity levels were considered.

Turbidity includes both organic and inorganic particles. The inorganic component of turbidity may be comprised of clay, silt, or other finely divided inorganic matter of less than 2 mm diameter (APHA et al. 1995). Plankton, microscopic organisms, and finely divided organic matter make up the organic component of turbidity. Generally speaking, the component of concern as it relates to physiological effects on fish and macroinvertebrates is the inorganic component.

Bacteria

Escherichia coli or *E. coli*, a species of fecal coliform bacteria, is used by the state of Idaho as the indicator for the presence of pathogenic microorganisms. Pathogens are a small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa), which, if taken into the body through contaminated water or food, can cause sickness or even death. Some pathogens are also able to cause illness by entering the body through the skin or mucous membranes.

Direct measurement of pathogen levels in surface water is difficult because pathogens usually occur in very low numbers and analysis methods are unreliable and expensive. Consequently, bacteria that are often associated with pathogens but generally occur in higher concentrations and are thus more easily measured are assessed and treated as an indicator of pathogens.

Coliform bacteria are unicellular organisms found in feces of warm-blooded animals such as humans, domestic pets, livestock, and wildlife. Coliform bacteria are commonly monitored as part of point source discharge permits (National Pollution Discharge Elimination System [NPDES] permits), but may also be monitored in nonpoint source arenas. The human health effects from pathogenic coliform bacteria range from nausea, vomiting, and diarrhea to acute respiratory illness, meningitis, ulceration of the intestines, and even death. Coliform bacteria do not have a known effect on aquatic life.

Coliform bacteria from both point and nonpoint sources impact water bodies, although point sources are typically permitted and offer some level of bacteria-reducing treatment prior to discharge. Nonpoint sources of bacteria are diffuse and difficult to characterize. Unfortunately, nonpoint sources often have the greatest impact on bacteria concentrations in water bodies. This is particularly the case in urban storm water and agricultural areas. *E. coli* is often measured in colony forming units (cfu) per 100 ml.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. The excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system.

The first step in identifying a water body's response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass. Either phosphorus or nitrogen may be the limiting factor for algal growth, although phosphorus is most commonly the limiting nutrient in Idaho waters. Ecologically speaking, a resource is considered limiting if the addition of that resource increases growth.

Total phosphorus (TP) is the measurement of all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90% of the TP present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than TP that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the TP fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

Nitrogen may be a limiting factor at certain times if there is substantial depletion of nitrogen in sediments due to uptake by rooted macrophyte beds. In systems dominated by blue-green algae, nitrogen is not a limiting nutrient due to the algal ability to fix nitrogen at the water/air interface.

Total nitrogen to TP ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited system. Only biologically available forms of the nutrients are used in the ratios because these are the forms that are used by the immediate aquatic community.

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in the sediment or the water column, aquatic plants will store an abundance of such nutrients in excess of the plants' actual needs, a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays in the water column and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the river sediment. As a result of this process, nutrients (including orthophosphate) that are initially released into the water column in a dissolved form will eventually become incorporated into the river bottom sediment. Once these nutrients are incorporated into the river sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. This cycle is known as nutrient spiraling. Nutrient spiraling results in the availability of nutrients for later plant growth in higher concentrations downstream.

Sediment – Nutrient Relationship

The linkage between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems. Phosphorus is typically bound to particulate matter in aquatic systems and, thus, sediment can be a major source of phosphorus to rooted macrophytes and the water column. While most aquatic plants are able to absorb nutrients over the entire plant surface due to a thin cuticle (Denny 1980), bottom sediments serve as the primary nutrient source for most sub-stratum attached macrophytes. The USDA (1999) determined that other than harvesting and chemical treatment, the best and most efficient method of controlling growth is by reducing surface erosion and sedimentation.

Sediment acts as a nutrient sink under aerobic conditions. However, when conditions become anoxic, sediment releases phosphorus into the water column. Nitrogen can also be released, but the mechanism by which it happens is different. The exchange of nitrogen between sediment and the water column is, for the most part, a microbial process controlled by the amount of oxygen in the sediment. Under aerobic conditions, ammonia is oxygenated in a nitrification process, which releases nitrogen oxide (NO_x) to the atmosphere. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced, which results in a reduction of nitrogen oxide (NO_x) that is lost to the atmosphere.

Sediments can play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters and large rivers. In many cases there is an immediate response in phytoplankton biomass when external nutrient sources are reduced. In other cases, the response time is slower, often taking years. Nonetheless, the relationship is important and must be addressed in waters where phytoplankton is in excess.

Floating, Suspended, or Submerged Matter (Nuisance Algae)

Algae are an important part of the aquatic food chain. However, when elevated levels of algae impact beneficial uses, the algae are considered a nuisance aquatic growth. The excess growth of phytoplankton, periphyton, and/or macrophytes can adversely affect both aquatic life and recreational water uses. Algal blooms occur where adequate nutrients (nitrogen and/or phosphorus) are available to support growth. In addition to nutrient availability, flow rates, velocities, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. Low velocity conditions allow algal concentrations to increase because physical removal by scouring and abrasion does not readily occur. Increases in temperature and sunlight penetration also result in increased algal growth. When the aforementioned conditions are appropriate and nutrient concentrations exceed the quantities needed to support normal algal growth, excessive blooms may develop.

Commonly, algae blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, blue-green algae often produce toxins that can result in skin irritation to swimmers and illness or even death in organisms ingesting the water. The toxic effect of blue-green algae is worse when an abundance of organisms die and accumulate in a central area.

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water and can produce intense coloration of both the water and shorelines as cells accumulate along the banks. In extreme cases, algal blooms can also result in impairment of agricultural water supplies due to toxicity. Water bodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. The extent of the effect is dependent on both the type(s) of algae present and the size, extent, and timing of the bloom.

When algae die in areas with low flow velocity, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, a large algal bloom can substantially deplete DO concentrations near the bottom. Low DO in these areas can lead to decreased fish habitat as fish will not frequent areas with low DO. Both living and dead (decomposing) algae can also affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low DO levels caused by decomposing organic matter can lead to changes in water chemistry and a release of sorbed phosphorus to the water column at the water/sediment interface.

Excess nutrient loading can be a water quality problem due to the direct relationship of high TP concentrations with excess algal growth within the water column, combined with the direct effect of the algal life cycle on DO and pH within aquatic systems. Therefore, the reduction of TP inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae, which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in nutrient (phosphorus) levels, nuisance algae, DO, and pH.

2.4 Summary and Analysis of Existing Water Quality Data

This section presents the most recent data for the watershed. The reservoirs are discussed first, then water bodies that are not on the §303(d) list, and for which data is available that can be used to assess support of beneficial uses, are discussed as a group. Following that, the rest of the section discusses individual water bodies in the Boise-Mores Creek subbasin that are on the §303(d) list.

The information presented is used to determine whether beneficial uses (i.e., aquatic life, contact recreation) are impaired. A TMDL to restore beneficial uses is necessary if the data shows that beneficial uses are impaired by pollutants.

A temperature TMDL using the potential natural vegetation (PNV) approach has been developed for Mores Creek and all its tributaries. This TMDL includes allocations for all assessment units for Daggett Creek, Elk Creek, Granite Creek, Grimes Creek, Mack's Creek, Smith Creek, and Thorn Creek. Available temperature monitoring data and assessment outcomes for these water bodies can be found in Appendix C.

Data Assessment Methods

Several methods were used to evaluate the data for this subbasin assessment. A brief description of each method is located below. For pollutants like temperature and bacteria that have numeric criteria, the data were initially assessed by comparing results to the numeric standard. More information about targets used for narrative criteria such as sediment and nutrients for water bodies that require TMDLs is found in section 5 in the Water Quality Targets subsection.

The analysis of the water quality data for the listed water bodies followed these steps:

1. A general description of the water body and the land surrounding the water body was developed.
2. Hydrology was also described, as this could be a major contributing factor to water body impairment.
3. Water quality data was analyzed to confirm beneficial use support.
4. Biological data was then analyzed to determine if beneficial uses were fully supported.

DEQ – Water Body Assessment Guidance-Second Edition (Grafe et al. 2002)

The WBAG II describes DEQ's methods used to consistently evaluate data and determine the beneficial use support status of Idaho water bodies. The WBAG II utilizes a multi-index approach to determine overall stream support status. The methodology addresses many reporting requirements of state and federal rules, regulations, and policies. For the most part, DEQ Beneficial Use Reconnaissance Program (BURP) data are used in the assessment. However, where available, other data are integrated into the assessment process. An assessment entails analyzing and integrating multiple types of water body data such as biological, physical/chemical, and landscape data to address multiple objectives. The objectives are as follows:

1. Determine beneficial use support status of the water body (i.e., fully supporting versus not fully supporting).
2. Determine biological integrity using biological information or other measures.
3. Compile descriptive information about the water body and data used in the assessment.

The multi-metric index approach measures biological, physiochemical, and physical habitat conditions within a stream. The indexes include several characteristics to gauge overall stream health. Three primary indexes are used: the Stream Macroinvertebrate Index (SMI), the Stream Fish Index (SFI), and the Stream Habitat Index (SHI). The SMI is a direct measure of cold water aquatic life health. The SFI is also a direct measure of cold water aquatic life health, but it is also specific to fish populations. The SHI is used to measure in-stream habitat suitability, although some of the measurements used to generate the SHI are linked to the riparian area. All available BURP data was considered when completing this subbasin assessment. Only data that meets Tier 1 quality requirements was used to make recommendations for changes to the integrated report. A list with BURP site locations and dates of sampling is available in Appendix D**.**

The Stream Habitat Index (SHI) is calculated from a range of habitat inventory parameters including bank stability, riparian cover, percent surface fines, pool quality, large organic debris, etc. Scores range from 1-3, with 3 being the highest score. The Stream Macroinvertebrate Index (SMI) is calculated from nine macroinvertebrate metrics having to do with pollutant tolerance, species diversity, number of individuals, species distribution, etc. Scores range from the lowest, which is below minimum threshold, through the highest score of 3. The below minimum threshold score indicates an impaired aquatic environment and lack of beneficial use support. The Stream Fish Index (SFI) is also calculated from a range of fish metrics and the scores also range from below minimum through a high score of 3. ‘NS’ means that that the stream was not electrofished (NS= not sampled). Not all streams are electrofished, depending upon the safety conditions for electrofishing and whether or not a DEQ staff person with an electrofishing permit is available to electrofish the stream with the stream inventory crew.

A few of the habitat parameters discussed in this report in reference to DEQ, USFS, and U.S. Bureau of Land Management (BLM) data are described below.

Bank Stability

Bank stability is rated by observing existing or potential detachment of soil from upper and lower stream banks and its potential movement into the stream. Measurements of bank angle and bank height may also be recorded. Generally, steeper banks are more subject to erosion and streams with unstable banks will often have poor in-stream habitat. Eroding banks can result in sedimentation, excessively wide streams, decreased depth, and lack of vegetative cover. Banks that are protected by plant root systems or boulder/rock material are less susceptible to erosion.

Surface Fines

The particle size of the substrate directly affects the flow resistance of the channel, stability of the streambed, and amount of aquatic habitat. If the substrate is predominantly composed of fines, then the spaces between the particles are too small to provide refuge for most organisms. The greatest number of species, and thus the greatest diversity, is found in complex substrate habitats, with boulders, stone, gravels, and sand. Coarse materials such as gravels provide a variety of small niches for juvenile fish and benthic invertebrates. Because salmonids have adapted to the natural size distributions of substrate materials, no single sized particle class will provide the optimum conditions for all life stages of salmonids. A mix of gravel with a small amount of fine sediment and small rubble creates optimal conditions for fish spawning. When small fines (< 6.35

mm) exceed 20-25% of the total substrate, embryo survival and emergence of swim-up fry is reduced by 50% (Bjornn and Reiser 1991).

Subsurface Fines

Excessive subsurface fines have detrimental effects on salmonid and invertebrate habitat suitability and redd conditions. Salmonid egg survival and fry emergence of salmonids is lower if substrate has a high percentage of subsurface fines (< 6.35 mm). The fine particles fill pore spaces and suffocate developing fish in their redds (Kondolf 2000). Studies have also found that invertebrate colonization decreases as fine sediment increases from 0 to 30% (Andgradi 1999).

StreamStats

StreamStats is a map-based Web application that allows users to obtain streamflow statistics, basin characteristics, and other information from U.S. Geological Survey (USGS) data-collection stations and ungaged sites of interest. StreamStats users can choose locations of interest from an interactive map and obtain information for these locations. For a USGS data-collection station, the user will get previously published information for the station from a database. If a user selects a location where no data are available (an ungaged site), a Geographic Information System (GIS) program will estimate information for the site. The following paragraph is based on information from the USGS Web site (http://streamstats.usgs.gov) outline the general workings and limitations of StreamStats. Please refer to the Web site for more details about this tool.

StreamStats, a cooperative effort of the USGS and ESRI, Inc., is an integrated GIS application that uses ArcIMS, Arc SDE, Arc GIS and the Arc Hydro Tools. It incorporates a map-based user interface for site selection, a Microsoft Access database that contains information for data collection stations, a GIS program that delineates drainage-basin boundaries and measures physical and climatic characteristics of the drainage basins; and a GIS database that contains land elevation models, historic weather data, and other data needed for measuring drainage basin characteristics and for locating sites of interest in the user interface. For this subbasin assessment, StreamStats was used to gain information on drainage area, stream miles, and the percent of the drainage that is forested.

Lucky Peak Reservoir

Lucky Peak Reservoir is maintained for flood control, water storage, power generation, and recreation. Construction on the dam began in 1949 and was completed in 1961. Lucky Peak Reservoir inundated 11.5 river miles of mainstem Boise River habitat and 4.35 river miles of Mores Creek. The reservoir, when full (elevation 3,055), is 12 miles long. It has 45 miles of shoreline and 3,019 acres of surface area. There are 4,288 acres of public lands surrounding Lucky Peak Lake. These lands are managed for public recreation and wildlife habitat. A paved road traverses the northern shoreline from the Highway 21 Bridge over the Mores Creek arm of the reservoir to Arrowrock Dam. An additional paved road provides access from Highway 21 to Robie Creek. There are ten major and ten minor recreation sites along the lake that are managed by the U.S. Army Corps of Engineers or the Idaho Parks and Recreation Department. The reservoir lies within the Idaho Department of Fish and Game's Boise River Wildlife Management

Area, the major game range in the state. The State of Idaho has developed wildlife habitat especially for mule deer on Lucky Peak government-managed lands.

Flow Characteristics

Lucky Peak reservoir has an active storage capacity of about 264,000 acre-feet. The dam is operated primarily for flood-control purposes and irrigation storage. Lucky Peak Reservoir is generally filled by Memorial Day to provide recreational opportunities and maintained nearly full until Labor Day (Figure 22). Inflow to the reservoir starts with the typical snowmelt regime; however a higher inflow is drawn out due to irrigation releases upstream from Arrowrock Reservoir through Lucky Peak Reservoir during the summer months. Irrigation water is drawn from April through October, and the reservoir is typically maintained at a low level during winter for flood control purposes. In drought years, Lucky Peak Reservoir is drafted when Arrowrock Reservoir nears minimum pool level and releases from Arrowrock are insufficient to meet irrigation demand. The reservoir fills quickly from March through June and then is typically maintained at or near full pool until the end of August.

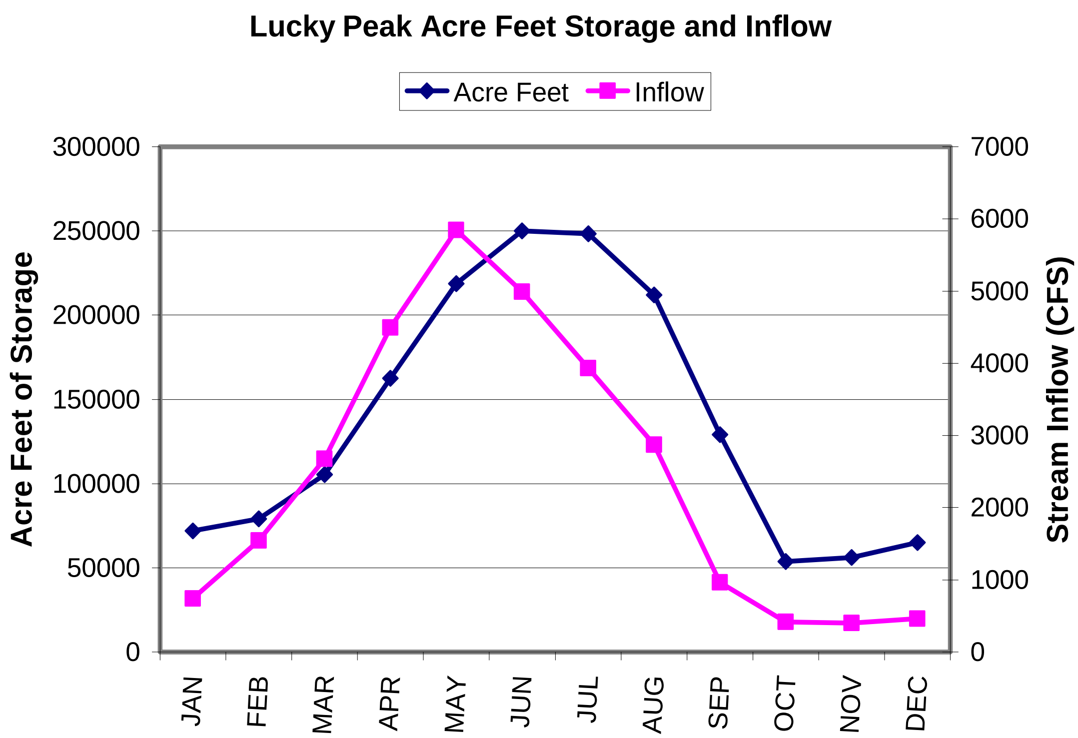


Figure 22. Lucky Peak Reservoir Average Monthly Water Storage and Inflow (1990-2006).

Water Quality Data

Water quality monitoring was done by the Army Corps of Engineers in May, July, and September of 1996 and 1997 and again in October 1998. Measurements of dissolved oxygen, pH, and turbidity were taken at 1- meter intervals for the first 15 meters, 2-meter intervals until 30 meters was reached, and then 5-meter intervals to the bottom. Data show no exceedances of water quality standards (Table 15).

Table 15. Lucky Peak Reservoir water quality data for 1996-1998 sampling.

Water Quality Parameter	Water Quality Standard	Range	Median	Average	% Criterion Exceedance	Beneficial Use Support Status
Dissolved Oxygen** mg/L	DO > 6.0 mg/L	6.3 – 13.1	9.4	9.7	0%	FS
pH	pH between 6.5 and 9.0	7 - 8.9	7.5	7.56	0%	FS
Turbidity (NTU)	5 NTUs over natural background	0 - 3.9	0	0	0	FS

**Does not accommodate for reservoir stratification, FS – Fully Supporting Cold Water Aquatic Life

Bacteria

On June 13, 2006, during routine sampling by the US Army Corps of Engineers (USACE) a sample for *E. coli* was collected at a public swimming beach near the mouth of Robie Creek to determine the beneficial use support status of primary contact recreation. The sample result was 2,400 colony forming units per 100 milliliters of sample (cfu/100ml). Because this result was above Idaho water quality standards trigger point for a public beach of 235 cfu/ml, additional samples were collected by USACE and DEQ over the next 30 days to calculate a geometric mean. Samples continued to exceed the geometric mean criteria of 126 cfu/100 ml until late July (Table 16). At the time these samples were collected, large populations of nesting and rearing geese were present in the beach area and large amounts of feces were observed on the beach. On June 30th, 2006 DEQ collected samples from contributing water bodies in order to determine the potential source of bacteria. A sample from Robie Creek upstream of swimming beach area had 110 cfu/100 ml. Robie Creek at the mouth of the reservoir upstream from the swimming beach had 130 cfu/100 ml. Two samples were also collected from Mores Creek. The sample from the Mores Creek mouth entering Lucky Peak reservoir had 87cfu/100 ml and Mores Creek downstream of Mores Creek Park had 35 cfu/100 ml. The lower bacteria counts from samples away from the beach area helped affirm that the source of *E. coli* bacteria was likely the nesting geese. At times when bacteria levels violate WQS, signs are posted at the beach warning recreationists of potential health risks.

Bacteria samples were collected at Robie Creek beach at least every seven days during summer months in 2007 and 2008 (Figure 23). Each year contaminant levels violated the WQS then receded to below the geometric mean criterion value of 126 cfu/100ml when the geese moved from the area (Table 17). Therefore, it is necessary to propose listing Lucky Peak Reservoir for bacteria until a means to control *E. coli* bacteria is successful.

Weekly samples were also collected in the summer months of 2006, 2007 and 2008 at Barclay Bay, another popular recreation area on Lucky Peak Reservoir. Bacteria sample results were well below the trigger point of 235 cfu/ml with the range being from <1 to 9 cfu/100 ml. This indicates that *E. coli* bacteria is likely a localized problem at the Robie Creek site. Potential bacteria sources include nesting geese or human waste.

Table 16. E. coli results from samples collected near Robie Creek in Lucky Peak Reservoir in summer 2006.

Date	Time	Colony Forming Units per 100 ml Sample (cfu/100 ml)
6/13/2006	9:45 a.m.	2400
6/20/2006	10:50 a.m.	100
6/28/2006	12:22 p.m.	1700
7/5/2006	10:02 a.m.	4600
7/12/2006	13:32 p.m.	180
7/18/2006	10:45 a.m.	340
7/24/2006	10:31 a.m.	54
8/1/2006	10:26 a.m.	16
8/9/06	10:40 a.m.	5
Geometric Mean as 0f 8/9/2006 = 48		

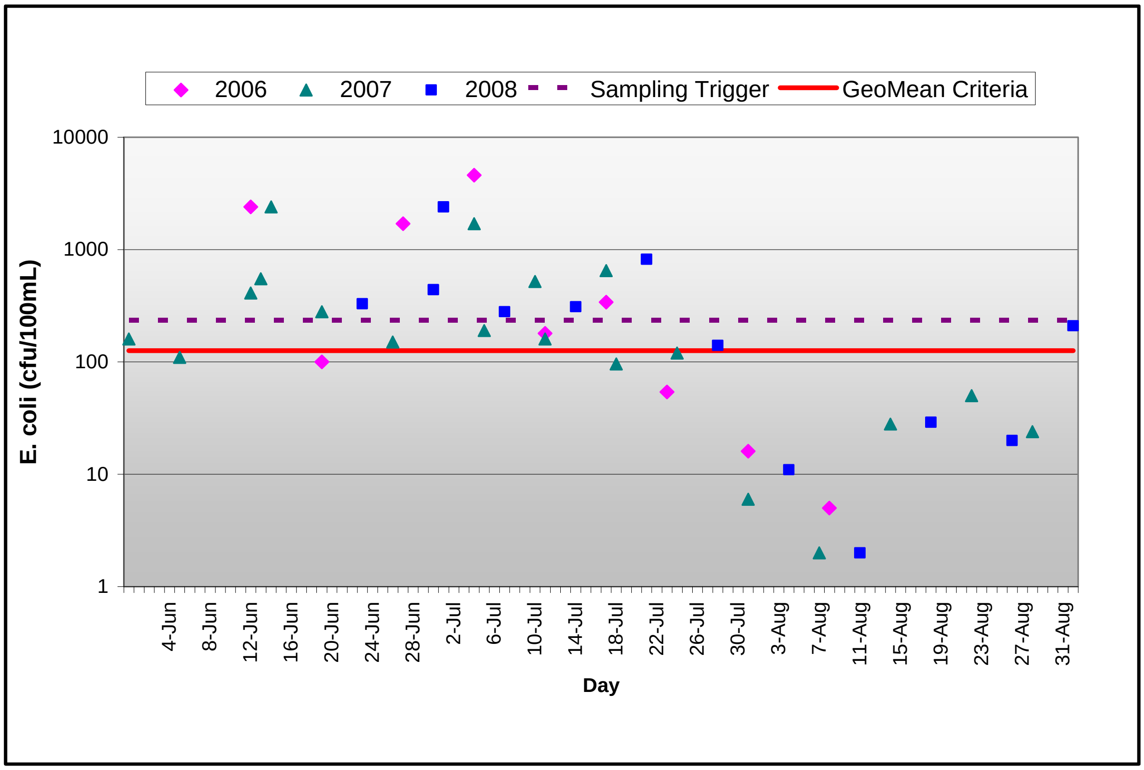


Figure 23. Lucky Peak Reservoir *E.coli* Lab Results from Samples Collected in Summer 2006-2008.

Table 17. *E. coli* Geometric mean calculation results from samples collected near Robie Creek in Lucky Peak Reservoir in summer 2006-2008.

Date of Last Sample used to Calculate Geometric Mean	5 Sample 30 day Geometric Mean		
	2006	2007	2008
Jun-27-July 3	-	327	-
Jul-4 – July 10	-	459	-
Jul-11 – July 17	805	499	-
Jul-18 – July 23	544	357	540
Jul-24 – July 30	481	272	468
Jul-31 – August 6	189	182	161
Aug-7 – August 13	48	69	60
Aug-14 – August 20	-	37	37
Aug-21 – August 27	-	18	18
Aug-28 – September 2	-	13	19

- Geometric mean not calculated

Summary of Status of Beneficial Uses

Lucky Peak Reservoir is currently not on the §303(d) list. Hydrologic regime and water quality collected show full support of CWAL, SS, DWS and SRW beneficial uses (Table 18). Bacteria data collected at Robie Creek boat indicate that primary contact recreation beneficial use is not fully supported. DEQ recommends further investigation and a bacteria source survey. In the interim DEQ has developed a bacteria TMDL for the Robie Creek beach area and added Lucky Peak Reservoir to the Section 4a of the Integrated Report.

Table 18. Summary of beneficial use support determinations for Lucky Peak Reservoir.

Beneficial Use	Support Determination	Basis for Determination
Cold Water Aquatic Life	Fully Supporting	Water quality data
Salmonid Spawning	Fully Supporting	No evidence to the contrary exists
Primary Contact Recreation	Not Fully Supporting	Elevated bacteria counts
Drinking Water Source	Fully Supporting	Bacteria and turbidity data
Special Resource Water	Fully Supporting	No evidence to the contrary exists

Arrowrock Reservoir

Arrowrock Reservoir is maintained for flood control, water storage, and recreation. Construction of the dam began in 1911 and was completed in 1915. The development of Arrowrock Reservoir inundated an estimated 20.5 miles of mainstem river habitat. The reservoir has a drainage area of 2,210 square miles and provides a total storage capacity of 286,600 acre-feet. A sedimentation survey completed in 1997 estimated the water storage capacity of Arrowrock Reservoir at 272,200 acre-feet. There are two established recreation areas with primitive camp areas and vault restrooms. An unpaved road traverses the northern shoreline. Another unpaved road traverses a short distance of the South Fork Boise River arm of the reservoir, which includes a bridge crossing just upstream from full pool elevation.

Flow Characteristics

Arrowrock Dam is operated primarily for flood-control purposes and irrigation storage. Arrowrock is the first of the Boise River reservoirs to meet irrigation needs in the system. Irrigation water is drawn from mid-March through the beginning of September, and the reservoir is typically allowed to fill slowly during winter, with only minimal release to Lucky Peak Reservoir (Figure 24). Spring inflow to the reservoir starts prior to the typical snowmelt regime due to pre-snow melt releases from Anderson Ranch Reservoir 26 miles upstream on the South Fork Boise River. The reservoir is generally filled by mid-June to provide recreational opportunities, and then water levels slowly decrease throughout summer. The reservoir is normally drafted to a pool of 28,000 acre feet (below 10,000 acre-feet in drought years) before Lucky Peak Reservoir is allowed to drop below full pool level.

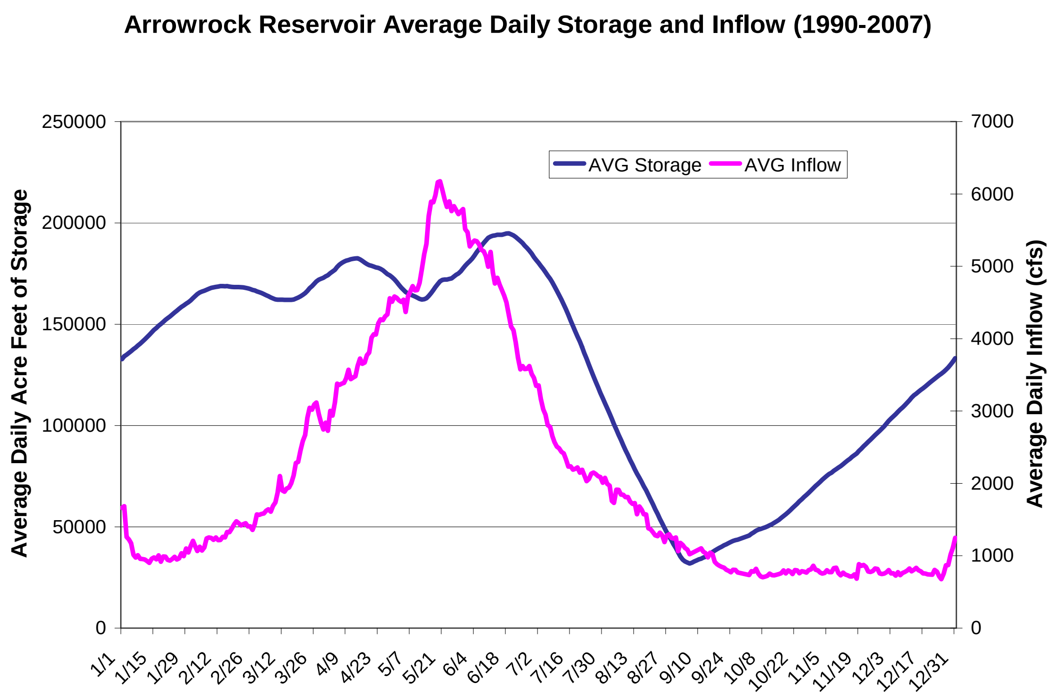


Figure 24. Arrowrock Reservoir Average Monthly Water Storage and Inflow.

Water Quality Data

Water quality monitoring was conducted by the U. S. Bureau of Reclamation bi-weekly from April 2002 through August 2003 and April through August 2004. Measurements of dissolved oxygen, pH, and turbidity were taken at 1-meter intervals for the first 15 meters, 2-meter intervals until 30 meters was reached and then 5-meter intervals to the bottom. Data show no exceedances of water quality standards (Table 19).

Table 19. Arrowrock Reservoir water quality data for 2002-2005 sampling.

Water Quality Parameter	Water Quality Standard	Range	Median	Mean	% Criterion Exceedance	Beneficial Use Support Status
Dissolved Oxygen** mg/L	DO > 6.0 mg/L	5.1-8.8	7.4	7.3	9 (8/86 observations)	FS
pH	pH between 6.5 and 9.0	6.6-9.0	7.5	7.5	0	FS
Turbidity (NTU)	5 NTUs over natural background	Non-detect – 5 NTU	2 NTU	2 NTU	0	FS
E. coli	no sample > 406 organisms/100 ml, 5 day geometric mean < 126 /100ml	Non-detect	Non-detect	Non-detect	0	FS

**Accommodates for reservoir stratification and livable reservoir space, NTU – nephelometric turbidity units

Summary of Status of Beneficial Uses

Arrowrock Reservoir is currently not on the §303(d) list. Hydrologic regime, water column and bacteria data collected show full support of beneficial uses (Table 20)

Table 20. Summary of beneficial use support determinations for Arrowrock Reservoir.

Beneficial Use	Support Determination	Basis for Determination
Cold Water Aquatic Life	Fully Supporting	Water quality data
Salmonid Spawning	Fully Supporting	No evidence to the contrary exists
Primary Contact Recreation	Fully Supporting	Bacteria origin from natural sources
Drinking Water Source	Fully Supporting	Bacteria and turbidity data
Special Resource Water	Fully Supporting	No evidence to the contrary exists

Water Bodies Not on the §303(d) List

Water bodies in the Boise-Mores Creek Subbasin that are not on the §303(d) list and have BURP data indicating support of beneficial uses (Figure 25) are briefly described in this subsection. There are two additional water bodies, Smith Creek and Deer Creek, in this subbasin, but they have not been assessed and have no information available for assessment purposes; therefore, they are not included here. The assessed water bodies include 1st through 4th order perennial streams (Table 21). Water bodies will be referred to by stream names or by assessment unit numbers, which are abbreviated as discussed earlier. (Briefly, all assessment units are referred to by the 5-digit water body ID, for example, 2nd order Sheep Creek, AU 17050112SW005_02, is referred to as AU 005_02.)

Table 21. Non-§303(d)-listed stream characteristics.

DEQ BURP Site ID	Water Body (Stream)	Stream Order	Rosgen Channel Type	Channel Gradient	Sampling Date	Time	Temperature
1997SBOIA006	Grouse	2	B	2	6/12/97	12:30	13
2004SBOIA083	Sheep	4	B	3.5	7/28/2004	19:00	20.2
2004SBOIA155	Sheep	4	B	2	9/16/2004	12:15	11.4
1997SBOIC003	Browns	1	A	5	8/27//1997	11:35	13
2004SBOIA068	NF Cottonwood	2	B	3	7/22/2004	13:50	17.0
2004SBOIA067	Cottonwood	3	B	2	7/22/2004	12:00	17.3
2004SBOIA022	Sheep	2	A	11	6/30/2004	NA	12.5
2004SBOIA030	Daggett	3	B	3	7/3/2004	15:30	16.3
2004SBOIA024	SF Robie	2	A	4.5	7/1/2004	11:50	13.3
2004SBOIA023	Robie	3	A	3.5	7/1/2004	11:30	13.8

NA – Not available

Water Quality Data

Continuous stream temperature monitoring data was not available for these streams. However, DEQ will conduct continuous temperature monitoring in the future to determine whether water quality standards are exceeded. Instantaneous data recorded during BURP monitoring does not indicate readily apparent temperature criteria violations (Table 21).

Data for several water quality parameters was collected at BURP sites in three assessment units: 016_02, 016_03, and 017_03, and is shown in Table 22. Chlorophyll *a* and total phosphorous results indicate there are not excessive nutrients in these water bodies. The water quality standard for pH states that pH should be between 6.5 and 9.0. All three measurements meet the pH water quality standard. Water quality standards state that a water body is impaired if turbidity levels are 50 NTUs above natural background for more than 10% of measurements or more than 25 NTUs above background for more than 10 consecutive days. Daggett Creek and Robie Creek have low instantaneous turbidity readings, and water quality data do not indicate any impairment in the three AUs sampled.

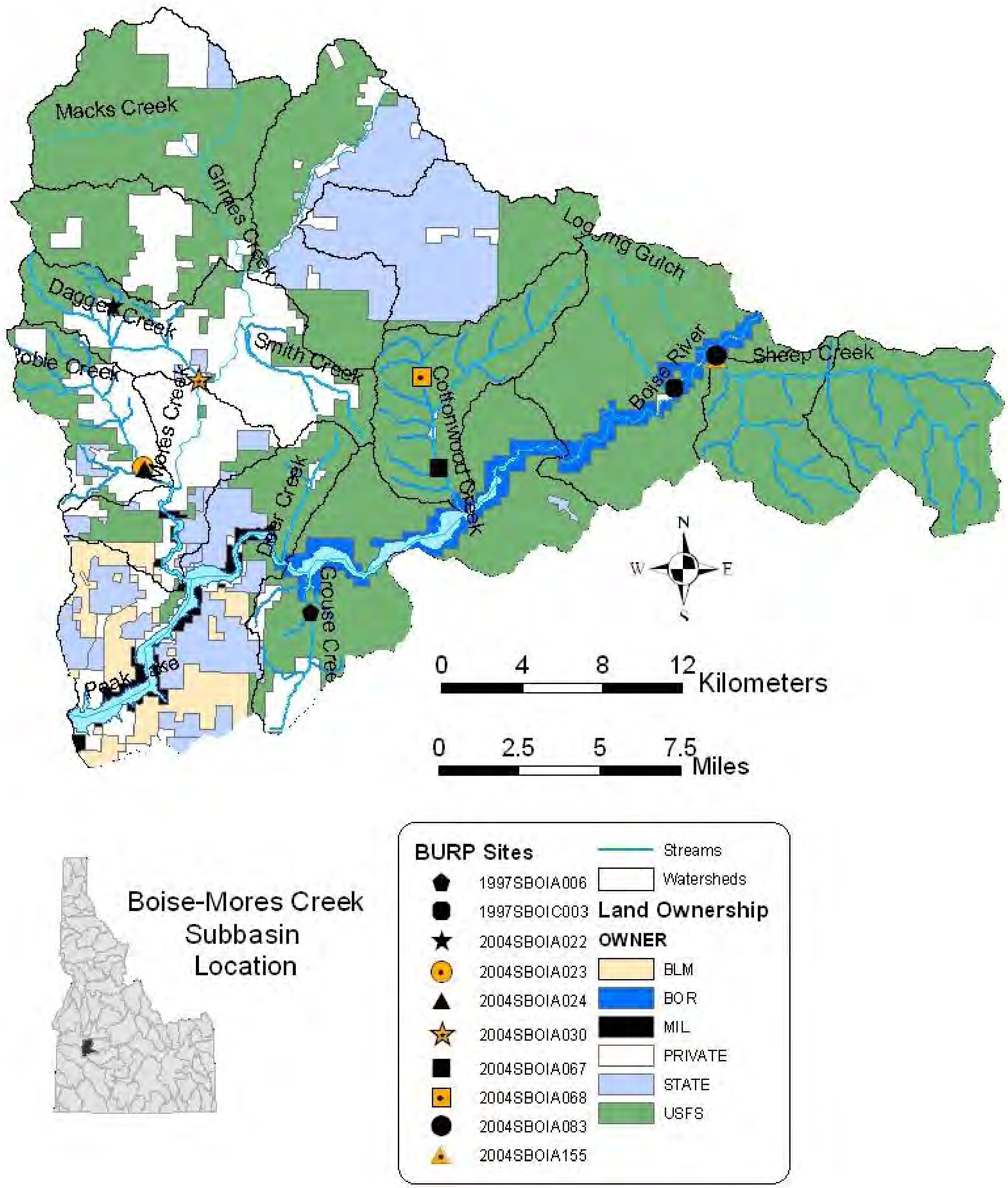


Figure 25. Assessment Units Fully Supporting Beneficial Uses or Not Assessed in the Boise-Mores Creek Subbasin.

Table 22. Water quality data summary.

Stream	AU	Chlorophyll *a* (mg/L)	Total Phosphorous (mg/L)	pH	Turbidity (NTU)	Bacteria (E. coli)
Sheep Creek (6/30/2004)	016_02	NS	NS	7.94	NS	83 cfu/100 ml
Daggett Creek (7/3/2004)	016_02	0.65	0.038	7.87	2.44	NS
Robie Creek (6/30/2004)	017_03	0.48	0.036	8.04	2.32	32 cfu/100 ml

NS– Not Sampled; NTU – nephelometric turbidity unit; cfu – colony forming units

Bacteria

In 2004, one sample for *E. coli* was collected at BURP site 2004SBOI023 in Robie Creek and one at site 2004SBOI030 in the Daggett Creek drainage to determine the support status of recreational uses. The sample results were 32 and 83 cfu/100ml respectively. Because these results do not exceed the PCR single sample indicator value of 406 cfu/100 ml or the SCR single sample indicator value of 576 cfu/100 ml, dependent on designated beneficial use, no further samples were collected. PCR is determined to be a supported use in AU 017_03 and SCR is fully supported in AU 016_03. Other AUs were assessed using a GIS bacteria screening procedure outlined in WBAG II. All AUs were found to have limited or no grazing and limited human impacts that may produce bacteria.

Two additional bacteria samples were collected on June 29, 2006 to help identify the source of high bacteria counts at Robie Creek beach on Lucky Peak Reservoir. The sample at the mouth of Robie Creek had 130 cfu/100 ml and the sample slightly upstream from the Robie Creek park area had 110 cfu/100 ml. Because all samples were below the PCR single sample indicator value of 406 cfu/100ml, additional monitoring to determine whether the numeric geometric mean of 126 cfu/100ml was exceeded was not required.

Biological and Habitat Data

Water body assessment scores indicate that cold water aquatic life (CWAL) beneficial uses are fully supported at all AUs sampled in the non-§303(d)-listed water bodies. Recreation and roads are factors that BURP personnel listed as having potential to negatively affect water quality. SHI scores are high for all sites sampled and habitat quality indicators of percent fines, bank stability and large woody debris have very high scores that contribute to this SHI index, indicating that habitat quality is not degraded to the point that beneficial uses are not supported. In addition, the SMI scores are high for all AUs. Low macroinvertebrate scores could indicate a community that was tolerant of pollution. Fish index scores also support the determination that streams are not impaired. All sampled streams had populations of rainbow trout under 100 mm in length indicating that salmonid spawning is an existing use. Fish communities were not sampled in Browns Creek, Grouse Creek or AU 016_02 in Daggett Creek.

Table 23. BURP condition rating scores for water bodies that support assessed beneficial uses.

DEQ BURP Site ID	Stream Sampled	AU #	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average
			Score 0-3 (3 is the highest score)			
1997SBOIA006	Grouse	003_02	3	NS	3	3
2004SBOIA083	Sheep	005_04	3	NS	3	3
2004SBOIA155	Sheep	005_04	3	3	3	3
1997SBOIC003	Browns	006_02	2	NS	3	2.5
2004SBOIA068	NF Cottonwood	007_02	3	2	3	2.67
2004SBOIA067	Cottonwood	007_03	3	2	3	2.67
2004SBOIA022	Sheep	016_02	3	NS	3	3
2004SBOIA030	Daggett	016_03	3	2	3	2.67
2004SBOIA024	SF Robie	017_02	3	3	3	3
2004SBOIA023	Robie	017_03	3	2	3	2.67

NS– Not Sampled

Summary of Status of Beneficial Uses

CWAL beneficial uses are supported in all non-listed assessment units described above. As per the WBAG II, since the status for CWAL is fully supporting, and there are not data appropriate for numeric criteria evaluation specific to salmonid spawning (SS), DEQ concludes SS is fully supported. Bacteria samples were in compliance with the water quality standards, and contact recreation was fully supported in all assessment units.

Table 24. Summary of beneficial use support determinations for non-§303(d)-listed streams.

AU	Beneficial Uses Assessed and Supported	Basis for Determination
003_02	CWAL, SCR	BURP data, bacteria screening
005_02	SCR	Bacteria screening
005_03	SCR	Bacteria screening
005_04	CWAL, SS, SCR	BURP data, presence of salmonids <100mm, bacteria screening
006_02	CWAL, SCR	BURP data, bacteria Screening
007_02	CWAL, SS, SCR	BURP data, presence of salmonids <100mm, bacteria screening
007_03	CWAL, SS, SCR	BURP data, presence of salmonids <100mm, bacteria screening
016_02	CWAL, SCR	BURP data, , bacteria sample
016_03	CWAL, SS, SCR	BURP data, presence of salmonids <100mm, bacteria screening
017_02	CWAL, SS, PCR	BURP data, presence of salmonids <100mm, bacteria screening
017_03	CWAL, SS, PCR	BURP data, presence of salmonids <100mm, bacteria sample

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, SCR – Secondary Contact Recreation

Boise River

Boise River segments in the Boise-Mores Creek watershed are comprised of the mainstem Boise River, AU 004_05, and its first and second order tributaries, AU 004_02. The mainstem river section begins downstream from the North Fork Boise River and flows southwest for approximately 11 river miles before emptying into Arrowrock Reservoir. The Boise River mainstem is constrained along most of its length by Forest Road 268. There are 38.26 miles of tributary streams.

Hydrology

The Boise River is a moderately sinuous river with Rosgen Stream Type (Rosgen) A/B channel tributaries plunging up to 4,000 feet in three to five miles of stream length. USGS stream gage (flow volume) records for the Boise River near Twin Springs at the Forest Road 113 Bridge exist from 1911-2007. The stream follows a typical hydrologic regime for southwestern Idaho, with peak flows occurring from mid-April to late May, and base flow occurring by early August (Figure 26).

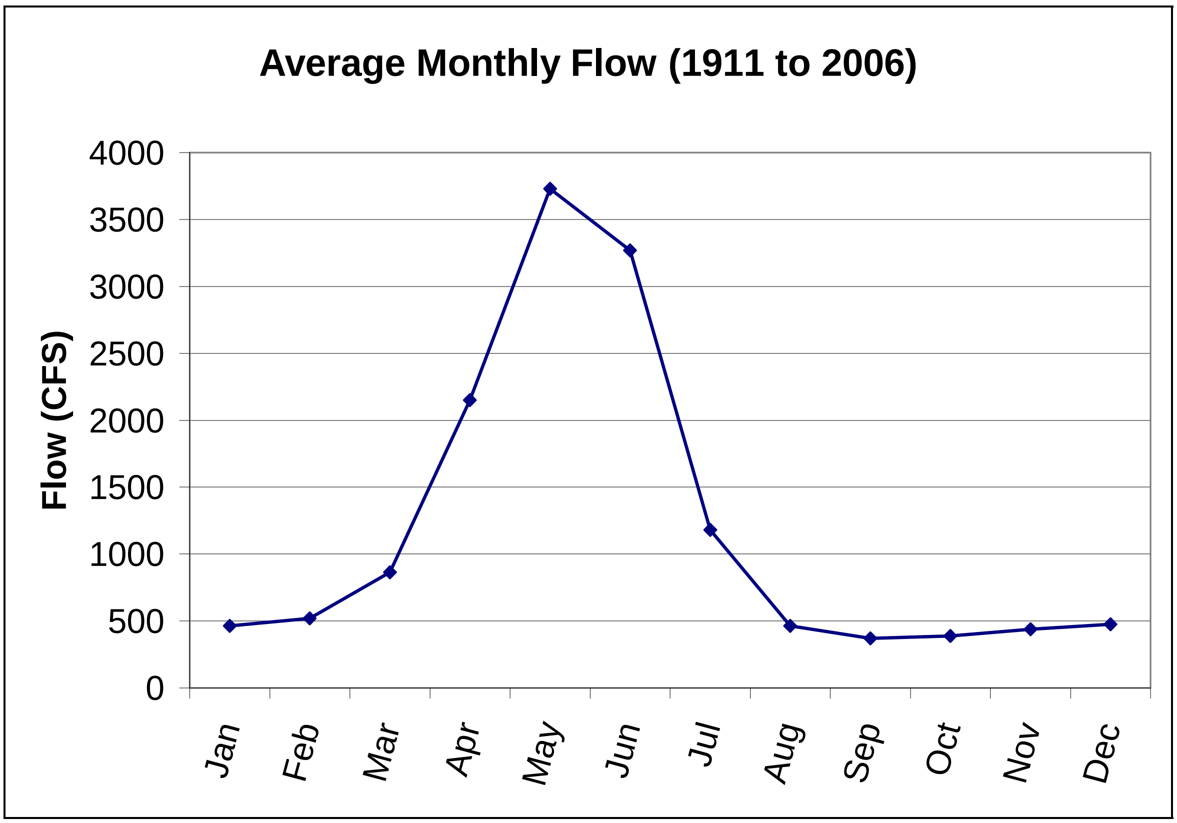


Figure 26. Average Daily Flow at the Boise River near Twin Springs USGS Gauging Station.

Water Quality Data

Instantaneous measurements were taken during monitoring at BURP sites in the first order tributaries. Temperature measurements of 16 and 9.5 degrees Celsius that were recorded at BURP sites do not show exceedance of temperature numeric criteria for the tributaries. Temperature data for the mainstem Boise River is recorded at the Twin

Springs stream gage station. The average daily temperature and daily maximum temperature shows greater than 10% exceedance every year from 2003-2007 for both cold water aquatic life and rainbow trout salmonid spawning beneficial uses (Figure 27, Figure 28, Figure 29, Figure 30, Table 25, and Table 26). Bull trout salmonid spawning criteria do not apply to AU 004_05 since this is a 5th order mainstem water body (IDAPA 58.01.02.250.01.i).

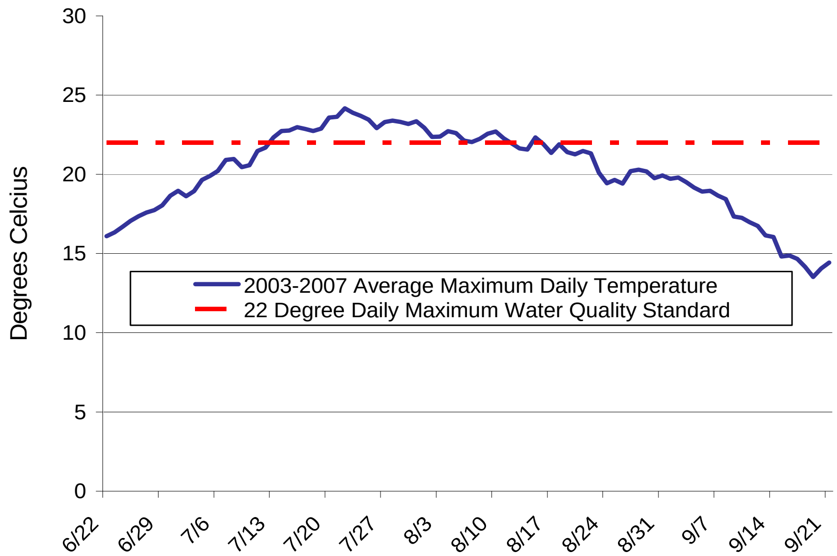


Figure 27. Summer Months (June 22-September 21) Average Maximum Daily Temperature for 2003-2007 at Boise River near Twin Springs USGS Gauging Station.

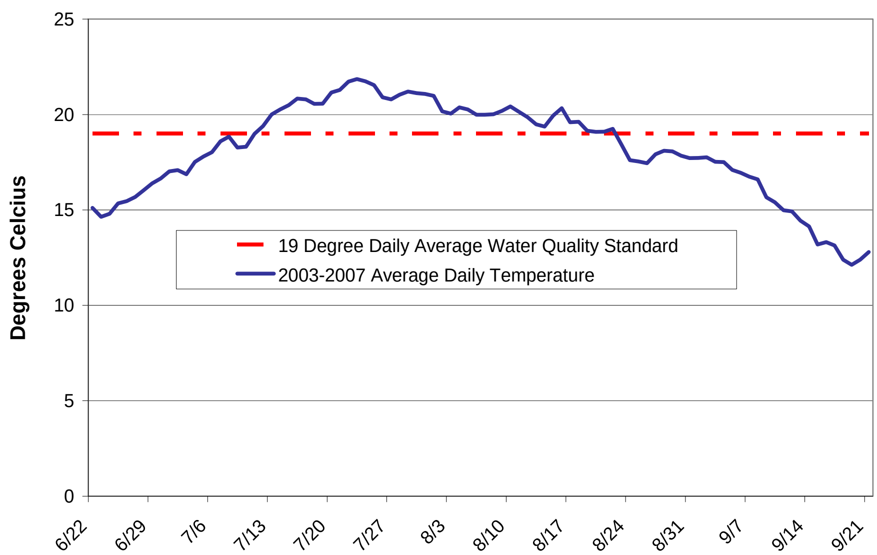


Figure 28. Summer Months (June 22-September 21) Average Daily Temperature for 2003-2007 at Boise River near Twin Springs USGS Gauging Station.

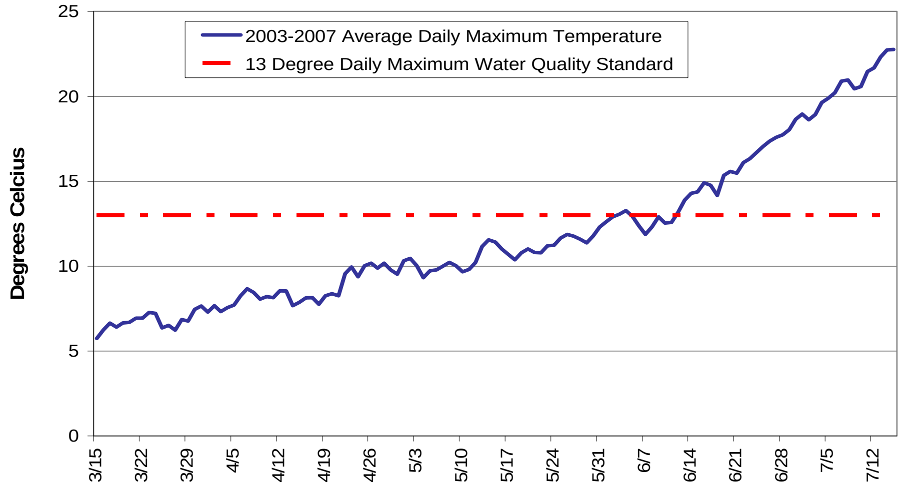


Figure 29. Average Maximum Daily Temperature during Critical Period for Salmonid Spawning (March 15-July 15) for 2003-2007 at Boise River near Twin Springs USGS Gauging Station.

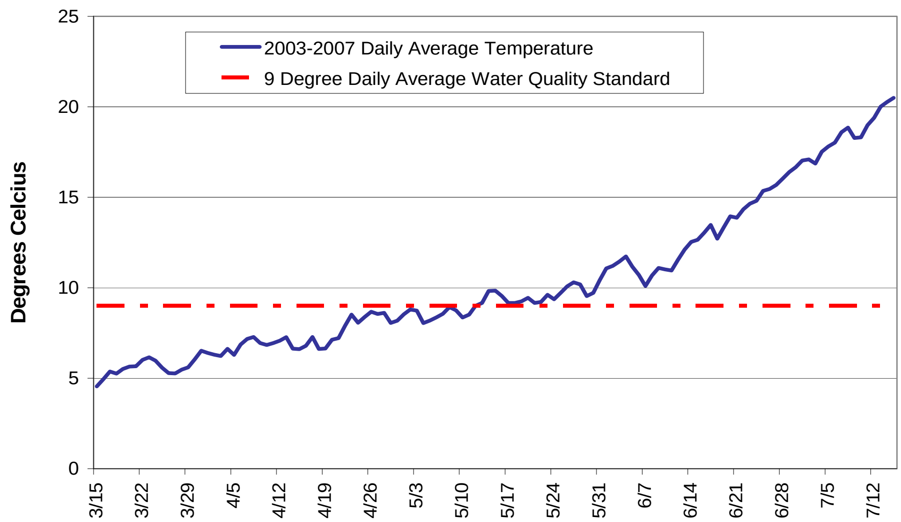


Figure 30. Average Daily Temperature during Critical Period for Salmonid Spawning (March 15-July 15) for 2003-2007 at Boise River near Twin Springs USGS Gauging Station.

Table 25. Boise River temperature data and number of days water temperatures exceeded cold water aquatic life criteria.

Cold Water Aquatic Life (June 22 – September 21)						
	22°C Daily Maximum			19°C Daily Average		
# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
92	28 (30)	24.6	7/21/03	47 (50)	22.3	7/21/03
92	28 (30)	24.2	7/16/04	38 (41)	21.8	7/16/04
92	34 (37)	24.4	7/22/05	42 (46)	22.3	7/22/05
92	19 (21)	25.3	7/24/06	28 (30)	23.4	7/24/06
92	43 (47)	25.6	7/31/07	53 (58)	23.0	7/31/07

Table 26. Boise River temperature data and number of days water temperatures exceeded salmonid spawning criteria.

Salmonid Spawning (Rainbow and Redband Trout, March 15 – July 15)						
	13°C Daily Maximum			9°C Daily Average		
# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
123	28 (23)	21.7	7/15/03	57 (46)	19.5	7/13/03
123	39 (32)	23.4	7/15/04	74 (60)	21.1	7/15/04
123	34 (28)	23.7	7/13/05	59 (48)	21.3	7/13/05
123	36 (29)	21.6	7/13/06	56 (46)	19.2	7/15/06
123	50 (41)	25.4	7/14/07	77 (63)	22.8	7/14/07

Water quality samples were collected from the Boise River at the Twin Springs USGS stream gage near Willow Creek twice each month in 1999 and from April through November in 2001. Results of dissolved oxygen, pH, and instantaneous turbidity measurements indicate that water chemistry provides full support of beneficial uses in the Boise River AU 004_05 (Table 26).

Table 27. Boise River AU 004_05 water quality data summary.

Water Quality Parameter	Water Quality Standard	Range	Median	Average	(events) % Criterion Exceedances	Beneficial Use Support Status
Dissolved Oxygen mg/L	DO > 6.0	7.6 – 15.1	10.9	11.4	0%	FS
pH	pH between 6.5 and 9.0	6.9 – 8.4	7.8	7.7	0%	FS
Turbidity	Not to exceed background by 50 NTU	Non-detect to 54 NTU	1	4	(2) 5%	FS

FS – Fully Supporting Beneficial Use

Biological and Other Data

Water body assessment scores (Table 28) from 1997 and 2004 BURP sites indicate that CWAL beneficial uses are fully supported for the 1st and 2nd order tributaries. Recreation and roads are factors that BURP personnel listed as having potential to affect water quality. SHI scores are high for both sites sampled, with percent fines, bank stability, and large woody debris scores contributing to the high SHI index ratings, indicating that habitat quality is not degraded and beneficial uses are supported. The mainstem Boise River AU 004-005, is not wadeable and therefore has not been sampled during stream BURP surveys. It is recommended that this stream reach be sampled using large river BURP protocol to complete this assessment.

DEQ BURP site 2005SBOIF004 was electrofished in August 2005. Twelve rainbow trout between 45 and 130 millimeters were identified. The presence of rainbow trout less than 100 mm indicates that SS beneficial uses are fully supported in AU 004_02.

Table 28. Boise River first and second order tributaries (AU 004_02), BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	Water Body (Stream)	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
		Score 0-3 (3 is the highest score)				
1997SBOIC004	Badger	3	NS	1	2	FS
2004SBOIA160	Unnamed Tributary to Boise River	3	NS	3	3	FS
2005SBOIF004	Logging Gulch	NS	3	NS	n.a.	n.a.

NS– Not Sampled, FS – Fully Supporting Cold Water Aquatic Life, n.a. – Not Applicable

Summary of Status of Beneficial Uses

As per DEQ WBAG II, since BURP scores indicate beneficial use support of CWAL as does BURP data collected in 2005, SS is fully supported in AU 004_02. Exceedances of stream temperature numeric criteria for CWAL and SS in the Boise River mainstem result in beneficial uses being not fully supported and prompt placing this AU on the next §303(d) list. Contact recreation was not assessed due to lack of available data. The support determinations are summarized in Table 29.

Table 29. Summary of beneficial use support determinations for the Boise River.

AU	Beneficial Use	Support Determination	Basis for Determination
004_02	CWAL	FS	BURP data
004_05	CWAL	NFS	Numeric temperature criteria exceedance
004_02	SS	FS	Presence of salmonids < 100mm and BURP data
004_05	SS	NFS	Numeric temperature criteria exceedance
004_02	SCR	NA	Data not available
004_05	PCR	NA	Data not available
	DWS	NA	Data not available
	SRW	FS	No evidence to the contrary exists

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, PCR–Primary Contact Recreation, SCR–Secondary Contact Recreation, DWS–Domestic Water Supply, SRW–Special Resource Water, FS–Fully Supported, NFS – Not Fully Supported, NA – Not Assessed

Mores Creek

Mores Creek is a 6th order perennial stream that bisects the subbasin from northeast to southwest. Its headwaters originate in two forks on Freeman Peak at 8,110 feet elevation and it flows generally southwest into Lucky Peak Reservoir at 3,090 feet elevation just upstream of Robie Creek. Mores Creek drains approximately 397 square miles. The Mores Creek watershed includes AUs 009_02, 009_03, 009_04, and 009_06, all of which are on the §303(d) list for elevated stream temperature. In addition AU 009_02 is listed for an unknown pollutant. Data is presented for support status determination by AU.

Hydrology

Mores Creek is a moderately sinuous stream with Rosgen Type A or B channels in higher elevation 1st, 2nd, and 3rd order segments and Rosgen Type B or C channels through the remaining stream segments. The watershed has been extensively altered by dredge and hydraulic mining. Dredge waste tailings are present in the valley bottoms and constrain stream channels in many areas. Mores Creek is also constrained along most of its length by Highway 21.

USGS stream gage (flow volume) records for Mores Creek exist from 1950-2007. The stream follows a typical hydrologic regime for southwestern Idaho, with peak flow occurring mid-April to late May and base flow occurring by early July (Figure 31).

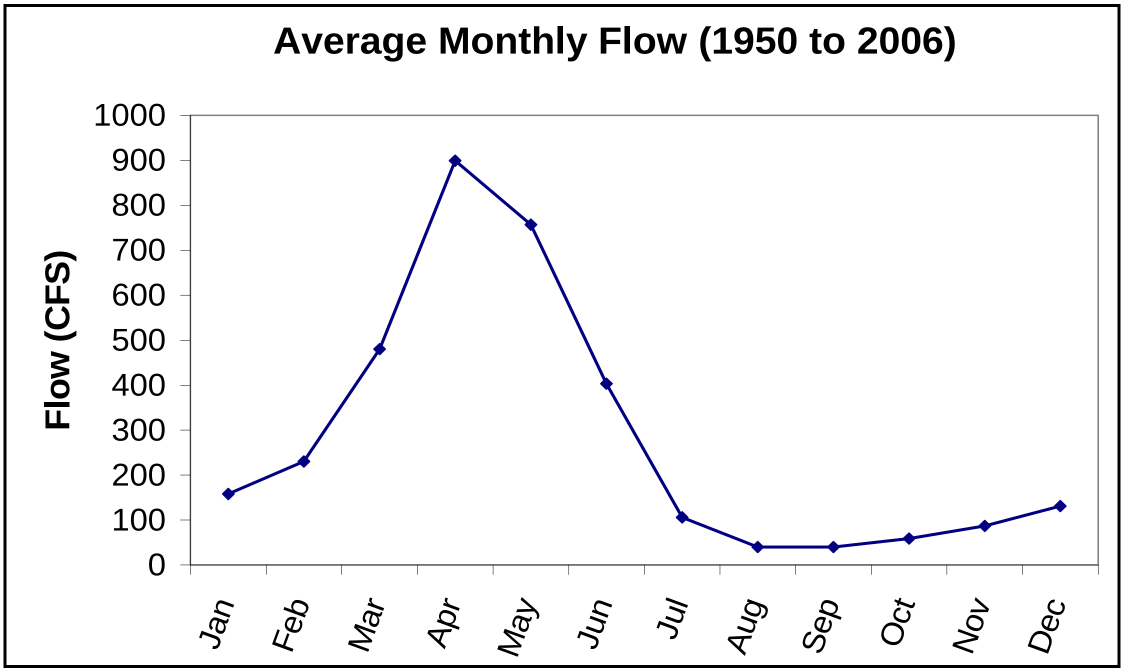


Figure 31. Average Monthly Flow, USGS Gauging Station, Mores Creek above Robie Creek near Arrowrock Dam.

Water Quality Data

Data for nutrient and sediment water quality parameters was collected at BURP sites in three assessment units: 009_02, 009_03, and 009_06 (Table 30). Water column data was collected at a BURP site on Minneha Creek in 2004 and at two sites on Mores Creek in 2006.

Total phosphorous was measured in single grab samples, with only one sample per location. Idaho's narrative criteria specifies that streams should be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses (see Criteria to Support Beneficial Uses, starting on page 43). In 10.9 miles of Mores Creek surveyed, there were no appearances of excess algal growth.

Minneha Creek had a low instantaneous turbidity measurement, and both sites on Mores Creek had low amounts of total suspended solids (TSS). The numeric water quality standard states that a water body is impaired if turbidity levels are 50 NTUs above natural background for more than 10% of measurements or more than 25 NTUs above background for more than 10 consecutive days. Based on sample results for nutrients, turbidity, and TSS, the three AUs sampled are not impaired for those constituents (Table 30). Turbidity and TSS measurements were taken during BURP monitoring in the summer months, it is probable that values may be much higher during heavy runoff in fall rain events and spring runoff.

Table 30. Mores Creek water quality data summary.

Stream	AU	Chl. *a* (mg/L)	Total Phosphorous (mg/L)	Ammonia (mg/l)	Nitrate/ Nitrite (mg/l)	Turbidity (NTU)	TSS (mg/l)	Bacteria (*E. coli*)
Minneha Cr. (7/3/2004)	009_02	0.49	0.12	NS	NS	11.7	NS	NS
Mores Cr. (8/2006)	009_03	NS	0.01	0.023	0.03	NS	4.8	NS
Mores Cr. (6/29/2006)	009_06 Mouth	NS	NS	NS	NS	NS	NS	87 cfu/100ml
Mores Cr. (6/29/2006)	009_06 Park	NS	NS	NS	NS	NS	NS	34 cfu/100ml
Mores Cr. (8/2006)	009_06 Gage	NS	0.02	0.022	<0.01	NS	2.8	47 cfu/100ml

NS– Not Sampled, cfu– colony forming units

Bacteria

In June and August 2006, *E. coli* samples were collected in Mores Creek AU 009_06 to determine the support status of recreational uses (Table 30). Two samples were collected on June 29 to assess the source of high bacteria counts at Robie Creek beach in Lucky Peak. The sample at the mouth of Mores Creek had 87 cfu/100 ml and the sample slightly upstream near Mores Creek Park had 34 cfu/100 ml. The sample taken at the USGS gage near Robie Creek had 47 cfu/100ml. Because all samples were below the PCR single sample indicator value of 406 cfu/100ml, additional monitoring to determine if the numeric geometric mean of 126 cfu/100ml was exceeded was not required. Therefore no further samples were collected and PCR is determined to be a supported use in this assessment unit. Other assessment units were assessed using a GIS bacteria screening procedure outlined in WBAG II. All AUs were found to have limited or no grazing and limited human impacts that may produce bacteria.

Biological and Other Data

The following subsections discuss the data for fisheries, habitat, fine sediment, and bank stability in the Mores Creek watershed.

Fisheries

Fish communities were sampled by DEQ BURP staff and Boise National Forest personnel. These fisheries surveys were conducted in 1993, 2000, 2001, and 2003. Fish species and length distributions are listed in Table 31.

Table 31. Mores Creek Boise National Forest fisheries data.

AU	Stream	Sample Date	Rainbow Trout				Bull Trout			Brook Trout			Sculpin	Sucker
			0-3”	4-7”	8-11”	12+”	0-3”	4-7”	8-11”	0-3”	4-8”	8-11”	#	#
Mores 1st and 2nd Order	Mores Creek	2000	3	48	1		2	7	5		1			
	Mores Creek	2001	54	99	1			2	1				6	
	Mores Creek	2003	7	24	1			4					61	
	Bad Bear Creek	2003	3	5	8								8	
	Hayfork	2003	3	3	6						4		29	
	Ten Mile Creek	2003	1	1									28	
	Minneha Creek	1994	84	27										
Mores 3rd	Mores Creek	1993	75	33	6									16
	Mores Creek	2003	36	142	5			5		5	10	1	473	
Mores 4th	Mores Creek	1993	7	18	6	5								40
Mores 6th	Mores Creek	1993	1	4										

BURP fisheries scores are included in Table 32 and Table 33. Survey crews found bull trout in AU 009_02. Throughout the sampled sites, juvenile salmonids (less than 100 mm) were found, indicating that salmonid spawning is an existing use; however, this data does not reveal where successful spawning is occurring.

Scores for individual streams from 2004 BURP surveys in AU 009_02 had very different results from each other, with Granite Creek scoring a 3 and Minneha Creek scoring a 1. Minneha Creek had a high percentage of species and individuals that were tolerant to warm water, resulting in a low score. Granite Creek had a healthy cold water community that showed evidence of salmonid spawning. Scores for AU 009_04 were below the minimum threshold. In AU 009_04, the fish community contained native salmonids, but had a high proportion of non-salmonid warm water-tolerant species and individuals, resulting in a very low score. The low BURP SFI scores throughout the AUs support the result from temperature data that CWAL and SS beneficial uses are not fully supported in AUs 009_02 and 009_04.

Habitat Data

DEQ BURP crews sampled sites in all AUs of Mores Creek (Figure 32). Water body assessment scores (Table 32 and Table 33) from BURP sites indicate that beneficial uses are not fully supported for AU 009_02, 009_03, and 009_04. A 1996 BURP site in AU 009_06 indicates full support of beneficial uses. Recreation, roads, urban areas, and mining are factors that BURP personnel listed as having potential to affect water quality. Many of the SHI and SMI scores are low with several sites receiving a zero SMI, meaning that the score was below a minimum threshold, which automatically results in the site receiving a failing condition rating average. Scores are separated between those based on Tier 1 and those based on Tier 2 data. Tier 1 data includes BURP data collected within the last 5 years. Tier 2 data presented in this document is BURP data collected more than five years ago.

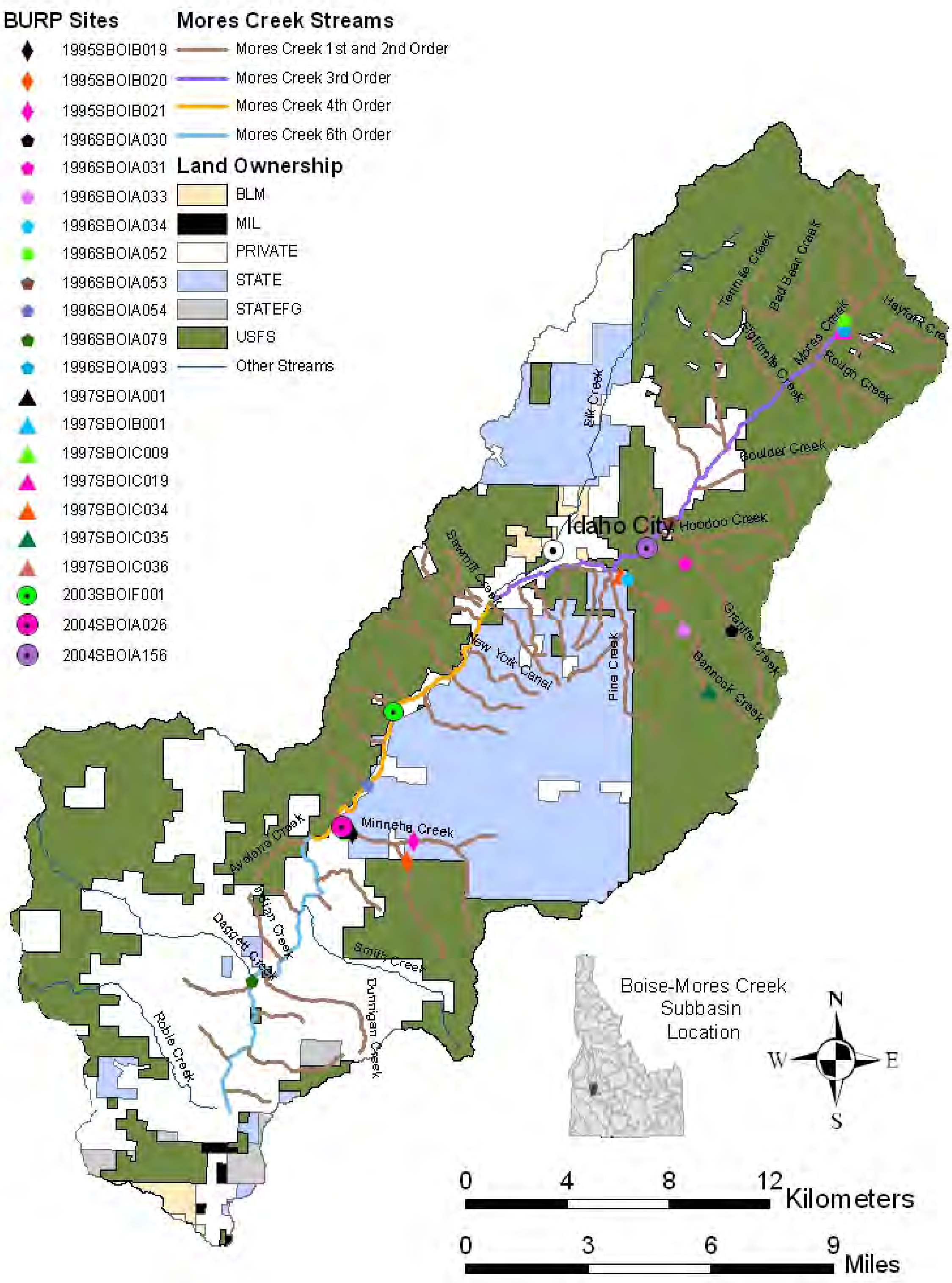


Figure 32. Mores Creek Watershed BURP Sampling Locations.

Table 32. Mores Creek first and second order (AU 009_02) BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	Water Body (Stream)	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
		Score 0-3 (3 is the highest score)				
Scores based on Tier 1 Data						
2004SBOIA026	Minneha	1	1	0	0	NFS
2004SBOIA156	Granite	3	3	3	3	FS
Condition Rating based on Tier 1 Data					**0**	**NFS**
Scores based on Tier 2 Data						
1997SBOIC036	Bannock (Middle)	1	NS	3	2	FS
1997SBOIC035	Bannock (Upper)	1	NS	1	1	NFS
1997SBOIC034	Bannock (Lower)	1	NS	1	1	NFS
1997SBOIC019	Hayfork	2	NS	3	2.5	FS
1997SBOIC009	Minneha (Upper)	1	NS	0	0	NFS
1997SBOIB001	Minneha	1	NS	1	1	NFS
1997SBOIA001	Minneha (Upper)	1	NS	0	0	FS
1996SBOIA093	Hayfork	3	3	3	3	FS
1996SBOIA052	Mores	2	NS	2	2	FS
1996SBOIA034	Bannock	3	3	0	0	NFS
1996SBOIA033	Bannock	2	1	0	0	NFS
1996SBOIA031	Granite	3	NS	1	2	FS
1996SBOIA030	Granite	2	1	2	1.67	NFS
1995SBOIB021	Minneha	3	NS	1	2	FS
1995SBOIB020	SF Minneha	1	NS	0	0	NFS
1995SBOIB019	Minneha	3	NS	1	2	FS
Average Condition Rating based on Tier 2 data					**1.26**	**NFS**

NS– Not Sampled, FS – Fully Supporting Cold Water Aquatic Life, NFS – Not Fully Supporting Cold Water Aquatic Life

Table 33. Mores Creek AU 009_03, 009_04, and 009_06 BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	AU	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
		Score 0-3 (3 is the highest score)				
1996SBOIA053	009_03	1	NS	1	1	NFS
2003SBOIF001	009_04	NS	0	NS	0	NFS
1996SBOIA054	009_04	1	NS	0	0	NFS
1996SBOIA079	009_06	1	NS	3	2	FS

NS– Not Sampled, NFS – Not Fully Supporting Cold Water Aquatic Life, FS – Fully Supporting Cold Water Aquatic Life

Fine Sediment and Bank Stability

A high percentage of land in the Mores Creek basin has been altered by surface vegetation removal, mining, road construction, and timber harvest. Removal of vegetation results in soil which is more susceptible to erosion. Mean percent surface fines in sites sampled in Mores Creek AUs range from 8 to 46 % over the past 11 years (Table 34). Recommended target levels for surface fine sediment (< 6.0 mm) were developed by the Forest Service and Bureau of Land Management for the Upper Columbia River Basin for plutonic Rosgen A, B, and C channels (DEQ 2003). The percent surface fine material for some streams in Mores Creek AU 009_02 are 9-11% higher than the recommended values for C and A channel types with plutonic parent material.

Table 34. Mores Creek recorded mean percent surface fines and recommended targets.

DEQ BURP Site ID	AU	Percent Surface Fines	Rosgen Channel Type	Recommended Target (%)	Target Met
2004SBOIA026 Minneha Cr.	009_02	23	B	23	Yes
2004SBOIA156 Granite Cr.	009_02	15	B	23	Yes
1997SBOIC036 Bannock Cr.	009_02	46	C	37	No
1997SBOIC035 Bannock Cr.	009_02	18	B	23	Yes
1997SBOIC019 Hayfork Cr.	009_02	8	B	23	Yes
1997SBOIC009 Minneha Cr.	009_02	14	B	23	Yes
1997SBOIB001 Minneha Cr.	009_02	37	A	26	No
1997SBOIA001 Minneha Cr.	009_02	12	B	23	Yes
1996SBOIA093 Hayfork Cr.	009_02	8	B	23	Yes

The percentage of fine material on the surface of a stream bed does not always provide a clear picture of bedload sediment. Surface fine sediment amounts can be highly dependent on stream flow and channel morphology. Measurements of depth fines can give a more accurate representation of stream sediment bedload and potential impacts to aquatic life. The recommended TMDL target for depth fines is less than or equal to 27% (DEQ 2003). The percentage of depth fines (< 6 mm) were measured in AUs 009_02, 009_03 and 009_06 by DEQ personnel using McNeil sediment core samples (Figure 33). All core samples had fine material percentages greater than the recommended maximum of 27%t (Table 35).

Table 35. Mores Creek depth percent fines calculated from McNeil sediment cores.

DEQ Stream Site ID	Assessment Unit	Percent Depth Fines	Target Value	Target Met
2005SBOIP005 Minneha Creek	009_02	32	≤ 27%	No
2005SBOIP003 Bannock Creek	009_02	78	≤ 27%	No
2005SBOIP007 Mores Creek	009_03	56	≤ 27%	No
2005SBOIP004 Mores Creek	009_03	46	≤ 27%	No
2006 Sediment Core Mores Creek	009_06	40	≤ 27%	No

Vegetation removal and overland erosion often result in increased stream discharge and velocity, which increases streambank erosion. Bank stability measured during DEQ BURP inventories ranged from 0 to 100% between 1995 and 2004 (Table 36). Streambanks are considered to be functioning properly if bank stability is greater than 80% (Overton et. al. 1995). The streambanks of some sites in Mores Creek AU 009_02 do not meet this criteria and streambank instability is negatively impacting beneficial uses at five of the sampled sites in 1995 and 1997.

A high percentage of the BURP data for streambank stability is dated and from small tributaries. In 2006, streambank erosion inventories (USDA NRCS 1983) were conducted for all AUs in mainstem Mores Creek to determine support status of beneficial uses and the extent of impairment (Figure 33). The TMDL bank stability target to support CWAL and SS beneficial uses is 80% (DEQ 2003). The erosion inventory indicates that streambank erosion could be a factor that causes Mores Creek AU 009_04 to not support CWAL and SS beneficial uses (Table 37).

Table 36. Mores Creek bank stability measured during BURP site inventories.

DEQ BURP Site ID	AU	Bank Stability (%)	Target Met (Target=80%)
2004SBOIA026 Minneha Cr.	009_02	97	Yes
2004SBOIA156 Granite Cr.	009_02	100	Yes
1997SBOIC036 Bannock Cr. (Middle)	009_02	96	Yes
1997SBOIC035 Bannock Cr. (Upper)	009_02	69	No
1997SBOIC034 Bannock Cr. (Lower)	009_02	0	No
1997SBOIC019 Hayfork Cr.	009_02	100	Yes
1997SBOIC009 Minneha Cr. (Upper)	009_02	86	Yes
1997SBOIB001 Minneha Cr.	009_02	70	No
1997SBOIA001 Minneha Cr. (Upper)	009_02	58	No
1996SBOIA093 Hayfork Cr.	009_02	100	Yes
1996SBOIA052 Mores Cr.	009_02	100	Yes
1996SBOIA034 Bannock Cr. (Lower)	009_02	94	Yes
1996SBOIA033 Bannock Cr. (Upper)	009_02	100	Yes
1996SBOIA031 Granite Cr. (Lower)	009_02	95	Yes
1996SBOIA030 Granite Cr. (Upper)	009_02	100	Yes
1995SBOIB021 Minneha Cr. (Upper)	009_02	98	Yes
1995SBOIB020 SF Minneha Cr.	009_02	0	No
1995SBOIB019 Minneha Cr. (Lower)	009_02	94	Yes
1996SBOIA053 Mores Cr.	009_03	100	Yes
1996SBOIA054 Mores Cr.	009_04	100	Yes
1996SBOIA079 Mores Cr.	009_06	100	Yes

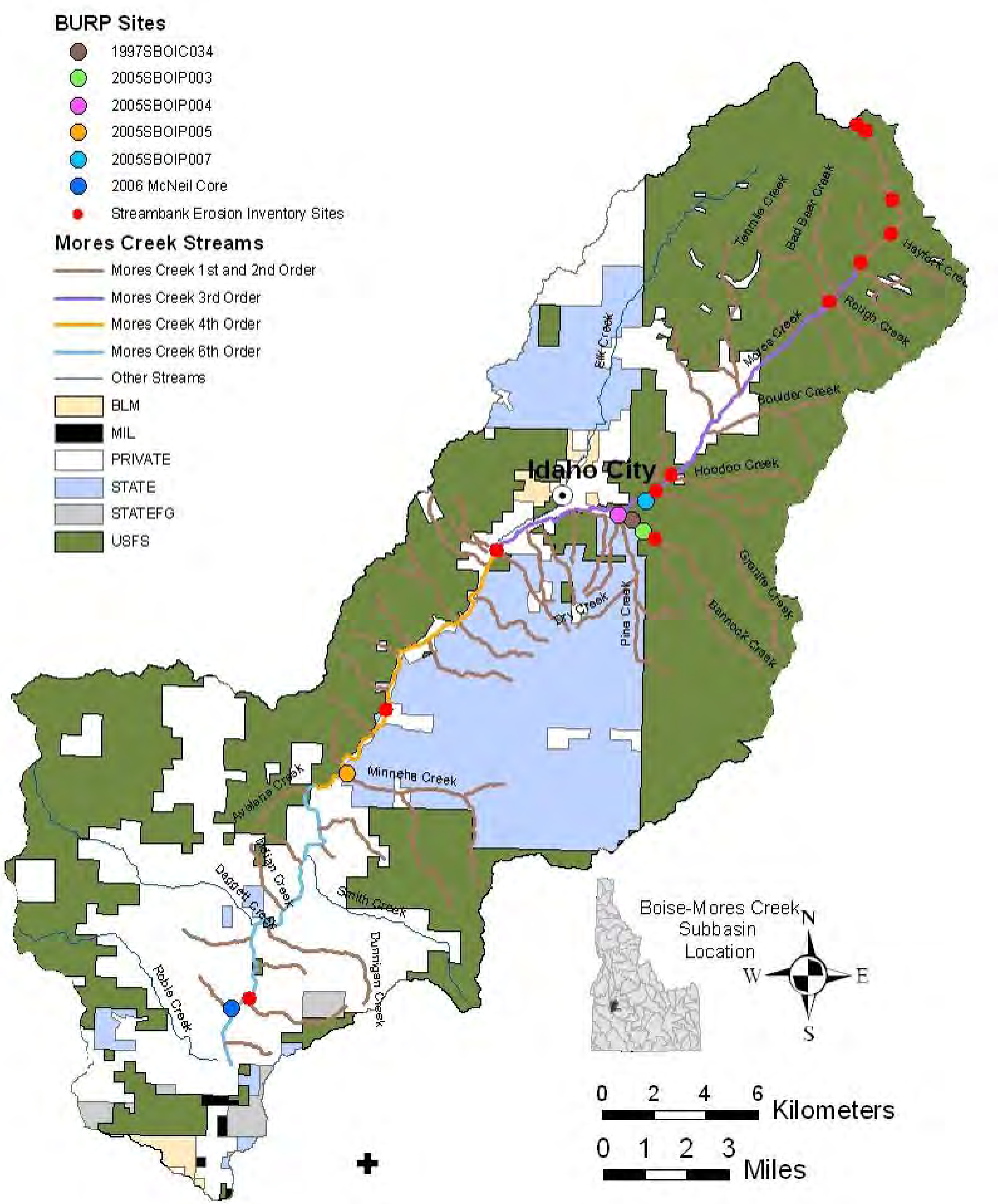


Figure 33. Mores Creek McNeil Core Sampling and Streambank Erosion Inventory Sites.

Table 37. Mores Creek streambank erosion inventory results (September 2006).

Mores Creek Reach Location	AU	Total Inventoried Feet	Eroding Feet	% Eroding (Target = ≤20)	Extrapolated Length (feet)	Erosion Rate (Tons/mile/year)	Tons of Sediment per Year
Source to 350 m upstream of First Hwy 21 Crossing	009_02	1551	63	4	250920	2.43	116.29
Upper Hwy 21 Crossing to 10 mile Creek	009_02	4587	102	2	446080	0.25	21.65
10 Mile Creek to Granite Creek	009_03	3039	570	19	34632	12.83	91.57
Granite Creek to Sawmill Creek	009_03	2142	426	20	25078	24.95	128.62
Sawmill Creek to Thorn Creek	009_04	8373	2655	32	20351	54.25	295.10
Thorn Creek to Grimes Creek	009_04	2205	351	16	14737	6.35	20.39
Grimes Creek to Mores Gauging station	009_06	1560	66	4	47861	0.97	9.03

Summary of Status of Beneficial Uses

Cold water aquatic life and salmonid spawning beneficial uses are not supported in all Mores Creek AUs (Table 38). Excessive stream temperatures and sediment are negatively impacting these AUs. Contact recreation was found to be fully supported in all AUs through bacteria risk screening and collected bacteria samples. DEQ has prepared a TMDL for stream temperature and sediment for AUs 009_02, 009_03, 009_04 and 009_06.

DEQ proposes that AUs 009_02, 009_03, and 009_04 be added to the §303(d) list for habitat and flow alteration due to impacts of extensive historic placer mining in the basin.

Table 38. Summary of beneficial use support determination for Mores Creek.

AU	Beneficial Uses Assessed	Support Status	Basis for Determination
009_02	CWAL	NFS	BURP, temperature and sediment data
	SS	NFS	Stream temperature data
	PCR	FS	Bacteria screening
	DWS	FS	Bacteria screening
009_03	CWAL	NFS	BURP, temperature and sediment data
	SS	NFS	Stream temperature data
	PCR	FS	Bacteria screening
	DWS	FS	Bacteria screening
009_04	CWAL	NFS	BURP, temperature and sediment data
	SS	NFS	Temperature data
	PCR	FS	Bacteria screening
	DWS	FS	Bacteria screening
009_06	CWAL	NFS	Temperature and sediment data
	SS	NFS	Stream temperature data
	PCR	FS	Bacteria sample results
	DWS	FS	Bacteria sample results

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, PCR – Primary Contact Recreation, DWS – Domestic Water Supply, FS – Fully Supported, NFS – Not Fully Supported

Thorn Creek

Thorn Creek is a 3rd order perennial stream that lies in the central part of the Boise-Mores Creek Subbasin. The headwaters begin at Thorn Creek Butte at an elevation of 7,460 feet and flow aspect is generally west to the confluence with Mores Creek at 3,450 feet, approximately 2 miles upstream of Grimes Creek. Thorn Creek and its tributaries total 34.6 miles of stream. Thorn Creek drains approximately 27.2 square miles. The Thorn Creek watershed includes AUs 011_02 and 011_03 and neither is on the §303(d) list for any pollutants.

Hydrology

Thorn Creek and its tributaries are Rosgen Type B channels with relatively low sinuosity and gradients between 2 and 2.5%. Instantaneous flow measurements were taken at DEQ BURP monitoring sites (Figure 34). In early July 2004, flow was estimated at 4.6 cfs at site 2004SBOIA027. In the South Fork (SF) Thorn Creek, flow was measured as 0.7 cfs at site 2004SBOIA025.

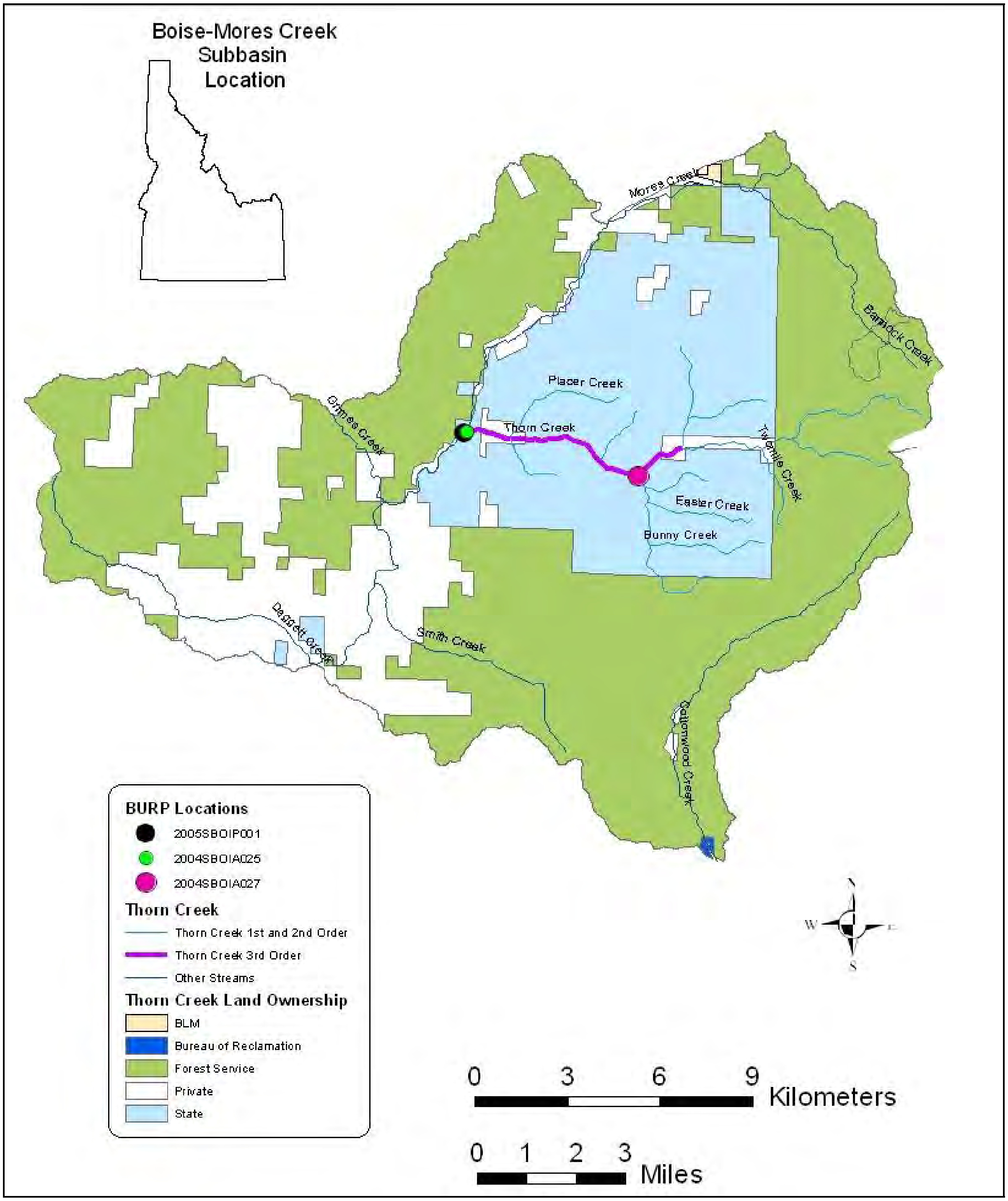


Figure 34. Thorn Creek Watershed.

Water Quality and Other Data

Water quality, habitat, and fisheries are discussed in the following subsections.

Water Quality Data

Water quality data was collected at BURP sites during routine monitoring at two sites in early July 2004 (Table 39). Based on criteria described earlier in this report, total phosphorus and chlorophyll *a* measurements do not indicate a problem with excessive nutrients. The numeric water quality standard states that a water body is impaired if turbidity levels are 50 NTUs above natural background for more than 10% of measurements or more than 25 NTUs above background for more than 10 consecutive days.. Turbidity data was within numeric criteria. Turbidity measurements were taken during BURP monitoring in the summer months, it is possible that values may be much higher during heavy runoff in fall rain events and spring runoff. To better assess whether there is excessive sediment DEQ recommends that turbidity and/or TSS samples be collected during high water events in fall and spring.

Although a bacteria sample was not collected, a bacteria screening procedure was completed using GIS. The subbasin was found to have limited grazing and limited human impacts that may produce bacteria. Overall, data collected and information analyzed do not indicate any impairment by nutrients or bacteria in the AUs sampled.

Table 39. Thorn Creek water quality data summary.

Stream	AU	Chlorophyll *a* (mg/L)	Total Phosphorous (mg/L)	Turbidity (NTU)
SF Thorn Creek (6/30/2004)	011_02	0.71	0.032	1.31
Thorn Creek (7/3/2004)	011_03	0.56	0.023	2.04

Habitat Data

BURP data for Thorn Creek is listed in Table 40. BURP scores for SF Thorn Creek indicate full support of beneficial uses in AU 011_02. Thorn Creek BURP scores indicate that beneficial uses are not fully supported in AU 011_03. Severe wildfires burned much of the subbasin in 1994. In the winter of 1996-1997 a historic rain-on-snow event resulted in a massive debris flow that washed out parts of the road that parallels Thorn Creek. This resulted in high amounts of bedload sediment in the main channel downstream of the mass wasting zone. The debris flow impacted Thorn Creek AU 011_03 but not the south fork of Thorn Creek where the AU 011_02 BURP site is located. This sediment has not fully worked through the system, as evidenced by finding 44% subsurface fines in McNeil core samples taken in 2005 at BURP Site 2005SBOIP001. Although habitat scores are low in AU 011_03 and sediment core samples reveal high amounts of subsurface fine sediment, the assessment unit should not be regarded as impaired due to anthropogenic sources. High sediment levels are due to fire which is part of a natural ecosystem. The surface percent fine measurements at both BURP sites in 2004 were low, at 2 and 9%, which indicates that the stream is exporting surface sediment and not accruing additional material. The road that was damaged in the debris flow has been decommissioned in accordance with the Forest Practices Act. Since this action requires appropriate sediment control BMPs, any erosion that may currently be occurring is the slope eroding to the angle of repose, which is a natural process. DEQ recommends that land management agencies monitor recovery of this area with streambank and/or road bed erosion surveys to ensure beneficial uses are restored.

Table 40. Thorn Creek (AU 011_02 and 011_03) BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	AU	Stream Sampled	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
			Score 0-3 (3 is the highest score)				
2004SBOIA025	011_03	Thorn	2	1	2	1.67	NFS
2004SBOIA027	011_02	SF Thorn	3	2	3	2.66	FS

FS – Fully Supporting Cold Water Aquatic Life, NFS – Not Fully Supporting Cold Water Aquatic Life

Fisheries

Salmonids were collected at both BURP sites sampled in the Thorn Creek watershed. Fish from the BURP site in AU 011_02 were exclusively rainbow trout from 3 to 7 inches. Fish collected at the BURP site in AU 011_03 included 1 juvenile and 2 adult rainbow trout, sculpin, dace, suckers and a bluegill. The low proportion of cold water species and the presence of a nonnative warm water fish species resulted in a low SFI score and confirm temperature impairment of AU 011_03.

Summary of Status of Beneficial Uses

Instantaneous temperature measurements during BURP surveys and poor SFI scores indicate that cold water aquatic life and salmonid spawning beneficial uses are not supported in Thorn Creek AU 011_03. Secondary contact recreation was found to be in full support in both AUs through bacteria risk screening. DEQ has prepared a TMDL for stream temperature for 011_03 (Table 41).

Table 41. Summary of beneficial use support determination for Thorn Creek.

AU	Beneficial Uses Assessed and Supported	Support Status	Basis for Determination
011_02	CWAL	FS	BURP data
	SS	FS	BURP data
	SCR	FS	Bacteria Screening
011_03	CWAL	NFS	BURP and temperature data
	SS	NFS	BURP and temperature data
	SCR	FS	Bacteria Screening

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, SCR – Secondary Contact Recreation, FS – Fully Supported, NFS – Not Fully Supported

Elk Creek

Elk Creek is a 3rd order perennial stream that lies in the north central part of the Boise-Mores Creek Subbasin. The headwaters begin on the south slopes of Wilson Peak at 7,200 feet elevation and it flows generally south into Mores Creek at 3,980 feet in Idaho City. Elk Creek and its tributaries total 55.7 miles of stream. Elk Creek drains approximately 24.1 square miles. The Elk Creek watershed includes AU 012_02 and 012_03. The presumed beneficial uses are cold water aquatic life and salmonid spawning. Ground water from the watershed is used as a drinking water source for Idaho City. Elk Creek is not listed on the §303(d) list.

Hydrology

Elk Creek is a moderately sinuous Rosgen Type B channel. Gauging records for Elk Creek above the mining diversion exist from March 1940 to August 1941. The stream (upstream of diversions) follows a typical hydrologic regime for southwestern Idaho with peak flow occurring during mid-April to late May and base flow occurring by late July (Figure 35). Instantaneous stream flow measurements of 5.9, 7.4, and 8.0 cfs (in order from lowest in drainage to highest) recorded at BURP sites (Figure 36) were slightly higher than the average for early August. At the time of the continuous flow measurements recorded by the USGS gauge, numerous diversions were present in the watershed to support hydraulic and placer mine operations.

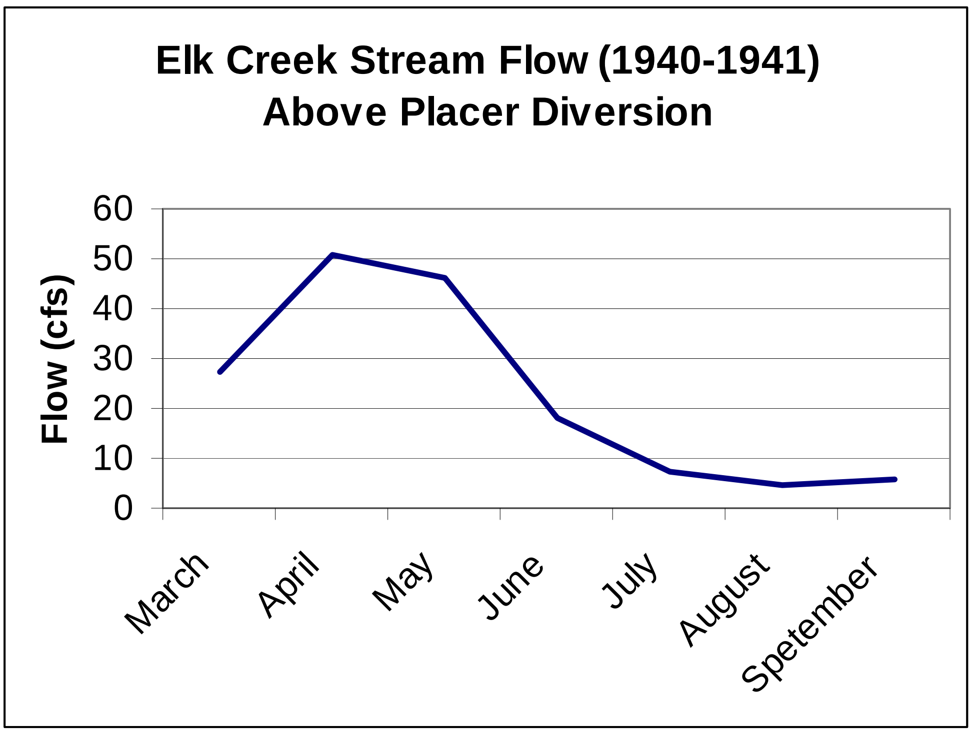


Figure 35. Average Monthly Stream Flow at Elk Creek gauging site above Gold Hill Placer Diversion near Idaho City (USGS 1940-1941).

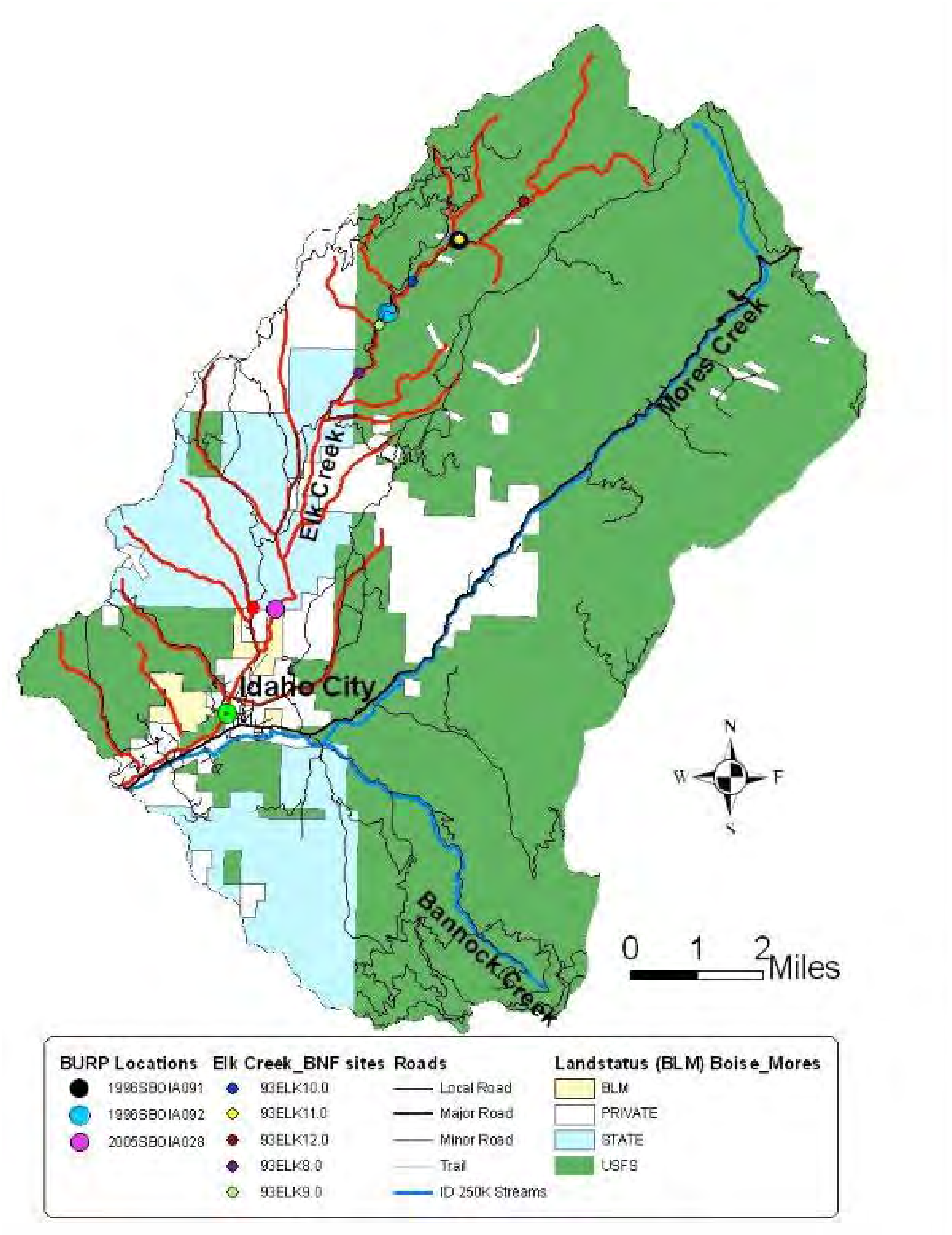


Figure 36. Elk Creek Watershed BURP Sites.

Biological and Other Data

The following subsections discuss data for temperature, bacteria, habitat, and fisheries.

Temperature

Water temperature was collected at BURP sites during BURP monitoring. At site 2005SBOIA028, in early August, the stream temperature was 16.9 degrees Celsius. In early August at site 1996SBOIA091, stream temperature was 14 degrees Celsius. At site 1996SBOIA092, in early August, stream temperature was 18 degrees Celsius. Even though the temperature measurements were not collected during critical time periods for salmonid spawning and rearing, stream temperatures collected to date meet numeric criteria to support cold water aquatic life beneficial uses.

Bacteria

A GIS bacteria screening procedure was performed to assess risk of bacteria contamination. There is limited grazing in the subbasin and little human impact that may produce bacteria, therefore samples were not necessary. Elk Creek is designated as a small public water supply for Idaho City (IDAPA 58.01.02.252.01.b.i). At a location adjacent to Elk Creek, drinking water is taken from below the ground surface through gravel and sand deposits which are presumed to act as a filter. Bacteria and turbidity measurements are recorded daily at the drinking water supply inlet and throughout the filtration process, with results submitted to the DEQ Drinking Water Section.

Habitat Data

BURP data for Elk Creek is listed in Table 42. BURP scores for all sites show full support of beneficial uses. The most recent BURP data from Elk Creek (site 2005SBOIA028 at the lowest elevation in the system) has the highest possible condition ratings for habitat and macroinvertebrates. Although there are historic load, placer, and hydraulic mine sites in the drainage, indicating that bedload sediment may cause impairment, *the data do not indicate such impairment*. The percentage of surface fines at BURP site 2005SBOIA028 was 13%, which is below the recommended maximum of 23% for Rosgen Type B channel streams in plutonic parent material. In addition, bank stability was observed at 100% for all BURP sites. This data reinforces other evidence that Elk Creek is supporting beneficial uses.

Table 42. Elk Creek AU 012_02 and AU 012_03 BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
	Score 0-3 (3 is the highest score)				
2005SBOIA028	3	NS	3	3	FS
1997SBOIA092	1	NS	3	2	FS
1996SBOIA091	2	NS	3	2.5	FS
Average Condition Rating				**2.5**	**FS**

NS– Not Sampled, FS – Fully Supporting Cold Water Aquatic Life

Fisheries

Boise National Forest personnel performed electrofishing surveys in Elk Creek in 1993. Sites are marked on Figure 34. At the five sites sampled in 1993, 66 rainbow trout less than 100 mm were collected, along with 58 between 4 and 8 inches, and 13 sculpin. These data show salmonid spawning as an existing use. The dominance of salmonid species indicates that stream conditions support salmonid spawning.

Summary of Status of Beneficial Uses

Cold water aquatic life and salmonid spawning beneficial uses are supported in all Elk Creek AUs (Table 43). Contact recreation is determined to be fully supported in all AUs through bacteria risk screening. DEQ has prepared a TMDL for stream temperature since Elk Creek is contributing to the thermal load of Mores Creek. DEQ proposes that AUs 009_02, 009_03, and 009_04 be added to the §303(d) list for habitat and flow alteration due to impacts of extensive historic placer mining in the basin.

Table 43. Summary of beneficial use support determination for Elk Creek.

AU	Beneficial Uses Assessed and Supported	Support Status	Basis for Determination
012_02	CWAL	FS	BURP
	SS	FS	Sediment data and existing salmonid spawning
	SCR	FS	Bacteria screening
012_03	CWAL	FS	Sediment data and existing salmonid spawning
	SS	FS	Stream temperature data
	SCR	FS	Bacteria screening

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, SCR – Secondary Contact Recreation, FS – Fully Supported, NFS – Not Fully Supported

Grimes Creek

Grimes Creek is a 5th order perennial stream that lies in the western part of the Boise-Mores Creek subbasin. The headwaters begin on the north face of Freeman Peak at 7,950 feet elevation and stream aspect is generally south into Mores Creek at 3,330 feet, approximately 9 miles upstream of Lucky Peak Reservoir. Grimes Creek and its tributaries total 185.4 miles of stream. Grimes Creek drains approximately 196.0 square miles. The Grimes Creek watershed comprises AUs 013_02, 013_03, 013_04, and 013_05.

Hydrology

Grimes Creek is a moderately sinuous Rosgen Type B channel in most tributary and headwater segments. The lower reaches of Grimes Creek are also moderately sinuous but are Rosgen Type F channels. The watershed has been extensively altered by dredge and hydraulic mining. Dredge waste piles are present in the valley bottoms and constrain stream channels in many areas. Unimproved Boise National Forest roads parallel Grimes Creek and many of its tributaries. The road bed materials are often in direct contact with stream riparian areas or the stream bank.

Continuous gauging records are not available for Grimes Creek. The nearest gauge is 8 miles downstream of the mouth of Grimes Creek on Mores Creek. Mores Creek follows a typical hydrologic regime for southwestern Idaho, as discussed earlier (Figure 31). Instantaneous stream flow measurements recorded at BURP sites range from 6 cfs in Clear Creek, a tributary to 3rd order Grimes Creek, to 23 cfs in 5th order Grimes Creek in late July.

Water Quality Data

Data for several water quality parameters was collected at two BURP sites, one in AU 013_02 and one in AU 013_05 (Table 44). Chlorophyll *a*, total phosphorous, ammonia, and nitrate-nitrite results indicate there are not excessive nutrients in either AU. Although the best method to evaluate nutrient data is to establish a site-specific target, water quality narrative criteria can be used to interpret these findings. Idaho's Water Quality Standards contain the following narrative standard for excess nutrients: "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses" (IDAPA 58.01.02.200.06).

Nitrate-nitrite values for Grimes Creek are less than 0.06 mg/L. Total phosphorus concentrations in 2nd and 5th order Grimes Creek are shown in Table 44. In 5.4 miles of Grimes Creek surveyed, there were no documented observations of excess algal growth, indicating that the intent of the narrative standard is met.

Additionally, the Golden Age Mine site (Figure 37) on Grimes Creek has a low instantaneous turbidity reading, and both sites sampled had low amounts of total suspended sediment (TSS). The numeric water quality standard states that a water body is impaired if turbidity levels are 50 NTUs above natural background for more than 10% of measurements or more than 25 NTUs above background for more than 10 consecutive days. Water quality data do not indicate any nutrient or sediment impairment in the three AUs sampled. Turbidity measurements were taken during BURP monitoring in the summer months, it is possible that values may be much higher during heavy runoff in fall rain events and spring runoff. In order to better assess whether there is excessive sediment DEQ recommends that turbidity and/or TSS samples be collected during high water events in fall and spring.

In August 2000, one sample for *E. coli* was collected at one site in Grimes Creek AU 013_02, at a previous BURP site 1997SBOIA002, to determine the support status of recreational uses. The sample result was 21 cfu/100ml. Two samples were collected in AU 013_05, one in August 2006 near the mouth of Grimes Creek and one in August 2000 at a previous BURP site 1998SBOIA075. The sample results were 15 and 11 cfu/100ml, respectively. Because these results were below the single sample indicator value of 406 cfu/100ml, PCR is determined to be a supported use in both AUs. Other AUs were assessed using a GIS bacteria screening procedure outlined in WBAG II. All AUs were found to have limited or no grazing and limited human impacts that may produce bacteria. Table 44 shows the water quality data summary for Grimes Creek.

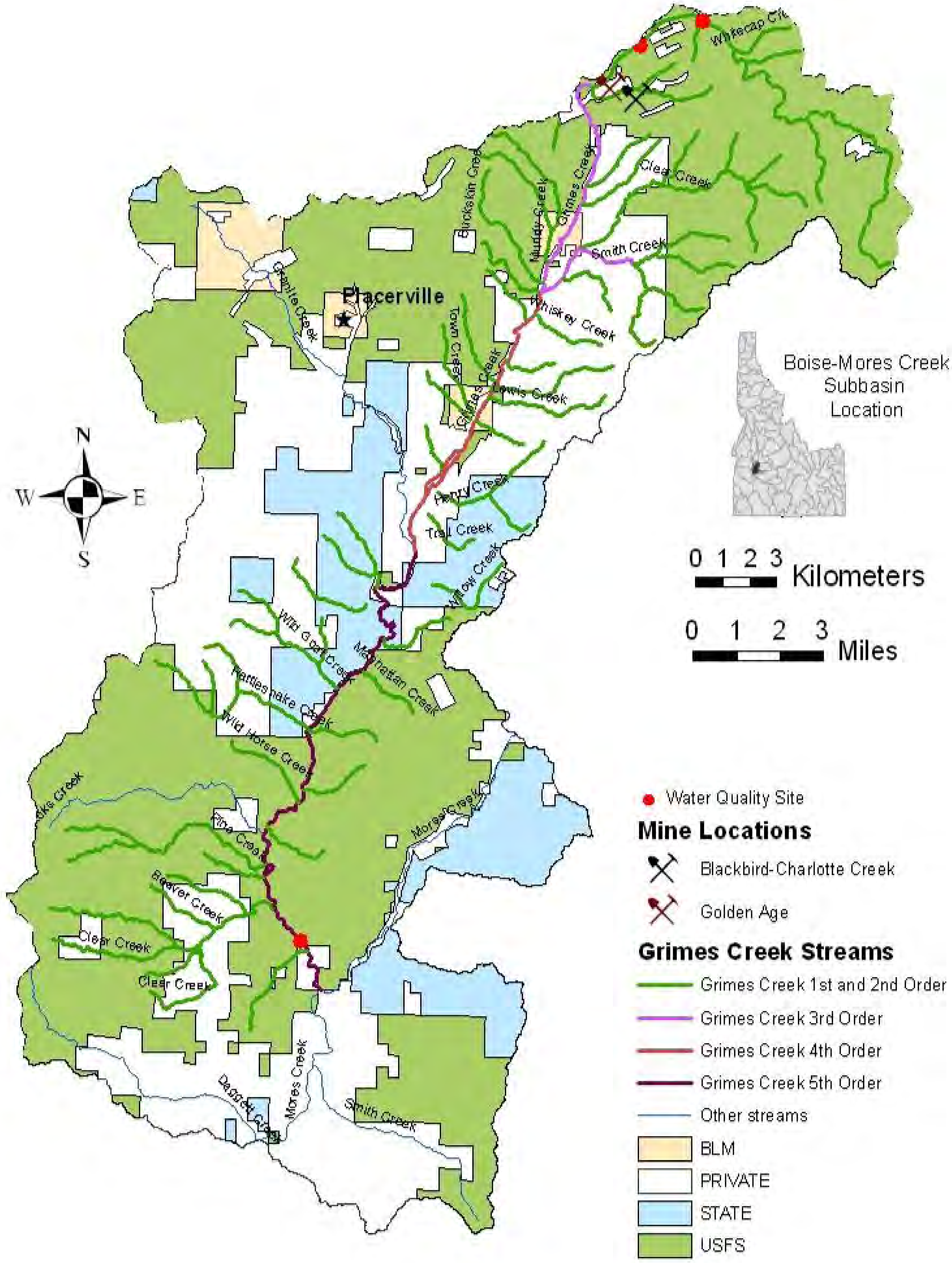


Figure 37. Grimes Creek Watershed Water Quality Sites.

Table 44. Grimes Creek water quality data summary.

Stream	AU	DO (mg/L)	Total Phosphorus (mg/L)	NH_3 (mg/)l	Nitrate-Nitrite (mg/l)	Turbidity (NTU)	TSS (mg/l)	Bacteria (*E. coli*) (cfu)
Grimes Creek near Golden Age Mine (1998)	013_02	9.6	NS	0	0	0.19	2.2	NS
2nd Order Grimes (8/2006)	013_03	7.0	0.033	0.040	0.04	NS	2.8	NS
5th Order Grimes Creek (8/2006)	013_05	6.0	0.02	<0.005	<0.01	NS	<2.0	15/100ml

NS– Not Sampled

Metals

In July 2007, DEQ collected water quality samples from two sites that were historic lode mine sites in AU 013_02. The water samples came from mine adit drainages (SW1, SW2, and SW3) or from streams. Some metal concentrations were above the water quality standard at mine adit drainages; however, the stream samples met water quality standards (Table 45 and Table 46). The metals concentrations show that CWAL and SCR beneficial uses are not impaired by metals at either site.

Table 45. Metal analysis results (µg/l) for Blackbird Mine on Charlotte Gulch, a first order tributary to Grimes Creek (samples collected 7/11/07).

Metal	SW1 drainage	SW2 drainage	SW3 (duplicate) drainage	Charlotte Creek above mill tails (background)	Cold Water Biota Standard Acute	Cold Water Biota Standard Chronic
Arsenic	<0.0030	<0.0030	<0.0030	<0.0030	0.36	0.19
Barium	0.0213	.0193	0.195	0.0177	n.a.	n.a.
Cadmium	<0.0020	<0.0020	<0.0020	<0.0020	0.00082 (H)	0.00037 (H)
Chromium	<0.006	<0.006	<0.006	<0.006	n.a.	n.a.
Copper	<0.010	<0.010	<0.010	<0.010	0.0046 (H)	0.0035 (H)
Lead	0.00700	0.00463	0.00348	<0.00300	0.014 (H)	.00054 (H)
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	.0021	.000012 (T)
Selenium	<0.04	<0.04	<0.04	<0.04	0.018 (T)	0.005 (T)
Silver	<0.005	<0.005	<0.005	<0.005	0.00032 (H)	n.a.
Zinc	0.122	0.102	0.025	<0.010	0.035 (H)	0.032 (H)

(H) – Hardness dependent @ 25 mg/l, (T) – Standard in Total, n.a. – Not Applicable

Table 46. Metal analysis results (µg/l) for Golden Age Mine on second order Grimes Creek (samples collected 7/10/07).

Metal	Golden Age Spring Adit	Grimes Creek Downstream of Golden Age spring	Grimes Creek upstream from Golden Age spring (background)	Cold Water Biota Standard Acute	Cold Water Biota Standard Chronic
Arsenic	0.0877	<0.0030	<0.0030	0.36	0.19
Barium	0.0695	0.0154	0.0167	n.a.	n.a.
Cadmium	0.0434	<0.0020	<0.0020	0.00082 (H)	0.00037 (H)
Chromium	<0.006	<0.006	<0.006	- n.a.	- n.a.
Copper	0.155	<0.010	<0.010	0.0046 (H)	0.0035 (H)
Lead	0.108	<0.00300	<0.00300	0.014 (H)	.00054 (H)
Mercury	0.00059	<0.00020	<0.00020	.0021	.000012 (T)
Selenium	<0.04	<0.04	<0.04	0.018 (T)	0.005 (T)
Silver	<0.005	<0.005	<0.005	0.00032 (H)	- n.a.
Zinc	2.68	<0.010	<0.010	0.035 (H)	0.032 (H)

(H) – Hardness dependent @ 25 mg/l, (T) – Standard in Total n.a. – Not Applicable

Biological and Other Data

The following subsections discuss data on fisheries, habitat, fine sediment, and bank stability for Grimes Creek AUs.

Fisheries

Fish communities were sampled by BURP staff and Boise National Forest personnel. Boise National Forest (BNF) fisheries surveys were conducted in 1993; fish species and length distributions from the BNF surveys are listed in Table 47. BURP fish surveys were completed in Clear Creek for AU 013_02. The SFI scores from BURP surveys indicate that SS beneficial uses are supported (Table 48). Throughout the sampled sites, juvenile salmonids (<100mm) were found, indicating that salmonid spawning is an existing use for AUs 013_02 and 013_03; however, this data does not reveal where successful spawning is occurring.

Table 47. Grimes Creek BNF fisheries data.

AU	Stream	Sample Date	Rainbow Trout				Bull Trout			Brook Trout			Sculpin
			0-3”	4-7”	8-11”	12+”	0-3”	4-7”	8-11”	0-3”	4-7”	8-11”	
Grimes 1st and 2nd Order	Grimes Creek	1993	8	17	1					18	19	2	27
	Grimes Creek	1994	4	26						52	134	3	125
	Clear Creek near Pioneerville	1993	34	12	1					13	7	1	15
	Clear Creek near Pioneerville	1994	13	31						6	16		14
	Clear Creek near Mores Creek confluence	1993	17	10									3
	Pine Creek	1993	27	11									6
Grimes 3rd Order	Grimes	1993								1			2
	Grimes	1994	5	4	2					1	6		21

Habitat Data

BURP crews sampled sites in all AUs of Grimes Creek (Figure 38). Water body assessment scores (Table 48 and Table 49) from BURP sites indicate that beneficial uses are fully supported for all AUs except AU 013_05. Recreation, roads, urban areas and mining are factors that BURP personnel listed as having potential to affect water quality. Many of the SHI scores are low; however, the average condition ratings have an acceptable score except in Grimes Creek AU 013_05. BURP site 1996SBOIA029 has an SMI score of 0. The BURP crew noted this site had fast water and that a good seal may not have been formed on the sampler. This score was excluded from consideration for beneficial use support.

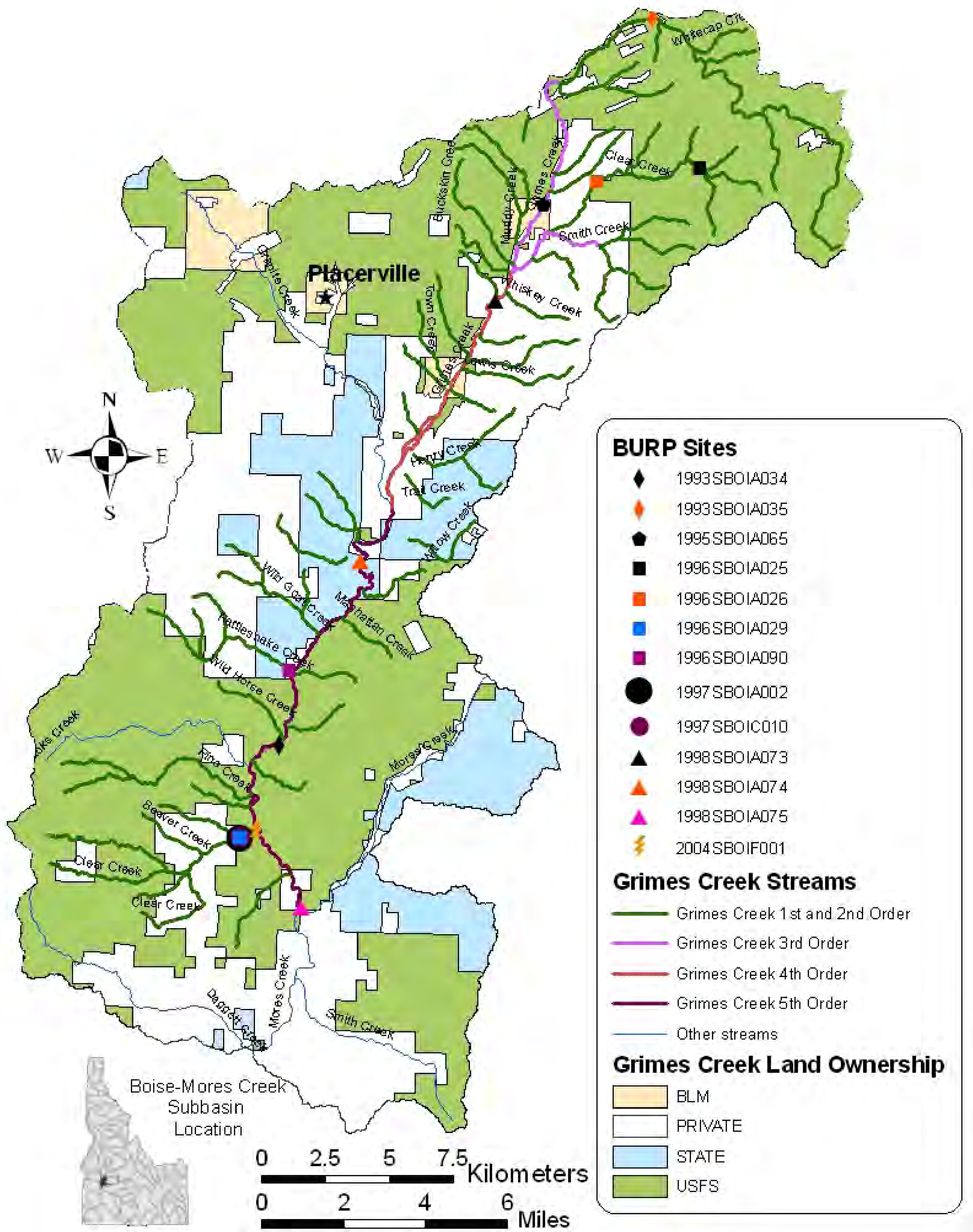


Figure 38. Grimes Creek Watershed BURP Sites.

Table 48. Grimes Creek first and second order (AU 013_02) BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	Water Body (Stream)	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
		Score 0-3 (3 is the highest score)				
2004SBOIF001	Clear	NS	2	NS	n.a	n.a
1997SBOIC010	Clear	1	NS	3	2	FS
1997SBOIA002	Clear	2	NS	3	2.5	FS
1996SBOIA090	Rattlesnake	3	NS	3	3	FS
1996SBOIA029	Clear	1	3	0	0	NFS
1996SBOIA026	Clear	2	3	3	2.67	FS
1996SBOIA025	Clear	2	2	3	2.33	FS
1993SBOIA035	Grimes	1	NS	3	2	FS
Average of Condition Rating for all Sites					**2.07**	**FS**

NS– Not Sampled, FS – Fully Supporting Cold Water Aquatic Life, NFS – Not Fully Supporting Cold Water Aquatic Life, n.a. – Not Applicable

Table 49. Grimes Creek AUs 013_03, 013_04, and 013_05 BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	AU	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
		Score 0-3 (3 is the highest score)				
1995SBOIA065	013_03	1	NS	3	2	FS
1998SBOIA073	013_04	2	NS	3	2.5	FS
1993SBOIA034	013_05	1	NS	2	1.5	NFS
1998SBOIA074	013_05	1	NS	1	1	NFS
1998SBOIB075	013_05	1	NS	2	1.5	NFS

NS– Not Sampled, FS – Fully Supporting Cold Water Aquatic Life

Fine Sediment and Bank Stability

Much of the land in the Grimes Creek basin has been altered by surface vegetation removal, mining, road construction, and timber harvest. Removal of vegetation results in unstable soil which is more susceptible to erosion. The mean percentage of surface fines in sites sampled in Grimes Creek AU 013_02 ranges from 14 to 20% in 1995 and 1997 (Table 50). Recommended target levels for surface fine sediment (< 6.0 mm) were developed by the Forest Service and Bureau of Land Management for the Upper Columbia River Basin for plutonic Rosgen A, B, and C channels (DEQ 2003). The values recorded at the sample sites are below the recommended maximum levels for Rosgen Type B channels with plutonic parent material. Additional percent fine measurements were taken in streams with Rosgen Type F channels; however, there is not a literature-recommended target value. The percent fine measurements were below 10% in Rosgen Type F channels, so it is likely beneficial uses are not impaired by sediment. Rosgen Type F channels are meandering channels that naturally promote higher sediment deposition.

Table 50. Grimes Creek recorded percent surface fines and recommended target levels.

DEQ BURP Site ID	AU	Percent Surface Fines	Rosgen Channel Type	Recommended Target (%)	Target Met
1997SBOIC010 Clear Creek	013_02	16	B	23	yes
1997SBOIA002 Clear Creek	013_02	14	B	23	yes
1995SBOIA065 Grimes Creek	013_03	20	B	23	yes

The percentage of fine material on the surface of a stream bed does not provide a clear picture of bedload sediment. Surface fine sediment can be highly dependent on stream flow and channel morphology. Measurements of depth fines can give a more accurate representation of stream sediment bedload and potential impacts to aquatic life. The recommended TMDL target for depth fines is less than or equal to 27% (IDEQ 2003). The percentage of depth fines (< 6 mm) was measured in AU 013_05 by DEQ personnel using McNeil sediment core samples. The core samples measured fines at 65% of the bed material, considerably higher than the recommended maximum of 27% fine material.

Vegetation removal and overland erosion often result in increased stream velocities and increased streambank erosion. BURP inventories recorded bank stability ranging from 75 to 100% (Table 51). Streambanks are considered to be functioning properly at values greater than 80%. The streambanks in some of the sites in Grimes Creek AU# 013_04 and AU# 013_05 do not meet this target indicating sediment is negatively impacting beneficial uses.

A high percentage of the BURP data for streambank stability is older than allowed by Tier 1 data requirements, and is from small tributaries. In 2006, streambank erosion inventories were conducted in all AUs in mainstem Grimes Creek to determine support status of beneficial uses and the extent of impairment, based on a TMDL target value of 80% bank stability (Figure 39). The erosion inventory found bank stability characteristic of streams that support beneficial uses (Table 52). This data is not necessarily representative of all reaches; sampling occurred in areas that were easily accessible or not on private land.

Table 51. Grimes Creek measured bank stability.

DEQ BURP Site ID	AU	Bank Stability (%)	Target Met (Target=80%)
1997SBOIC010 Clear Creek	013_02	98	yes
1997SBOIA002 Clear Creek	013_02	100	yes
1996SBOIA090 Clear Creek	013_02	100	yes
1996SBOIA029 Clear Creek	013_02	94	yes
1996SBOIA026 Clear Creek	013_02	95	yes
1996SBOIA025 Clear Creek	013_02	100	yes
1995SBOIA065 Grimes Creek	013_03	92	yes
1998SBOIA073 Grimes	013_04	79	no
1993SBOIA034 Grimes	013_05	92	yes
1998SBOIA074 Grimes	013_05	75	no
1998SBOIB075 Grimes	013_05	89	yes

Table 52. Grimes Creek streambank erosion inventory (September 2006).

Reach Location	Total Inventoried Feet	Eroding Feet	% Eroding	Extrapolated Length (feet)	Erosion Rate – Tons/mile	Tons of Sediment per Year
Source to first White Cap Road Crossing	2892	0	0	507816	0	0
Road Crossing to Cup Creek	1320	72	5	298241	2.45	138.97
Cup Creek to Buckskin Creek	3180	12	0	42070	0.05	0.05
Buckskin Creek to Granite Creek	5631	366	6	40358	5.31	46.27
Granite Creek to Macks Creek	1800	0	0	19944	0	0
Macks Creek to Mouth	1500	0	0	54058	0	0

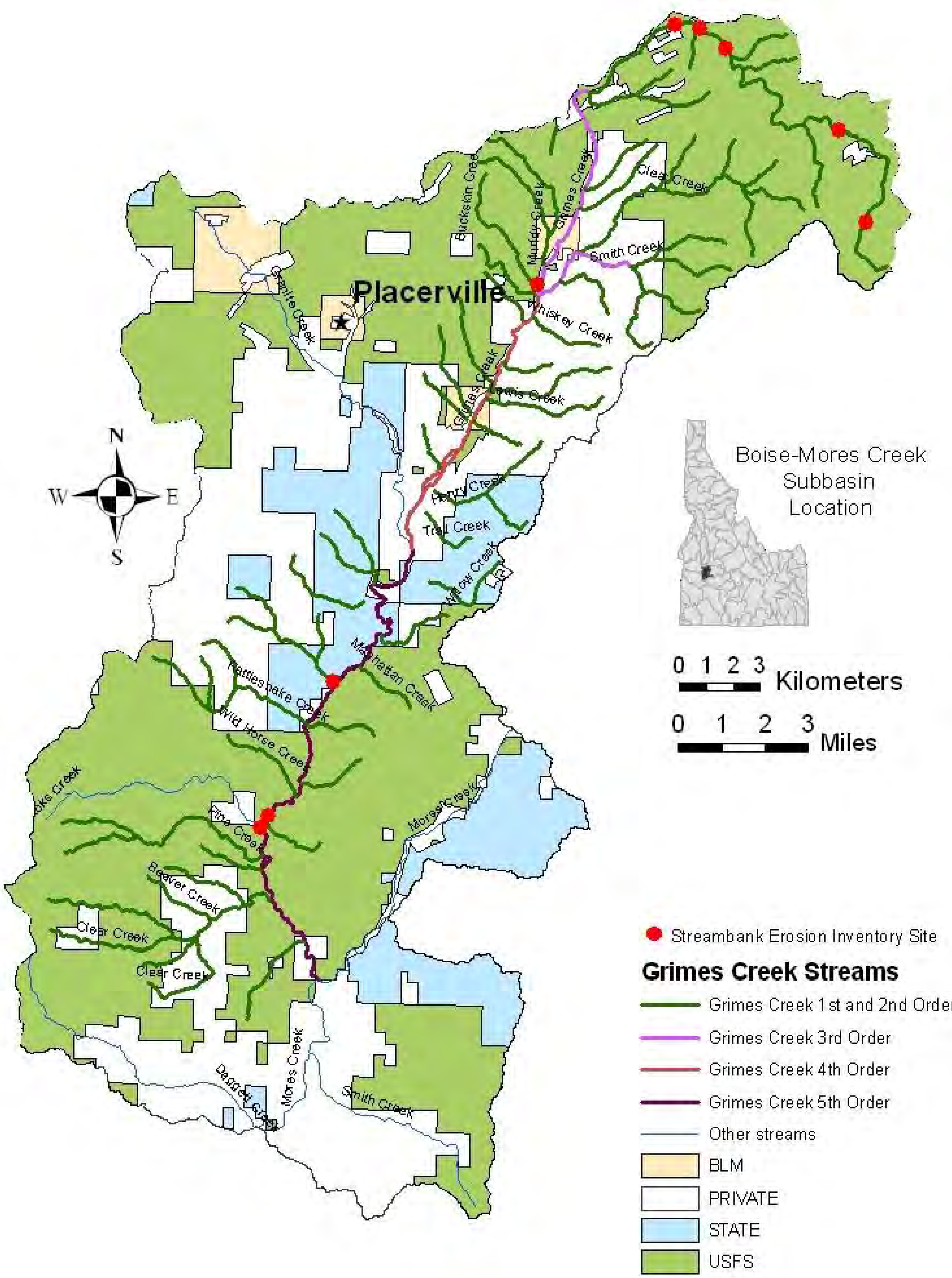


Figure 39. Grimes Creek Watershed Streambank Erosion Inventory Sites.

Summary of Status of Beneficial Uses

Cold water aquatic life and salmonid spawning beneficial uses are not supported in all Grimes Creek AUs (Table 52). Excessive stream temperatures are negatively impacting these AUs. DEQ has prepared temperature TMDLs for all Grimes Creek AUs. According to surface and subsurface fine sediment sampling results, sediment is impairing beneficial uses in AU 013_04 and 013_05. A sediment TMDL will be prepared for these AUs. Contact recreation was found to be full supported in all AUs through bacteria risk screening and collected bacteria samples. DEQ proposes that AUs 013_03 and 013_04 be added to the §303(d) list for habitat and flow alteration due to impacts of extensive historic placer mining in the basin.

Table 53. Summary of beneficial use support determination for Grimes Creek.

AU	Beneficial Uses Assessed	Support Status	Basis for Determination
013_02	CWAL	FS	Stream temperature and water quality samples
	SS	NFS	Stream temperature data
	SCR	FS	Bacteria screening and water quality samples
013_03	CWAL	NFS	Stream temperature data
	SS	NFS	Stream temperature data
	SCR	FS	Bacteria screening
013_04	CWAL	NFS	Temperature and sediment data
	SCR	FS	Bacteria screening
013_05	CWAL	NFS	Temperature and sediment data
	PCR	FS	Bacteria sample results

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, SCR – Secondary Contact Recreation, PRC – Primary Contact Recreation; FS – fully supporting; NFS – not fully supporting

Macks Creek

Macks Creek is a 2nd order perennial stream that lies in the west central part of the Boise-Mores Creek subbasin. The headwaters originate on the eastern slopes of Mores Mountain at 7,500 feet elevation and it flows generally east into Grimes Creek at 3,540 feet, approximately 4 miles upstream of the confluence of Grimes and Mores Creeks (Figure 40). Macks Creek and its tributaries total 17.8 miles of stream and drain approximately 12.4 square miles. The Macks Creek watershed comprises AU 015_02.

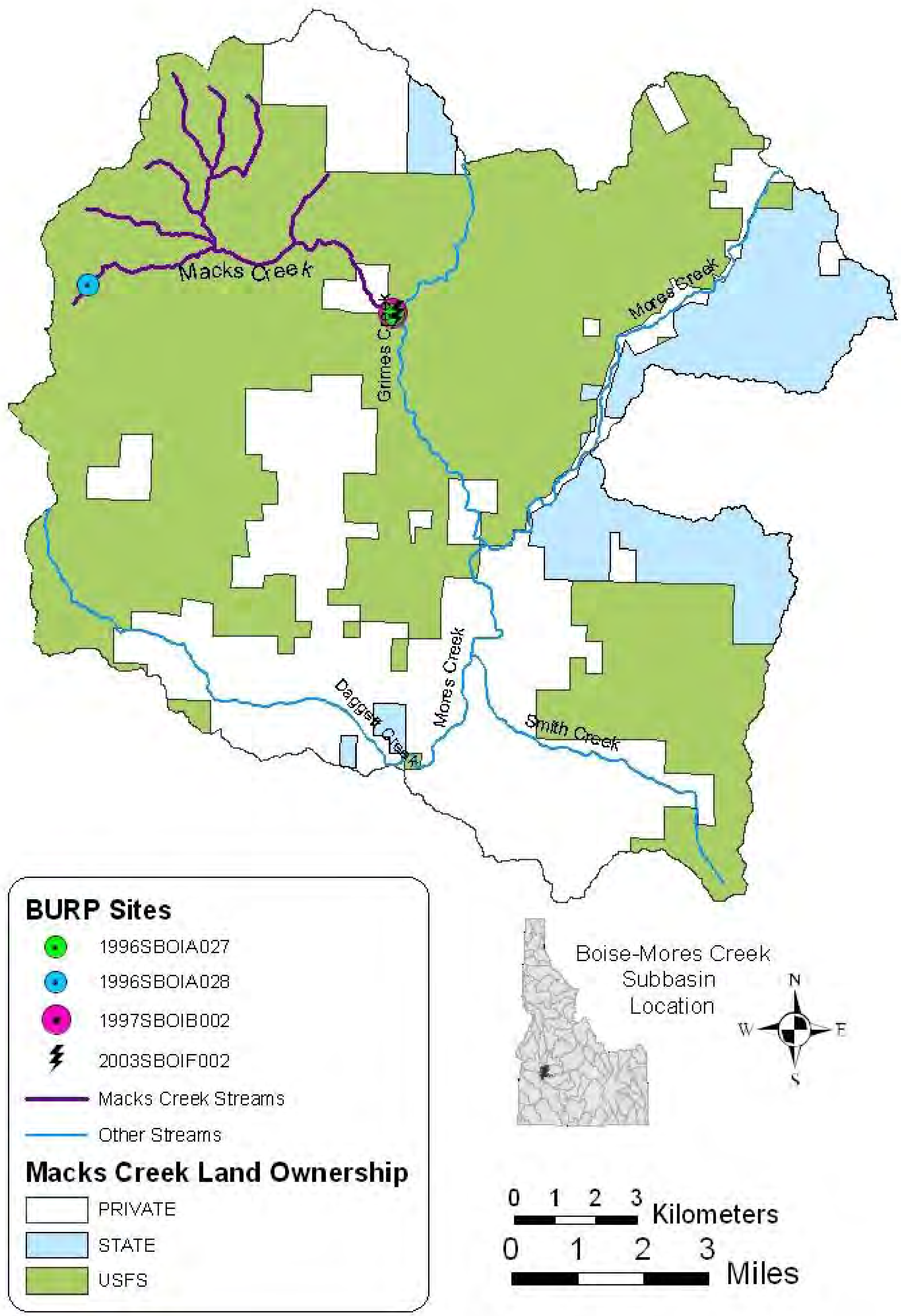


Figure 40. Macks Creek watershed.

Biological and Other Data

The following subsections discuss the data for bacteria, fisheries, and habitat in Macks Creek.

Bacteria

In June 1997, one sample for *E. coli* was collected at one site in Macks Creek, at BURP site 1997SBOIB002, to determine the support status of recreational uses (Figure 40). The sample result was 6 cfu/100ml. Since the result was below the single sample indicator value of 406 cfu/100ml, no further samples were collected and PCR is determined to be a supported use.

Fisheries and Habitat Data

BURP crews sampled sites in Macks Creek in 1996, 1997 and 2003 (Figure 40). Water body assessment scores (Table 54) from BURP sites would indicate that CWAL and SS beneficial uses are fully supported for this assessment unit. Recreation, roads, and urban development are factors that BURP personnel listed as having potential to affect water quality. The SMI and SFI scores from 1996 are low; however, the average condition ratings from 1997 include the highest possible score, and salmonids from 2 age classes were collected during the 2003 BURP sampling. The higher SFI in 2003 and the higher average condition rating in 1997 may indicate that water quality is improving or that there were problems with the 1996 sampling.

Table 54. Macks Creek first and second order (AU 015_02) BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
	Score 0-3 (3 is the highest score)				
2003SBOIF002	NS	2	NS	n.a.	n.a.
1997SBOIB002	3	NS	3	3	FS
1996SBOIA028	2	NS	1	1.5	NFS
1996SBOIA027	3	1	1	1.67	NFS
Grand Average Condition Rating for all Sites				**2.0**	**FS**

NS– Not Sampled, NFP – No Fish Present, FS – Fully Supporting Cold Water Aquatic Life, NFS – Not Fully Supporting Cold Water Aquatic Life, n.a. – Not Applicable

Summary of Status of Beneficial Uses

Cold water aquatic life and salmonid spawning beneficial uses are not supported in Macks Creek due to excessive stream temperature (Table 55). A temperature TMDL has been prepared for Macks Creek. PCR was found to be fully supported based on collected bacteria samples.

Table 55. Summary of beneficial use support determination for Macks Creek.

AU	Beneficial Uses Assessed and Supported	Support Status	Basis for Determination
015_02	CWAL	NFS	Temperature data
	SS	NFS	Temperature data
	PCR	FS	Bacteria sample

CWAL – Cold Water Aquatic Life, SS – Salmonid Spawning, PCR – Primary Contact Recreation

Granite Creek

Granite Creek is a 4th order perennial stream in the northeast section of the Boise-Mores Creek subbasin. The headwaters begin on the south and eastern slopes of Hawley Mountain at 7,280 feet elevation and stream aspect flows southeast to Grimes Creek at 4,100 feet, in New Centerville. Granite Creek and its tributaries total 78.7 miles of stream and drain approximately 51.3 square miles. The Granite Creek watershed includes AUs 014_02, 014_03, and 014_04.

Hydrology

Granite Creek is a moderately sinuous Rosgen Type C channel in most segments. The meadow segments of Granite Creek tributaries are also moderately sinuous but are low gradient Rosgen Type E channels. The watershed has been extensively altered by dredge and hydraulic mining. Dredge waste piles are present in the valley bottoms and constrain stream channels in many areas. An improved road parallels Granite Creek from New Centerville to Placerville Junction. Unimproved BNF roads parallel most of the remaining length of Granite Creek and many of its tributaries. The road-bed materials are often in direct contact with stream riparian areas or the stream bank and often restrict the channel from natural behaviors such as widening or meandering.

Continuous gauging records are not available for Granite Creek and the nearest gauge is on Mores Creek, downstream of the Grimes Creek confluence and upstream of Lucky Peak Reservoir. Mores Creek follows a typical hydrologic regime for southwestern Idaho with peak flow occurring from mid-April to late May and base flow occurring by late July (Figure 31). Instantaneous stream flow measurements recorded at BURP sites range from 0.2 cfs in Woof Creek, a Rosgen Type E channel tributary to Granite Creek, to 7.9 cfs in 3rd order Granite Creek in early July.

Biological and Other Data

The following subsections discuss bacteria, metals, fisheries, habitat, surface fines, and bank stability data for Granite Creek.

Bacteria

In July and September 2005, a sample for *E. coli* was collected from Granite Creek at BURP site 2005SBOIA023 (AU 014_03) to determine the support status of recreational uses (Figure 41). The sample results were 68 and 42 cfu/100ml, respectively. A sample was also collected in AU 014_02 at BURP site 1997SBOIC012 with results reported as

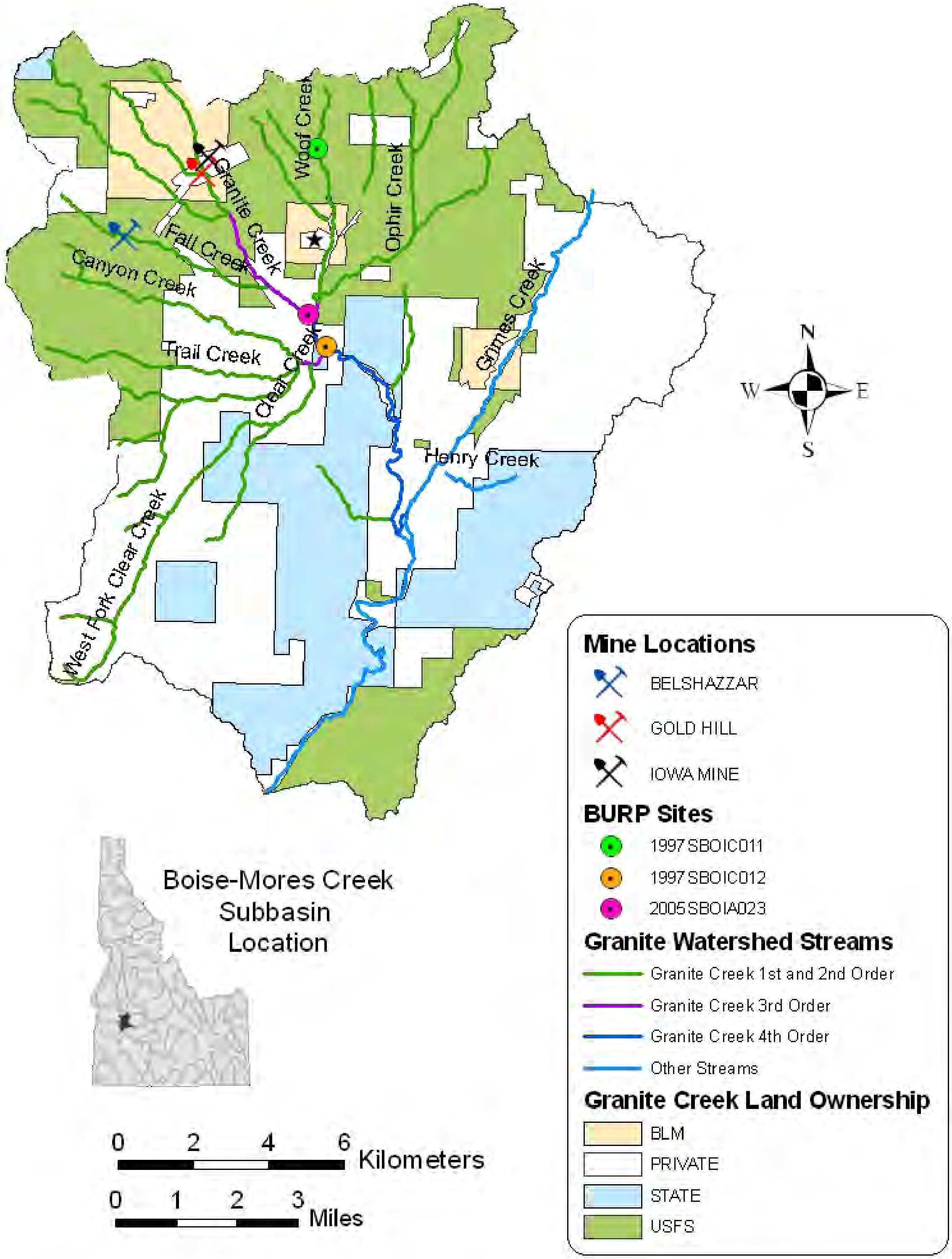


Figure 41. Granite Creek watershed.

44 cfu/100ml. Since all results were below the PCR single sample indicator value of 406 cfu/100ml, no further samples were collected and PCR is determined to be a supported use in both AUs. Other AUs were assessed using a GIS bacteria screening procedure outlined in WBAG II. All AUs were found to have limited or no grazing and limited human impacts that may produce bacteria.

Metals

In July 2007, DEQ collected water quality samples from two sites AU 014_02 where historic lode mines were operated. The water samples came from mine adit drainages or from streams. Some metal concentrations were above the water quality standard at adit drainages but not in stream samples (Table 56 and 57). The metals data indicate that CWAL and SCR beneficial uses are fully supported at both sites.

Table 56. Metal analysis results (µg/l) for Belshazaar Mine on Fall Creek, a first order tributary to Granite Creek (September 2007).

Metal	Adit 1 drainage (8/15/07)	Adit 1 drainage (9/07/07)	Adit 2 drainage	Fall Creek above mill tails (background)	Cold Water Biota Standard Acute	Cold Water Biota Standard Chronic
Arsenic	<0.025	<0.025	**<0.953**	<0.025	0.36	0.19
Barium	0.023	0.0361	0.154	0.0193	n.a.	n.a.
Cadmium	<0.0020	<0.0020	**0.0410**	<0.0020	0.00082 (H)	0.00037 (H)
Chromium	<0.0060	<0.0060	<0.0070	<0.0060	n.a.	n.a.
Copper	<0.010	<0.010	**0.163**	<0.010	0.0046 (H)	0.0035 (H)
Lead	<0.0075	0.0075	<0.0075	<0.0075	0.014 (H)	.00054 (H)
Selenium	<0.040	<0.040	<0.040	<0.040	0.018 (T)	0.005 (T)
Silver	<0.0050	<0.0050	<0.0050	<0.0050	0.00032 (H)	n.a.
Zinc	0.0282	**0.0989**	**5.08**	0.0156	0.035 (H)	0.032 (H)

(H) – Hardness dependent @ 25 mg/l, (T) – Standard in Total, n.a. – Not Available, < values = less than the method detection limit

Table 57. Metal analysis results (µg/l) for Quartzburg (Gold Hill and Iowa Mines) on Granite Creek (9/18/2007).

Metal	Iowa Mine Adit #1	Iowa Mine Adit #2	Iowa Mine Adit #3	Gold Hill Mine Adit 1	Upstream From Gold Hill Mine	Downstream from Gold Hill Mine	Cold Water Biota Standard Acute	Cold Water Biota Standard Chronic
Arsenic	0.014	<0.010	<0.010	0.841	<0.010	<0.010	0.36	0.19
Barium	0.0310	0.0359	0.0611	0.535	0.0907	0.0758	n.a.	n.a.
Cadmium	<0.002	<0.002	<0.002	0.0087	<0.002	<0.002	0.00082 (H)	0.00037 (H)
Chromium	<0.006	<0.006	<0.006	0.0927	<0.006	<0.006	n.a.	n.a.
Lead	<0.005	<0.005	<0.005	4.02	<0.005	<0.005	0.014 (H)	.00054 (H)
Mercury	<0.0002	<0.0002	<0.0002	0.0109	<0.0002	<0.0002	.0021	.000012 (T)
Selenium	<0.01	<0.01	<0.01	0.011	<0.01	<0.01	0.018 (T)	0.005 (T)
Silver	<0.005	<0.005	<0.005	0.0686	<0.005	<0.005	0.00032 (H)	n.a.

(H) – Hardness dependent @ 25 mg/l, (T) – Standard in Total, n.a. – Not Available

Fisheries and Habitat Data

BURP crews sampled sites in the Granite Creek drainage in 1997 and 2005 (Figure 41). Rainbow trout and brook trout were collected during the 2005 BURP sampling and juvenile salmonids were not identified in the sample population. Water body assessment scores (Table 58) from BURP sites indicate that CWAL beneficial uses are fully supported for these AUs. Recreation, roads, and mining are factors that BURP personnel listed as having potential to affect water quality. Granite Creek AU 014_04 has not been monitored using BURP protocol, therefore it remains unassessed for cold water aquatic life beneficial use. DEQ recommends that this AU be scheduled for BURP monitoring when resources become available.

Table 58. Granite Creek BURP condition rating scores and beneficial use support status.

DEQ BURP Site ID	AU	Stream	Stream Habitat Index (SHI)	Stream Fish Index (SFI)	Stream Macroinvertebrate Index (SMI)	Condition Rating Average	Beneficial Use Support Status
			Score 0-3 (3 is the highest score)				
2005SBOIA023	014_03	Granite	1	2	3	2	FS
1997SBOIC011	014_02	Woof	1	NS	3	2	FS
1997SBOIC012	014_02	Woof	1	NS	3	2	FS

NS– Not Sampled, FS – Fully Supporting Cold Water Aquatic Life

Surface Fine Sediment and Bank Stability

Much of the land in the Granite Creek basin has been altered, including surface vegetation removal, through historic mining, road construction, and timber harvest. Removal of vegetation results in unstable soil which is more susceptible to erosion. Mean percentages of surface fines for sites sampled in Granite Creek AUs 014_02 and 014_03 ranged from 3 to 78% in 1997 and 2005 (Table 59). Surface fine sediment (< 6.0 mm) recommended target levels were developed by the Forest Service and Bureau of Land Management for the Upper Columbia River Basin. The values are below the recommended maximum levels for Rosgen Type C channels with plutonic parent material. Additional measurements of percent fines were recorded in a stream with a Rosgen Type E channel; however, there is not a literature-recommended target value. The percent fine levels were 78% in this stream, so beneficial uses may be supported. Habitat surveys inventory performed by DEQ found bank stability to be 96% on Granite Creek AU 014_03 (Upper Granite Creek) and 100 and 99% from two sites sampled in Woof Creek. All survey data results are above the recommended bank stability value of 80% in streams sampled in AU 014_02. However, this is not representative of lower Granite Creek AU 014_03 or 014_04 (personal communication, Hana West, BNF Hydrologist). DEQ recommends BURP, bank erosion and continuous temperature monitoring to determine beneficial use support of 4th order Granite Creek.

Table 59. Granite Creek surface percent fines and recommended targets.

DEQ Stream Site ID	AU	Percent Fines	Rosgen Channel Type	Recommended Target	Target Met
2005SBOIA023 Granite Creek	014_03	32	C	37	Yes
1997SBOIC011 Woof Creek	014_02	78	E	n.a.	n.a.
1997SBOIC012 Woof Creek	014_02	3	C	37	Yes

Summary of Status of Beneficial Uses

Cold water aquatic life and salmonid spawning beneficial uses are supported in all Granite Creek AUs sampled (Table 60). PCR was determined to be fully supported in all AUs based on results of bacteria risk screening and collected bacteria samples. As per WBAG II, because SMI and SHI index scores indicate CWAL use is fully supported and samples have not been collected, DEQ assumes SS is fully supported. DEQ has prepared a temperature TMDL including load allocations for Granite Creek, since it is contributing to the thermal load of Grimes and Mores Creeks. DEQ proposes that AUs 014_02, 014_03, and 014_04 be added to the §303(d) list for habitat and flow alteration due to impacts of extensive historic placer mining in the basin.

Table 60. Summary of beneficial use support determination for Granite Creek.

AU	Beneficial Uses Assessed and Supported	Support Status	Basis for Determination
014_02	CWAL	FS	BURP and sediment data
	PCR	FS	Bacteria samples
014_03	CWAL	FS	BURP and sediment data
	PCR	FS	Bacteria sample
014_04	CWAL	Not assessed	
	PCR	FS	Bacteria screening

CWAL – Cold Water Aquatic Life, SCR – Secondary Contact Recreation; FS – fully supporting

2.5 Data Gaps

This section of the report describes gaps in the data available for the subbasin. The best available data were used to determine beneficial use support status and develop the subbasin assessment and TMDL. However, DEQ acknowledges that there are additional data that would be helpful to increase the accuracy of the analyses. The data gaps that have been identified are outlined in Table 61.

Table 61. Data gaps identified during SBA and TMDL development.

Parameter	Data Gap
Flow	Continuous flow data is not available for most assessment units. Additional data would be helpful to assess sediment transport.
Biological	Much of the data is older than five years. More current data collected over a range of water years would be helpful.
Bacteria	Bacteria samples for all assessment units in Mores, Elk, Grimes and Granite Creek watersheds.
Sediment	Subsurface bedload sediment core samples for all listed assessment units.
Temperature	Vegetation and percent shade characterization for tributary reaches and shade curves developed using native subbasin vegetation.
	Continuous temperature monitoring for AUs that do not have current temperature records and for those that have PNV TMDLs developed in order to corroborate major sources of heat loading and confirm 303(d) list status.
Nutrients	Increased sampling of nutrients at previously sampled locations and upstream and downstream from areas with municipal or private septic treatment. Sample periphyton chlorophyll a rather than water column chlorophyll. Measure chlorophyll a in Arrowrock and Lucky Peak reservoirs during critical summer months.
Metals	There was historic gold mining in the subbasin with known stamp mills and ore processing facilities, therefore, there should be additional heavy metal water column and fish tissue sampling in Mores Creek, its tributaries and Lucky Peak and Arrowrock Reservoirs.

3. Subbasin Assessment–Pollutant Source Inventory

3.1 Sources of Pollutants of Concern

This section addresses sources in the watershed, identified and potential, that may contribute to water quality impairments preventing attainment of beneficial uses. This section provides an inventory of both point and nonpoint pollutant sources.

Point Sources

A point source of pollutants is characterized by having a discrete conveyance to surface water, such as a pipe, ditch or other identified point of discharge into a receiving water body. Point sources in the watershed are lode and placer mine sites and a municipal wastewater treatment facility.

Superfund Sites

In 1980, Congress enacted the Comprehensive Environmental Response and Liability Act (CERCLA), commonly known as Superfund, to respond to threats posed by uncontrolled releases of hazardous substances into the environment. Criteria were established to determine priorities among releases or threatened releases of hazardous substances for the purpose of taking remedial action. Three Superfund sites were identified in the Boise-Mores Creek subbasin, by searching EPA databases using the Envirofacts Warehouse at http://www.epa.gov/enviro/. The assessment process and predicted threats to humans and beneficial uses are outlined for each site in the paragraphs below. The mine sites were listed as Superfund sites due to potential for heavy metals contamination. Ore from the lode mines was milled to fine particles and the resulting mine tailings are also a source of stream sediment.

Belshazzar Mine

The Belshazzar Mine is on Boise National Forest (BNF) land located in the upper reaches of Fall Creek, a tributary to Granite Creek watershed, approximately 1.75 miles southwest of the old Quartzburg mining area and 4.3 miles west of Placerville, Idaho. The site is comprised of several unpatented lode and placer claims that are administered by the BNF. The last known extraction of gold or silver was in 1941, although shallow excavations were observed during recent site visits. In addition to ongoing mining activities, the site is used for recreation (bike and ATV riding and hunting) and grazing.

A site discovery visit was conducted by Idaho Geological Society (IGS) on July 1, 1994, which concluded that additional investigation of the Belshazzar was warranted. On May 31, 2002, and briefly again on July 26, 2002, the IGS conducted site inspection visits at the mine (IGS, 2007).

On August 15, 2007, DEQ and BNF representatives conducted a site visit to assess current site conditions and potential contaminant concerns. DEQ conducted a subsequent site visit on September 7, 2007, broadening the scope of investigation.

Waste and tailings are subject to runoff from the mill site and mine adit locations during precipitation events. Rilling is evident in tailings and waste dumps and Fall Creek is incising through one of the mine waste dumps. Mine adits, tailings, and waste dumps are potential sources for production of metals-laden sediment. Discharge (25-30 cfs) may also be traced from a mine adit directly to Fall Creek. These factors indicate that contaminated material is eroding into Fall Creek Based on soil and water quality samples collected at probable points of entry (PPE) to surface water from the mine site and in groundwater test wells, it does not appear that there is significant surface or ground water transportation of heavy metals to downstream receptors. At this time, streambank and upland erosion inventories have not been completed to assess whether this area is contributing a sediment load to Fall Creek and ultimately impaired segments of Grimes Creek. The DEQ Mine Project Coordinator reviewed the site and concluded that the tailings are a very small sediment source which should not pose a water quality concern.

Based on concentrations of heavy metals in various mine and mill waste dumps, the disconnection between those sources and receptors, and the very low potential for prolonged exposures to heavy metal concentrations, DEQ has concluded that no remedial action is planned for this site. However, DEQ recommended that serious consideration should be taken by USDA to discourage recreational use of the site.

Gold Hill and Iowa Mines

The Gold Hill lode mine is situated along Granite Creek, a tributary to Grimes Creek, just below the town of Quartzburg. The Iowa lode existed approximately one-quarter mile northeast of Gold Hill and was abandoned prior to 1900. The Gold Hill lode deposit was discovered in 1863 and was working continuously until 1938. Andereson (1947) reported that much of the ore had no visible free gold. About 95% of the gold was recovered by fine grinding and amalgamation. Material was hand-sorted, with over-sized pieces fed into a crusher. Crushed ore passed to a ball mill with an amalgamator. Concentrates were reground in cyanide solution, agitated and settled into tanks. Zinc shavings were used to precipitate gold and silver.

DEQ conducted a site visit on July 20, 2004, which included a visual inspection of the Quartzburg mines and collection of one soil sample and six surface water samples.

The Quartzburg mining area drains westward toward Granite Creek. Water is discharging from the former Iowa Adit at a rate of approximately 0.5 gallons per minute. Water from Waste Dump #1 at the Gold Hill Mine is barely a trickle, and returns to the soil within about 20 feet of coming to the surface. A potential Probable Point of Entry (PPE) exists at the waste piles located at the Gold Hill Mine site and at the Iowa Adit. Overland flow across or in the vicinity of the waste piles would flow directly into Granite Creek.

Since camping occurs in many places along Granite Creek, it is expected that fishing occurs, at least occasionally. The use of surface water for watering of livestock and wildlife is expected. Crop irrigation is not considered a significant use locally; however, in the lower reaches of Granite Creek, water may be diverted to fields. Primary targets for surface water include residents and outdoor enthusiasts along Granite Creek. There is no information that Granite Creek's water is not utilized for domestic activities such as bathing, cooking, and drinking. Secondary targets include livestock, wildlife and fish.

Waste rock piles, abandoned machinery, a few standing structures, some decommissioned structures, and the remains of a few collapsed adits can be seen in the area. No adits remain open and the majority of the existing structures were properly restricted with locking gates and warning signs. A soil sample taken from the toe of a fine-grained tailings pile did not contain elevated concentrations of any contaminants. The water samples collected throughout the drainage also show no significant signs of overall water quality degradation. Based on limited sampling data, heavy metals contamination from this site is not a significant threat to humans or wildlife.

Missouri Mine

The Missouri Mine is located approximately two miles north of Pioneerville, Idaho, about 1.5 miles southwest of Grimes Pass, Idaho, and 13 miles northwest of Idaho City on Boise National Forest lands. Site elevation is approximately 5,000 feet above mean sea level. The site occupies approximately 100 acres adjacent to Muddy Creek, a tributary to Grimes Creek. Mining activity began in 1878 with sporadic activity until 1953. The mine was primarily a silver, lead, and zinc operation with high amounts of cadmium and copper. The mine was an underground operation where adits were driven horizontally to intersect veins of sulfide ore. Ore processing facilities included a crusher, ball mill with flotation circuit to separate the metal medium, and three tailings ponds. The ore concentrates were shipped to Salt Lake City for refinement. Small cyanide heap leach was operated in the mid to late 1980's.

In September 1991, three sheep were found dead at the site. In 1992, the site was inspected by BNF and DEQ staff. They found a release of arsenic from 55 gallon barrels abandoned on the site. A removal action was initiated in 1993 to protect public health and the environment. The site inspection in 1992 initiated a site evaluation that was completed in 1998. Surface water and sediment samples showed nine metals elevated more than three times over background concentrations, supporting the conductance of removal action at the rest of the site. Site cleanup was initiated in 2001 and completed in 2002. Acid rock drainage was reduced by backfilling four vertical mine shafts. A covered repository was engineered for the waste rock pile, tailings pond material, and the heap leach pile. Reclaimed areas were re-sloped, drainage ditches and channels were created to divert runoff from the contaminated material areas, and the engineered cell and the site were re-vegetated to improve soil stability.

NPDES Permit Sites

There are no National Pollution Discharge Elimination System (NPDES)-regulated point sources discharging to streams in the affected watersheds. Should a point source be proposed that would have discharge to surface waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 & IDAPA 58.01.02.401.03) should be considered. Boise County is growing rapidly, and it is anticipated that current wastewater treatment facilities operating rapid infiltration basins may have to upgrade to direct discharge, therefore reserve waste load allocations have been designated in the sediment and temperature TMDLs.

Other Permits

Idaho City operates a municipal wastewater treatment plant which has a wastewater reuse (land application) permit that was originally issued in January 1993. The treatment facility generates 45.4 million gallons per year. Influent is treated in a baffled three cell lagoon and land-applied to four rapid infiltration basins. The permit requires monitoring of daily flow and grab samples collected quarterly from wastewater plant influent, rapid infiltration basin influent, and ponded water. In addition, percolate is monitored weekly and grab samples are collected quarterly from ground water quality monitoring sites and surface water sites upstream and downstream from the treatment facility. All water samples are tested for biochemical oxygen demand, total suspended solids, nitrogen and phosphorous constituents, and fecal coliform.

Dredge Mining

Mineral discoveries in the Boise Basin in 1862 brought thousands to mining camps in the Mores and Grimes Creek basins. The large placer deposits of the basin could only be efficiently worked during spring runoff, until water returned to base flow in mid-summer. The first placer mining boom in the basin lasted until 1870. By that time, the easily worked gravels near the stream bottoms had yielded most of their gold and miners shifted to washing down higher bench placer deposits with hydraulic cannons. To get water to the higher elevations, extensive systems of flumes and ditches were built. Some of them ran 8 to 10 miles in length. These hydraulic mining operations continued until 1898. Dredging operations resumed in the late 1920s and continued until 1952 when most of the soil surface of the Mores Creek, Grimes Creek, and tributaries watersheds had been exposed by dredge or hydraulic mining. Small dredge claims continue to be actively worked in the basin today. Historic placer mining in the basin is evidenced by disturbance of surface outcrops and placer deposits, hydraulic pits, dredge tailings and abandoned ditches, flumes and stream diversions.

Small dredge claims continue to be actively worked in Mores and Grimes Creeks and their tributaries with suction dredge mining equipment. A suction dredge typically consists of a floating platform on which a pump and sluice box are mounted, with a 2” to 12” flexible suction hose that reaches the bottom of the stream. The gasoline-powered pump is used to lift gravel from the stream bottom through the hose onto the sluice box mounted on a floating platform for gold recovery. The objective is to get to bedrock where it is most common to find the largest deposits of gold. The intake size of the hose and the horsepower of the engine driving the pump determine the volume of gravel that a dredge can potentially move. The amount of material actually moved depends on the skill of the operator and the conditions in which the operator is working (USEPA 1993).

Large gravel and cobble discharged to the stream is typically deposited immediately behind the sluice box. Finer material such as fine gravel and sand may move some distance downstream as bedload, and silt and finer materials are carried further downstream in the water column. Large rock and boulder piles can form where dredges have remained in one place for a long time. Large pools may also be formed by this process.

The Idaho Department of Water Resources (IDWR) regulates suction dredging through the Idaho Stream Channel Protection Act (IDAPA 37.03.07.064). Under this statute, dredge miners are required to obtain a permit from IDWR (IDWR 2003). Small-scale operations (< 5” nozzle; < 15 horsepower) are covered under the Individual Recreational Dredging Application permit process (a.k.a. General Permit). In Mores Creek, dredging is currently (2009) limited to downstream from Boulder Creek from July 1 through September 30 each year. Dredging in Elk Creek has the same season with dredging allowed anywhere upstream from Eldorado Gulch. The dredging season on Grimes Creek and its tributaries is open year round; however, most dredging occurs from June through August (Personal Communication, Russ Hicks; Mineral Specialist, BNF). The USEPA reviewed the IDWR General Permit for suction dredge mines in 1998, and found that it adequately addressed environmental concerns from these operations (USEPA 1998). There is currently no limit on the number of such facilities allowed to operate in the Boise-Mores Creek Subbasin under the General Permit.

When compared to other sediment sources in the subbasin, including roads and natural erosion processes, sediment loading from current recreational suction dredge operations appears to be minimal, given their limited number, size, and short annual operating window allowed under the current IDWR general permit (approximately three months). This is consistent with Harvey and Lisle (1998) who indicate that single dredging operations cannot mobilize significant volumes of fine sediment compared with the volume mobilized throughout a watershed during high seasonal flows, when large portions of the streambed are entrained.

A great deal of literature exists on the effects of suction dredge mining on water quality and stream habitat. While the literature is mixed in terms of assessments of the nature and severity of effects from dredge mining operations, serious impacts to water quality and habitat have been documented, depending on the size, location, and manner in which dredges are operated. For a recent summary of suction dredge impacts, see Harvey and Lisle (1998).

A suction dredge is considered to be a point source, and therefore required to obtain an NPDES permit to discharge (USEPA 1998). Currently no NPDES permits have been issued for suction dredges within the Boise-Mores Subbasin. It is anticipated that EPA may issue a general NPDES permit for suction dredge operators beginning in 2010. A wasteload allocation for suction dredging is included in the sediment TMDL.

Nonpoint Sources

Nonpoint sources of pollution are generated from a geographical area where pollutants are dissolved or suspended in runoff and then delivered to surface water. The primary sources of sediment pollution to streams are sediment from riparian disturbance and streambank erosion associated with riparian disturbance, roads, placer mining, and urban development.

Sediment

Sediment may originate from natural causes, such as bank erosion, mass wasting, forest or range fires, high flow events; or from anthropogenic activities such as urban/stormwater runoff or erosion from roadways, agricultural lands, and construction sites. Sediment loads within the system are highest in spring when high flow volumes and velocities result from snowmelt at high elevations.

The amount of surface erosion in forest terrain is predominantly a function of slope steepness, soil texture/structure, and the amount of root material in the surface layers of soil. Soil characteristics are related to the geologic parent material.

Mass wasting can be predicted by slope steepness and geologic material as well as other factors, such as whether the area has burned recently or been disturbed by land management activities such as timber harvest or mining. In general, a few mass failures occur every year, but the major contributors of sediment are the major episodes of mass failure that occur during large rain-on-snow events or during high precipitation events when the soil mantle becomes supersaturated. The contribution of mass wasting to sediment loading has been estimated in the hydraulic mined hillsides of the Boise-Mores Creek subbasin. An aerial photo survey and subsequent field survey of the subbasin detected a lack of vegetative cover, unstable slopes, and significant erosion from ephemeral tributaries in the Elk Creek watershed and also in ephemeral tributaries of Mores Creek to the south and east of Idaho City.

Roads, depending upon their condition and location, can deliver large sediment loads to streams. Road erosion is directly influenced by road use including season of use, type of vehicles traveling, road drainage patterns, and the type of road surfacing and maintenance. Controlling these variables will affect the amount of sediment delivered to streams.

Temperature

Modifications to the riparian zone of Mores Creek and its tributaries from historic placer and hydraulic mining have increased the solar load to the surface water system, resulting in increased water temperatures. Highway 21 and the numerous forest service roads adjacent to streams increase microclimate temperatures and often result in decreased amounts of riparian vegetation. The most critical time frame for water temperature is in the summer months when stream flows are naturally at the lowest levels. Grazing activity, timber harvest in the riparian zone, lack of riparian vegetation, the presence of dredge waste tailings, and the presence of asphalt and other exposed soil or rock surfaces along stream banks increase the solar load to the surface water system.

Flow and Habitat Alteration

Dredge tailings confine streams into tight channels, restricting meandering and confining stream energy to downcutting action. The current stream morphology limits the natural function of the stream and the floodplains in the watershed by increasing flow velocity and redirecting flow away from the floodplain. In addition, the dredge tailings piles sever connectivity of the stream with the hyporheic zone, resulting in increased stream temperature in the absence of near-stream groundwater influences. Dredge tailings piles contain particle sizes from silt to boulder. Over time, the small particles settle below the surface and are washed out of the waste piles and into waterways during precipitation events. The absence of soil on the dredge tailings piles makes vegetation colonization difficult, which further exacerbates bank instability and results in increased sedimentation and higher stream temperatures. Without an adequate functional flood plain, vegetation which would serve to mitigate high-energy discharge events can not be re-established.

The presence of flow diversions may also be cause impairment. Numerous flow controls have been constructed in the watershed, some of which serve to augment the periodic high-energy flows, which occur naturally in the watershed as a function of ecoregion and terrain. The current stream morphology limits the natural function of the streams and floodplains by increasing flow velocity and redirecting flow away from the stream channels and the floodplain. Irrigation diversions and impoundments result in dewatered channels, which also contribute to loss of aquatic habitat and riparian vegetation. Without year-round channel flow and an adequate functional flood plain, beneficial uses are likely to remain impaired.

Pollutant Transport

Sediment

While no quantitative information is available, it is recognized that a substantial amount of sediment can be generated and transported relatively long distances during high flow events. Sediment transport, and the transport and delivery of sediment-bound pollutants, are directly associated with increased flow volumes and high velocities. During peak flows, upland areas and streams with unstable banks may have high sediment loads due to upland and bank erosion.

Temperature

Thermal pollution, caused by lack of vegetative cover and resulting exposed sediment appears to be highest in placer and hydraulically mined areas. Vertical banks lacking vegetation are visible on aerial photographs taken throughout the subbasin as part of the 2004 National Agriculture Imagery Program (NAIP).

3.2 Data Gaps

Sediment

Sediment loading analysis would benefit greatly from additional erosion inventory and bedload sediment data. Bank erosion inventories on tributaries to Mores and Grimes Creeks could help identify and prioritize areas in need of erosion control BMPs. Additional bedload sediment data from water bodies that have been impacted by historic placer mining would further identify the extent of impairment. Several mass wasting areas were identified during the problem assessment phase. Quantifying actively eroding areas would be beneficial for selecting effective BMPs to minimize stream sedimentation. In addition, continuous flow data is not available for most assessment units. Additional data would be helpful to assess sediment transport. Overall, a more precise data set including additional bank erosion inventory and subsurface sediment collection sites would be beneficial to develop and prioritize implementation projects or improved BMPs.

Temperature

Local shade curves are currently being developed that will be available to refine the load analysis for the five-year review of this TMDL. As remote sensing technology becomes more economical, new data may be available to quantify the temperature load of tributaries or contributions to temperature impairment from sources not yet identified. In the interim, it would be helpful to have continuous temperature monitoring for AUs that do not have current temperature records and for those that have PNV TMDLs developed in order to corroborate major sources of heat loading and confirm 303(d) list status.

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4. Subbasin Assessment – Summary of Past and Present Pollution Control Efforts

A number of pollution prevention efforts have resulted in water quality improvement in the subbasin. These projects include floodplain restoration, road closures, culvert replacement, and mine site reclamation.

Floodplain Restoration

Floodplain is being recreated along portions of Mores Creek on Forest Service lands. Mine tailings are being removed from what should be a riparian area, and the 2 year flow elevation is being excavated. Phase I was completed in 2006 and additional riparian plantings were completed in 2007. Over 4,000 sedges and rushes were planted by volunteers. Cottonwood trees, alders, willows, and other species were planted heavily by over 600 school children and various other volunteers. One half mile of creek was restored. Nine large woody debris structures and boulder clusters were added to the stream to add complexity and fish habitat features. The University of Idaho is monitoring the geomorphology of the reach.

Phase II of the Mores Creek project has been completed. Another ½ mile section has been treated, using the same applications that we employed in Phase I. Force Account employees were very cost effective and completed the work after their field season the last two seasons. Large woody debris, boulder clusters and floodplain were added to this reach. Volunteers have planted the new floodplain bringing our total to nearly 850 volunteers working on the project.

The Private Partnership Grant that was secured through the Fish and Wildlife Service allowed additional habitat work to be completed on two private properties last year. 95 boulders were installed in a reach glide reach to create pools and riffles and refugia for fish. The other property employed a rock barb to halt sediment from an eroding bank, and added one boulder cluster for fish habitat. Both of these projects were on Mores Creek. Additional barbs and boulder clusters will be installed this winter with the remaining funds.

Elk Creek has experienced sedimentation problems due to colloidal soil conditions. A 319 grant has been secured and a source of sediment, the intake for the school football field, was replaced in March of this year. The eroding banks were rip-rapped and were planted by volunteers in the spring of 2008. Additionally two sections of stream bank were treated for erosion, one downstream of the intake and one upstream on BLM lands. A series of sediment settling basins was installed at the base of Gold Hill, a major source of sediment to Elk Creek. Additionally, we have used the Idaho State Corrections inmate crew to cleanout all of the sediment traps in downtown Idaho City. These silt traps were completely filled. We will monitor how long they will operate effectively.

A Private Stewardship grant project is underway on Grimes Creek. Habitat and temperature is being addressed on lengthy portions of the creek, near Centerville. We are using the tested true floodplain generation / in-stream structure formula that we have used on Mores Creek.

Approximately one mile has been restored this past year. Plantings will continue in the spring of 2009.

Road Closures

The BNF and Idaho Department of Lands have improved roads, implemented seasonal road closures, and trained road maintenance staff regarding BMPs to reduce erosion and sedimentation from unpaved roads. Bannock Creek road (FR 203), which impinged most of the length of Bannock Creek, was decommissioned, reducing sedimentation in this drainage. In addition, Pine Creek road (FS 304), a primary connector to upper Thorn and Bannock creeks, was relocated to an area with less erosive soil, away from riparian habitat, to reduce impacts to water quality in Pine Creek. A total of 40 miles of unpaved roads have been decommissioned so far on BNF administered land.

Culvert Removal

The BNF Idaho City Ranger District removed 9 culverts on Macks Creek that were barriers to aquatic organism passage. Removal of these culverts restored connectivity to 7 miles of stream habitat. Restoration of connectivity allows salmonids to pass from Grimes Creek to headwater sections of Macks Creek for spawning and thermal refuge. Elevated stream temperatures in low-elevation segments of Macks Creek resulted in a temperature TMDL for this AU.

Mine Site Reclamation

In September of 1990, after three sheep were found dead at the Missouri Mine site from arsenic poisoning, a Time Critical Removal Action under CERCLA was initiated by the Forest Service to protect public health and the environment by preventing any continued releases of chemicals from three 55 gallon barrels on the site, and to clean up other potential contamination. In July 1993, the BNF removed three 55-gallon barrels of abandoned chemicals containing arsenic from the Missouri Mine site. A site evaluation at that time prompted a Removal Evaluation (Preliminary Assessment) which was finalized in March of 1998. The findings in the Removal Evaluation supported that a Non-Time Critical Removal Action be conducted at the rest of the site. Therefore a plan was developed to clean up acid mine drainage and reduce potential for heavy metal contamination of Grimes Creek or its tributaries. Road construction and site cleanup were initiated on October 12, 2001, and the project was completed November 26, 2002. The removal alternatives selected and implemented for the site are described below.

The waste rock pile, the tailing ponds, and the heap leach pile/pond-contaminated materials were excavated and placed in an engineered cell. The purpose was to minimize exposure of the materials to the environment by minimizing infiltration through and reducing migration of the contaminated material, and minimizing contact with surface waters. In addition, a designed, low-permeability cap was placed over the cell to reduce infiltration of waters into the underground workings. The total volume of these materials was 12,248 cubic yards.

The volume of acid rock drainage from the adit portal was reduced by the following actions:

- Four vertical mine shafts were backfilled with 1,000 cy of country rock and covered with low permeability soil. The surface was covered with a growth media, seeded with local grasses, and sloped at 6 percent to provide surface runoff away from the fill.
- An engineered drainage channel of approximately 1,000 feet in length was constructed around the repository. The lined channel was designed with a diversion structure at its lower end that empties into a pipe and discharges into a tributary to Muddy Creek at a location that would bypass the waste rock pile just below the mine portal.
- The disturbed areas east of the mine adit portal were backfilled and re-contoured to prevent ponding and accelerated infiltration into the underground workings. After backfilling, the soil surface was sloped to drain away from the estimated alignment of the mine adit.
- Finally, to reduce the incidence of contact between rainfall and snowmelt surface runoff and the contaminated materials on the ground surface, interception ditches were constructed to channel surface runoff away from contaminated material areas. The areas from which run-on was diverted were the previous mine waste rock piles located southwest and northwest of the mine portal. The total length of interception ditches constructed was approximately 600 feet.

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5. Total Maximum Daily Loads

A TMDL prescribes an upper limit (the load capacity) on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA).

Natural background (NB), when present, is part of the total LA, but is often broken out and considered separately because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL. In practical terms, the margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human-made pollutant sources.

These parts of the load capacity are summarized symbolically in this equation:

LC = WLA + MOS + NB + LA = TMDL

LC = load capacity
MOS = margin of safety
NB = natural background
LA = load allocation
WLA = wasteload allocation
TMDL = total maximum daily load

The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the load capacity is determined. Then the wasteload allocation is determined. The remaining amount is divided between the 1) necessary margin of safety, 2) the natural background, if relevant, and 3) the load allocations among non-point pollutant sources. When the breakdown and allocations are completed the result is a TMDL, which must equal the LC.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear at first.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

Mores Creek AUs 009_02, 009_03, and 009_04, Elk Creek AU 012_03, Grimes Creek AUs 013_03, 013_04, and 013_05 and Granite Creek AUs 014_02, 014_03, and 014_04 are impaired due to flow and habitat alteration. Flow and habitat are not considered by EPA to be pollutants, and so. TMDLs are not required. Based on the results of the SBA, sediment has been determined to be a pollutant of concern for Mores Creek AUs 009_02, 009_03 and 009_04, 009_06; and Grimes Creek AU 013_04 and 013_05. A TMDL for sediment has been developed for those AUs. Temperature TMDLs were developed for all AUs of Daggett Creek, Elk Creek, Granite Creek, Grimes Creek, Macks Creek, Mores Creek, Robie Creek, Smith Creek, and Thorn Creek. The water quality targets, design conditions, load capacity, existing load estimates, and load allocations are separated into two sections: 5.1 for sediment and 5.2 for temperature. Sections 5.3 through 5.5, covering construction storm water, implementation strategies, and conclusions, respectively, include both sediment and temperature.

5.1 Sediment

In-stream Water Quality Targets

The goal of a TMDL is to restore “full support of designated beneficial uses” (Idaho Code 39.3611, 3615). The objective of this TMDL is to reduce sediment loading to quantities that are in conformance with the load capacity for each AU. Monitoring of the pollutant load and beneficial use support will occur throughout the implementation phase of the TMDL. Pollutant reduction can be attained by improving channel dimension, restoring vegetative buffers, improving stream bank stability, and identifying activities responsible for sediment contribution to streams and implementing stream protection BMPs for those activities.

Idaho has a narrative criterion for sediment and so DEQ uses surrogate measures (e.g. substrate or channel condition, hill-slope indicators of erosion, road density, stream crossings, etc.) to determine the level of pollution reduction necessary to achieve full support of beneficial uses.

Design Conditions

Climate and hydrology must be considered when quantifying seasonal and annual variability and critical timing of sediment loading. Annual erosion and sediment delivery are functions of climatic variability and above-average water years typically produce greater erosion and increased sediment loads. Additionally, the annual average sediment load is not equally distributed throughout the year. Erosion typically occurs during a few critical months when bankfull flow occurs; during spring runoff or intense storm events. Streams are most vulnerable to erosion and sedimentation during these events. Because it is difficult to quantify these events in remote or sparsely populated areas, a single annual load from each source type (stream banks, upland forested areas, urban areas, roads, and mass wasting) is calculated to represent annual average sediment loading.

In an attempt to reflect seasonal sediment loading and current EPA guidance, daily sediment loads were developed for each stream based on calculated annual sediment load targets.

Stream flow data was used to determine sediment loads for each month. Refer to Appendix J for further information regarding these calculations. Although daily sediment load calculations were made, annual sediment load targets should be followed due to the natural variability of sediment loading.

This sediment analysis characterizes sediment loads using average annual rates determined from empirical characteristics (bank stability and subsurface (depth) fine sediment) that developed over time within the influence of all flow conditions. The BMPs most likely to reduce erosion and sedimentation are soil stabilization and re-vegetation, runoff collection and dispersion from roads, road re-sloping, appropriate maintenance of road surfaces and culvert maintenance.

Target Selection

Sediment targets for this TMDL are based on quantification of erosion from stream banks, hill-slopes, roads, and specific observations of mass wasting in tons per year (tons/year; t/yr). The reduction of sediment delivery prescribed in this TMDL is directly linked to restoring the upland vegetation community and improving riparian vegetation density along stream banks. Over time, re-vegetation will result in sediment retention, reduced lateral stream recession, and decreased flow velocity, which in turn reduces near-stream erosion and in-stream sediment loads. It is presumed that beneficial uses can be regained through reducing acute and chronic sediment loads, which will result in a decrease in subsurface fine sediment in streams. Sediment targets focus on three areas:

Bank Stability

It is assumed that, on average, natural background sediment loading rates from bank erosion equate to 80% bank stability based on Overton et al. (1995), where stable banks are expressed as a percentage of the total estimated bank length. No reference streams exist in this subbasin, therefore the 80% bank stability target was chosen. For banks that currently have greater than 80% stability then the target is to maintain existing stability. This target accommodates natural disturbances that create temporarily unstable banks such as large precipitation events or wildfires. Decreased bank stability caused from anthropogenic activity should be prevented, even in cases where banks retain greater than 80% stability.

In-Stream Sediment

The second target for the sediment TMDL is the percent of in-stream depth fine sediment. Stream substrate sediment size composition has been shown to directly influence spawning success, egg survival to emergence, rearing habitat, and fish escapement from streambed spawning gravels. It is necessary to reduce the component of subsurface fine sediment (< 6.35 mm) to a five-year mean below 28%, with no individual year to exceed 29% to achieve suitable habitat for salmonid survival (DEQ, 2003). Current values of subsurface fine sediment range from 32 to 78% in the Mores Creek watershed (Table 35). Sediment particle size should continue to be considered as a target for monitoring and use attainment determination.

Upland Sources

Similar to targets for stream bank erosion, the sediment yield target for contributions from upland sources for this TMDL is equal to the sediment yield expected from natural background conditions. This yield was derived by multiplying the number of acres of each land use type in the watershed by natural sediment yield coefficients, which are based on literature-established values for the soil types and geological parent material in the watershed. Using natural background conditions for the watershed as the target provides a conservative estimate which is practical, considering the sediment load in the basin originates from multiple nonpoint sources which are difficult to quantify.

Sediment Monitoring Points

Sediment loads are based on stream bank erosion inventories of representative reaches, percent depth fine measured in McNeil core samples, aerial photo interpretation of mass wasting sites and WEPP modeling of land use types and road density. Future implementation monitoring should include these or other suitable sediment loading assessment methods or models.

Each reach sampled in the stream bank erosion inventory is representative of similar streams in the watershed. It is optimal to revisit locations, but new sites may need to be added to account for variation throughout the watershed. Additionally, it may be useful to collect bedload sediment data for trend analysis. McNeil core samples should be collected at the downstream end of each AU. Computer modeling of sediment load incorporates the entire watershed to account for sources outside of, but not necessarily contributing to, impaired AUs.

Load Capacity

The LC is “the greatest load a water body can receive without violating water quality standards” (40 CFR §130.2). Seasonal variations and a MOS to account for uncertainty are considered within the LC. Likely sources of uncertainty include lack of knowledge of assimilative capacity, uncertain relation of selected target(s) to beneficial use(s), and variability in target measurement. Sediment sources are outlined in this section and a summary of load capacity is found in Table 62.

It is assumed beneficial uses are supported with natural background sediment loading rates resulting from stream bank stability of 80% or greater. The load capacity for each stream segment is the sediment load in tons/yr from banks that are 80% stable. For banks that currently have greater than 80% stability, the target is to maintain existing stability. This target accommodates natural disturbances that create temporarily unstable banks, such as large precipitation events or wildfires. Due to high existing sediment loads from legacy mining, which may take many years to assimilate, decreased bank stability caused from anthropogenic activity, should be prevented, even in cases where banks retain greater than 80% stability.

The sediment load capacity for stream bank stability of 80% uses an erosion rate based on the recession rate and stream size evaluated in each stream bank erosion inventory (see Appendix F). For this TMDL, 15% of Mores Creek and 12% of Grimes Creek was surveyed. Figure 33 and Figure 39 show the survey locations on Mores and Grimes Creeks, respectively. The inventoried reaches were used to represent similar streams in the same assessment unit. Each inventoried reach and the length of stream that the inventory represents has a proposed erosion rate (tons/mile/year; t/mi/yr) and proposed total erosion per year (tons/yr; t/yr) (see Table 63 and Table 64) based on 80% bank stability. These erosion rates were extrapolated to the non-inventoried stream miles in the same assessment unit. These values, also seen on each stream segment survey inventory worksheet in Appendix F, represent the LC of the stream. Proposed erosion rates vary from 1 on lower sections of Grimes Creek to 34 tons/mile/year on 4th order Mores Creek. Bank erosion inventories were only completed in AUs that were thought to be impaired by sediment. An assessment of impairment status is based on BURP scores and other available information (see Section 2.4). DEQ recognizes that there is a data gap in the overall sediment budget by not including the sediment load contributed to Mores and Grimes Creeks by non-impaired AUs. In the future, other AUs may be inventoried for stream bank erosion as resources allow. All streams contributing sediment to listed AUs in the subbasin should meet the target of 80% bank stability. Sediment delivery from forested, urban, paved, and unpaved roads is estimated using USDA Forest Service Water Erosion Prediction Project (WEPP) modeling. Sediment delivery from mass wasting areas disturbed by hydraulic and/or placer mining were estimated by aerial photo interpretation along with physical inspection. Sediment delivery from these sites was then estimated using stream bank erosion inventories and WEPP hill-slope erosion modeling to determine the range of probable annual sediment delivery. Sediment LCs are estimated by determining the surface area of each land use type and multiplying the area by an erosion coefficient specific to that land use type. The erosion coefficients represent sediment delivery in the land use area if there were no human disturbance, in essence, the natural sediment delivery in the system. A target of natural background sediment delivery is assumed to support beneficial uses for impaired streams. Achievement of stream bank stability and percent depth fines sediment targets will result in attainment of beneficial uses.

Suction dredge mining occurs in Mores Creek, Grimes Creek and their tributaries. The assimilative capacity of these streams for sediment load in addition to natural background has not been determined. However, extensive evaluation of suction dredge impacts to water quality has been conducted in the South Fork Clearwater basin (DEQ 2004). It was found that the operation of a small number of recreational dredges appears to result in minimal downstream increases in bedload or surface fine sediment levels. The daily volume of sediment processed by these existing operations therefore appears to be a reasonable surrogate measure to prevent increased bedload movement and surface fine sediment downstream of suction dredges for this stream. The portion of the SF Clearwater basin where suction dredging occurs is similar in geology and land use to the Boise-Mores Creek subbasin. In the absence of detailed information regarding suction dredge impacts in the Mores Creek basin; it is appropriate to model the suction dredge load capacity after the SF Clearwater where more detailed studies have been done. In the SF Clearwater the load from suction dredging that the river was able to assimilate was 33% of the total load capacity for the stream. Due to similar geology, this fraction of capacity was assumed to be similar for the Mores Creek watershed.

The total load capacity for the impaired streams, excluding suction dredging, in this watershed is 4,639 tons/year (Table 62). Therefore the load capacity designated for the suction dredge industry is 2,319 tons/year, which is 33% of the total sediment load (4,639 + 2,319 = 6,958).

Table 62. Sediment load capacity by source in the Boise-Mores Creek Subbasin.

Source	Load Capacity Estimate (tons/year)	Method of Estimation
Forest	2154	WEPP
Urban	7	WEPP
Unpaved Roads	129	WEPP
Paved Roads	10	WEPP
Stream Bank Erosion	2152	Streambank Erosion Inventory
Historic Hydraulic Mined Areas[1]	187	BNF Soil Surveys
Additional Assimilated Load (Allocations for Suction Dredge Industry and MOS)	2319	Based on SF Clearwater Basin
Watershed Total	6958	

1

Estimates of Existing Pollutant Loads

Federal regulations allow that loads "...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)). There are no permitted point sources of sediment in the Boise-Mores Creek Subbasin. All nonpoint loads that could be quantified are outlined below. Wasteload allocations for suction dredging and future wastewater discharge are also estimated.

Stream Bank Erosion

Existing sediment loads and natural background load capacity estimates for stream bank erosion have been derived for each assessment unit in Mores Creek and Grimes Creek, and are listed in Table 63 and Table 64 and Appendix F. The load capacity for streambank erosion is the sediment load that results from 80% stable stream banks. Stream segments for which measured stream bank stability was at least 80% stable were considered to be at background conditions, and so were not assigned a load reduction. The additional load capacity for streams which currently have greater than 80% stable banks serves as a buffer to accommodate natural disturbances that create temporarily unstable banks, such as large precipitation events or wildfires. Decreased bank stability caused from anthropogenic activity should be prevented, even in cases where banks retain greater than 80% stability. A summary of the sediment loading analysis from the Streambank Erosion Index (SEI) is provided in Table 63 and Table 64.

Analysis of stream bank stability survey results showed stream bank sediment impairment in Mores Creek. Highway 21 impinges on the stream channel for most of the length of the creek and road-fill material is accumulating in the stream at several locations. Urban and recreational activities also deliver sediment to the stream where stream bank vegetation has been removed to allow access to the stream. A stream restoration project, designed to improve bank stability and floodplain connectivity, is being implemented along the stream banks near Idaho City in 3rd order Mores Creek. The project's construction activities are creating unstable stream banks and delivering additional sediment to the stream; however, this sediment delivery is a short-term problem and the project will result in lower sediment input as vegetation becomes established. After completing restoration construction activities in a given area, crews have been planting cuttings of riparian plants, which are becoming established along the re-contoured stream banks. In Grimes Creek, stream bank stability survey results indicate stable stream banks with little sediment impairment. The most disturbed stream segments in Grimes Creek are lined with tailing piles from historic placer mining, but these tailings provide stable stream banks of cobble, similar to modern-day rip-rap. Observations from DEQ, EPA, and BNF personnel reported that segments of Grimes Creek and a major tributary, Granite Creek, which was not surveyed, may be contributing excessive sediment. Efforts were made to inventory representative sections of Grimes Creek; however property access may have restricted survey reaches and skewed bank stability results in Grimes Creek. Granite Creek remains unassessed therefore the load capacity; allocations and percent reductions in Grimes Creek were calculated using available data and do not include a sediment load input from Granite Creek. Future monitoring efforts should concentrate on these segments and may identify additional areas of stream bank instability. As mentioned earlier in this TMDL, bank erosion inventories were only completed in AUs that were listed or believed to be impaired by sediment. DEQ recognizes that there is a data gap in the overall sediment budget by not including the sediment load contributed to Mores and Grimes Creeks by non-impaired AUs. Other AUs may be inventoried for stream bank erosion as resources allow. If areas of instability are identified these areas shall be assessed a target of 80% stable banks and corresponding load capacities and reductions to bring the system to natural background conditions.

Table 63. Sediment loading analysis from stream bank erosion inventories on mainstem Mores Creek.

Mainstem Segment Measured	Segments Represented	Existing Load		Load Capacity (80% Stable Banks)		Necessary Reduction (t/yr)	Percent (%) Reduction
		Erosion Rate (t/mi/yr)	Total Erosion (t/yr)	Erosion Rate (t/mi/yr)	Total Erosion (t/yr)		
Mores source to 1st Hwy 21 crossing	009_02	2.4	116	12	573	0	0
Hwy 21 crossing to 10 Mile Creek	009_02	0.25	22	2	195	0	0
10 Mile Creek to Granite Creek	009_03	12.8	92	14	98	0	0
Granite Creek to Sawmill Creek	009_03	24.9	129	25	129	0	0
Sawmill Creek to Thorn Creek	009_04	54.2	295	34	186	109	37
Thorn Creek to Grimes Creek	009_04	6.3	20	8	26	0	0
Grimes Creek to Mores Gauging Station	009_06	1.0	9	5	43	0	0
Mores Creek Total	**Mores Creek Watershed**		**683**		**1250**	**109**	0

Table 64. Sediment loading analysis from stream bank erosion inventories on mainstem Grimes Creek.

Mainstem Segment Measured	Segments Represented	Existing (Current Load)		Load Capacity (80% Stable Banks)		Necessary Reduction (t/yr)	Percent (%) Reduction
		Erosion Rate (t/mi/yr)	Total Erosion (t/yr)	Erosion Rate (t/mi/yr)	Total Erosion (t/yr)		
Grimes source to 1st road crossing	013_02	0	0	2	221	0	0
Road Crossing to Cup Creek	013_02	2.5	139	9	510	0	0
Cup Creek to Buckskin Creek	013_03	0.1	0.4	2.0	21	0	0
Buckskin Creek to Granite Creek	013_04	5.3	46	16.0	142	0	0
Granite Creek to Macks Creek	013_05	0	0	1.0	2	0	0
Macks Creek to mouth	013_05	0	0	1.0	6	0	0
Grimes Creek Total	**Grimes Creek Watershed**		**185.4**		**902**	**0**	**0**

Mass Wasting of Hydraulic Mine Sites

Existing loads and natural background load estimates for gully erosion have been derived for each area that was historically mined hydraulically that could be identified using aerial photographs. Appendix G includes photographs and erosion calculation worksheets. Sites were selected using aerial photographs. The eroding channel of Noble Gulch and two of the gullies conveying sediment into this channel were surveyed in the field, and this information was compared to estimates of bank height and gully length from aerial photographs. Aerial photograph interpretations underestimated the surface area that was eroding. This was expected, considering that a photograph supplies a two-dimensional surface compared to the three-dimensional field measurements. Due to time and staff constraints, all erosion estimates from hydraulically-mined areas were calculated using measurements interpreted from aerial photographs. The results are shown in Table 65 as existing erosion rates. Proposed erosion rates which would support beneficial uses of Mores Creek are also provided in Table 65. Natural background was derived from natural sediment yield estimates from BNF soil surveys and BOISED model information. BOISED is a computer model developed to predict sediment yield from upland erosion on the Boise and Payette National Forests. The erosion rate for the intermittent tributary, Noble Gulch, was estimated using the Streambank Erosion Index (SEI) since it is a natural stream channel delivering water to Mores Creek during more than just precipitation events. It is assumed that all sediment eroding from these areas is transported to Mores Creek within each water year. Field surveys found no evidence of long-term channel storage in the gullies or intermittent tributary channel.

Table 65. Sediment loading analysis from stream bank erosion inventory of hydraulically-mined areas in the Boise-Mores Creek Subbasin.

Segment Measured	Existing		Proposed		Percent (%) Reduction
	Erosion Rate (t/mi/yr)	Total Erosion (t/yr)	Erosion Rate ($t/mi^2/yr$)	Total Erosion (t/yr)	
Bairds Gulch	22,929	4,182	140	0.45	99.9
Campbell Gulch	14,636	2,963	140	0.32	99.9
Char Gulch	21,466	7,842	140	0.85	99.9
Gold Hill	29,272	1,801	140	0.20	99.9
Humbug Gulch	17,563	3,585	140	0.39	99.9
Noble Gulch (intermittent tributary)	1,851	499	666 t/mi/yr	180	63.9
Noble Gulch Canyons	40,493	38,000	140	4.13	99.9
Upper Noble Gulch Canyons	20,490	5,437	140	0.59	99.9
Wet Creek	6,586	623	140	0.07	99.9
Total		**64,932**		**187.00**	**99.7**

In order to determine the range of potential sediment yield, additional modeling using the WEPP hill-slope erosion model was completed for hydraulically-mined sites in the watershed. The SEI analysis method is most accurate for determining sediment yield from perennial streams. This method is viable considering that most erosion occurring on stream banks occurs during periods of precipitation or high flow when water is also typically flowing overland on upland sites. The WEPP model simulates hill-slope erosion processes and calculates the amount of sediment leaving the upland area and entering streams. The WEPP model incorporates estimates of sediment intercepted by surficial roughness and filtered by riparian vegetation or filter strips before entering a stream. Input used in the WEPP model for hydraulically-mined areas is outlined in Appendix H. The acreages estimated using aerial photograph interpretation for the SEI were used for the WEPP model. Sediment yield rates and annual loads for hydraulically-mined sections are listed in Table 66. Sediment load from the intermittent channel of Noble Gulch was estimated using SEI since it is a water-bearing channel during times of sediment delivery.

WEPP modeling of sediment yield from hydraulically-mined areas may not accurately reflect sediment yield. The model has limited capacity to predict erosion in areas with permanent channels such as classical gullies, since the processes occurring in these types of channels are not simulated (USDA, ARS 1995). In addition, the model only accepts slope up to 50%, while slopes of the hydraulically-mined areas are nearly vertical in many places.

Table 66. Sediment loading analysis from WEPP modeling of upland erosion of hydraulically mined areas in the Boise-Mores Creek Subbasin.

Segment Measured		Existing		Proposed		Percent (%) Reduction
	Acres	Erosion Rate (t/ac/yr)	Total Erosion (t/yr)	Erosion Rate ($t/mi^2/yr$)	Total Erosion (t/yr)	
Bairds Gulch	2.08	25.2	52.37	140	0.45	99.1
Campbell Gulch	1.47	25.2	37.11	140	0.32	99.1
Char Gulch	3.9	25.2	98.20	140	0.85	99.1
Gold Hill	0.90	25.2	22.56	140	0.20	99.1
Humbug Gulch	1.78	25.2	44.90	140	0.39	99.1
Noble Gulch (intermittent tributary)	0.30	1,851 t/mi/year	499.96	666 t/mi/yr	180	63.9
Noble Gulch Canyons	18.88	25.2	475.84	140	4.13	99.1
Upper Noble Gulch Canyons	2.70	25.2	68.08	140	0.59	99.1
Wet Creek	0.31	25.2	7.81	140	0.07	99.1
Total	32.32		**1,306.83**		**187.00**	**85.7**

In order to calibrate the sediment yield from SEI and WEPP modeling, and determine if the yields are within the range of reality, the volume of soil was calculated that would be involved if the entire slope of the Noble Gulch Canyons segment eroded to the elevation of the Noble Gulch intermittent stream channel. Current elevations of the ridge top and Noble Gulch channel, and remnants of drainage ditches present on the surrounding hill-slope, were used to estimate the volume of soil that would be present if the hill-slope were contoured without the steep, eroded gullies now observed (see Appendix G, Photo G-6 for the area of interest). An unknown percentage of the original hill-slope volume is currently present. There are deep incisions with slope heights of the incised canyons ranging from 9 to 201 feet, with an average of 83 feet in height. The estimate of soil loss was spread at an even erosion rate over 125 years, which is the approximate length of time since hydraulic mining of the area concluded. If we consider an assumption that 35-50% of the total hill-slope has eroded, the SEI method likely overestimates erosion and the WEPP model almost certainly provides an underestimate of erosion rates if they are assumed to be constant over time (Table 67).

Table 67. Predicted sediment loss for Noble Gulch Canyons segment from SEI and WEPP model over 125 years.

Sediment Yield Estimation Method	Annual Erosion (tons/year)	Total Erosion over 125 years (tons)	Total volume of hill-slope in segment	Percent of total hill-slope eroded
SEI	38,000.89	4,750,110	6,810,345	69.74%
WEPP	475.84	59,480	6,810,345	0.87%

The soil in this area is composed of extremely erosive glacial lake-bed sediments similar to the soils of badland areas (personal communication, BNF). Though it is known that hydraulic mining occurred in the segments sampled, the extent of erosion that was present prior to human disturbance is unknown. The proposed rate is the rate that would occur under natural background conditions in these soil types. Currently, methods to stabilize the steep hydraulically-mined slopes are not financially feasible. This area is in the process of re-vegetation following timber harvest and hydraulic mining that occurred between 1863 and 1920 (See Appendix G, historical and present day photos). Given time with no land use activities that cause further perturbation of the unstable areas, the area will erode to the angle of repose and then stabilize and re-vegetate.

Upland Erosion

Natural background and human-caused nonpoint source loading from upland erosion was derived for the entire Mores Creek watershed including all tributaries. Sediment yield coefficients for each land use type define the relationship of land use to sediment delivery to surface water. Sediment yield coefficients and sediment loads for the relevant land use types are listed in Table 68. Coefficients for disturbed areas were derived from WEPP modeling, using BNF soil surveys. The erosion coefficients for undisturbed or properly managed land use types are based upon the geology, soil and potential natural vegetation and represent natural sediment delivery in the system. The WEPP model simulates hill-slope erosion processes and calculates the amount of sediment leaving the upland area and entering streams. Many other hill-slope erosion models calculate the upland erosion rate, but do not take into consideration the amount of sediment intercepted by surficial roughness and filtered by riparian vegetation or filter strips before entering a stream. The WEPP model calculations address interception and filtration factors and are believed to more accurately predict the sediment actually entering a stream. Although not all AUs are listed as impaired, they were included in the WEPP hill-slope erosion modeling due to the cumulative effects of sediment transport throughout the basin.

Stream bank erosion loads for streams in AUs that were not included in the stream bank erosion inventories are included in the WEPP upland erosion Forest source existing load and load capacity. Designating streambanks as upland forest may produce an underestimate of sediment load from stream bank erosion. A natural background target of 80% or greater bank stability should be met by all tributaries in this subbasin that are not explicitly listed in the TMDL. If resources allow stream bank erosion inventories should be conducted on tributaries in the subbasin that are considered high priority by land management agencies due to potential for high sediment loads.

Representative road segments from the basin were used to calculate sediment from roads. The loads from representative reaches were then extrapolated to similar road miles in the basin. Road mile and type information came from the Transportation Data Set Roads GIS layer of the DEQ database. Data used to create this layer was prepared by ESRI and the Idaho Geospatial Data Clearinghouse. Data for this analysis was last updated in 2007. The completeness of this layer with regard to road density, number of road miles, and frequency of travel is uncertain. The road coverage did not always match existing road conditions during field surveys. For example, roads on the maps could not always be located, and in other areas well traveled roads did not appear on the roads layer. In addition, there are residential subdivisions under development in the basin which may not be accounted for in the existing load or load capacity. It would be useful to have more intensive road sediment surveys in the future to further refine the load estimates. A Geomorphic Road Analysis & Inventory Package (GRAIP) survey was recently completed on roads in the Wilderness Ranch subdivision; however, the results are not yet available.

Table 68. Sediment yield coefficients used in WEPP modeling for upland erosion in the Boise-Mores Creek Subbasin sediment TMDL.

Land Use	Coefficient	Method to derive
Forest – natural background	0.006	Based on geology, potential natural vegetation and WEPP modeling
Disturbed Forest	0.009	Aerial photo interpretation and Disturbed WEPP modeling
Urban natural background	0.006	Based on geology, potential natural vegetation and WEPP modeling
Urban	0.022	Aerial photo interpretation and WEPP modeling
Unpaved Roads – properly constructed and maintained	0.07	WEPP Roads
Unpaved Roads current	0.34	WEPP Roads
Paved Roads – properly constructed and maintained	0.06	WEPP Roads
Paved Roads current	0.27	WEPP Roads

In terms of total erosion from stream bank erosion and upland sources affected by current land use practices, the Mores Creek watershed released 7% more sediment than the load capacity calculated based upon natural background erosion rates (Table 69). The sediment load allocations and reductions are presented for the watershed as a whole and by individual sediment source. Areas that were historically hydraulically mined are excluded from this table so that efforts could focus on load reductions that are feasible. Sediment load reductions to achieve target load capacities are predicted to bring about full support of beneficial uses. A total load reduction from all sources of erosion equal to 345 tons per year is necessary to meet the target sediment load conditions for streambank and upland erosion. A reduction of 7% for Mores Creek and all its tributaries is imposed in this TMDL to help mitigate effects of human disturbance in the watershed.

Table 69. Sediment allocations by source for stream bank and upland erosion in the Boise-Mores Creek Subbasin.

Source	Acres	Existing Load (t/yr)	Load Capacity (t/yr)	Percent (%) Reduction
Forest	3359,022.8	3231	2154	33
Urban	1,107.2	24	7	71
Unpaved Roads	1,843.1	627	129	79
Paved Roads	174.1	47	10	79
Stream Bank Erosion[1]	85.3	868	2152	0
Watershed Total		**4797**	**4,452**	**7**

[1] Necessary streambank erosion load reduction for watershed is zero, however Mores Creek AU 009_04 (see Table 63) streambank erosion needs to be reduced by 37% (109 t/yr) in order to meet the natural background target for this AU. The intent of this TMDL is to retain existing stream bank stability in areas that are at least 80% stable. Reductions in bank stability form natural events are acceptable and fluctuations are expected. Reductions in bank stability due to anthropogenic activities should be prevented, even in cases where bank stability exceeds 80%.

Load allocations and reductions for areas known to be recovering from historic hydraulic mining were calculated separately. The existing load calculations were estimated using two different models, neither of which may be a good fit for quantifying this sediment load due to limitations mentioned regarding each method. Due to this uncertainty, the existing loads for these sources are presented as a range from 1,307 to 64,932 tons per year (Table 70). In addition, reduction of erosion of hydraulically-mined sites will likely be achieved from long term natural recovery of the sites rather than active implementation of BMPs, since currently there are no known methods that are feasible to stabilize the steep, erosive slopes. DEQ recommends investigating BMPs to reduce delivery of sediment from these sources to perennial streams.

Table 70. Sediment allocations for hydraulically-mined areas left to recover with no further human perturbation for the Boise-Mores Creek Subbasin.

Source	Acres	Existing Load (t/yr)	Load Capacity (t/yr)	Percent (%) Reduction
Mass Wasting of hydraulically mined sites - SEI Model Estimate	32.3	64,932	187	99.7
Mass Wasting - WEPP model Estimate	32.3	1,307	187	85.7

Load Allocation

This section describes the sediment load allocations for Boise-Mores Creek watershed. Allocations for upland erosion, roads, historic hydraulically-mined areas, and stream bank erosion are treated as nonpoint sources. Upland erosion source allocations were distributed by land use type but not differentiated among AUs. The entire available load is allocated as a whole to the watershed conditions that may create sediment. Load allocations for historic hydraulically-mined areas are estimated for the basin as a whole and for individual areas of erosion. Technology does not currently exist to stop erosion of these areas; therefore focus should be on reducing the sediment load delivered to perennial streams while these areas naturally recover.

The smallest existing loads and load allocations for sediment in this subbasin are for urban areas, and paved and unpaved roads. However these sources require the largest percent reductions at 71% for urban areas and 79% for each road type. This is due to the fact that sediment delivery from urban areas and roads is largely controllable with appropriate BMPs.

Stream bank erosion rates are based on bank geometry and lateral recession rate (described in Appendix F) for each measured reach. The natural background load allocation is based on hydro-geologic conditions for that stream that would result in greater than 80% bank stability and a reference condition proportion of subsurface fine material in riffles for streams of similar geologic type.

The LC is the total load present when banks are at least 80% stable, upland erosion is at natural background conditions and the stream is able to assimilate transfer of sediment from suction dredging without negative impacts to beneficial uses. In addition a MOS is included in the load capacity. As such, the LC and the sum of WLAs, LAs and MOS are the same.

Note that stream bank LA consists of the overall decreases necessary where banks are less than 80% stable and retaining existing bank stability where it currently exceeds 80%. The natural background bank stability target of 80% in all streams allows for bank stability reduction due to natural conditions. Decreases in bank stability due to anthropogenic activity should be prevented, even in areas that currently exceed 80% stability.

Wasteload Allocation

There are no National Pollution Discharge Elimination System (NPDES)-regulated point sources discharging to streams in the affected watersheds other than the suction dredge facilities discussed below. Wasteload allocations presented here are estimates for anticipated NPDES permits for wastewater discharge and suction dredge mining. Should another point source be proposed that would contribute sediment to these waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 & IDAPA 58.01.02.401.03) should be involved (see Appendix B).

Wasteload Allocations for Future Wastewater Treatment Facility Discharge

A reserve for growth wasteload allocation is included in this TMDL for future wastewater treatment facilities (Table 72). Idaho City and several large subdivisions along Mores and Grimes Creeks are currently operating with rapid infiltration basins. Their capacity is expected to be exceeded in the near future based upon current population growth estimates.

Wasteload Allocations for Suction Dredge Mining.

As indicated in Chapter 3, suction dredging may have adverse effects on both water column and substrate sediment levels. A two-part allocation will be established to address these impacts. Turbidity, as a surrogate for sediment, is a parameter that can be measured easily and reliably in the field. It directly relates to the water column impacts of suction dredging, has specific criteria for water quality and treatment and is included in Idaho WQS. The water column portion of the interpretation of the narrative sediment standard is based upon treatment requirements for point sources in the Idaho WQS (IDAPA 58.01.02.401.03.b). In essence, the standard requires that turbidity below any applicable mixing zone must not exceed background turbidity by more than 5 NTU or more than 25 NTUs above background for more than 10 consecutive days, or by more than 10% if background turbidity is 50 NTU or higher.

Substrate sediment problems caused by increased bedload movement are difficult to measure and quantify in the field, and incorporate into a WLA or NPDES permit. There has not been detailed monitoring of the suction dredge industry in the Mores Creek watershed. The current permit process does not require permitees to designate the water body where dredging will occur or keep a log of hours dredged. These factors make calculating sediment loads challenging.

The approximate number of dredge days (one dredge operating 4 hours during one day by one individual) was estimated by Russ Hicks, the BNF Mineral Specialist. In Mores Creek, 15 dredge days are estimated, with dredging limited to the area downstream from Boulder Creek from July 1 through September 30 each year. Dredging in Elk Creek has the same season with dredging allowed anywhere upstream from Eldorado Gulch, with approximately 45 dredge days. The dredging season on Grimes Creek and its tributaries is open year round; however, most dredging occurs from June through August. BNF estimated 150 dredge days each year on Grimes Creek and its tributaries. The IDWR General Permit allows these dredges to process no more than 2 cubic yards (yd^3) of material per hour as averaged over the period of operation for the entire day.

Assuming each dredge moves no more than 2 cubic yards of material per hour, and further assuming a 4-hour work day, the current daily mass sediment loading from dredgers for Mores Creek downstream of Boulder Creek (6N 6E Sec 17) is:

15 dredge days x 2 yd^3/hour x 4 hr/day = 120 yd^3
1 yd^3 = 27 ft3
Sediment density = 96.8 lbs/ft^3 x 27 ft^3= 2614 lbs/yd^3 (Hausenbuiller 1985)
120 yd^3 x 2614 lbs/yd^3 = 313,680 lbs = 157 tons

Sediment load for each open section of stream were calculated using this formula. Current sediment loads are found in Table 71.

Table 71. Sediment load estimate for suction dredging in the Boise-Mores Creek Subbasin.

Stream Segment	Dredge days	Existing Load (yd^3)	Existing Load (t/yr)
Grimes Creek	150	1200	1568
Mores Creek	15	120	157
Elk Creek	45	360	471
Watershed Total	**210**	**2196**	**2196**

Extensive evaluation of suction dredge impacts has been conducted in the South Fork Clearwater basin (DEQ 2004). In consideration of similar geology and land use and the absence of detailed information regarding suction dredge impacts in the Mores Creek basin; it is appropriate to model the suction dredge allocation after the SF Clearwater where more detailed studies have been done. An expanded justification was presented in the load capacity section of this document. In the SF Clearwater the load from suction dredging that the river was able to assimilate was 33% of the total load capacity for the stream. Due to similar geology, this fraction of capacity was assumed to be similar for the Mores Creek watershed. The total load capacity for the impaired streams, excluding suction dredging, in this watershed is 4,639 tons/year (Table 73). The calculation for total load capacity and the suction dredge industry WLA is:

LAs + WLA (including Suction Dredging) + MOS = LC,
Where the suction dredging allocation was 33% of the LC
Example Calculation: where LAs = 4,639 t/yr, WLA = 2,319 t/yr MOS = 698 t/yr

Based upon the SF Clearwater basin, an additional 2,319tons/year, or 33% of the total sediment load of 6,958 should be able to be assimilated into the streams without negatively affecting beneficial uses. Since load allocations for non-point sources are based upon achieving natural background conditions, it is most appropriate to divide this allocation among suction dredging, reserve for growth of wastewater treatment facilities and MOS. The wastewater treatment discharge WLA is 8 tons/year (Table 72) based on projected needs for the community of Idaho City and large rural subdivisions. Ten percent (696 tons/year) of the load capacity is reserved as margin of safety. This leaves 1,615 tons/year (23% of total load capacity) remaining for the suction dredge industry.

A flow-proportional method to allocate suction dredge load allocations throughout the basin was used. The total mean annual stream flow at Mores Creek USGS stream gage near Robie Creek is 293 ft^3/s. Each stream with suction dredge season was allocated a sediment load based upon the proportion of flow it contributes. The load allocation calculations are as follows:

$$\frac{SegmentFlow(cfs)}{TotalFlow(cfs)}\left(SuctionDredgeIndustryLoad(Tons/Year)\right) \equiv SegmentAllocation(Tons/Year)$$

- Grimes Creek –Mean Annual flow =159.2 ft^3/s
  - $\frac{159.2}{293}\left(1615\right) \equiv 878$ tons/year = 84 four hour dredge days
- Mores Creek –Mean Annual flow =113.6 ft^3/s
  - $\frac{113.6}{293}\left(1615\right) \equiv 626$ tons/year = 60 four hour dredge days
- Elk Creek –Mean Annual flow =20.2 ft^3/s
  - $\frac{20.2}{293}(1615) \equiv 111$ tons/year = 11 four hour dredge days

Wasteload allocations for each open section of stream were calculated using this formula (Table 72). This is an industry-wide WLA that applies to dredges of all sizes. The WLA will be established for each designated stream section in the Boise-Mores watershed, including tributaries. If additional stream segments are proposed for suction dredging or the length of season changes, the WLA will be adjusted accordingly.

The effectiveness of this allocation in controlling bedload-related problems is also contingent upon the following two key assumptions:

- Each dredge complies with all applicable permitting processes, including those of USEPA (NPDES permit), IDWR (Stream Channel Alteration Permit), USFS (Plan of Operations approval; Decision Notice and Finding of No Significant Impact), BLM (Decision Notice and Finding of No Significant Impact), and Army Corps of Engineers (ACOE) (Clean Water Act Section 404 permit), which include important operational considerations to minimize substrate problems.
- The location of permitted dredges is such that mixing zones do not overlap, in order to avoid localized excessive impacts from suspended and bedload sediment mobilized by

these operations, and in no case are individual dredges separated by less than 100 feet, consistent with IDAPA 37.03.07.064.

Recommended implementation procedures

As indicated in Chapter 3, suction dredges are considered to be point sources and are therefore required to obtain NPDES permits from the USEPA. In order to most easily mesh with current IDWR permitting processes, in implementing this WLA it is recommended that USEPA adopt a similarly tiered NPDES permit process. Specifically, it is recommended that a general permit process be established for dredges with nozzle size less than or equal to 5 inches and horsepower less than or equal to 15, and that each dredge be limited to discharge no more than 2 yd^3/hour, as averaged over the period of operation for the entire day. Should the IDWR permitting process be terminated, it is recommended that the general permit conditions of, and attachments to, the IDWR permit be incorporated into the USEPA general NPDES permit.

Given the greater volume of material discharged, and greater chance of causing sediment-related problems, it is recommended that larger dredges be required to apply for an individual NPDES permit. Finally, since the WLA applies to the entire industry, it should be available for allocation on a first-come, first-served basis, with first opportunity given to facilities currently permitted by IDWR.

It is expected that achieving the wasteload allocation will ensure compliance with the numeric turbidity criteria and the narrative sediment standard. Given the lack of consistent monitoring of the effects of this industry in the Boise-Mores watershed, it is recommended that the USFS, DEQ, and USEPA establish a monitoring plan to further characterize and assess these impacts on an ongoing basis.

Current dredging seasons in the Boise-Mores watershed vary by stream. Headwater areas of Mores Creek are closed to dredging year round as is the lower portion of Elk Creek from Eldorado Gulch to the mouth, which includes the intake for the Idaho City drinking water facility. Based upon current recommendations from the IDFG SW Regional Fishery Manager, DEQ recommends that changes to the IDWR permits include restriction on the dredging season on all 1^{st} and 2^{nd} order tributaries in the basin to a season open from July 15^{th} to August 31^{st} in order to protect redds and fry of spring and fall spawning salmonid species. Load allocations in the TMDL reflect this recommended dredge season amendment. This season limitation coincides with when most dredging occurs, therefore the impacts to users will be minimal. The majority of the current designated season for Mores Creek and Elk creek is in this window. The season for Grimes Creek 1^{st} and 2^{nd} order tributaries would be reduced from a year-round season to a July15^{th} to August 31^{st} season. The Grimes Creek restricted dredge season coincides with when most dredging occurs; therefore user impacts should be minimized. The suction dredge industry WLA results in a reduction of allowable dredge days from the current estimate of 210 dredge days to 155 days. Details of the WLAs are in Table 72.

Table 72. Sediment wasteload allocations for wastewater treatment discharge and suction dredge mining in the Boise-Mores Creek Subbasin.

<table>
<tr><th rowspan="2">Source</th><th rowspan="2">Design Flow (MGD)[a]</th><th colspan="3">Wasteload Allocation [b]</th></tr>
<tr><th>Monthly Average TSS Concentration (mg/L)</th><th>Weekly Average TSS concentration (mg/L)</th><th>Annual TSS Load (t/y)</th></tr>
<tr><td>Wastewater Treatment Discharge</td><td>0.12</td><td>45</td><td>60</td><td>8</td></tr>
<tr><td rowspan="2">Suction Dredge Industry [f]</td><td colspan="3">Suction Dredge Industry Total Annual Load Allocation [c]</td><td>1,615</td></tr>
<tr><td colspan="4">Grimes Creek and tributaries [d]
• WLA: 878 tons/year (672 yd^3) total sediment discharge [e] - (84 dredge days)
• Dredge discharge to stream: - 1st and 2nd order tributaries – July 15 – August 31st
- 3rd order segments – Year round
• Turbidity below any mixing zone shall not exceed background turbidity by more than 5 NTU when background turbidity is 50 NTU or less
• Turbidity below any applicable mixing zone shall not exceed background turbidity by more than 10% when background turbidity is more than 50 NTU
• Turbidity shall not exceed 25 NTU above background for more than 10 consecutive days
Mores Creek, downstream from Boulder Creek (6N 6E Sec 17)[d]
• WLA: 626 tons/year (479yd^3) total sediment discharge [e] - 60 dredge days
• Dredge discharge to stream: - 1st and 2nd order tributaries – July 15 – August 31st
- 3rd order segments – July 15- September 30th
• Turbidity below any mixing zone shall not exceed background turbidity by more than 5 NTU when background turbidity is 50 NTU or less
• Turbidity below any applicable mixing zone shall not exceed background turbidity by more than 10% when background turbidity is more than 50 NTU
• Turbidity shall not exceed 25 NTU above background for more than 10 consecutive days
Mores Creek above Boulder Creek [d]
• Zero wasteload allocation

Elk Creek upstream of Eldorado Gulch (6N 5E Sec 12)[d]
• WLA: 111 tons (85 yd^3) total sediment discharge [e] - 11 dredge days
• Dredge discharge to stream: - 1st and 2nd order tributaries – July 15 – August 31st
- 3rd order segments – July 15- September 30th
• Turbidity below any mixing zone shall not exceed background turbidity by more than 5 NTU when background turbidity is 50 NTU or less
• Turbidity below any applicable mixing zone shall not exceed background turbidity by more than 10% when background turbidity is more than 50 NTU
• Turbidity shall not exceed 25 NTU above background for more than 10 consecutive days
Elk Creek below Eldorado Gulch [d]
• Zero wasteload allocation</td></tr>
</table>

[a] MGD = million gallons per day
[b] TSS = total suspended solids, mg/L = milligrams per liter, t/y = tons year, NTU = nephelometric turbidity unit
[c] All provisions of the WLA must be met
[d] Each facility must comply with all other applicable permitting processes, including those of the Idaho Department of Water Resources, US Forest Service, Bureau of Land Management, Army Corps of Engineers, and US Environmental Protection Agency, which include important operational considerations to minimize substrate problems.
[e] This WLA only allows discharge of sediment that occurs on the bed of the stream, and does not allow the discharge of sediment which occurs above the high water mark either directly or through undercutting of stream banks.
[f] Should changes occur to the IDWR suction dredge seasons the most current regulations and season lengths will apply. The time frames for sediment waste load allocations in this table will still apply.

Margin of Safety

A 10% margin of safety is included in the load capacity to account for model uncertainty and data gaps in the sediment load. In addition, a margin of safety for the Boise-Mores Creek sediment TMDL is implicit due to several conservative factors used to determine existing sediment loads. Modeling reaches incorporate the margin of safety in the target by using conservative sediment delivery targets. The sediment yield coefficients were selected based on the most erosive soil types in the watershed.

The margin of safety may require adjustment in the future to accommodate more accurate sediment loads derived from emerging technological methods or field surveys.

Seasonal Variation

Sediment delivery to a stream is highly dependent on seasonal events. The majority of bank erosion and sediment delivery occurs during high runoff associated with snowmelt and spring rains. It is often difficult to monitor these events, thus sediment loading analysis is based on sediment delivery from stream banks and upland sources over an entire year.

Seasonal variation in the examined watersheds is driven primarily by stream flow. Spring runoff flows represent the highest flow regimes, recorded as peaks in the hydrograph, and pollutant delivery is associated primarily with runoff flows.

Reasonable Assurance

Load allocations (LAs) are developed to reduce sediment from nonpoint source activities. Sediment LAs are calculated from stream bank erosion inventories, bedload sediment sample analysis, and land use assessments. A basic implementation strategy to address nonpoint source sediment reduction is outlined later in this document. An implementation plan must be developed within 18 months of TMDL approval. In addition, the 319 program provides an avenue for nonpoint source pollution reduction project funding. Future monitoring should include stream bank erosion inventories and subsurface sediment sampling to assess changes in the sediment load. In addition, land use assessments of sediment delivery should be calculated where feasible. The combination of implementation activities and monitoring to determine progress toward reducing sediment loads provides reasonable assurance that the targets will be met.

Background

Sediment TMDLs are often based on the concept of meeting background condition target measures (80% bank stability and less than 28% subsurface fine sediment). Hill-slope erosion and mass wasting in undisturbed regions of the watershed are considered to be natural processes. Anthropogenic exacerbation has increased the amount of hill-slope erosion and mass wasting in many areas in the subbasin. WEPP modeling of the watersheds and soil studies of the basins determined natural sediment yield (natural background). For this particular watershed, natural background for streambank and upland erosion is 4,639 tons of sediment per year. This does not include the MOS, suction dredge WLA or reserve for growth WLA for future wastewater treatment facilities. The current load must be reduced by 1,465 (or up to 65,090 tons dependent on actual sediment load from hydraulic mined areas) tons per year to achieve background condition. Management activities in the basin should focus on decreasing sediment loads to achieve background condition measures.

Reserve

A reserve for growth wasteload allocation is included in this TMDL for future wastewater treatment facilities (Table 72). Idaho City and several large subdivisions along Mores and Grimes Creeks are currently operating with rapid infiltration basins. Their capacity is expected to be exceeded in the near future based upon current population growth estimates. All allocations are based on achieving background conditions for stream bank stability and depth percent fines through application of BMPs. Bank stability can be maintained through forestry and urban/suburban BMPs as outlined in IDAPA 58.01.02 § 350. If it is determined that beneficial use support is achieved and water quality standards are being met at sediment loading rates higher than those outlined in this TMDL, then the TMDL may be revised accordingly.

To summarize the load capacity and load allocations for sediment in the impaired assessment units of the Boise-Mores Creek watershed:

LC = LAs + WLAs +MOS = TMDL

6,958 = 4,639 + 1,623 + 696 = 6,958

A summary of existing loads, load capacity and load reductions separated by pollutant source is in Table 73.

Table 73. Sediment load allocations for the Boise-Mores Creek Subbasin.

Source	Existing Load (t/yr)	Load Allocation (t/yr)	Load Reduction (t/yr)	Percent (%) Reduction
Nonpoint Sources				
Forest	3231	2154	1077	33
Urban	24	7	17	71
Unpaved Roads	627	129	498	79
Paved Roads	47	10	37	79
Stream Bank Erosion	868	2152	0	0
Historic Hydraulic Mining	1307[1]	187	1120	85.7
Point Sources				
Waste Water[2]	0	8	-	-
Suction Dredging[3]	2,196	1615	581	26
Margin of Safety	-	696	-	-
Watershed Total	**8,300**	**6,958**	**3330**	**25**

[1]Used hydraulic mine WEPP load estimate for the watershed total sediment load.
[2]Reserve for growth for waste water treatment facility
[3]Existing load, load capacity and reduction for suction dredging are estimated based on current knowledge.

5.2 Temperature

In-stream Water Quality Targets

The goal of a TMDL is to restore “full support of designated beneficial uses” (Idaho Code 39.3611, 3615). For the Mores Creek temperature TMDLs, DEQ uses a potential natural vegetation (PNV) approach. According to the provision in the Idaho water quality standards (WQS) regarding natural background conditions (IDAPA 58.01.02.200.09), if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered to be a violation of WQS. In these situations, natural conditions essentially become the WQS, and, for temperature, the natural level of shade and channel width becomes the target of the TMDL. The in-stream temperature that results from attainment of these conditions is consistent with the WQS, even though it may exceed numeric temperature criteria. See Appendix B for further discussion of WQS and background provisions. The PNV approach is described below. Additionally, the procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in this section. For a more complete discussion of shade and its affects on stream water temperature, the reader is referred to the South Fork Clearwater Subbasin Assessment and TMDL (DEQ, 2004)

Design Conditions

There are several important contributors of heat to a stream including ground water temperature, air temperature and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most likely to be controlled or manipulated. The parameters that affect or control the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology affects how closely riparian vegetation grows together and water storage in the alluvial aquifer. Streamside vegetation and channel morphology are factors influencing shade, which are most likely to have been influenced by anthropogenic activities, and which can most readily be corrected and addressed by a TMDL.

Depending on how much vertical elevation also surrounds the stream, vegetation further away from the riparian corridor can provide shade; however, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure the amount of shade that a stream receives in a number of ways. One way is to measure effective shade, which is the shade provided by all objects that intercept the sun as it makes its way across the sky, that can be measured in a given spot with a solar pathfinder (or other optical equipment) similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and stream aspect. A second way is to measure canopy cover, which is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream. Canopy cover can be measured using a densiometer or estimated visually either with on-site visual observation or from aerial photography interpretation. All of these methods provide information about how much the stream is covered and how much of it is exposed to direct solar radiation.

Potential natural vegetation along a stream is that riparian plant community that has grown to an overall mature state, although some level of natural disturbance is usually included in the development and use of shade targets. The natural vegetation can be removed naturally (wildfire, disease/old age, wind-blown, wildlife grazing) or anthropogenically (domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade-producing vegetation. Anything less than PNV results in stream temperature increases from anthropogenically created additional solar inputs. We can estimate PNV from models of plant community structure (shade curves for specific riparian plant communities), and we can measure existing vegetative cover or shade. Comparing the two will tell us how much excess solar load the stream is receiving, and what potential there is to decrease solar gain. Streams disturbed by wildfire require their own time to recover. Streams that have been disturbed by human activity may require additional restoration beyond natural recovery.

Existing shade or cover was estimated for Mores Creek and ten associated tributaries from interpretation of aerial photos. These estimates were field-verified by measuring shade with a solar pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of the stream. With taller vegetation, the plant community is able to provide more shade at any given channel width. To convert existing and PNV shade values to solar loads, data collected on flat plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather station were used (of the NREL stations that collect such data). In this case, data from the Boise, Idaho station was used. The difference between existing and potential solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are assumed to be natural (so long as there are no point sources or any other anthropogenic sources of heat in the watershed), and are thus considered to be consistent with the Idaho WQS, even though they may exceed numeric criteria.

The Boise-Mores Creek subbasin lies in the Southern Forested Mountain Ecoregion (McGrath et al., 2001). Grand fir and subalpine fir grow in higher elevations of this area, while ponderosa pine grows in the hotter, dryer canyons. In between these extremes, open Douglas fir is common throughout the watershed and mountain brush/sagebrush is found on drier slopes. Streams in this subbasin typically begin in mixed conifer/ponderosa pine forests and, as they get wider, flow through more open shrub-dominated riparian vegetation where the trees are varying distances from the bank.

The riparian vegetation in much of the Boise-Mores Subbasin has been highly disturbed by dredge mining practices. Riparian vegetation types were assigned to streams according to the type of plant communities expected based on observations of remnant plant populations currently present.

Areas where the conifer forest is closest to the stream was classified as being in a conifer riparian vegetation type. Areas where the conifers are further from the stream bank so as to provide less shade and where shrubs dominate the stream-side ground cover were classified as conifer/meadow. A few areas on the upper portion of Grimes Creek were classified as being in a meadow riparian vegetation type, due to the distance of the conifer forests from the bank and to the riparian cover consisting of grasses and low shrubs. Areas dominated by willow, alder, dogwood, and/or hawthorn were classified as medium shrub and areas where deciduous trees (cottonwoods, aspens) are more prevalent along the bank where classified as tall shrub. The lower portion of Mores Creek is surrounded by high canyons with ponderosa pines on the slopes and tall shrubs closer to the banks. We assigned this area slightly higher shade targets than those used for the tall shrub type to accommodate for the influence of the canyon slopes.

Pathfinder Methodology

The solar pathfinder is a device that allows the user to trace the outline of shade-producing objects on specialized charts (monthly solar path charts). The percentage of the sun's path covered by these objects is the effective shade on the stream at the spot where the tracing is made. In order to adequately characterize the effective shade on a reach of stream, ten traces should be taken at systematic or random intervals along the length of the stream in question.

At each sampling location, the solar pathfinder is placed in the middle of the stream about the bankfull water level. The manufacturer's instructions for taking traces are followed (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. The user starts at a unique location such as 100 meters from a bridge or fence line and then proceed upstream or downstream, stopping to take additional traces at fixed intervals (e.g. every 100m, every 100 paces, every degree change on a GPS, every 0.1 mile change on an odometer, etc.). The user could instead randomly locate points of measurement by generating random numbers to be used as interval distances.

When taking solar pathfinder traces, the user should measure bankfull widths and take notes and photographs documenting the stream at several unique locations. Special attention should also be paid to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade-producing ones) are present. Additionally or as a substitution, the user may record densiometer readings at the same locations where solar pathfinder traces are taken. This provides the potential for later developing relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

To estimate canopy coverage or expected shade based on plant type and density, natural breaks in vegetation density are marked out on a 1:100K or 1:250K hydrography. Each resulting stream segment is then assigned a single value representing the bottom of the respective 10% cover (canopy coverage) or shade class as described below (adapted from the CWE process, IDL, 2000). For example, if estimated canopy cover for a particular stretch of stream is somewhere between 50% and 59%, the value of 50% is assigned to that section of stream. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and the width of the stream. The typical vegetation type (below) shows the kind of landscape a particular cover class usually falls into for a stream 5m wide or less. For example, if a section of a 5m wide stream is identified as 20% cover class, it is usually because it is in agricultural land, meadows, open areas, or clearcuts. However, that does not mean that the 20% cover class cannot occur in shrublands and forests, because it does on wider streams.

Shade (canopy cover) class	Typical vegetation type on 5m-wide stream
0 = 0 – 9% cover	agricultural land, denuded areas
10 = 10 –19%	ag land, meadows, open areas, clearcuts
20 = 20 – 29%	ag land, meadows, open areas, clearcuts
30 = 30 – 39%	ag land, meadows, open areas, clearcuts
40 = 40 – 49%	shrublands/meadows
50 = 50 – 59%	shrublands/meadows, open forests
60 = 60 – 69%	shrublands/meadows, open forests
70 = 70 – 79%	forested
80 = 80 – 89%	forested
90 = 90 –100%	forested

It is important to note that the visual estimates made from interpreting the aerial photos are strongly influenced by canopy cover. It is not always possible to visualize or anticipate shade characteristics resulting from topography and landform. We assume that canopy coverage and shade are similar based on research conducted by Oregon DEQ. The visual estimates of shade in this TMDL were field-verified with a solar pathfinder. The pathfinder measures effective shade and accounts for other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, man-made structures). The estimate of shade made visually from an aerial photo does not always take into account topography or any shading that may occur from physical features other than vegetation. However, research has shown that shade and cover measurements are remarkably similar (OWEB 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade.

Stream Morphology

Measures of current bankfull width or near-stream disturbance zone (NSDZ) width may not reflect widths that were present under PNV. As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase as streams become wider and shallower. Shadow length produced by vegetation covers a lower percentage of the water surface in wider streams, and widened streams can also have less vegetative cover if shoreline vegetation has been eroded away.

In this analysis, the only factor not developed from aerial photo interpretation is channel width (i.e., NSDZ or bankfull width). Accordingly, this parameter must be estimated from available information. We use regional curves that relate drainage area with bankfull width for the major basins in Idaho, data compiled by Diane Hopster of Idaho Department of Lands (Figure 42 and Table 74).

For each stream segment evaluated in the loading analysis, bankfull width was estimated based on drainage area, using the Upper Snake curve from the Idaho Regional Curves for Bankfull Width (Figure 42). We also examined bankfull width estimates from the Salmon and Payette/Weiser regional curves; however, the Upper Snake curve was most consistent with the lower precipitation regime and geology found in the Mores Creek watershed. The Salmon basin has larger snow accumulations, releasing more water that creates larger bankfull widths per unit of drainage area. The Payette/Weiser basin tends to have rapid snow melt in the spring and can be slightly flashy in flooding response. It also produces bankfull widths that are larger per unit of drainage area than the Upper Snake curve. The Upper Snake basin is the region in the state with the least precipitation and produces the smallest bankfull width estimates per unit of drainage area. Additionally, existing width was evaluated from available data (Table 74). Despite the Upper Snake curve producing smaller bankfull widths than any of the other regional curves, existing bankfull widths in the Boise/Mores subbasin were consistently smaller than those produced by the Upper Snake curve.

Generally, if the stream's existing width was substantially wider than the estimated width based on the Upper Snake curve, then the curve-based estimate of bankfull width is used in the loading analysis. If existing width is smaller than the curve-based estimate, then existing width is used in the loading analysis. However, in the Boise/Mores subbasin, the curve-based estimate of bankfull width was consistently used for natural bankfull width, despite the fact that existing width data produced slightly smaller widths than curve-based estimates (Table 74). The curve-based estimates were used for the following reasons: precipitation and snowmelt patterns in the Boise-Mores Creek subbasin should be similar to those in the Upper Snake, there are no regional curves that produce smaller bankfull width values, the Mores Creek area is likely impacted (narrowed) by a history of dredge mining, and existing width measurement locations don't necessarily match curve-estimated width locations. Stream widths in the Mores Creek watershed are not necessarily natural, as the area has been extensively dredge-mined during the last two centuries. Dredge mining that piles stream gravel high alongside the stream can actually decrease channel width by confining the stream to a narrow dredged channel. Many of the major streams in this watershed also have roads along the sides that further impinge upon the streams' natural channel morphology.

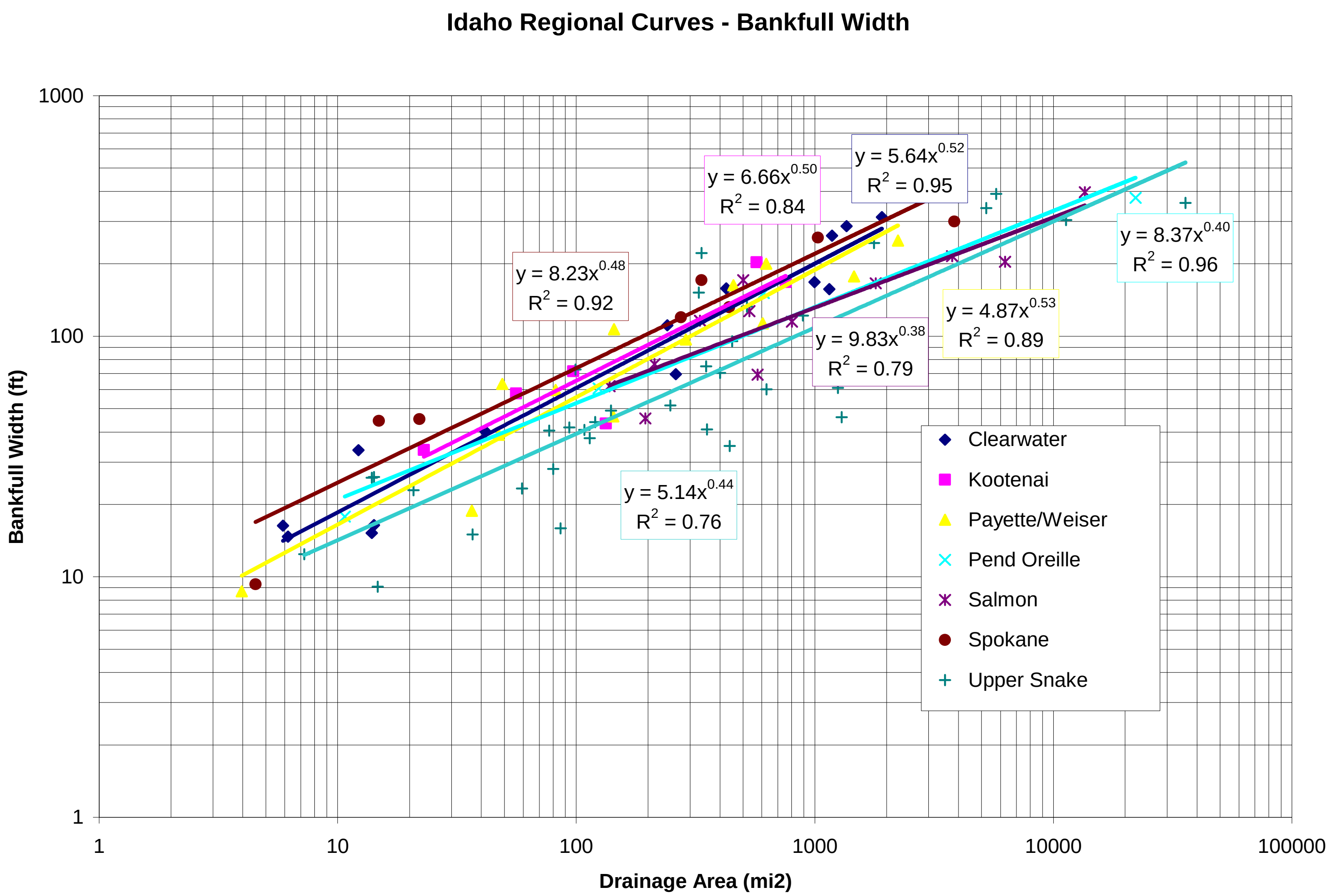

Figure 42. Bankfull Width as a Function of Drainage Area

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Table 74. Bankfull Width Estimates Based on Drainage Area and Existing Measurements

Location	area (sq mi)	US (m)	Salm (m)	P/W (m)	existing (m)
Bannock Creek @ mouth	6.75	4	6	4	3.25
Dagget Creek @ mouth	12.3	5	8	6	3.1
Robie Creek @ mouth	16.1	5	9	6	
Smith Creek @ mouth	6.92	4	6	4	
Mack's Creek @ mouth	12.5	5	8	6	4.43
Granite Creek @ mouth	51.5	9	13	12	
Granite Creek @ middle	8.71	4	7	5	4.2
Elk Creek @ mouth	31.1	7	11	9	
Elk Creek @ middle	13.8	5	8	6	5.75
Clear Creek @ mouth	18.2	6	9	7	
Clear Creek ab Smith Creek	9.58	4	7	5	3.9
Thorn Creek @ mouth	27.2	7	11	9	4
MF Thorn Creek ab NF Thorn Creek	9.16	4	7	5	
Grime's Creek @ mouth	196	16	22	24	12.45
Grime's Creek ab Mack's Creek	157	14	20	22	12.45
Grime's Creek ab Granite Creek	70.8	10	15	14	
Grime's Creek @ Charlotte Gulch	19.1	6	9	7	7.68
More's Creek ab reservoir	398	22	29	35	15.1
More's Creek ab Grime's Creek	163	15	21	22	12.3
Mores Creek ab Elk Creek	66.2	10	15	14	10.75
Mores Creek ab Washington Gulch	24.2	6	10	8	6.7
Mores Creek @ HWY 21 crossing	2.49	2	4	2	4.45

US-Upper Snake River, Salm-Salmon River, P/W-Payette and Weiser Rivers

Target Selection

To determine PNV shade targets for the Boise-Mores Creek subbasin, effective shade curves from several existing temperature TMDLs were examined. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. As a stream becomes wider, a given vegetation type loses its ability to shade wider and wider streams. For the TMDLs examined, vegetation community modeling was used to produce the shade curves. For the Boise-Mores Creek subbasin, curves for the most similar vegetation types were selected for shade target determinations. Because no two landscapes are exactly the same, shade targets were derived by taking an average of values from the various shade curves available. Thus, the selected shade curves represent a range of shade conditions that presumably represent the riparian community of interest in this TMDL.

The effective shade calculations are based on a six-month period from April through September. This time period coincides with the critical time period when temperatures affect beneficial uses such as spawning of spring and fall salmonids and when temperature criteria for cold water aquatic life may be exceeded during summer months. Late July and early August typically represent a period of highest stream temperatures. Solar gains can begin early in the spring and affect not only the highest temperatures reached in the summer, but solar loadings also affect salmonids spawning temperatures in spring and fall. Thus, solar loading in these streams is evaluated from spring (April) to early fall (September).

Shade Curves Used

For the Boise-Mores Creek TMDL, an attempt was made to match the various vegetation types using effective shade curves from a variety of Pacific Northwest TMDLs. Although these TMDLs reflect a wide variety of geomorphologies and topographies, effective shade values for the same stream widths were remarkably similar. For each vegetation type, the following tables (75-79) show derivations of shade targets at the natural stream widths (e.g., 1m = 1 meter wide) encountered in the loading analysis. Numbers in these tables are percent shade values. The percent shade values in a column are averaged, then the average is converted to a target (%) by rounding to the nearest whole number (there is no averaged value in Table 75 because it has values from just one effective shade curve). These shade target percentages are also shown on the map in Figure 43.

For the conifer vegetation type, only one curve was used to derive shade targets (Table 75): the effective shade curve for the ponderosa pine community from the Salmon-Chamberlain (Crooked Creek) TMDL (DEQ 2002), which represents an average height of 59 feet and an average canopy cover of 58%.

Table 75. Shade Targets for the Conifer Vegetation Type at Various Stream Widths

Mixed Conifer	1m	2m	3m	4m	5m	6m	7m	8m	10m	12m	13m	14m	15m	16m	17m
ponderosa pine (IDEQ, 2002)	84	80	77	75	73	72	68	65	59	55	53	51	49	48	47
Target (%)	**84**	**80**	**77**	**75**	**73**	**72**	**68**	**65**	**59**	**55**	**53**	**51**	**49**	**48**	**47**

For the conifer/meadow community (Table 76), two shade curves were used to produce shade targets. The ponderosa pine community from the Salmon-Chamberlain (Crooked Creek) TMDL (DEQ 2002) has an average height of 59 ft and an average canopy cover of 58%. From the Alvord Lake TMDL (ODEQ 2003) we included the willow mix community from the East Steens ecological province (average height = 20 ft. and density = 50%). Note that shade targets in Table 77 vary from 4% to 18% lower than targets in Table 76 reflecting less shade contribution from trees further away from the stream.

Table 76. Shade Targets for the Conifer/Meadow Vegetation Type at Various Stream Widths

Conifer/Meadow	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m	14m	15m	16m	17m
ponderosa pine (IDEQ, 2002)	84	80	77	75	74	72	69	65	62	59	57	55	53	51	49	48	45
willow mix-ESteens (ODEQ, 2003)	75	70	61	55	47	42	37	33	28	25	22	21	19	17	15	14	13
Average	79.5	75	69	65	60.5	57	53	49	45	42	39.5	38	36	34	32	31	29
Target (%)	**80**	**75**	**69**	**65**	**61**	**57**	**53**	**49**	**45**	**42**	**40**	**38**	**36**	**34**	**32**	**31**	**29**

Two shade curves were useful in deriving shade targets for the meadow vegetation type (Table 77). Shade curves used were the tufted hairgrass meadow type from the Salmon-Chamberlain (Crooked Creek) TMDL (IDEQ 2002), in the Salmon basin (average height = 2 feet and canopy cover = 42%), and the co-dominant mesic graminoid-willow community from the Alvord Lake TMDL (ODEQ 2003) (average height = 8.5 feet and canopy cover = 10%). Table 77 below shows expected shade levels (%) for a 1-m through a 10-m wide stream with meadow vegetation type.

Table 77. Shade Targets for the Meadow Vegetation Type at Various Stream Widths

Meadow	1m	2m	3m	4m	5m	6m	8m	9m	10m
tufted hairgrass (IDEQ, 2002)	43	30	17	15	12	10	8	7	6
graminoid/willow-Trout (ODEQ, 2003)	39	26	18	14	10	9	6	5	4
Average	41	28.00	17.5	14.5	11.00	9.5	7	6	5
Target (%)	**41**	**28**	**18**	**15**	**11**	**10**	**7**	**6**	**5**

The medium shrub mix type (Table 78) represents a wide variety of willow-dominated riparian types in the subbasin where trees are not present in the near-stream vegetation. The average of three willow-dominated shade curves was used to form targets for this vegetation type (Table 78). All three curves are from the Alvord Lake TMDL (ODEQ 2003), and include the willow mix community from the East Steens ecological province (average height = 20 feet and density = 50%), the willow mix community from the Pueblo Mountains province (average height = 14 feet and density = 50%), and the willow community from the Trout Creek province (average height = 18 feet and density = 60%).

Table 78. Shade Targets for the Medium Shrub Mix Vegetation Type at Various Stream Widths

Medium Shrub Mix	1m	2m	3m	4m	5m	6m	7m	8m	9m
willow mix-ESteens (ODEQ, 2003)	75	70	61	55	47	42	37	33	28
willow-Pueblo (ODEQ, 2003)	79	70	58	50	41	34	29	25	21
willow-Trout (ODEQ, 2003)	85	80	68	61	54	44	40	35	30
Average	79.667	73.333	62.333	55.333	47.333	40	35.333	31	26.33
Target (%)	**80**	**73**	**62**	**55**	**47**	**40**	**35**	**31**	**26**

Medium Shrub Mix	10m	11m	12m	13m	14m	15m	16m	17m	20m
willow mix-ESteens (ODEQ, 2003)	25	22	21	19	17	15	14	13	11
willow-Pueblo (ODEQ, 2003)	19	16	15	13	12	11	10	9	7
willow-Trout (ODEQ, 2003)	27	24	23	21	19	17	16	15	12
Average	23.667	20.667	19.667	17.667	16	14.333	13.333	12.333	10
Target (%)	**24**	**21**	**20**	**18**	**16**	**14**	**13**	**12**	**10**

Shade targets for the tall shrub vegetation type (Table 79) were derived from two shade curves found in the Alvord Lake TMDL (ODEQ 2003). The Aspen/Alder/Willow community from the Pueblo Mountains ecological province has an average canopy height of 33 feet and an average canopy density of 85%. The Willow/Cottonwood/Aspen community from the East Steens province has an average canopy height of 25 feet and an average canopy density of 65%. Note that targets in Table 79 are from 4% to 17% higher than those in Table 78, reflecting the increased shade that taller shrub vegetation can provide.

Table 79. Shade Targets for the Tall Shrub Vegetation Type at Various Stream Widths

Tall Shrub Mix	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m
aspen/alder/willow-Pueblo (ODEQ, 2003)	85	82	76	71	65	58	54	50	44	41	39	33
willow/cottonwood/aspen-ES (ODEQ, 2003)	82	77	70	62	57	53	49	44	39	34	33	31
Average	83.5	79.5	73	66.5	61	55.5	51.5	47	41.5	37.5	36	32
Target (%)	**84**	**80**	**73**	**67**	**61**	**56**	**52**	**47**	**42**	**38**	**36**	**32**

Tall Shrub Mix	13m	14m	15m	16m	17m	18m	19m	20m	21m	22m	25m
aspen/alder/willow-Pueblo (ODEQ, 2003)	32	30	27	25	23	21	20	19	17	17	15
willow/cottonwood/aspen-ES (ODEQ, 2003)	29	27	25	23	20	18	17	16	14	14	12
Average	30.5	28.5	26	24	21.5	19.5	18.5	17.5	15.5	15.5	13.5
Target (%)	**30**	**29**	**26**	**24**	**22**	**20**	**19**	**18**	**16**	**16**	**14**

Temperature Monitoring Points

The accuracy of the aerial photo interpretations was field-verified with a solar pathfinder with 122 traces at 17 sites throughout the watershed (Figure 44). The average difference between our original aerial photo interpretation and the solar pathfinder readings was 13% ± 6.4 (mean ± 95% confidence interval [C.I.]). Hence, the original aerial photo interpretations were too high, and each was adjusted downward to the next lower 10%-class. Existing shade values used in this document represents those adjusted values. In a few areas, additional adjustments were made to existing shade values based on information provided by the Boise-Mores Creek Watershed Advisory Group (WAG).

Future monitoring of effective shade can take place on any reach throughout the Boise-Mores Creek Subbasin and values obtained can be compared to the estimates of existing shade seen on the map in Figure 44 and described in the load analysis tables (Table 80 through Table 92). Those areas with the largest disparity between existing shade estimates and shade targets (identified as lack of shade in Figure 45) should be monitored with solar pathfinders, to verify the existing shade estimates and to determine progress towards meeting shade targets. It is important to note that many existing shade estimates used in this analysis have not been field-verified and may require adjustment during the implementation process. The lengths of the stream segments assigned to existing shade classes vary, depending on land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade toward target levels. An average of ten solar pathfinder measurements, equally spaced within a given segment no matter how long it is, should suffice to determine existing shade values for future use.

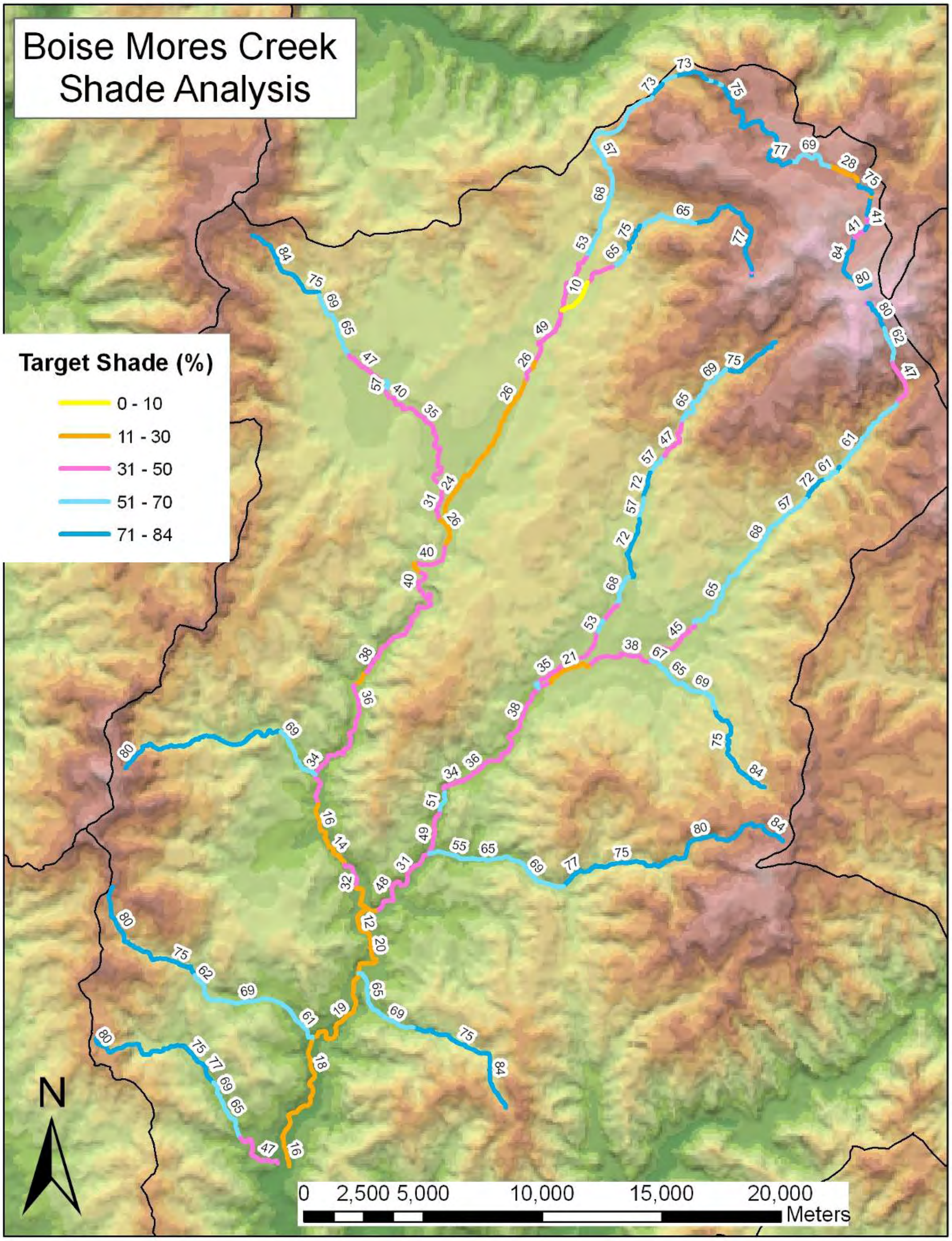

Figure 43. Target Shade Values for Stream Segments in the Boise-Mores Creek Subbasin.

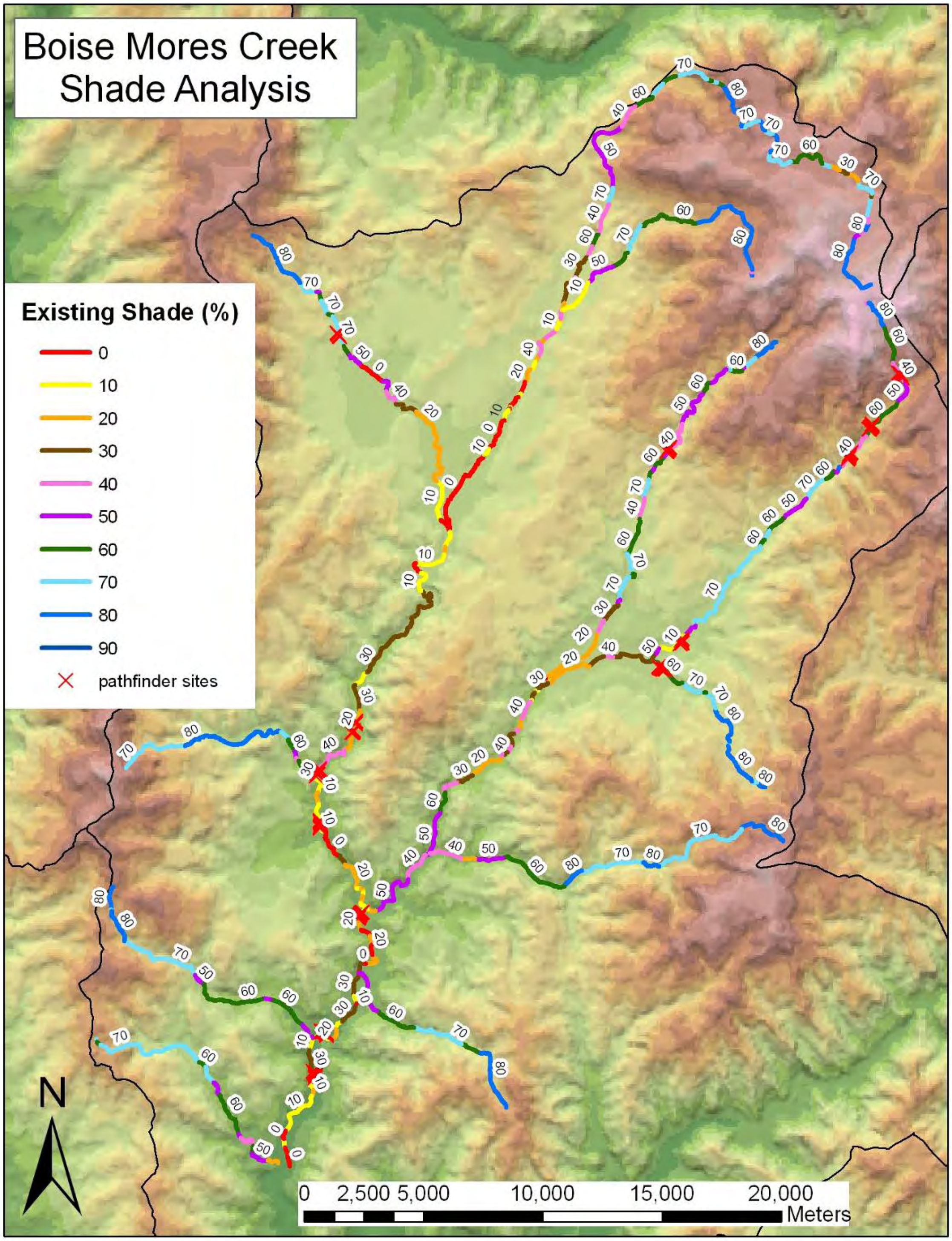

Figure 44. Existing Shade Values Estimated by Aerial Photo Interpretation for Boise-Mores Creek Subbasin.

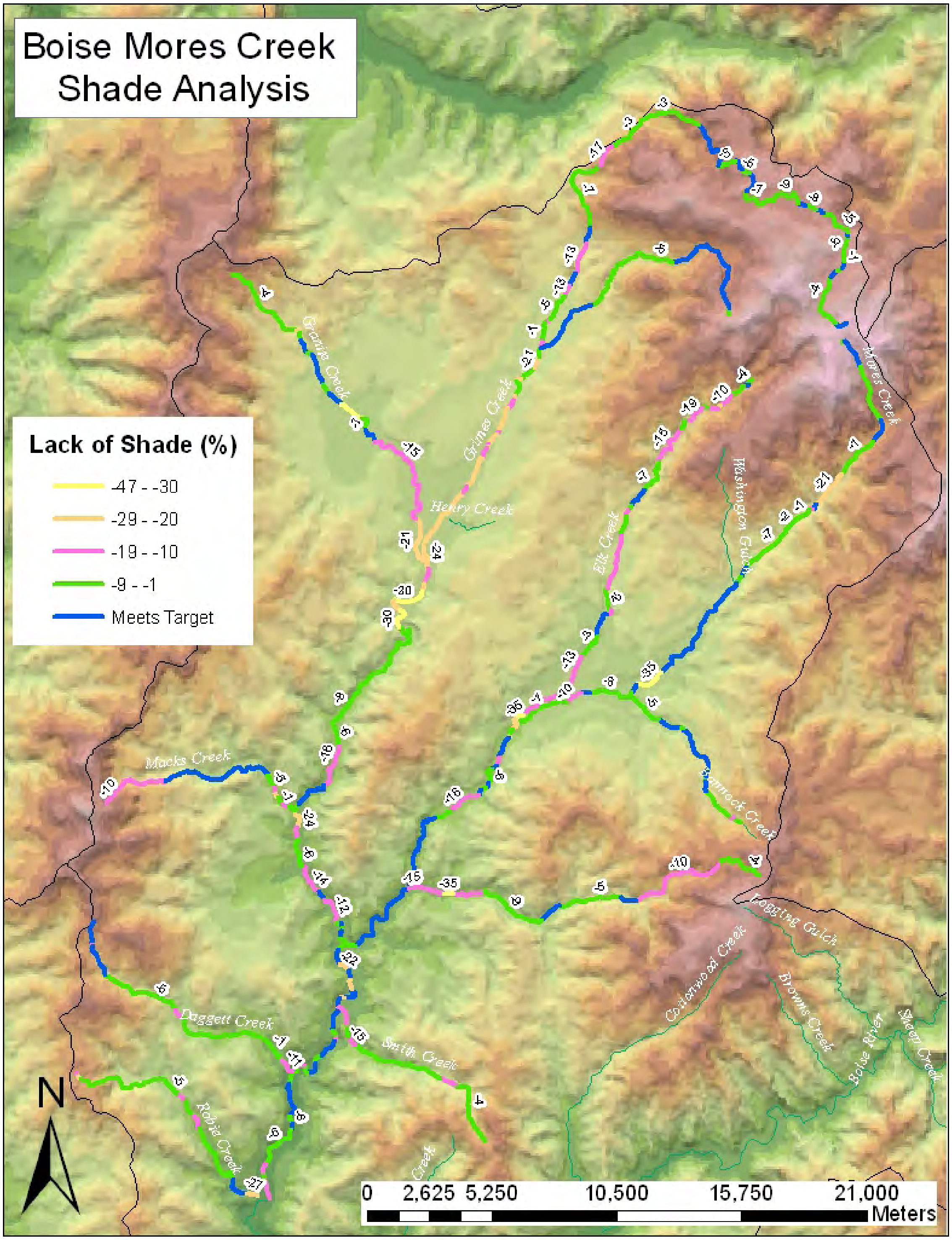

Figure 45. Lack of Shade (Difference Between Existing and Target) for Boise Mores Creek Subbasin.

Load Capacity

The load capacity for a stream under PNV is essentially the solar load allowed under the shade targets specified for the reaches within that stream. These potential/target loads are determined by multiplying the solar radiation load measured on a flat plat collector (under full sun), for a given period of time, by the fraction of the solar radiation that is not blocked by shade (i.e., it is "open"). To find the "percent open" value, we subtract the "percent shade" value (converted to decimal/fraction form) from 1.0. This can be expressed as

1.0 minus "percent (decimal) shade" = "percent (decimal) open," or
100% - %shade = %open.

For example, if a shade target is 60% (or 0.6), then the solar load hitting the stream under that target is 40% (1.0 – 0.6 = 0.4) of the load hitting the flat plate collector under full sun. Therefore, in this case, the load recorded under full sun would be multiplied by 0.4.

Solar load data recorded on a flat plate collector was obtained from the Boise, Idaho National Renewable Energy Laboratory (NREL) weather station. The solar loads used in this TMDL are spring/summer averages, thus, we use an average load for the six-month period from April through September. These months coincide with time of year that stream temperatures are increasing and deciduous vegetation is in leaf.

The load analysis tables (Table 80 through Table 92) show the PNV shade targets (identified as Target Shade or Potential Shade) and the corresponding potential summer loads that serve as the load capacities for the streams (on an area basis, in kilowatt hours per square meter per day [kWh/m^2/day] and as a total load, in kilowatt hours per day [kWh/day]).

Load capacities vary from a little less than 2.2 million kWh/day on the largest stream (Mores Creek below New York Gulch, Table 81) to 37,472 kWh/day on Bannock Creek (Table 86).

Estimates of Existing Pollutant Loads

Federal regulations allow that loads "...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)). There are no identified point sources of temperature in the Boise-Mores Creek Subbasin. All nonpoint loads that could be quantified are outlined below.

Existing loads used in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. Like target shade, existing shade was converted to a solar load by multiplying the fraction of stream that is open by the solar radiation measured on a flat plate collector at the Boise, Idaho NREL weather station. Existing shade data are presented on the map in Figure 44 and in Table 80 through Table 92. Like load capacities (potential loads), existing loads are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day) (Table 80 through Table 92).

Existing loads vary from 2.2 million kWh/day on lower Mores Creek (Table 81) to 38,695 kWh/day on Bannock Creek (Table 86).

Existing and potential loads in kWh/day can be summed for the entire stream, or for a portion of stream examined, in a single load analysis table (loading table). These total loads are shown at the bottom of their respective columns in each table. The difference between potential load and existing load is also summed for the entire table. If existing load exceeds potential load, this difference becomes the excess load to be discussed next, in the load allocation section. The percent lack of shade (% reduction) shown in the lower right corner of each table represents how much total excess load there is in relation to total existing load.

Table 80. Existing and Potential Solar Loads for Mores Creek above New York Gulch (AUs 009_02 and 009_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	**Mores Creek above New York Gulch**
100	0.4	3.828	0.41	3.7642	-0.06	1	1	100	382.8	100	376.42	-6.38	-0.1	meadow
1340	0.8	1.276	0.8	1.276	0	1	1	1340	1709.84	1340	1709.84	0	0.0	conifer/meadow
1540	0.6	2.552	0.62	2.4244	-0.1276	3	3	4620	11790.24	4620	11200.728	-589.512	-0.4	medium shrub
970	0.4	3.828	0.62	2.4244	-1.4036	3	3	2910	11139.48	2910	7055.004	-4084.476	-4.2	
1090	0.5	3.19	0.47	3.3814	0.1914	5	5	5450	17385.5	5450	18428.63	1043.13	0.0	
2000	0.6	2.552	0.61	2.4882	-0.0638	5	5	10000	25520	10000	24882	-638	-0.3	conifer/meadow
1720	0.4	3.828	0.61	2.4882	-1.3398	5	5	8600	32920.8	8600	21398.52	-11522.28	-6.7	
270	0.8	1.276	0.73	1.7226	0.4466	5	5	1350	1722.6	1350	2325.51	602.91	0.0	conifer
200	0.5	3.19	0.61	2.4882	-0.7018	5	5	1000	3190	1000	2488.2	-701.8	-3.5	conifer/meadow
430	0.6	2.552	0.61	2.4882	-0.0638	5	5	2150	5486.8	2150	5349.63	-137.17	-0.3	
1220	0.7	1.914	0.72	1.7864	-0.1276	6	6	7320	14010.48	7320	13076.448	-934.032	-0.8	conifer
1310	0.5	3.19	0.57	2.7434	-0.4466	6	6	7860	25073.4	7860	21563.124	-3510.276	-2.7	conifer/meadow
790	0.6	2.552	0.68	2.0416	-0.5104	7	7	5530	14112.56	5530	11290.048	-2822.512	-3.6	conifer
450	0.7	1.914	0.68	2.0416	0.1276	7	7	3150	6029.1	3150	6431.04	401.94	0.0	
340	0.6	2.552	0.68	2.0416	-0.5104	7	7	2380	6073.76	2380	4859.008	-1214.752	-3.6	
4830	0.7	1.914	0.65	2.233	0.319	8	8	38640	73956.96	38640	86283.12	12326.16	0.0	
660	0.5	3.19	0.45	3.509	0.319	9	9	5940	18948.6	5940	20843.46	1894.86	0.0	conifer/meadow
1360	0.1	5.742	0.45	3.509	-2.233	9	9	12240	70282.08	12240	42950.16	-27331.92	-20.1	
390	0.5	3.19	0.45	3.509	0.319	9	9	3510	11196.9	3510	12316.59	1119.69	0.0	
230	0.3	4.466	0.38	3.9556	-0.5104	10	10	2300	10271.8	2300	9097.88	-1173.92	-5.1	tall shrub
70	0.2	5.104	0.38	3.9556	-1.1484	10	10	700	3572.8	700	2768.92	-803.88	-11.5	
1840	0.3	4.466	0.38	3.9556	-0.5104	10	10	18400	82174.4	18400	72783.04	-9391.36	-5.1	
390	0.4	3.828	0.38	3.9556	0.1276	10	10	3900	14929.2	3900	15426.84	497.64	0.0	
770	0.3	4.466	0.4	3.828	-0.638	11	11	8470	37827.02	8470	32423.16	-5403.86	-7.0	conifer/meadow
2120	0.2	5.104	0.21	5.0402	-0.0638	11	11	23320	119025.28	23320	117537.464	-1487.816	-0.7	medium shrub
550	0.3	4.466	0.38	3.9556	-0.5104	12	12	6600	29475.6	6600	26106.96	-3368.64	-6.1	conifer/meadow
210	0.1	5.742	0.38	3.9556	-1.7864	12	12	2520	14469.84	2520	9968.112	-4501.728	-21.4	
350	0.3	4.466	0.38	3.9556	-0.5104	12	12	4200	18757.2	4200	16613.52	-2143.68	-6.1	
80	0.1	5.742	0.38	3.9556	-1.7864	12	12	960	5512.32	960	3797.376	-1714.944	-21.4	
960	0.4	3.828	0.38	3.9556	0.1276	12	12	11520	44098.56	11520	45568.512	1469.952	0.0	
370	0.2	5.104	0.38	3.9556	-1.1484	12	12	4440	22661.76	4440	17562.864	-5098.896	-13.8	
260	0.4	3.828	0.38	3.9556	0.1276	12	12	3120	11943.36	3120	12341.472	398.112	0.0	
							Total	**214,540**	**765,651**	**214,540**	**696,824**	**-68,827**		**-9** **% Reduction**

Table 81. Existing and Potential Solar Loads for Mores Creek below New York Gulch (AUs 009_03, 009_04 and 009_06).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Segment Area (m²)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	**Mores Creek below New York Gulch**
740	0.3	4.466	0.36	4.0832	-0.3828	13	13	9620	42962.92	9620	39280.384	-3682.536	-5.0	
310	0.4	3.828	0.36	4.0832	0.2552	13	13	4030	15426.84	4030	16455.296	1028.456	0.0	
270	0.3	4.466	0.36	4.0832	-0.3828	13	13	3510	15675.66	3510	14332.032	-1343.628	-5.0	
230	0.4	3.828	0.36	4.0832	0.2552	13	13	2990	11445.72	2990	12208.768	763.048	0.0	
1490	0.2	5.104	0.36	4.0832	-1.0208	13	13	19370	98864.48	19370	79091.584	-19772.896	-13.3	
770	0.3	4.466	0.34	4.2108	-0.2552	14	14	10780	48143.48	10780	45392.424	-2751.056	-3.6	
840	0.4	3.828	0.34	4.2108	0.3828	14	14	11760	45017.28	11760	49519.008	4501.728	0.0	
970	0.6	2.552	0.51	3.1262	0.5742	14	14	13580	34656.16	13580	42453.796	7797.636	0.0	conifer
2040	0.5	3.19	0.49	3.2538	0.0638	15	15	30600	97614	30600	99566.28	1952.28	0.0	
400	0.4	3.828	0.32	4.3384	0.5104	15	15	6000	22968	6000	26030.4	3062.4	0.0	conifer/meadow
980	0.4	3.828	0.31	4.4022	0.5742	16	16	15680	60023.04	15680	69026.496	9003.456	0.0	
1970	0.5	3.19	0.48	3.3176	0.1276	16	16	31520	100548.8	31520	104570.752	4021.952	0.0	conifer
620	0.5	3.19	0.47	3.3814	0.1914	17	17	10540	33622.6	10540	35639.956	2017.356	0.0	
390	0.2	5.104	0.29	4.5298	-0.5742	17	17	6630	33839.52	6630	30032.574	-3806.946	-9.8	conifer/meadow
440	0.1	5.742	0.12	5.6144	-0.1276	17	17	7480	42950.16	7480	41995.712	-954.448	-2.2	medium shrub
670	0.2	5.104	0.12	5.6144	0.5104	17	17	11390	58134.56	11390	63948.016	5813.456	0.0	
480	0	6.38	0.22	4.9764	-1.4036	17	17	8160	52060.8	8160	40607.424	-11453.376	-23.9	tall shrub/canyon
410	0.2	5.104	0.2	5.104	0	18	18	7380	37667.52	7380	37667.52	0	0.0	
420	0	6.38	0.2	5.104	-1.276	18	18	7560	48232.8	7560	38586.24	-9646.56	-23.0	
880	0.2	5.104	0.2	5.104	0	18	18	15840	80847.36	15840	80847.36	0	0.0	
190	0	6.38	0.2	5.104	-1.276	18	18	3420	21819.6	3420	17455.68	-4363.92	-23.0	
400	0.3	4.466	0.2	5.104	0.638	18	18	7200	32155.2	7200	36748.8	4593.6	0.0	
70	0	6.38	0.2	5.104	-1.276	18	18	1260	8038.8	1260	6431.04	-1607.76	-23.0	
400	0.3	4.466	0.2	5.104	0.638	18	18	7200	32155.2	7200	36748.8	4593.6	0.0	
320	0.3	4.466	0.19	5.1678	0.7018	19	19	6080	27153.28	6080	31420.224	4266.944	0.0	
290	0.2	5.104	0.19	5.1678	0.0638	19	19	5510	28123.04	5510	28474.578	351.538	0.0	
340	0.1	5.742	0.19	5.1678	-0.5742	19	19	6460	37093.32	6460	33383.988	-3709.332	-10.9	
140	0	6.38	0.19	5.1678	-1.2122	19	19	2660	16970.8	2660	13746.348	-3224.452	-23.0	
880	0.3	4.466	0.19	5.1678	0.7018	19	19	16720	74671.52	16720	86405.616	11734.096	13.3	
430	0.1	5.742	0.19	5.1678	-0.5742	19	19	8170	46912.14	8170	42220.926	-4691.214	-10.9	
640	0.2	5.104	0.19	5.1678	0.0638	19	19	12160	62064.64	12160	62840.448	775.808	0.0	
410	0.1	5.742	0.18	5.2316	-0.5104	20	20	8200	47084.4	8200	42899.12	-4185.28	-10.2	
340	0	6.38	0.18	5.2316	-1.1484	20	20	6800	43384	6800	35574.88	-7809.12	-23.0	
890	0.1	5.742	0.18	5.2316	-0.5104	20	20	17800	102207.6	17800	93122.48	-9085.12	-10.2	
1530	0.3	4.466	0.18	5.2316	0.7656	20	20	30600	136659.6	30600	160086.96	23427.36	0.0	
380	0.1	5.742	0.16	5.3592	-0.3828	21	21	7980	45821.16	7980	42766.416	-3054.744	-8.0	
280	0.2	5.104	0.16	5.3592	0.2552	21	21	5880	30011.52	5880	31512.096	1500.576	0.0	
2130	0.1	5.742	0.16	5.3592	-0.3828	21	21	44730	256839.66	44730	239717.016	-17122.644	-8.0	
390	0	6.38	0.16	5.3592	-1.0208	22	22	8580	54740.4	8580	45981.936	-8758.464	-22.5	
360	0.1	5.742	0.16	5.3592	-0.3828	22	22	7920	45476.64	7920	42444.864	-3031.776	-8.4	
820	0	6.38	0.16	5.3592	-1.0208	22	22	18040	115095.2	18040	96679.968	-18415.232	-22.5	
							Total	**467,790**	**2,245,179**	**467,790**	**2,193,914**	**-51,265**		**-2** **% Reduction**

Table 82. Existing and Potential Solar Loads for Grimes Creek above Clear Creek (AUs 013_02 and 013_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Segment Area (m²)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	**Grimes Creek, above Clear Creek**
600	0.8	1.276	0.8	1.276	0.00	1	1	600	765.6	600	765.6	0	0.0	conifer/meadow
2400	0.8	1.276	0.84	1.0208	-0.2552	1	1	2400	3062.4	2400	2449.92	-612.48	-0.3	conifer
330	0.5	3.19	0.41	3.7642	0.5742	1	1	330	1052.7	330	1242.186	189.486	0.0	meadow
240	0.4	3.828	0.41	3.7642	-0.0638	1	1	240	918.72	240	903.408	-15.312	-0.1	
350	0.8	1.276	0.8	1.276	0	1	1	350	446.6	350	446.6	0	0.0	conifer/meadow
310	0.4	3.828	0.41	3.7642	-0.0638	1	1	310	1186.68	310	1166.902	-19.778	-0.1	meadow
540	0.7	1.914	0.75	1.595	-0.319	2	2	1080	2067.12	1080	1722.6	-344.52	-0.6	conifer/meadow
260	0.7	1.914	0.75	1.595	-0.319	2	2	520	995.28	520	829.4	-165.88	-0.6	
150	0.3	4.466	0.28	4.5936	0.1276	2	2	300	1339.8	300	1378.08	38.28	0.0	meadow
260	0.7	1.914	0.75	1.595	-0.319	2	2	520	995.28	520	829.4	-165.88	-0.6	conifer/meadow
700	0.7	1.914	0.75	1.595	-0.319	2	2	1400	2679.6	1400	2233	-446.6	-0.6	
630	0.2	5.104	0.28	4.5936	-0.5104	2	2	1260	6431.04	1260	5787.936	-643.104	-1.0	meadow
390	0.3	4.466	0.28	4.5936	0.1276	2	2	780	3483.48	780	3583.008	99.528	0.0	
500	0.2	5.104	0.28	4.5936	-0.5104	2	2	1000	5104	1000	4593.6	-510.4	-1.0	
400	0.7	1.914	0.69	1.9778	0.0638	3	3	1200	2296.8	1200	2373.36	76.56	0.0	conifer/meadow
1910	0.6	2.552	0.69	1.9778	-0.5742	3	3	5730	14622.96	5730	11332.794	-3290.166	-1.7	
1460	0.7	1.914	0.77	1.4674	-0.4466	3	3	4380	8383.32	4380	6427.212	-1956.108	-1.3	conifer
1010	0.8	1.276	0.75	1.595	0.319	4	4	4040	5155.04	4040	6443.8	1288.76	1.3	
370	0.7	1.914	0.75	1.595	-0.319	4	4	1480	2832.72	1480	2360.6	-472.12	-1.3	
530	0.8	1.276	0.75	1.595	0.319	4	4	2120	2705.12	2120	3381.4	676.28	1.3	
860	0.7	1.914	0.75	1.595	-0.319	4	4	3440	6584.16	3440	5486.8	-1097.36	-1.3	
2340	0.8	1.276	0.75	1.595	0.319	4	4	9360	11943.36	9360	14929.2	2985.84	0.0	
240	0.6	2.552	0.61	2.4882	-0.0638	5	5	1200	3062.4	1200	2985.84	-76.56	-0.3	conifer/meadow
240	0.7	1.914	0.73	1.7226	-0.1914	5	5	1200	2296.8	1200	2067.12	-229.68	-1.0	
200	0.6	2.552	0.61	2.4882	-0.0638	5	5	1000	2552	1000	2488.2	-63.8	-0.3	conifer/meadow
1450	0.7	1.914	0.73	1.7226	-0.1914	5	5	7250	13876.5	7250	12488.85	-1387.65	-1.0	conifer
640	0.6	2.552	0.61	2.4882	-0.0638	5	5	3200	8166.4	3200	7962.24	-204.16	-0.3	conifer/meadow
750	0.7	1.914	0.73	1.7226	-0.1914	5	5	3750	7177.5	3750	6459.75	-717.75	-1.0	conifer
850	0.6	2.552	0.61	2.4882	-0.0638	5	5	4250	10846	4250	10574.85	-271.15	-0.3	conifer/meadow
1060	0.4	3.828	0.57	2.7434	-1.0846	6	6	6360	24346.08	6360	17448.024	-6898.056	-6.5	
3740	0.5	3.19	0.57	2.7434	-0.4466	6	6	22440	71583.6	22440	61561.896	-10021.704	-2.7	
750	0.7	1.914	0.68	2.0416	0.1276	7	7	5250	10048.5	5250	10718.4	669.9	0.0	conifer
1390	0.4	3.828	0.53	2.9986	-0.8294	7	7	9730	37246.44	9730	29176.378	-8070.062	-5.8	conifer/meadow
550	0.6	2.552	0.53	2.9986	0.4466	7	7	3850	9825.2	3850	11544.61	1719.41	0.0	
560	0.4	3.828	0.53	2.9986	-0.8294	7	7	3920	15005.76	3920	11754.512	-3251.248	-5.8	
1150	0.3	4.466	0.35	4.147	-0.319	7	7	8050	35951.3	8050	33383.35	-2567.95	-2.2	medium shrub
210	0.4	3.828	0.49	3.2538	-0.5742	8	8	1680	6431.04	1680	5466.384	-964.656	-4.6	conifer/meadow
250	0.2	5.104	0.31	4.4022	-0.7018	8	8	2000	10208	2000	8804.4	-1403.6	-5.6	medium shrub
990	0.3	4.466	0.31	4.4022	-0.0638	8	8	7920	35370.72	7920	34865.424	-505.296	-0.5	
410	0.2	5.104	0.31	4.4022	-0.7018	8	8	3280	16741.12	3280	14439.216	-2301.904	-5.6	
							Total	**139,170**	**405,787**	**139,170**	**364,856**	**-40,931**		**-10**
														% Reduction

Table 83. Existing and Potential Solar Loads for Grimes Creek below Clear Creek (AUs 013_04 and 013_05).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	**Grimes Creek, below Clear Creek**
320	0.4	3.828	0.49	3.2538	-0.5742	8	8	2560	9799.68	2560	8329.728	-1469.952	-4.6	conifer/meadow
620	0.1	5.742	0.31	4.4022	-1.3398	8	8	4960	28480.32	4960	21834.912	-6645.408	-10.7	medium shrub
760	0.4	3.828	0.49	3.2538	-0.5742	8	8	6080	23274.24	6080	19783.104	-3491.136	-4.6	conifer/meadow
210	0.2	5.104	0.49	3.2538	-1.8502	8	8	1680	8574.72	1680	5466.384	-3108.336	-14.8	
730	0.4	3.828	0.49	3.2538	-0.5742	8	8	5840	22355.52	5840	19002.192	-3353.328	-4.6	
200	0.2	5.104	0.45	3.509	-1.595	9	9	1800	9187.2	1800	6316.2	-2871	-14.4	
420	0.1	5.742	0.26	4.7212	-1.0208	9	9	3780	21704.76	3780	17846.136	-3858.624	-9.2	medium shrub
650	0.2	5.104	0.45	3.509	-1.595	9	9	5850	29858.4	5850	20527.65	-9330.75	-14.4	conifer/meadow
550	0	6.38	0.26	4.7212	-1.6588	9	9	4950	31581	4950	23369.94	-8211.06	-14.9	medium shrub
160	0.1	5.742	0.26	4.7212	-1.0208	9	9	1440	8268.48	1440	6798.528	-1469.952	-9.2	
580	0	6.38	0.26	4.7212	-1.6588	9	9	5220	33303.6	5220	24644.664	-8658.936	-14.9	
100	0.1	5.742	0.26	4.7212	-1.0208	9	9	900	5167.8	900	4249.08	-918.72	-9.2	
80	0	6.38	0.26	4.7212	-1.6588	9	9	720	4593.6	720	3399.264	-1194.336	-14.9	
500	0.1	5.742	0.26	4.7212	-1.0208	9	9	4500	25839	4500	21245.4	-4593.6	-9.2	
1490	0	6.38	0.26	4.7212	-1.6588	9	9	13410	85555.8	13410	63311.292	-22244.508	-14.9	
350	0.1	5.742	0.24	4.8488	-0.8932	10	10	3500	20097	3500	16970.8	-3126.2	-8.9	
4110	0	6.38	0.24	4.8488	-1.5312	10	10	41100	262218	41100	199285.68	-62932.32	-15.3	
690	0.1	5.742	0.24	4.8488	-0.8932	10	10	6900	39619.8	6900	33456.72	-6163.08	-8.9	
350	0.2	5.104	0.4	3.828	-1.276	11	11	3850	19650.4	3850	14737.8	-4912.6	-14.0	conifer/meadow
1400	0.1	5.742	0.4	3.828	-1.914	11	11	15400	88426.8	15400	58951.2	-29475.6	-21.1	
600	0	6.38	0.21	5.0402	-1.3398	11	11	6600	42108	6600	33265.32	-8842.68	-14.7	medium shrub
1130	0.1	5.742	0.4	3.828	-1.914	11	11	12430	71373.06	12430	47582.04	-23791.02	-21.1	conifer/meadow
5710	0.3	4.466	0.38	3.9556	-0.5104	12	12	68520	306010.32	68520	271037.712	-34972.608	-6.1	
770	0.1	5.742	0.18	5.2316	-0.5104	13	13	10010	57477.42	10010	52368.316	-5109.104	-6.6	medium shrub
1190	0.3	4.466	0.36	4.0832	-0.3828	13	13	15470	69089.02	15470	63167.104	-5921.916	-5.0	conifer/meadow
1990	0.2	5.104	0.36	4.0832	-1.0208	13	13	25870	132040.48	25870	105632.384	-26408.096	-13.3	
1640	0.4	3.828	0.34	4.2108	0.3828	14	14	22960	87890.88	22960	96679.968	8789.088	0.0	
460	0.3	4.466	0.34	4.2108	-0.2552	14	14	6440	28761.04	6440	27117.552	-1643.488	-3.6	
740	0.1	5.742	0.34	4.2108	-1.5312	14	14	10360	59487.12	10360	43623.888	-15863.232	-21.4	
540	0.2	5.104	0.34	4.2108	-0.8932	14	14	7560	38586.24	7560	31833.648	-6752.592	-12.5	
1260	0.1	5.742	0.16	5.3592	-0.3828	14	14	17640	101288.88	17640	94536.288	-6752.592	-5.4	medium shrub
1480	0	6.38	0.14	5.4868	-0.8932	15	15	22200	141636	22200	121806.96	-19829.04	-13.4	
470	0.3	4.466	0.32	4.3384	-0.1276	15	15	7050	31485.3	7050	30585.72	-899.58	-1.9	conifer/meadow
1330	0.2	5.104	0.32	4.3384	-0.7656	15	15	19950	101824.8	19950	86551.08	-15273.72	-11.5	
220	0.1	5.742	0.13	5.5506	-0.1914	16	16	3520	20211.84	3520	19538.112	-673.728	-3.1	medium shrub
210	0.2	5.104	0.13	5.5506	0.4466	16	16	3360	17149.44	3360	18650.016	1500.576	0.0	
160	0.1	5.742	0.13	5.5506	-0.1914	16	16	2560	14699.52	2560	14209.536	-489.984	-3.1	
320	0.2	5.104	0.13	5.5506	0.4466	16	16	5120	26132.48	5120	28419.072	2286.592	0.0	
440	0.1	5.742	0.13	5.5506	-0.1914	16	16	7040	40423.68	7040	39076.224	-1347.456	-3.1	
							Total	**409,100**	**2,165,232**	**409,100**	**1,815,208**	**-350,024**		**-16** **% Reduction**

Table 84. Existing and Potential Solar Loads for Elk Creek (AUs 012_02 and 012_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Elk Creek
340	0.8	1.276	0.84	1.0208	-0.26	1	1	340	433.84	340	347.072	-86.768	-0.3	conifer
190	0.8	1.276	0.8	1.276	0	1	1	190	242.44	190	242.44	0	0.0	conifer/meadow
660	0.8	1.276	0.84	1.0208	-0.2552	1	1	660	842.16	660	673.728	-168.432	-0.3	conifer
630	0.7	1.914	0.8	1.276	-0.638	2	2	1260	2411.64	1260	1607.76	-803.88	-1.3	
190	0.5	3.19	0.75	1.595	-1.595	2	2	380	1212.2	380	606.1	-606.1	-3.2	conifer/meadow
500	0.6	2.552	0.75	1.595	-0.957	2	2	1000	2552	1000	1595	-957	-1.9	
170	0.7	1.914	0.75	1.595	-0.319	2	2	340	650.76	340	542.3	-108.46	-0.6	
1030	0.5	3.19	0.69	1.9778	-1.2122	3	3	3090	9857.1	3090	6111.402	-3745.698	-3.6	
410	0.6	2.552	0.69	1.9778	-0.5742	3	3	1230	3138.96	1230	2432.694	-706.266	-1.7	
2140	0.5	3.19	0.65	2.233	-0.957	4	4	8560	27306.4	8560	19114.48	-8191.92	-3.8	
1650	0.4	3.828	0.47	3.3814	-0.4466	5	5	8250	31581	8250	27896.55	-3684.45	-2.2	medium shrub
200	0.5	3.19	0.4	3.828	0.638	6	6	1200	3828	1200	4593.6	765.6	0.0	
780	0.6	2.552	0.57	2.7434	0.1914	6	6	4680	11943.36	4680	12839.112	895.752	0.0	conifer/meadow
220	0.5	3.19	0.57	2.7434	-0.4466	6	6	1320	4210.8	1320	3621.288	-589.512	-2.7	
300	0.6	2.552	0.72	1.7864	-0.7656	6	6	1800	4593.6	1800	3215.52	-1378.08	-4.6	conifer
840	0.7	1.914	0.72	1.7864	-0.1276	6	6	5040	9646.56	5040	9003.456	-643.104	-0.8	
910	0.4	3.828	0.57	2.7434	-1.0846	6	6	5460	20900.88	5460	14978.964	-5921.916	-6.5	conifer/meadow
1630	0.6	2.552	0.72	1.7864	-0.7656	6	6	9780	24958.56	9780	17470.992	-7487.568	-4.6	conifer
890	0.7	1.914	0.72	1.7864	-0.1276	6	6	5340	10220.76	5340	9539.376	-681.384	-0.8	
370	0.6	2.552	0.72	1.7864	-0.7656	6	6	2220	5665.44	2220	3965.808	-1699.632	-4.6	
1110	0.7	1.914	0.68	2.0416	0.1276	7	7	7770	14871.78	7770	15863.232	991.452	0.0	
330	0.5	3.19	0.53	2.9986	-0.1914	7	7	2310	7368.9	2310	6926.766	-442.134	-1.3	conifer/meadow
920	0.3	4.466	0.35	4.147	-0.319	7	7	6440	28761.04	6440	26706.68	-2054.36	-2.2	medium shrub
1290	0.4	3.828	0.53	2.9986	-0.8294	7	7	9030	34566.84	9030	27077.358	-7489.482	-5.8	conifer/meadow
2460	0.2	5.104	0.35	4.147	-0.957	7	7	17220	87890.88	17220	71411.34	-16479.54	-6.7	medium shrub
380	0	6.38	0.35	4.147	-2.233	7	7	2660	16970.8	2660	11031.02	-5939.78	-15.6	
330	0.3	4.466	0.53	2.9986	-1.4674	7	7	2310	10316.46	2310	6926.766	-3389.694	-10.3	conifer/meadow
							Total	**109,880**	**376,943**	**109,880**	**306,341**	**-70,602**		**-19**
														% Reduction

Table 85. Existing and Potential Solar Loads for Granite Creek (AUs 014_02, 014_03 and 014_04).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	**Granite Creek**
3130	0.8	1.276	0.84	1.0208	-0.26	1	1	3130	3993.88	3130	3195.104	-798.776	-0.3	conifer
890	0.7	1.914	0.75	1.595	-0.319	2	2	1780	3406.92	1780	2839.1	-567.82	-0.6	conifer/meadow
250	0.5	3.19	0.75	1.595	-1.595	2	2	500	1595	500	797.5	-797.5	-3.2	
280	0.6	2.552	0.69	1.9778	-0.5742	3	3	840	2143.68	840	1661.352	-482.328	-1.7	
690	0.7	1.914	0.69	1.9778	0.0638	3	3	2070	3961.98	2070	4094.046	132.066	0.0	
210	0.6	2.552	0.69	1.9778	-0.5742	3	3	630	1607.76	630	1246.014	-361.746	-1.7	
1370	0.7	1.914	0.65	2.233	0.319	4	4	5480	10488.72	5480	12236.84	1748.12	0.0	
470	0.6	2.552	0.61	2.4882	-0.0638	5	5	2350	5997.2	2350	5847.27	-149.93	-0.3	
760	0.5	3.19	0.47	3.3814	0.1914	5	5	3800	12122	3800	12849.32	727.32	0.0	medium shrub
1100	0	6.38	0.47	3.3814	-2.9986	5	5	5500	35090	5500	18597.7	-16492.3	-15.0	
730	0.5	3.19	0.57	2.7434	-0.4466	6	6	4380	13972.2	4380	12016.092	-1956.108	-2.7	conifer/meadow
860	0.4	3.828	0.4	3.828	0	6	6	5160	19752.48	5160	19752.48	0	0.0	medium shrub
1140	0.3	4.466	0.4	3.828	-0.638	6	6	6840	30547.44	6840	26183.52	-4363.92	-3.8	
4230	0.2	5.104	0.35	4.147	-0.957	7	7	29610	151129.44	29610	122792.67	-28336.77	-6.7	
1890	0.1	5.742	0.31	4.4022	-1.3398	8	8	15120	86819.04	15120	66561.264	-20257.776	-10.7	
670	0	6.38	0.26	4.7212	-1.6588	9	9	6030	38471.4	6030	28468.836	-10002.564	-14.9	
							Total	**93,220**	**421,099**	**93,220**	**339,139**	**-81,960**		**-19**
														% Reduction

Table 86. Existing and Potential Solar Loads for Bannock Creek (AU 009_02).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	**Bannock Creek**
400	0.8	1.276	0.84	1.0208	-0.26	1	1	400	510.4	400	408.32	-102.08	-0.3	conifer
270	0.7	1.914	0.84	1.0208	-0.8932	1	1	270	516.78	270	275.616	-241.164	-0.9	
1480	0.8	1.276	0.84	1.0208	-0.2552	1	1	1480	1888.48	1480	1510.784	-377.696	-0.3	
430	0.8	1.276	0.75	1.595	0.319	2	2	860	1097.36	860	1371.7	274.34	0.0	conifer/meadow
250	0.7	1.914	0.75	1.595	-0.319	2	2	500	957	500	797.5	-159.5	-0.6	
1830	0.8	1.276	0.75	1.595	0.319	2	2	3660	4670.16	3660	5837.7	1167.54	0.0	
840	0.7	1.914	0.69	1.9778	0.0638	3	3	2520	4823.28	2520	4984.056	160.776	0.0	
60	0.6	2.552	0.69	1.9778	-0.5742	3	3	180	459.36	180	356.004	-103.356	-1.7	
820	0.7	1.914	0.69	1.9778	0.0638	3	3	2460	4708.44	2460	4865.388	156.948	0.0	
250	0.7	1.914	0.65	2.233	0.319	4	4	1000	1914	1000	2233	319	0.0	
1340	0.6	2.552	0.65	2.233	-0.319	4	4	5360	13678.72	5360	11968.88	-1709.84	-1.3	
340	0.6	2.552	0.67	2.1054	-0.4466	4	4	1360	3470.72	1360	2863.344	-607.376	-1.8	tall shrub
							Total	**20,050**	**38,695**	**20,050**	**37,472**	**-1,222**		**-3**
														% Reduction

Table 87. Existing and Potential Solar Loads for Mack's Creek (AU 015_02).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Macks Creek
3210	0.7	1.914	0.8	1.276	-0.64	1	1	3210	6143.94	3210	4095.96	-2047.98	-0.6	conifer/meadow
4860	0.8	1.276	0.8	1.276	0	2	2	9720	12402.72	9720	12402.72	0	0.0	conifer
480	0.7	1.914	0.69	1.9778	0.0638	3	3	1440	2756.16	1440	2848.032	91.872	0.0	conifer/meadow
600	0.6	2.552	0.65	2.233	-0.319	4	4	2400	6124.8	2400	5359.2	-765.6	-1.3	
330	0.5	3.19	0.65	2.233	-0.957	4	4	1320	4210.8	1320	2947.56	-1263.24	-3.8	
170	0.4	3.828	0.65	2.233	-1.595	4	4	680	2603.04	680	1518.44	-1084.6	-6.4	
430	0.6	2.552	0.61	2.4882	-0.0638	5	5	2150	5486.8	2150	5349.63	-137.17	-0.3	
310	0.5	3.19	0.61	2.4882	-0.7018	5	5	1550	4944.5	1550	3856.71	-1087.79	-3.5	
340	0.6	2.552	0.61	2.4882	-0.0638	5	5	1700	4338.4	1700	4229.94	-108.46	-0.3	
							Total	**24,170**	**49,011**	**24,170**	**42,608**	**-6,403**		**-13** **% Reduction**

Table 88. Existing and Potential Solar Loads for Daggett Creek (AUs 016_02 and 016_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Dagget Creek
1010	0.8	1.276	0.8	1.276	0.00	1	1	1010	1288.76	1010	1288.76	0	0.0	conifer/meadow
80	0.7	1.914	0.8	1.276	-0.638	1	1	80	153.12	80	102.08	-51.04	-0.6	
1450	0.8	1.276	0.8	1.276	0	1	1	1450	1850.2	1450	1850.2	0	0.0	
3780	0.7	1.914	0.75	1.595	-0.319	2	2	7560	14469.84	7560	12058.2	-2411.64	-0.6	
530	0.5	3.19	0.62	2.4244	-0.7656	3	3	1590	5072.1	1590	3854.796	-1217.304	-2.3	medium shrub
3110	0.6	2.552	0.69	1.9778	-0.5742	3	3	9330	23810.16	9330	18452.874	-5357.286	-1.7	conifer/meadow
500	0.5	3.19	0.55	2.871	-0.319	4	4	2000	6380	2000	5742	-638	-1.3	medium shrub
1680	0.6	2.552	0.61	2.4882	-0.0638	5	5	8400	21436.8	8400	20900.88	-535.92	-0.3	conifer/meadow
810	0.5	3.19	0.61	2.4882	-0.7018	5	5	4050	12919.5	4050	10077.21	-2842.29	-3.5	
							Total	**35,470**	**87,380**	**35,470**	**74,327**	**-13,053**		**-15** **% Reduction**

Table 89. Existing and Potential Solar Loads for Smith Creek (AU 010_02).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Smith Creek
3040	0.8	1.276	0.84	1.0208	-0.26	1	1	3040	3879.04	3040	3103.232	-775.808	-0.3	conifer
740	0.6	2.552	0.75	1.595	-0.957	2	2	1480	3776.96	1480	2360.6	-1416.36	-1.9	conifer/meadow
2250	0.7	1.914	0.75	1.595	-0.319	2	2	4500	8613	4500	7177.5	-1435.5	-0.6	
1820	0.6	2.552	0.69	1.9778	-0.5742	3	3	5460	13933.92	5460	10798.788	-3135.132	-1.7	
550	0.5	3.19	0.65	2.233	-0.957	4	4	2200	7018	2200	4912.6	-2105.4	-3.8	
520	0.6	2.552	0.65	2.233	-0.319	4	4	2080	5308.16	2080	4644.64	-663.52	-1.3	
890	0.5	3.19	0.65	2.233	-0.957	4	4	3560	11356.4	3560	7949.48	-3406.92	-3.8	
							Total	**22,320**	**53,885**	**22,320**	**40,947**	**-12,939**		**-24** **% Reduction**

Table 90. Existing and Potential Solar Loads for Robie Creek (AUs 017_02 and 017_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Segment Area (m²)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Robie Creek
130	0.7	1.914	0.8	1.276	-0.64	1	1	130	248.82	130	165.88	-82.94	-0.6	conifer/meadow
210	0.6	2.552	0.8	1.276	-1.276	1	1	210	535.92	210	267.96	-267.96	-1.3	
5280	0.7	1.914	0.75	1.595	-0.319	2	2	10560	20211.84	10560	16843.2	-3368.64	-0.6	
340	0.6	2.552	0.77	1.4674	-1.0846	3	3	1020	2603.04	1020	1496.748	-1106.292	-3.3	conifer
810	0.7	1.914	0.77	1.4674	-0.4466	3	3	2430	4651.02	2430	3565.782	-1085.238	-1.3	
660	0.5	3.19	0.69	1.9778	-1.2122	3	3	1980	6316.2	1980	3916.044	-2400.156	-3.6	conifer/meadow
1950	0.6	2.552	0.65	2.233	-0.319	4	4	7800	19905.6	7800	17417.4	-2488.2	-1.3	
190	0.5	3.19	0.55	2.871	-0.319	4	4	760	2424.4	760	2181.96	-242.44	-1.3	medium shrub
850	0.4	3.828	0.47	3.3814	-0.4466	5	5	4250	16269	4250	14370.95	-1898.05	-2.2	
360	0.6	2.552	0.47	3.3814	0.8294	5	5	1800	4593.6	1800	6086.52	1492.92	0.0	
790	0.5	3.19	0.47	3.3814	0.1914	5	5	3950	12600.5	3950	13356.53	756.03	0.0	
550	0.2	5.104	0.47	3.3814	-1.7226	5	5	2750	14036	2750	9298.85	-4737.15	-8.6	
							Total	**37,640**	**104,396**	**37,640**	**88,968**	**-15,428**		**-15**
														% Reduction

Table 91. Existing and Potential Solar Loads for Clear Creek (AUs 013_02 and 013_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Segment Area (m²)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Clear Creek
140	0.8	1.276	0.84	1.0208	-0.26	1	1	140	178.64	140	142.912	-35.728	-0.3	conifer
110	0.4	3.828	0.41	3.7642	-0.0638	1	1	110	421.08	110	414.062	-7.018	-0.1	meadow
4980	0.8	1.276	0.77	1.4674	0.1914	3	3	14940	19063.44	14940	21922.956	2859.516	0.0	conifer
2700	0.6	2.552	0.65	2.233	-0.319	4	4	10800	27561.6	10800	24116.4	-3445.2	-1.3	conifer/meadow
1400	0.7	1.914	0.75	1.595	-0.319	4	4	5600	10718.4	5600	8932	-1786.4	-1.3	conifer
910	0.6	2.552	0.65	2.233	-0.319	4	4	3640	9289.28	3640	8128.12	-1161.16	-1.3	conifer/meadow
1380	0.5	3.19	0.47	3.3814	0.1914	5	5	6900	22011	6900	23331.66	1320.66	0.0	medium shrub
1720	0.1	5.742	0.1	5.742	0	6	6	10320	59257.44	10320	59257.44	0	0.0	meadow
							Total	**52,450**	**148,501**	**52,450**	**146,246**	**-2,255**		**-2**
														% Reduction

Table 92. Existing and Potential Solar Loads for Thorn Creek (AUs 011_02 and 011_03).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Segment Area (m²)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Excess Load/Linear Meter	Thorn Creek
2160	0.8	1.276	0.84	1.0208	-0.26	1	1	2160	2756.16	2160	2204.928	-551.232	-0.3	conifer
4470	0.7	1.914	0.8	1.276	-0.638	1	1	4470	8555.58	4470	5703.72	-2851.86	-0.6	conifer/meadow
770	0.8	1.276	0.8	1.276	0	2	2	1540	1965.04	1540	1965.04	0	0.0	conifer
2770	0.7	1.914	0.75	1.595	-0.319	2	2	5540	10603.56	5540	8836.3	-1767.26	-0.6	conifer/meadow
1010	0.8	1.276	0.77	1.4674	0.1914	3	3	3030	3866.28	3030	4446.222	579.942	0.0	conifer
3100	0.6	2.552	0.69	1.9778	-0.5742	3	3	9300	23733.6	9300	18393.54	-5340.06	-1.7	conifer/meadow
1220	0.5	3.19	0.65	2.233	-0.957	4	4	4880	15567.2	4880	10897.04	-4670.16	-3.8	
430	0.2	5.104	0.55	2.871	-2.233	4	4	1720	8778.88	1720	4938.12	-3840.76	-8.9	medium shrub
1540	0.4	3.828	0.55	2.871	-0.957	4	4	6160	23580.48	6160	17685.36	-5895.12	-3.8	
							Total	**38,800**	**99,407**	**38,800**	**75,070**	**-24,337**		**-24**
														% Reduction

Load Allocation

Because this TMDL is based on loading that does or would occur under PNV, which is equivalent to background load, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Load allocations are therefore stream reach-specific and are dependent upon the target load for a given reach. Table 80 through Table 92 show the target or potential shade which is converted to a potential summer load by multiplying the average of total loads recorded on a flat plate collector for the months of April through September by the "percent open, " which is calculated as described above. That is the load capacity of the stream and it is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the waters examined here need to be at natural background condition in order to prevent excess heat loads to the system.

Table 93 shows the total existing, total target, and total excess heat load (kWh/day) experienced by each water body examined. The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths as compared to smaller streams. Table 93 lists the streams in order of their excess loads from highest to lowest. Therefore, larger streams tend to be listed first and smaller tributaries are listed last.

Although the following analysis dwells on total heat loads for streams in this TMDL, it is important to note that differences between existing shade and target shade, as depicted in Figure 45, are the key to successfully restoring these waters to achieving WQS. Target shade levels for individual reaches should be the goals that managers strive for with future implementation plans. Managers should key in on the areas with the largest differences between existing and target shade as locations to prioritize implementation efforts. Each loading table contains a final column that lists the excess load (kWh/day) per linear meter of stream. It is derived from dividing the excess load for each segment by the length of each segment. Thus, stream segments with the largest excess load per meter are in the worst shape regarding shade. The range of those values from the loading tables is also listed in Table 93.

Table 93. Excess Solar Loads and Total Reductions Needed for All Streams.

Water Body	Total Existing Load (kWh/day)	Total Target Load (kWh/day)	Total Excess Load (kWh/day)	Range of Excess Load/Linear Meter (kWh/day/m)
Grimes Creek below Clear Creek AU# 013_04 and 013_05	2,165,232	1,815,208	350,024	0 to 21.4
Granite Creek AU# 014_02, 014_03 and 014_04	421,099	339,139	81,960	0 to 15.0
Elk Creek AU# 012_03	376,943	306,341	70,602	0 to 15.6
Mores Creek above New York Gulch Au# 009_02 and 009_03	765,651	696,824	68,827	0 to 21.4
Mores Creek below New York Gulch AU# 009_03, 009_04 and 009_06	2,245,179	2,193,914	51,265	0 to 23.9
Grimes Creek above Clear Creek AU# 013_02 and 013_03	405,787	364,856	40,931	0 to 6.5
Thorn Creek AU# 011_02 and 011_03	99,407	75,070	24,337	0 to 8.9
Robie Creek AU# 017_02 and 017_03	104,396	88,968	15,428	0 to 8.6
Daggett Creek AU# 016_02 and 016_03	87,380	74,327	13,053	0 to 3.5
Smith Creek AU# 010_02	53,885	40,947	12,939	0.3 to 3.8
Mack's Creek AU# 015_02	49,011	42,608	6,403	0 to 6.4
Clear Creek AU# 013_02 and 013_03	148,501	146,246	2,255	0 to 1.3
Bannock Creek AU# 009_02	38,695	37,472	1,222	0 to 1.8

All streams examined had excess solar loads. Lower Grimes Creek had the highest excess load, but not necessarily the highest existing and target load. Mores Creek below New York Gulch had the highest existing and target loads while having the fifth highest excess load. Of all the smaller tributaries to Mores Creek (not including Grimes Creek), Granite Creek and Elk Creek had the highest excess loads. Upper Grimes Creek, although of similar size to Granite and Elk Creeks, had half as much excess load. Clear Creek stands out as a stream with relatively high existing and target loads, but a very small excess load in relation to its size. The range of excess load per linear meter varies such that larger streams tend to have higher excess loads per linear meter.

In addition to excess load per linear meter, Table 88 shows the difference between existing shade and target shade. Places that stand out as lacking shade include Grimes Creek below Clear Creek, Elk Creek, and lower Granite Creek. These areas were historically dredge-mined and extensive gravel piles remain.

Wasteload Allocation

There are no National Pollution Discharge Elimination System (NPDES)-regulated point sources discharging to streams in the affected watersheds. Thus, there are no wasteload allocations presented here. Suction dredging and tailings from Belshazaar Mine have been previously described as potential point sources. These sources are not expected to be a source of heat loading therefore, they have not been designated an allocation in this TMDL. Should a point source be proposed that would have thermal consequence on these waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 & IDAPA 58.01.02.401.03) would be involved (see Appendix B).

Margin of Safety

The MOS in the temperature TMDL is considered implicit in the design. Because the target is essentially background conditions, loads (shade levels) are allocated to lands adjacent to these streams at natural background levels. Because shade levels are established at natural background or system potential levels, it is unrealistic to set shade targets at higher, or more conservative, levels. Additionally, existing shade levels are reduced to the next lower 10%-class as discussed above, which likely underestimates actual shade in the loading analysis. Although the loading analysis used in this TMDL involves gross estimations that are likely to have large variances, there are no load allocations that may benefit or suffer from that variance.

Seasonal Variation

The temperature TMDL is based on average summer loads. All loads have been calculated to be inclusive of the six-month period from April through September. This time period was chosen because it represents the time period when the combination of increasing air and water temperatures coincides with increasing solar inputs and increasing vegetative shade. The critical time period is June when spring salmonids spawning is occurring, July and August when maximum temperatures tend to exceed cold water aquatic life criteria, and September during fall salmonids spawning. Water temperature is not likely to be a problem for beneficial uses outside of this time period because of cooler weather and lower sun angle.

Reasonable Assurance

Load allocations are directed at nonpoint source activities. Sediment loading is based on stream bank erosion inventories, bedload sediment measurements, and land use assessments. Future monitoring should include stream bank erosion inventories and subsurface sediment sampling. In addition, land use assessments of sediment delivery should be calculated where feasible.

Reserve

A reserve for growth wasteload allocation is included in this TMDL for future wastewater treatment facilities. Idaho City and several large subdivisions along Mores and Grimes Creeks are currently operating with rapid infiltration basins. Their capacity is expected to be exceeded in the near future based upon current population growth estimates. Temperature monitoring is required for effluent discharge to ensure compliance with the TMDL. This WLA is based on the water quality standard for point sources which states that “no temperature increase will be allowed which raises the receiving water temperature greater than 0.3 degrees C"(IDAPA 58.01.02). The temperature should not result in an increase in 0.3 degrees Celsius in the stream when cold water criteria are applicable assuming an ambient in-stream temperature of 19 degrees Celsius.

No reserves for other pollutant additions have been made in this TMDL. All current allocations are based on achieving background shade levels through application of best management practices. Bank stability can be maintained through forestry, and urban/suburban BMPs as outlined in IDAPA 58.01.02 § 350. If it is determined that beneficial use support is achieved and water quality standards are being met at shade levels lower than those outlined in this TMDL then the TMDL may be revised accordingly.

5.3 Bacteria

In-stream Water Quality Targets

The goal of a TMDL is to restore "full support of designated beneficial uses" (Idaho Code 39.3611, 3615). The objective of this TMDL is to reduce bacteria loading to concentrations that are in conformance with the WQS for recreational uses, specifically public swimming beaches. Monitoring of the pollutant load and beneficial use support will occur throughout the implementation phase of the TMDL. Pollutant reduction can be attained by managing waterfowl populations and through appropriate actions to eliminate contamination from human waste if that is found to be a source.

Design Conditions

In the case of bacteria and its effect on recreational uses, the warmer months of the year including late spring, summer and early fall are considered the critical time period to protect recreational users of surface waters from bacterial contamination. In this TMDL bacteria were collected from June through August. *E. coli* bacteria levels in the Robie Creek beach area of Lucky Peak Reservoir were measured to be above the geometric mean criterion allowed by the Idaho WQS, based on data presented in Table 17. General statistics about those geometric means presented in Table 17 that exceed the WQS of 126 cfu/100 ml are shown below in Table 94. Only geometric means exceeding 126 cfu/100 ml were used, thus geometric means calculated after August 6th were not included in Table 94.

Table 94. Descriptive Statistics for *E. coli* Geometric Means from Table 17 (July 27 to August 6).

General Statistic	Value (cfu/100ml)
Median	459
Average	407
Standard Deviation	183
95% Confidence Interval	± 99
90th Percentile	543
80th Percentile	524
70th Percentile	499
Range	161-805

Target Selection

The Idaho WQS for recreation uses (*E. coli* bacteria) used as the target for the development of the TMDL is a geometric mean of 126 cfu/100 ml (IDAPA 58.01.02.251.02).

Monitoring Points

Monitoring of bacteria is done by USACE at several locations throughout the summer months (June-August). Currently it is not known whether bacteria are from animal or human sources, although evidence suggests geese are the source. Future monitoring may also include DNA analysis of animal source.

Load Capacity

The *E. coli* bacteria load capacity is expressed as the geometric mean of 126 cfu/100 ml. The load capacity is expressed as a concentration (cfu/100 ml) because it is difficult to calculate a mass load due to several variables (i.e. temperature and water volume) that influence growth and die-off rate or *E. coli* bacteria in the environment. In the case of Robie Creek beach, the volume and temperature of water in the reservoir and in Robie Creek fluctuate throughout the season, causing ever changing conditions. Sampling data shown in Figure 23 suggest that bacteria levels increase in early June above harmful levels and then subside by late July suggesting that water conditions in August, while similar to July, are not necessarily the primary influence.

Estimates of Existing Pollutant Loads

Waterfowl populations, especially geese, are the most likely source of *E coli* bacteria found in the reservoir at Robie Creek beach. Levels of bacteria upstream in Robie Creek are not high suggesting that the source is within the beach area itself. Park-like conditions (grass lawns, food sources associated with people) tend to be an attraction for nuisance waterfowl. Geese especially are attracted to green lawns and their fecal droppings are a constant problem for parks along the Boise River in the City of Boise. The lawn areas at Robie Creek beach are not irrigated but usually remain green until late July.

Since a good amount of data is available on *E coli* bacteria concentrations in the reservoir at the Robie Creek beach (see Table 17), existing loads can be estimated with some precision. For the purpose of setting existing loads for this bacteria TMDL, we have chosen the 90th percentile of geometric means available from the data set (see Table 94). Thus, the existing load will be represented by 543 cfu/100 ml of *E coli* bacteria.

Load Allocation

Bacteria are living organisms that have an associated die-off rate. The die-off rate fluctuates with varying water quality and environmental conditions. Flow and temperature dictate the actual mass of bacteria in the water and complicate the load allocation process because of the continuous fluctuation of flow and temperature that occurs during any given time period. To simplify this process, the daily allocation is expressed in terms of 126 cfu/100 ml, the target geometric mean concentration currently allowed by Idaho's WQS.

In-stream allocations are developed for a specific control point—the established monitoring sites where future water quality monitoring will occur to assess compliance with Idaho Water Quality Standards. Table 95 lists the existing E. coli bacteria load (as a concentration) found at the control point where violations of the geometric mean criterion occurred, the load capacity based on the allowable geometric mean for primary contact recreation, the load allocation, and the reduction in E. coli bacteria concentration that must occur to meet the load allocation.

Table 95. Load Allocation (expressed as allowable concentration) for *E. coli* Bacteria.

Location (Control Point)	Existing Load (#cfu/100 ml)	Load Capacity (#cfu/100 ml)	NPS Load Reduction (%)
Lucky Peak Reservoir at Beach below Robie Creek	543	126	77

Wasteload Allocation

There are no National Pollution Discharge Elimination System (NPDES)-regulated point sources discharging to Lucky Peak Reservoir. Thus, there are no wasteload allocations presented here. Should a point source be proposed that would have bacterial consequence on these waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 & IDAPA 58.01.02.401.03) would be involved (see Appendix B).

Margin of Safety

The establishment of a TMDL requires that a margin of safety (MOS) be identified to account for uncertainty. An MOS is expressed as either an implicit or explicit portion of a water body's loading capacity that is reserved to account for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body. The MOS is not allocated to any sources of a pollutant.

An implicit MOS is built into the load allocation through use of the 90th percentile of E. coli data as a conservative assumption when calculating the existing load.

Critical Time Period

The *E. coli* bacteria allocations apply to 30-day time periods associated with primary contact recreation activities, especially those associated swimming beaches. This allocation ensures water quality standards are attained for the protection of public health. Table 96 shows the critical time period for bacteria. Although swimming may occur at the reservoir into September, bacteria data show concentrations decreasing to safe levels by the end of July.

The critical time period provided in this TMDL provides a month buffer on both ends into safe level time periods.

Table 96. Critical time period for the E. coli bacteria TMDL.

Pollutant	Critical Period
E. coli Bacteria	May through August

5.4 Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

The CWA requires operators of construction sites to obtain permit coverage to discharge storm water to a water body or to a municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites. In the past, storm water was treated as a nonpoint source of pollutants. However, because storm water can be managed on site through management practices or when discharged through a discrete conveyance such as a storm sewer, it now requires a National Pollution Discharge Elimination System (NPDES) Permit.

The Construction General Permit (CGP)

If a construction project disturbs more than one acre of land or is part of larger common development that will disturb more than one acre, the operator is required to apply for permit coverage from EPA after developing a site-specific Storm Water Pollution Prevention Plan.

Storm Water Pollution Prevention Plan (SWPPP)

In order to obtain the Construction General Permit operators must develop a site-specific Storm Water Pollution Prevention Plan. The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically and maintain the best management practices (BMPs) through the life of the project

Construction Storm Water Requirements

When a stream is on Idaho’s § 303(d) list and has a TMDL developed, DEQ may incorporate a gross waste load allocation (WLA) for anticipated construction storm water activities, however this is difficult to estimate. TMDLs that do not have a WLA for construction storm water activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate BMPs.

Typically, there are specific requirements that must be followed to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction storm water management. Sediment is usually the main pollutant of concern in storm water from construction sites. The application of specific BMPs from *Idaho’s Catalog of Storm Water Best Management Practices for Idaho Cities and Counties* is generally sufficient to meet the standards and requirements of the CGP, unless local ordinances have more stringent and site-specific standards that are applicable. It is presumed that if the requirements of the general construction permit are met than the load allocations for this TMDL will be met as well.

5.5 Implementation Strategies

DEQ and designated management agencies responsible for TMDL implementation will make every effort to address past, present, and future pollution problems in an attempt to link them to watershed characteristics and management practices designed to improve water quality and restore beneficial uses of the water body. Any and all solutions to help restore beneficial uses of a stream will be considered as part of a TMDL implementation plan in an effort to make the process as effective and cost efficient as possible. Using additional information collected during the implementation phase of the TMDL, DEQ and the designated management agencies will continue to evaluate suspected sources of impairment and develop management actions appropriate to deal with these issues.

Implementation strategies for this TMDL, which was produced using PNV-based shade and solar loads, should incorporate the loading tables presented in this TMDL. These tables need to be updated, first to field-verify the estimates of existing shade that have not yet been field-verified, and second, to monitor progress toward achieving needed reductions and the goals of the TMDL. Using a solar pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further field verification will find discrepancies with estimated existing shade levels provided in the loading tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include solar pathfinder monitoring to simultaneously field-verify the TMDL and mark progress towards achieving needed reductions in solar loads.

There are a variety of techniques available to control geese populations in parks. These include the use of dogs and/or noise making devices to harass waterfowl away from public areas. It is recommended that such techniques be investigated for use in the Robie Creek beach area and on other public beaches on Lucky Peak Reservoir where waterfowl may become a problem. If bacterial contamination is found to be from another source implementation activities will address those sources.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

Time Frame

The expected time frame for attaining water quality standards and restoring beneficial use is a function of management intensity, climate, ecological potential, and natural variability of environmental conditions. Even with aggressive BMP implementation, some natural processes required to satisfy the requirements of the TMDL may not be seen for many years. The effects of historic land management activities have accrued over many years and recovery of natural systems may take longer than anticipated.

Recovering streamside vegetation to levels near PNV is going to take some time. Depending on the quality of the existing riparian vegetation, new growth will take years to occur. In the case of shrubs and herbaceous material where some remnants of the community exist, recovery after disturbance may only take a few years. Conversely, recovery of streamside forest that has been lost may take a century to reach its full potential.

Approach

TMDLs will be implemented through continuation of ongoing pollution control activities in the watershed. DEQ recognizes that natural background conditions may not provide the most appropriate load capacity. A successful management approach would achieve reductions based on BMP implementation. Bank stability and percent depth fines monitoring data could determine a loading rate at which beneficial uses are supported that is different from the target values used in this TMDL. This TMDL used the maximum threshold measures for bank stability and percent depth fines as a definition for natural background conditions because no other data or reference stream was available beyond previously published research results for salmonid spawning studies.

Minimizing nonpoint sources of sediment delivery to streams is important. Activities that appear to be associated with nonpoint source sediment pollution in Mores and Grimes Creeks are:

- Road maintenance.
- Density of road and trail stream crossings.
- Hydraulic mining, historical and recent.
- Road construction and associated cut and fill.
- Forest management activities exposing erosive soil layers.

A comparison of practiced BMPs with BMPs required by IDAPA 58.01.02 should be undertaken by land management agencies to identify or prioritize specific implementation strategies to reduce nonpoint source sediment pollution in the subbasin.

Responsible Parties

Development of the implementation plan for the Boise-Mores Creek TMDL will proceed under the existing practice established for the state of Idaho. DEQ, the Boise-Mores Creek WAG, federal land management agencies, affected private landowners, and other watershed stakeholders with input through the established public process will cooperatively develop and implement the plan. Other individuals may be identified to assist in the development of site-specific implementation plans if their areas of expertise are identified as beneficial to the process.

Designated state agencies are responsible for assisting with preparation of specific implementation plans, particularly for those sources which they have regulatory authority or programmatic responsibilities. Idaho’s designated state management agencies are:

- Idaho Department of Lands (IDL): timber harvest, oil and gas exploration and development, mining
- Idaho Soil Conservation Commission (ISCC): grazing and agriculture

- Idaho Department of Transportation (ITD): public roads
- Idaho Department of Agriculture (IDA): agriculture, aquaculture, AFOs, CAFOs
- Idaho Department of Environmental Quality: all other activities

To the maximum extent possible, the implementation plan will be developed with the participation of federal partners and land management agencies (i.e., ACOE, BLM, BNF, Natural Resources Conservation Service [NRCS], and Bureau of Reclamation [BOR]). In Idaho, these agencies and their federal and state partners are charged by the CWA to lend available technical assistance and other appropriate support to local efforts/projects for water quality improvements.

All stakeholders in the Boise-Mores Creek subbasin have responsibility for implementing the TMDL. DEQ and the "designated agencies" in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. Their general responsibilities are outlined below.

- **DEQ** will oversee and track overall progress on the specific implementation plan and monitor the watershed response. DEQ will also work with local governments on urban/suburban issues.

- **IDL,** working in cooperation with USFS, will maintain and update approved BMPs for forest practices and mining. IDL is responsible for ensuring use of appropriate BMPs on state and private lands.

- **ISCC**, working in cooperation with local Soil and Water Conservation Districts and ISDA, the ISCC will provide technical assistance to agricultural landowners. These agencies will help landowners design BMP systems appropriate for their property, and identify and seek appropriate cost-share funds. They also will provide periodic project reviews to ensure BMPs are working effectively.

- **ITD** will be responsible for ensuring appropriate BMPs are used for construction and maintenance of public roads.

- **IDA** will be responsible for working with agriculture and aquaculture to install appropriate pollutant control measures. Under a memorandum of understanding with EPA and DEQ, IDA also inspects AFOs, CAFOs and dairies to ensure compliance with NPDES requirements.

- **USFS,** working in cooperation with IDL**,** will maintain and update approved BMPs for forest practices and mining. BNF is responsible for ensuring use of appropriate BMPs on national forest lands.

- **ACOE** will be responsible for appropriate maintenance and operation of water storage and hydroelectric facilities and assessing and/or mitigating for the effects of pollutants on their facilities.

The designated agencies, the WAG, and other appropriate public process participants are expected to:

- Develop and implement BMPs to achieve LAs.

- Give reasonable assurance that management measures will meet LAs through both quantitative and qualitative analysis of management measures.
- Adhere to measurable milestones for progress.
- Develop a timeline for implementation, with reference to costs and funding.
- Develop and implement a monitoring plan to determine if BMPs are being implemented, BMP effectiveness, LA and WLA attainment, and WQS attainment.

In addition to the designated agencies, the public, through the WAG's process and other equivalent processes, will be provided with opportunities to be involved in developing the implementation plan to the maximum extent practical. Public participation significantly affects public acceptance of the document and the proposed control actions. Stakeholders (landowners, local governing authorities, taxpayers, industries, and land managers) are the most educated regarding the pollutant sources and will be called upon to help identify the most appropriate control actions for each area. Experience has shown that the best and most effective implementation plans are those that are developed with substantial public cooperation and involvement.

Monitoring Strategy

Sediment monitoring will be conducted using the DEQ-approved monitoring procedure at the time of sampling. It is optimal to revisit specific locations included in this subbasin assessment for stream bank erosion and depth fine measurements in order to measure change at each site. New sites may need to be added to fill data gaps or include representative reaches of each stream type and/or AU to account for variation throughout the watershed. It may be useful to collect bedload sediment data for trend analysis. Computer modeling of sediment load incorporates the entire watershed to account for sources outside of, but not necessarily contributing to, impaired AUs.

As indicated above, shade can be measured with a solar pathfinder at any time throughout the spring and summer on any stretch of creek to see if shade is increasing. After a period of ten years or more, aerial photo interpretation can be done to analyze solar loading to the entire stream as it was done for this TMDL. It is anticipated that as the riparian community develops, shade will increase and loadings will decrease toward PNV levels.

5.6 Conclusions

Assessment units 009_02, 009_03, 009_04 and 009_06 were placed on the 1998 §303d list by EPA for temperature impairment in 1998. Mores Creek AU 009_02 and Grimes Creek AUs 013_02 and 013_05 were assessed by DEQ in 2002 and subsequently listed for an unknown pollutant. Thorn Creek AU 011-03 was added for an unknown pollutant in 2008.

TMDLs were developed for the three §303(d)-listed streams (Table 11). A sediment TMDL has been developed for all AUs in Mores Creek and AUs 013_04 and 013_05 in Grimes Creek. Another TDML addresses temperature impairment of Mores Creek and 3rd order Thorn Creek and thermal contributions of their tributaries including Smiths Creek, Elk Creek, Grimes Creek, Granite Creek, Macks Creek, Daggett Creek, and Robie Creek. Table C shows the streams and pollutants for which TMDLs were developed and their impairment status. Table 97 is the summary of assessment outcomes.

Sediment loads for all AUs in Mores Creek and 4th and 5th order Grimes Creek were estimated in the sediment TMDL. Some sources of sediment are forest management, paved and unpaved roads, streambank erosion, urban runoff and historically mined areas. WLA were calculated for the suction dredge industry and as a reserve for growth for future WWT facilities.

Eleven streams in the Boise-Mores Creek subbasin were examined for riparian shade in this temperature TMDL. We utilized a comparison between existing shade and target shade to determine excess solar loading to these streams. All streams examined lacked shade to some degree. Grimes Creek, Elk Creek, and Granite Creek had the highest excess loads, consistent with streams that have been dredge-mined in the distant past. Mores Creek is in relatively good condition and has reasonably low amounts of excess loading considering its size. The remaining streams in the analysis were small in size, thus excess loads were small by comparison. However, these smaller streams had moderate to low excess loads, suggesting that small impacts have occurred throughout the watershed.

Achieving target shade and sediment levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should key in on areas with the largest differences between existing and target loads as locations to prioritize implementation efforts.

A bacteria TMDL was completed for near shore areas of Robie Creek beach in Lucky Peak Reservoir (AU 001L_0L). Collected samples show that *E. coli* levels are elevated from approximately mid-June through July or early August each year. Large populations of nested geese are thought to be the source since levels increase during the period that geese are present. A bacteria source assessment is recommended with appropriate management actions to be determined based on this assessment.

DEQ proposes listing Mores Creek AUs 009_02, 009_03 and 009_04, Elk Creek AU 012-03, Grimes Creek AUs 013_03, 013_04 and 013_05 and Granite Creek AUs 014_02, 014_03 and 014_04 for habitat alteration and flow alteration due to impacts from historic placer mining. No TMDL was completed for habitat alteration or flow alteration, in accordance with DEQ policy. The mainstem Boise River, AU 005_05 is recommended for listing for temperature, due to data showing exceedance of cold water aquatic life and salmonid spawning temperature criteria.

Table 97. Summary of assessment outcomes for the Boise-Mores Creek subbasin.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Lucky Peak Reservoir 17050112SW001L_0L Robie Creek Beach	Bacteria	Bacteria	Add to Section 4a of Integrated Report	Unlisted but data indicates *E. coli* bacteria impairment for PCR at Robie Creek Beach
Boise River Mainstem 17050112SW004_05	Temperature	None	Add to Section 5 of Integrated Report	Unlisted but data indicates temperature impairment for CWAL and SS
Mores Creek 17050112SW009_02	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for SS
	Sediment	Sediment	Change pollutant from unknown to sediment and move to Section 4a of Integrated Report	Data indicates sediment impairment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Mores Creek 17050112SW009_03	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but impaired by sediment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Mores Creek 17050112SW009_04	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but impaired by sediment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Mores Creek 17050112SW009_06	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but impaired by sediment
Smith Creek 17050112SW010_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Thorn Creek 17050112SW011_02	Temperature	Temperature	No impairment known	Contributes thermal load to 3rd order Thorn Creek and Mores Creek

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Thorn Creek 17050112SW011_03	Temperature	Temperature	Add to Section 4a of Integrated Report	Unlisted but contributes thermal load to Mores Creek and BURP data indicates temperature impairment
Elk Creek 17050112SW012_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Elk Creek 17050112SW012_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Grimes Creek 17050112SW013_02	Temperature	Temperature	Change from unknown pollutant to temperature and move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL and SS
Grimes Creek 17050112SW013_03	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
	Temperature	Temperature	Add to Section 4a of Integrated Report	Unlisted but data indicates temperature impairment for CWAL and SS
Grimes Creek 17050112SW013_04	Temperature	Temperature	Move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL
	Sediment	Sediment	Add to Section 4a of Integrated Report	Unlisted but data indicates sediment impairment
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Grimes Creek 17050112SW013_05	Temperature	Temperature	Change from unknown pollutant to temperature and move to Section 4a of Integrated Report	Data indicates temperature impairment for CWAL
	Sediment	Sediment	Change pollutant from unknown to sediment and move to Section 4a of Integrated Report	Data indicates sediment impairment
Granite Creek 17050112SW014_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores and Grimes Creeks
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Granite Creek 17050112SW014_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores and Grimes Creeks

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Granite Creek 17050112SW014_04	Temperature	Temperature	No impairment known	Contributes thermal load to Mores and Grimes Creeks
	Habitat and Flow Alteration	None	Place in Section 4c of the Integrated Report	Stream habitat alteration contributes to non-attainment of designated beneficial uses
Macks Creek 17050112SW015_02	Temperature	Temperature	Add to Section 4a of Integrated Report	Unlisted but impaired by temperature
Daggett Creek 17050112SW016_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Daggett Creek 17050112SW016_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Robie Creek 17050112SW017_02	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek
Robie Creek 17050112SW017_03	Temperature	Temperature	No impairment known	Contributes thermal load to Mores Creek

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GIS Coverages

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Glossary

305(b)	Refers to section 305 subsection “b” of the Clean Water Act. The term “305(b)” generally describes a report of each state’s water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.
§303(d)	Refers to section §303 subsection “d” of the Clean Water Act. §303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.
Acre-foot	A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers.
Adsorption	The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules
Aeration	A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.
Aerobic	Describes life, processes, or conditions that require the presence of oxygen.
Adfluvial	Describes fish whose life history involves seasonal migration from lakes to streams for spawning.
Adjunct	In the context of water quality, adjunct refers to areas directly adjacent to focal or refuge habitats that have been degraded by human or natural disturbances and do not presently support high diversity or abundance of native species.

Alevin

A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.

Algae

Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.

Alluvium

Unconsolidated recent stream deposition.

Ambient

General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).

Anadromous

Fish, such as salmon and sea-run trout, that live part or the majority of their lives in the saltwater but return to fresh water to spawn.

Anaerobic

Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.

Anoxia

The condition of oxygen absence or deficiency.

Anthropogenic

Relating to, or resulting from, the influence of human beings on nature.

Anti-Degradation

Refers to the U.S. Environmental Protection Agency's interpretation of the Clean Water Act goal that states and tribes maintain, as well as restore, water quality. This applies to waters that meet or are of higher water quality than required by state standards. State rules provide that the quality of those high quality waters may be lowered only to allow important social or economic development and only after adequate public participation (IDAPA 58.01.02.051). In all cases, the existing beneficial uses must be maintained. State rules further define lowered water quality to be 1) a measurable change, 2) a change adverse to a use, and 3) a change in a pollutant relevant to the water's uses (IDAPA 58.01.02.003.61).

Aquatic
Occurring, growing, or living in water.

Aquifer
An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.

Assemblage (aquatic)
An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).

Assessment Database (ADB)
The ADB is a relational database application designed for the U.S. Environmental Protection Agency for tracking water quality assessment data, such as use attainment and causes and sources of impairment. States need to track this information and many other types of assessment data for thousands of water bodies and integrate it into meaningful reports. The ADB is designed to make this process accurate, straightforward, and user-friendly for participating states, territories, tribes, and basin commissions.

Assessment Unit (AU)
A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.

Assimilative Capacity
The ability to process or dissipate pollutants without ill effect to beneficial uses.

Autotrophic
An organism is considered autotrophic if it uses carbon dioxide as its main source of carbon. This most commonly happens through photosynthesis.

Batholith
A large body of intrusive igneous rock that has more than 40 square miles of surface exposure and no known floor. A batholith usually consists of coarse-grained rocks such as granite.

Bedload
Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.

Beneficial Use
Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Beneficial Use Reconnaissance Program (BURP)
A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers

Benthic
Pertaining to or living on or in the bottom sediments of a water body

Benthic Organic Matter.
The organic matter on the bottom of a water body.

Benthos
Organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the lake and stream bottoms.

Best Management Practices (BMPs)
Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Best Professional Judgment
A conclusion and/or interpretation derived by a trained and/or technically competent individual by applying interpretation and synthesizing information.

Biochemical Oxygen Demand (BOD)
The amount of dissolved oxygen used by organisms during the decomposition (respiration) of organic matter, expressed as mass of oxygen per volume of water, over some specified period of time.

Biological Integrity
1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).

Biomass

The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.

Biota

The animal and plant life of a given region.

Biotic

A term applied to the living components of an area.

Clean Water Act (CWA)

The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.

Coliform Bacteria

A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).

Colluvium

Material transported to a site by gravity.

Community

A group of interacting organisms living together in a given place.

Conductivity

The ability of an aqueous solution to carry electric current, expressed in micro (μ) mhos/centimeter at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.

Cretaceous

The final period of the Mesozoic era (after the Jurassic and before the Tertiary period of the Cenozoic era), thought to have covered the span of time between 135 and 65 million years ago.

Criteria

In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.

Cubic Feet per Second

A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

Cultural Eutrophication

The process of eutrophication that has been accelerated by human-caused influences. Usually seen as an increase in nutrient loading (also see Eutrophication).

Culturally Induced Erosion

Erosion caused by increased runoff or wind action due to the work of humans in deforestation, cultivation of the land, overgrazing, and disturbance of natural drainages; the excess of erosion over the normal for an area (also see Erosion).

Debris Torrent

The sudden down slope movement of soil, rock, and vegetation on steep slopes, often caused by saturation from heavy rains.

Decomposition

The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.

Depth Fines

Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 millimeters depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 centimeters).

Designated Uses

Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.

Discharge

The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen (DO)

The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.

Disturbance

Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.

Drafted

Release of reservoir water.

E. coli

Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Ecology

The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.

Ecological Indicator

A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework.

Ecological Integrity

The condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes (EPA 1996).

Ecosystem

The interacting system of a biological community and its non-living (abiotic) environmental surroundings.

Effluent

A discharge of untreated, partially treated, or treated wastewater into a receiving water body.

Endangered Species

Animals, birds, fish, plants, or other living organisms threatened with imminent extinction. Requirements for declaring a species as endangered are contained in the Endangered Species Act.

Environment

The complete range of external conditions, physical and biological, that affect a particular organism or community.

Eocene
An epoch of the early Tertiary period, after the Paleocene and before the Oligocene.

Eolian
Windblown, referring to the process of erosion, transport, and deposition of material by the wind.

Ephemeral Stream
A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from melting snow or other sources. Its channel is at all times above the water table (American Geological Institute 1962).

Erosion
The wearing away of areas of the earth's surface by water, wind, ice, and other forces.

Eutrophic
From Greek for "well nourished," this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.

Eutrophication
1) Natural process of maturing (aging) in a body of water. 2) The natural and human-influenced process of enrichment with nutrients, especially nitrogen and phosphorus, leading to an increased production of organic matter.

Exceedance
A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

Existing Beneficial Use or Existing Use
A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

Exotic Species
A species that is not native (indigenous) to a region.

Extrapolation
Estimation of unknown values by extending or projecting from known values.

Fauna
Animal life, especially the animals characteristic of a region, period, or special environment.

Fecal Coliform Bacteria
Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

Fecal Streptococci
A species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.

Feedback Loop
In the context of watershed management planning, a feedback loop is a process that provides for tracking progress toward goals and revising actions according to that progress.

Fixed-Location Monitoring
Sampling or measuring environmental conditions continuously or repeatedly at the same location.

Flow
See *Discharge*.

Fluvial
In fisheries, this describes fish whose life history takes place entirely in streams but migrate to smaller streams for spawning.

Focal
Critical areas supporting a mosaic of high quality habitats that sustain a diverse or unusually productive complement of native species.

Fully Supporting
In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Fully Supporting Cold Water
Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

Fully Supporting but Threatened
An intermediate assessment category describing water bodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a "not fully supporting" status.

Geographical Information Systems (GIS)
A georeferenced database.

Geometric Mean	A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.
Grab Sample	A single sample collected at a particular time and place. It may represent the composition of the water in that water column.
Gradient	The slope of the land, water, or streambed surface.
Ground Water	Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.
Growth Rate	A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.
Habitat	The living place of an organism or community.
Headwater	The origin or beginning of a stream.
Hydrologic Basin	The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).
Hydrologic Cycle	The cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Atmospheric moisture, clouds, rainfall, runoff, surface water, ground water, and water infiltrated in soils are all part of the hydrologic cycle.
Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more

commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

Hydrologic Unit Code (HUC)
The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

Hydrology
The science dealing with the properties, distribution, and circulation of water.

Impervious
Describes a surface, such as pavement, that water cannot penetrate.

Influent
A tributary stream.

Inorganic
Materials not derived from biological sources.

Instantaneous
A condition or measurement at a moment (instant) in time.

Intergravel Dissolved Oxygen
The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.

Intermittent Stream
1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. 2) A stream that has a period of zero flow for at least one week during most years.

Interstate Waters
Waters that flow across or form part of state or international boundaries, including boundaries with Native American nations.

Irrigation Return Flow
Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams.

Key Watershed
A watershed that has been designated in Idaho Governor Batt's *State of Idaho Bull Trout Conservation Plan* (1996) as critical

	to the long-term persistence of regionally important trout populations.
Knickpoint	Any interruption or break of slope.
Land Application	A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge.
Limiting Factor	A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.
Limnology	The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.
Load Allocation (LA)	A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Load(ing) Capacity (LC)	A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.
Loess	A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.
Lotic	An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth.

Luxury Consumption	A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants' current needs.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Macrophytes	Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp.*), are free-floating forms not rooted in sediment.
Margin of Safety (MOS)	An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.
Mass Wasting	A general term for the down slope movement of soil and rock material under the direct influence of gravity.
Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Median	The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11.
Metric	1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)
A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm).

Million Gallons per Day (MGD)
A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Miocene
Of, relating to, or being an epoch of, the Tertiary between the Pliocene and the Oligocene periods, or the corresponding system of rocks.

Monitoring
A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

Mouth
The location where flowing water enters into a larger water body.

National Pollution Discharge Elimination System (NPDES)
A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition
The condition that exists with little or no anthropogenic influence.

Nitrogen
An element essential to plant growth, and thus is considered a nutrient.

Nodal
Areas that are separated from focal and adjunct habitats, but serve critical life history functions for individual native fish.

Nonpoint Source
A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Not Assessed (NA)

A concept and an assessment category describing water bodies that have been studied, but are missing critical information needed to complete an assessment.

Not Attainable

A concept and an assessment category describing water bodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

Not Fully Supporting

Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Not Fully Supporting Cold Water

At least one biological assemblage has been significantly modified beyond the natural range of its reference condition.

Nuisance

Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient

Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Nutrient Cycling

The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic

The Greek term for "poorly nourished." This describes a body of water in which productivity is low and nutrients are limiting to algal growth, as typified by low algal density and high clarity.

Organic Matter

Compounds manufactured by plants and animals that contain principally carbon.

Orthophosphate

A form of soluble inorganic phosphorus most readily used for algal growth.

Oxygen-Demanding Materials

Those materials, mainly organic matter, in a water body that consume oxygen during decomposition.

Parameter

A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.

Partitioning

The sharing of limited resources by different races or species; use of different parts of the habitat, or the same habitat at different times. Also the separation of a chemical into two or more phases, such as partitioning of phosphorus between the water column and sediment.

Pathogens

A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Perennial Stream

A stream that flows year-around in most years.

Periphyton

Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants.

Pesticide

Substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

pH

The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Phased TMDL	A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a water body. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.
Phosphorus	An element essential to plant growth, often in limited supply, and thus considered a nutrient.
Physiochemical	In the context of bioassessment, the term is commonly used to mean the physical and chemical factors of the water column that relate to aquatic biota. Examples in bioassessment usage include saturation of dissolved gases, temperature, pH, conductivity, dissolved or suspended solids, forms of nitrogen, and phosphorus. This term is used interchangeable with the term “physical/chemical.”
Plankton	Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.
Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Pollution	A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.
Population	A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.

Pretreatment	The reduction in the amount of pollutants, elimination of certain pollutants, or alteration of the nature of pollutant properties in wastewater prior to, or in lieu of, discharging or otherwise introducing such wastewater into a publicly owned wastewater treatment plant.
Primary Productivity	The rate at which algae and macrophytes fix carbon dioxide using light energy. Commonly measured as milligrams of carbon per square meter per hour.
Protocol	A series of formal steps for conducting a test or survey.
Qualitative	Descriptive of kind, type, or direction.
Quality Assurance (QA)	A program organized and designed to provide accurate and precise results. Included are the selection of proper technical methods, tests, or laboratory procedures; sample collection and preservation; the selection of limits; data evaluation; quality control; and personnel qualifications and training (Rand 1995). The goal of QA is to assure the data provided are of the quality needed and claimed (EPA 1996).
Quality Control (QC)	Routine application of specific actions required to provide information for the quality assurance program. Included are standardization, calibration, and replicate samples (Rand 1995). QC is implemented at the field or bench level (EPA 1996).
Quantitative	Descriptive of size, magnitude, or degree.
Reach	A stream section with fairly homogenous physical characteristics.
Reconnaissance	An exploratory or preliminary survey of an area.
Reference	A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.
Reference Condition	1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest

level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).

Reference Site

A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.

Representative Sample

A portion of material or water that is as similar in content and consistency as possible to that in the larger body of material or water being sampled.

Resident

A term that describes fish that do not migrate.

Respiration

A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riffle

A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.

Riparian

Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.

Riparian Habitat Conservation Area (RHCA)

A U.S. Forest Service description of land within the following number of feet up-slope of each of the banks of streams:

- 300 feet from perennial fish-bearing streams
- 150 feet from perennial non-fish-bearing streams
- 100 feet from intermittent streams, wetlands, and ponds in priority watersheds.

River

A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.

Runoff

The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.

Sediments

Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.

Settleable Solids

The volume of material that settles out of one liter of water in one hour.

Species

1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.

Spring

Ground water seeping out of the earth where the water table intersects the ground surface.

Stagnation

The absence of mixing in a water body.

Stenothermal

Unable to tolerate a wide temperature range.

Stratification

A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).

Stream

A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.

Stream Order

Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.

Storm Water Runoff

Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the stream. The water often carries pollutants picked up from these surfaces.

Stressors

Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Subbasin

A large watershed of several hundred thousand acres. This is the name commonly given to 4th field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)

A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed

A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units.

Surface Fines

Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 millimeters depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.

Surface Runoff

Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.

Surface Water

All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Suspended Sediments

Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Taxon

Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).

Tertiary

An interval of geologic time lasting from 66.4 to 1.6 million years ago. It constitutes the first of two periods of the Cenozoic Era, the second being the Quaternary. The Tertiary has five subdivisions, which from oldest to youngest are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs.

Thalweg

The center of a stream's current, where most of the water flows.

Threatened Species

Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Total Maximum Daily Load (TMDL)

A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Dissolved Solids

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Toxic Pollutants

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Tributary

A stream feeding into a larger stream or lake.

Trophic State

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

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Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

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Trophic State

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Turbidity

A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Vadose Zone

The unsaturated region from the soil surface to the ground water table.

Wasteload Allocation (WLA)

The portion of receiving water’s loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

Water Quality Limited

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Limited Segment (WQLS)

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."

Water Quality Management Plan

A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

Water Quality Modeling

The prediction of the response of some characteristics of lake or stream water based on mathematical relations of input variables such as climate, stream flow, and inflow water quality.

Water Quality Standards

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Table

The upper surface of ground water; below this point, the soil is saturated with water.

Watershed

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a water body.

Water Body Identification Number (WBID)

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

Wetland

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

Young of the Year

Young fish born the year captured, evidence of spawning activity.

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Appendix A. Unit Conversion Chart

Table A-1. Metric - English unit conversions.

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Volume	Gallons (gal) Cubic Feet (ft^3)	Liters (L) Cubic Meters (m^3)	1 gal = 3.78 L 1 L= 0.26 gal 1 ft^3 = 0.03 m^3 1 m^3 = 35.32 ft^3	3 gal = 11.35 L 3 L = 0.79 gal 3 ft^3 = 0.09 m^3 3 m^3 = 105.94 ft^3
Flow Rate	Cubic Feet per Second (cfs)[a]	Cubic Meters per Second (m^3/sec)	1 cfs = 0.03 m^3/sec 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 °C = 37.4 °F

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.
[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

Appendix B. State- and Site-Specific Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring-spawning salmonids, the default spawning and incubation period recognized by DEQ is generally from March 15^{th} to July 15^{th} each year (Grafe et al., 2002). Fall spawning can occur as early as August 15th and continue with incubation on into the following spring up to June 1^{st}. As per IDAPA 58.01.02.250.02.e.ii., the water quality criteria that need to be met during that time period are as follows:

- 13 ºC as a daily maximum water temperature
- 9 ºC as a daily average water temperature

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of highest annual maximum weekly maximum temperature air temperatures) is compared to the daily maximum criterion of 13 °C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during critical summer months. If potential natural vegetation targets are achieved, yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human-induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401.*

Section 401 of the federal Clean Water Act relates to point source wastewater treatment requirements. In this case, if temperature criteria for any aquatic life use are exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3 ^{o}C (IDAPA 58.01.02.401.03.a.v.).

Water Quality Standards Applicable to Coldwater Aquatic Life Temperature

As per IDAPA 58.01.02.250.02.b., waters designated for coldwater aquatic life are not to vary due to human activities from water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C.

Water Quality Standards Applicable to Primary Contact Recreation

As per IDAPA 58.01.02.251.01, waters designated for recreation are not to contain *E.coli* bacteria, which are used as indicators of human pathogens, in concentrations exceeding a geometric mean of one hundred twenty-six (126) E. coli organisms per one hundred (100) ml based on a minimum of five (5) samples taken every three (3) to seven (7) days over a thirty (30) day period.

> *A water sample exceeding the E. coli single sample maximums below indicates likely exceedance of the geometric mean criterion, but is not alone a violation of water quality standards. If a single sample exceeds the maximums set forth in Subsections 251.01.b.i., 251.01.b.ii., and 251.01.b.iii., then additional samples must be taken as specified in Subsection 251.01.c.*

For waters designated as primary contact recreation, the single sample maximum is four hundred six (406) E. coli organisms per one hundred (100) ml.

Appendix C. Stream Temperature Data

The city of Boise has monitored stream temperature in Mores Creek near the Highway 21 summit and upstream from Robie Creek from 2003 to 2005. The Boise National Forest monitored stream temperature in Mores Creek at the Hayfork Creek confluence in 2001 and 2002 . DEQ monitored stream temperature in Mores Creek at three locations: Granite Creek, Bannock Creek, and Cougar Lane Bridge. In addition, DEQ had temperature monitors in Grimes Creek at Golden Age Camp and Pioneerville in 2005 and in Macks Creek in 2006. The Mores Creek temperature data collected from the city of Boise, Boise National Forest, and DEQ is presented in the tables below.

Table C-1. Mores Creek temperature data and number of days that water temperatures exceeded the cold water aquatic life criteria.

		Cold Water Aquatic Life (June 22 – September 21)						
			22°C Daily Maximum			19°C Daily Average		
Stream Name	Sample Period	# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Mores Creek 1st and 2nd Order Segments								
Mores Creek near Hwy 21 Summit	6/22 to 9/21 2002	92	0 (0)	15.0	7/12/02	0 (0)	11.7	7/14/02
	6/22 to 9/21 2003	92	0 (0)	15.0	7/20/03	0 (0)	11.6	7/20/03
	6/22 to 9/21 2004	92	0 (0)	14.7	7/13/05	0 (0)	11.7	7/22/05
	6/22 to 8/15 2005	55	0 (0)	14.2	7/23/06	0 (0)	11.3	7/23/06
Mores Creek @ Hayfork Creek	7/20 to 9/21 2001	64	0 (0)	17.0	8/8/01	0 (0)	13.1	8/8/01
	6/22 to 8/11 2002	53	0 (0)	17.6	7/12/02	0 (0)	13.6	7/14/02
Mores Creek 3rd Order Segment								
Mores @ Granite Creek	6/22 to 9/21 2004	92	2 (2)	22.4	7/17/04	37 (30)	16.8	7/15/04
Mores Cr. @ Bannock Creek	6/22 to 9/21 2005	92	12 (13)	23.2	7/22/05	4 (4)	19.6	7/22/05
Mores @ Cougar Lane Bridge	6/22 to 9/21 2004	23	18 (20)	25.9	7/12/04	n.a.		
Mores Creek 6th Order Segment								
Mores Creek Upstream from Robie Creek	6/22 to 9/21 2002	92	67 (73)	29.2	7/14/02	56 (61)	25.3	7/14/02

		Cold Water Aquatic Life (June 22 – September 21)						
			22^{o}C Daily Maximum			19^{o}C Daily Average		
Stream Name	**Sample Period**	**# Days Evaluated**	**# Days Over (Percent Exceedance)**	**Max Temp**	**Date of Max Temp**	**# Days Over (Percent Exceedance)**	**Max Temp**	**Date of Max Temp**
	6/22 to 9/21 2003	**92**	**65 (71)**	**28.1**	**7/21/03**	**65 (71)**	**24.5**	**7/21/03**
	6/22 to 9/21 2004	**92**	**56 (61)**	**26.9**	**8/02/04**	**58 (63)**	**23.7**	**7/17/04**
	6/22 to 9/21 2005	**92**	**64 (70)**	**27.8**	**8/09/05**	**58 (63)**	**24.3**	**7/22/05**
	6/22 to 8/15 2006	**55**	**47 (51)**	**28.3**	**7/24/06**	**49 (53)**	**25.5**	**7/24/06**

Table C-2. Mores Creek temperature data and number of days that water temperatures exceeded the spring salmonid spawning criteria.

		Salmonid Spawning (Rainbow and Redband Trout, March 15 – July 15)						
			13^{o}C Daily Maximum			9^{o}C Daily Average		
Stream Name	**Sample Period**	**# Days Evaluated**	**# Days Over (Percent Exceedance)**	**Max Temp**	**Date of Max Temp**	**# Days Over (Percent Exceedance)**	**Max Temp**	**Date of Max Temp**
Mores Creek 1st and 2nd Order Segments								
Mores @ Hwy 21 Crossing	4/27 to 7/15 2002	110	11 (9)	15.05	7/12/02	15 (12)	11.7	7/14/02
	3/15 to 7/15 2003	123	6 (5)	13.7	7/12/03	7 (6)	13.6	7/12/03
	3/15 to 7/15 2005	123	7 (6)	14.7	7/13/05	9 (7)	11.0	7/13/05
	6/09 to 7/15 2006	40	0 (n.a.)	12.97	7/15/06	6 (5)	9.5	7/15/06
Hayfork	3/15 to 7/15 2002	123	26 (21)	17.6	7/12/02	25 (20)	13.6	7/14/02

		Salmonid Spawning (Rainbow and Redband Trout, March 15 – July 15)						
			13°C Daily Maximum			9°C Daily Average		
Stream Name	**Sample Period**	**# Days Evaluated**	**# Days Over (Percent Exceedance)**	**Max Temp**	**Date of Max Temp**	**# Days Over (Percent Exceedance)**	**Max Temp**	**Date of Max Temp**
Mores Creek 3rd Order Segment								
Mores Creek Above Idaho City	3/15 to 7/15 2004	123	35 (28)	21.3	7/14/04	37 (30)	16.8	7/15/04
Mores @ Bannock	3/15 to 7/15 2005	123	38 (31)	22.5	7/13/05	41 (33)	18.4	7/13/05
Mores Below Idaho City	3/15 to 7/13 2004	121	54 (44)	25.9	7/12/04	n.a.		
Mores Creek 6th Order Segment								
Mores Creek upstream from Robie Creek	4/26 to 7/15 2002	81	56 (69)	29.2	7/14/02	62 (76)	25.3	7/14/02
	3/15 to 7/15 2003	123	58 (47)	25.5	7/12/03	65 (53)	22.3	7/13/03
	3/15 to 7/15 2004	123	58 (47)	25.3	7/14/04	78 (63)	22.3	7/15/04
	3/15 to 7/15 2005	123	59 (48)	26.5	7/13/05	77 (62.6)	23.4	7/13/05
	3/15 to 7/15 2006	123	56 (45)	24.4	7/11/06	64 (52)	21.5	7/11/06

Table C-3. Mores Creek temperature data and number of days that water temperatures exceeded the bull trout spawning criteria.

Stream Name	Sample Period	13°C Daily Maximum (June – August)			9°C Daily Average (September – October)		
		# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Hwy 21	June – October 2002	14 (15)	14.4	7/11/02	4 (7)	9.7	9/03/02
	June – October 2003	37 (40)	14.4	7/17/03	8 (13)	10.6	9/5/03
	June – October 2005	28 (30)	14.0	8/04/05	1 (2)	9.1	9/02/05
	June – October 2006	10 (11)	13.7	7/22/06	n.a.		
Hayfork	July 20 – October 2001	43 (47)	16.0	7/14/01	17 (28)	11.6	9/01/01
	June – August 11th 2002	48 (52)	17.0	7/11/02	n.a.		

Table C-4. Grimes Creek temperature data and number of days that water temperatures exceeded the cold water aquatic life criteria.

		Cold Water Aquatic Life (June 22 – September 21)						
			22°C Daily Maximum			19°C Daily Average		
Stream Name	Sample Period	# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Grimes Creek 1st and 2nd Order Segments								
Grimes Creek Golden Age Mine	6/22 to 7/30 2005	40	0 (0)	17.1	7/22/05	0 (0)	15.2	7/22/05
Grimes Creek 3rd Order Segment								
Grimes Creek @ Pioneerville	6/22 to 7/30 2005	40	20 (21)	24.8	7/23/05	2 (2.2)	20.0	7/22/05

Table C-5. Grimes Creek temperature data and number of days that water temperatures exceeded the spring salmonid spawning criteria.

		Salmonid Spawning (Rainbow and Redband Trout, March 15 – July 15)						
			13°C Daily Maximum			9°C Daily Average		
Stream Name	Sample Period	# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Grimes Creek 1st and 2nd Order Segments								
Grimes Creek Golden Age Mine	5/05 to 7/15 2005	72	14 (11.4)	16.3	7/13/05	23 (18.7)	13.9	7/13/05
Grimes Creek 3rd Order Segment								
Grimes Creek @ Pioneerville	5/05 to 7/15 2005	72	30 (24.4)	24.0	7/13/05	32 (26)	18.6	7/13/05

Table C-6. Grimes Creek temperature data and number of days that water temperatures exceeded the bull trout spawning criteria.

Stream Name	Sample Period	13°C Daily Maximum (June – August)			9°C Daily Average (September – October)		
		# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Grimes @ Golden Age Mine	June 1 – July 30 2005	25 (26.9) 25 of 54 measured	15.7	7/18/05	n.a		

Table C-7. Macks Creek temperature data and number of days that water temperatures exceeded the cold water aquatic life criteria.

		Cold Water Aquatic Life (June 22 – September 21)						
			22°C Daily Maximum			19°C Daily Average		
Stream Name	Sample Period	# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Macks		Not in range						

Table C-8. Macks Creek temperature data and number of days that water temperatures exceeded the salmonid spawning criteria.

		Salmonid Spawning (Rainbow and Redband Trout, March 15 – July 15)						
			13°C Daily Maximum			9°C Daily Average		
Stream Name	Sample Period	# Days Evaluated	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp	# Days Over (Percent Exceedance)	Max Temp	Date of Max Temp
Macks	3/15 to 6/20 2006	98	19 (15.4)	14.5	6/08/06	31 (25.2)	11.8	6/08/06

Table C-9. Data sources for Boise-Mores Creek PNV TMDLs.

Water Body	Data Source	Type of Data	When Collected
Mores Creek & tributaries	DEQ State Technical Services Office	Pathfinder effective shade and stream width	September 2006
Mores Creek & tributaries	DEQ State Technical Services Office	Aerial Photo Interpretation of existing shade and stream width estimation	August 2006
	DEQ IDASA Database	Temperature	

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Appendix D. BURP Data

Table D-1. BURP sites locations and dates of sampling.

BURP ID	STREAM	ASSESSMENT UNIT	DATE OF SAMPLING
1993SBOIA034	GRIMES CK LO SITE	013_05	7/29/1993
1993SBOIA035	GRIMES CK HIGH SITE	013_02	7/29/1993
1995SBOIA065	GRIMES CREEK (UPPER)	013_03	8/23/1995
1995SBOIB019	MINNEHA CREEK (LOWER)	009_02	6/21/1995
1995SBOIB020	S FORK MINNEHA CREEK	009_02	6/21/1995
1995SBOIB021	MINNEHA CREEK (UPPER)	009_02	6/21/1995
1996SBOIA025	CLEAR CREEK (UPPER)	013_02	6/24/1996
1996SBOIA026	CLEAR CREEK (LOWER)	013_02	6/24/1996
1996SBOIA027	MACKS CREEK (LOWER)	015_02	6/25/1996
1996SBOIA028	MACK'S CREEK (UPPER)	015_02	6/25/1996
1996SBOIA029	CLEAR CREEK	013_02	6/25/1996
1996SBOIA030	GRANITE CREEK (UPPER)	009_02	6/25/1996
1996SBOIA031	GRANITE CREEK (LOWER)	009_02	6/25/1996
1996SBOIA033	BANNOCK CREEK (UPPER)	009_02	6/27/1996
1996SBOIA034	BANNOCK CREEK (LOWER)	009_02	6/27/1996
1996SBOIA052	MORES CREEK (UPPER)	009_02	7/23/1996
1996SBOIA053	MORES CREEK (UPPER-MIDDLE)	009_03	7/23/1996
1996SBOIA054	MORES CREEK (LOWER MIDDLE)	009_04	7/23/1996
1996SBOIA079	MORES CREEK (LOWER)	009_06	8/8/1996
1996SBOIA090	RATTLESNAKE CREEK	013_02	8/14/1996
1996SBOIA091	ELK CREEK (UPPER)	012_02	8/14/1996
1996SBOIA092	ELK CREEK (LOWER)	012_03	8/14/1996
1996SBOIA093	HAYFORK CREEK	009_02	8/15/1996
1997SBOIA001	MINNEHA CREEK(UPPER)	009_02	6/6/1997
1997SBOIA002	CLEAR CREEK	013_02	6/9/1997
1997SBOIA006	GROUSE CREEK(LOWER)	003_02	6/12/1997
1997SBOIB001	MINNEHA CREEK	009_02	6/6/1997
1997SBOIB002	MACKS CREEK	015_02	6/9/1997
1997SBOIC003	BROWNS CREEK	006_02	8/27/1997
1997SBOIC004	BADGER CREEK	004_02	8/27/1997
1997SBOIC009	MINNEHA CREEK(UPPER)	009_02	9/2/1997
1997SBOIC010	CLEAR CREEK	013_02	9/2/1997
1997SBOIC011	WOOF CREEK(UPPER)	014_02	9/3/1997
1997SBOIC012	WOOF CREEK(LOWER)	014_02	9/3/1997
1997SBOIC019	HAYFORK CREEK	009_02	9/9/1997
1997SBOIC034	BANNOCK CREEK(LOWER)	009_02	9/22/1997
1997SBOIC035	BANNOCK CREEK(UPPER)	009_02	9/22/1997
1997SBOIC036	BANNOCK CREEK(MIDDLE)	009_02	9/22/1997
1998SBOIA073	GRIMES CREEK (UPPER)	013_04	8/13/1998
1998SBOIA074	GRIMES CREEK (MIDDLE)	013_05	8/13/1998
1998SBOIA075	GRIMES CREEK (LOWER)	013_05	8/13/1998
2003SBOIF001	MORES CREEK	009_04	9/2/2003
2003SBOIF002	MACKS CREEK	015_02	9/2/2003

BURP ID	STREAM	ASSESSMENT UNIT	DATE OF SAMPLING
2004SBOIA022	SHEEP CREEK	016_02	6/30/2004
2004SBOIA023	ROBIE CREEK	017_03	7/1/2004
2004SBOIA024	SOUTH FORK ROBIE CREEK	017_02	7/1/2004
2004SBOIA025	THORN CREEK	011_03	7/1/2004
2004SBOIA026	MINNEHA CREEK	009_02	7/1/2004
2004SBOIA027	SOUTH FORK THORN CREEK	011_02	7/2/2004
2004SBOIA030	DAGGETT CREEK	016_03	7/3/2004
2004SBOIA067	COTTONWOOD CREEK	07_03	7/22/2004
2004SBOIA068	NORTH FORK COTTONWOOD CR	07_02	7/22/2004
2004SBOIA083	SHEEP CREEK	005_04	7/28/2004
2004SBOIA155	SHEEP CREEK	005_04	9/16/2004
2004SBOIA156	GRANITE CREEK	009_02	9/21/2004
2004SBOIA160	UNNAMED TRIBUTARY TO BOISE R	004_02	9/21/2004
2004SBOIF001	CLEAR CREEK	013_02	6/30/2004
2005SBOIA023	GRANITE CREEK	014_03	7/6/2005
2005SBOIA028	ELK CREEK	012_03	8/1/2005
2005SBOIF004	UNNAMED TRIBUTARY TO BOISE R	004_02	8/31/2005

Appendix E. Subsurface Fine Sampling

Subsurface Fine Sediment Sampling

McNeil (McNeil and Ahnell 1964) sediment core samples were collected to describe size composition of bottom materials in salmonid spawning beds of Antelope and Bear Creeks. Research has shown that subsurface fine sediment composition is important to egg and fry survival (Hall 1986 and Reiser and White 1988).

Site Selection

Sample sites selected displayed characteristics of gravel size, depth, and velocity required by salmonids to spawn and were determined to be adequate spawning substrate by an experienced fisheries biologist. Samples were collected during periods of low discharge, as described in McNeil and Ahnell (1964) to minimize loss of silt in suspension within the core sampling tube. Sample sites were generally in the lower reach of streams where spawning habitat was determined to exist.

Field Methods

A 12-inch diameter stainless steel open cylinder was worked at least 4 inches into spawning substrate without allowing flowing water to top the core sampling tube. Samples of bottom materials were removed by hand, using a stainless steel mixing bowl, to a depth of at least 4 inches and placed into buckets. After solids were removed from the core sampling tube and placed into buckets, the remaining suspended material was discarded. It is felt that this fine material would be removed through the physical action of a fish excavating a redd and would not be a significant factor with regard to egg to fry survival. Additionally, rinsing of sieves to process the sample results in some loss of the fraction below the smallest (0.0021 inches) mesh size.

Samples were placed wet into a stack of sieves and were separated into 10 size classes by washing and shaking them through nine standard Tyler sieves having the following square mesh openings (in inches): 2.5, 1.0, 0.5, 0.25, 0.187, 0.937, 0.331, 0.0083, and 0.0021. Silt passing the finest screen was discarded.

The volume of solids retained by each sieve was measured after the excess water had drained. The contents of each of the sieves were placed in a bucket filled with water to the level of a spigot for measurement by displacement. The water displaced by solids was collected in a plastic bucket, transferred to a graduated cylinder, and measured directly. Variation in sample volumes was caused by variation in porosity and core depth. All sample fractions were expressed as a percentage of the total sample with and without the 2.5-inch fraction. The 2.5-inch particles are eliminated since they are generally too large for resident salmonids to move while building a spawning redd.

Three sediment core samples were collected at each sample site and grouped together by fractions 0.25 inches and greater and from 0.187 inches to 0.0021 inches. The results for a particular site are the percentage of 0.187 inches to 0.0021 inches as a portion of the total sample. Standard deviation is calculated for estimates including and excluding particles 2.5 inches and above.

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Appendix F. Streambank Erosion Inventory

Streambank Erosion Inventory

The streambank erosion inventory used to estimate background and existing streambank erosion followed methods outlined in the proceedings from the Natural Resource Conservation Service (NRCS) Channel Evaluation Workshop (USDA NRCS, 1983). Using the direct volume method, subsections of 1996 §303(d) watersheds were surveyed to determine the extent of chronic bank erosion and estimate the needed reductions.

The NRCS Stream Bank Erosion Inventory is a field-based methodology, which measures streambank/channel stability, length of active eroding banks, and bank geometry (Stevenson, 1994). The streambank/channel stability inventories were used to estimate the long-term lateral recession rate. The recession rate is determined from field evaluation of streambank characteristics that are assigned a categorical rating ranging from 0 to 3. The categories of rating the factors and rating scores are as follows:

Bank Stability:
- Do not appear to be eroding - 0
- Erosion evident - 1
- Erosion and cracking present - 2
- Slumps and clumps sloughing off - 3

Bank Condition:
- Some bare bank, few rills, no vegetative overhang - 0
- Predominantly bare, some rills, moderate vegetative overhang - 1
- Bare, rills, severe vegetative overhang, exposed roots - 2
- Bare, rills and gullies, severe vegetative overhang, falling trees - 3

Vegetation / Cover On Banks:
- Predominantly perennials or rock-covered - 0
- Annuals / perennials mixed or about 40% bare - 1
- Annuals or about 70% bare - 2
- Predominantly bare – 3

Bank / Channel Shape:
- V - shaped channel, sloped banks - 0
- Steep V - shaped channel, near vertical banks - 1
- Vertical banks, U - shaped channel - 2
- U - shaped channel, undercut banks, meandering channel - 3

Channel Bottom:
- Channel in bedrock / non-eroding - 0
- Soil bottom, gravels or cobbles, minor erosion - 1
- Silt bottom, evidence of active downcutting - 2

Deposition:
- No evidence of recent deposition - 1
- Evidence of recent deposits, silt bars – 0

Cumulative Rating
Slight (0-4) Moderate (5-8) Severe (9+)

From the cumulative rating, the lateral recession rate is assigned.

0.01 - 0.05 feet per year	**Slight**
0.06 - 0.15 feet per year	**Moderate**
0.16 - 0.3 feet per year	**Severe**
0.5+ feet per year	**Very Severe**

Streambank stability can also be characterized by the factors found in the list below, which includes the corresponding streambank erosion condition ratings in italics.

Streambanks are considered stable if they do not show indications of any of the following features:

- **Breakdown** - Obvious blocks of bank broken away and lying adjacent to the bank breakage. *Bank Stability Rating 3*
- **Slumping or False Bank -** Bank has obviously slipped down; cracks may or may not be obvious, but the slump feature is obvious. *Bank Stability Rating 2*
- **Fracture** - A crack is visibly obvious on the bank, indicating that the block of bank is about to slump or move into the stream. *Bank Stability Rating 2*
- **Vertical and Eroding -** The bank is mostly uncovered, and the bank angle is steeper than 80 degrees from the horizontal. *Bank Stability Rating 1*

Streambanks are considered covered if they show any of the following features:

- Perennial vegetation ground cover is greater than 50%. *Vegetation/Cover Rating 0*
- Roots of vegetation cover more than 50% of the bank (deep-rooted plants such as willows and sedges provide such root cover). *Vegetation/Cover Rating 1*
- At least 50% of the bank surfaces are protected by rocks of cobble size or larger. *Vegetation/Cover Rating 0*
- At least 50% of the bank surfaces are protected by logs of 4 inch diameter or larger. *Vegetation/Cover Rating 1*

Streambank stability is estimated using a simplified modification of Platts, Megahan, and Minshall (1983, p. 13) as stated in *Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams* (Bauer and Burton, 1993). The modification allows for measuring streambank stability in a more objective fashion. The lengths of banks on both sides of the stream throughout the entire linear distance of the representative reach are measured and proportioned into four stability classes, as follows:

- **Mostly covered and stable (non-erosional).** Streambanks are over 50% covered as defined above. Streambanks are stable as defined above. Banks associated with gravel bars having perennial vegetation above the scour line are in this category. *Cumulative Rating 0 - 4 (slight erosion) with a corresponding lateral recession rate of 0.01 - 0.05 feet per year.*

- **Mostly covered and unstable (vulnerable).** Streambanks are over 50% covered as defined above. Streambanks are unstable as defined above. Such banks are typical of a false bank observed in meadows where breakdown, slumping, and/or fracture show instability, yet vegetative cover is abundant. *Cumulative Rating 5 - 8 (moderate erosion) with a corresponding lateral recession rate of 0.06 - 0.2 feet per year.*
- **Mostly uncovered and stable (vulnerable).** Streambanks are less than 50% covered as defined above. Streambanks are stable as defined above. Uncovered, stable banks are typical of streambanks trampled by concentrations of cattle. Such trampling flattens the bank so that slumping and breakdown do not occur even though vegetative cover is significantly reduced or eliminated. *Cumulative Rating 5 - 8 (moderate erosion) with a corresponding lateral recession rate of 0.06 - 0.2 feet per year*.
- **Mostly uncovered and unstable (erosional).** Streambanks are less than 50% covered as defined above. They are also unstable as defined above. These are bare eroding streambanks and include ALL banks mostly uncovered, which are at a steep angle to the water surface. *Cumulative Rating 9+ (severe erosion) with a corresponding lateral recession rate of over 0.5 feet per year.*

Streambanks were inventoried to quantify bank erosion rates and annual average erosion. These data were used to develop a quantitative sediment budget to be used for TMDL development.

Site Selection

The first step in the bank erosion inventory is to identify key problem areas. Streambank erosion tends to increase as a function of watershed area (NRCS, 1983). As a result, the lower stream segment of larger watersheds tends to be a problem area. These stream segments tend to be alluvial streams commonly classified as response reaches (Rosgen B and C channel types) (Rosgen,1996).

Because it is often unrealistic to survey every stream segment, sampled reaches were used and bank erosion rates were extrapolated over a larger stream segment. The length of the sampled reach is a function of stream type variability—stream segments with highly variable channel types need a large sample, whereas segments with uniform gradient and consistent geometry need a smaller sample. Typically between 10% and 30% of a streambank needs to be inventoried. Often, the location of some stream reaches that are inventoried is more dependent on land ownership than watershed characteristics. For example, private land owners are sometimes unwilling to allow access to stream segments within their property. Stream reaches are subdivided into *sites* with similar channel and bank characteristics. Breaks between sites are made where channel type and/or dominant bank characteristics change substantially. In a stream with uniform channel geometry, there may be only one site per stream reach, whereas in an area with variable conditions, there may be several sites. Subdivision of stream reaches is at the discretion of the field crew leader.

Field Methods

Streambank erosion or channel stability inventory field methods were originally developed by the United States Department of Agriculture United States Forest Service (Pfankuch, 1975). Further development of channel stability inventory methods are outlined in Lohrey (1989) and USDA NRCS (1983). The NRCS (1983) document outlines field methods used in this inventory; however, slight modifications to the field methods were made and are documented.

Field crews typically consist of two to four people who are trained as a group to ensure quality control and consistent data collection. Field crews survey selected stream reaches, measuring bank length, slope height, bankfull width and depth, and bank content. In most cases, a global positioning system (GPS) is used to locate the upper and lower boundaries of inventoried stream reaches. Additionally, field crews photograph key problem areas while surveying.

Bank Erosion Calculations

The direct volume method is used to calculate average annual erosion rates for a given stream segment based on bank recession rate determined in the survey (NRCS, 1983). The erosion rate (tons/mile/year) is used to estimate the total bank erosion of the selected stream corridor.

The direct volume method is summarized in the following equations:

$$E = [A_E * R_{LR} * \ {}_B]/2000 \text{ (lbs/ton)}$$

where:

- E = bank erosion over sampled stream reach (tons/yr/sample reach)
- A_E = eroding area (ft^2)
- R_{LR} = lateral recession rate (ft/yr)
- ${}_B$ = bulk density of bank material (lps/ft^3)

The bank erosion rate (E_R) is calculated by dividing the sampled bank erosion (E) by the total stream length sampled:

$$E_R = E/L_{BB}$$

where:

- E_R = bank erosion rate (tons/mile/year)
- E = bank erosion over sampled stream reach (tons/yr/sample reach)
- L_{BB} = bank to bank stream length over sampled reach

Total bank erosion is expressed as an annual average. However, the frequency and magnitude of bank erosion events are greatly a function of soil moisture and stream discharge (Leopold et al, 1964). Because channel erosion events typically result from above-average flow events, the annual average bank erosion value should be considered a long term average. For example, a 50-year flood event might cause five feet of bank erosion in one year, and over a ten year period, this event accounts for the majority of bank erosion. These factors have less of an influence where bank trampling is the major cause of channel instability.

The *eroding area* (A_E) is the product of linear horizontal bank distance and average bank slope height. Bank length and slope heights are measured while walking along the stream channel. Pacing is used to measure horizontal distance, and bank slope heights are continually measured and averaged over a given reach or site. The horizontal length is the length of the right or left bank, not both. Typically, one bank along the stream channel is actively eroding, such as the bank on the outside of a meander. However, in channels with severe headcuts or gullies, both banks will be eroding and are to be measured separately and eventually summed.

Determining the *lateral recession rate* (R_{LR}) is one of the most critical factors in this methodology (NRCS, 1983). Several techniques are available to quantify bank erosion rates, such as aerial photo interpretation, anecdotal data, bank pins, and channel cross-sections.

To facilitate consistent data collection, the NRCS developed rating factors used to estimate lateral recession rates. Similar to methods developed by Pfankuch (1975), the NRCS method measures bank and channel stability, and then uses the ratings as surrogates for bank erosion rates.

The *bulk density* (ρ_B) of bank material is measured occularly in the field. Soil bulk density is the weight of material divided by its volume, including the volume of its pore spaces. A table of typical soil bulk densities can be used, or soil samples can be collected and soil bulk density measured in the laboratory.

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Table F-1. Mores Creek Survey 1 Calculation Sheet.

					Stream Segment Location		
Stream	Mores Creek						
Section	Survey_1 – Mores Creek source to 1st Hwy 21 Crossing				Degrees	Minutes	Seconds
Date Collected	8/29/2006	Upstream		N	43	57	30.15
Field Crew	Darcy Sharp			W	-115	42	0.63
Data reduced by	Darcy Sharp	Downstream		N	43	57	22.31
Land Use	forest, mineral extraction			W	-115	41	46.22

Stream Bank Erosion Calculations

AVE. BankHeight:	3.6	ft
Total Inventoried Bank Length	1551	ft
Inv. Bank to Bank Length (LBB)	3102.0	ft
Erosive Bank Length	63	ft
Bank to Bank Eroding Segment Length	126	ft
Percent eroding bank	0.04	%
Eroding Area	453.6	ft^2
Recession Rate	0.035	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.71	tons/year/sample reach
Erosion Rate (ER)	2.43	tons/mile/year
Feet of Similar Stream Type	250,920	ft
Eroding Bank Extrapolation	20510.22	ft
Total Stream Bank Erosion	**116.29**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	2233.4	ft^2
Bank erosion over sampled reach (E)	4	tons/year/sample reach
Erosion Rate (ER)	12	tons/mile/year
Feet of Similar Stream Types	250,920	ft
Eroding bank extrapolation	100988.40	ft
Total stream bank erosion	**572.6**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0.5
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	2.5
Recession Rate	0.035

Load Reduction Summary

Existing		Proposed		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
2.43	**116.3**	**12**	**572.6**	**0**

Table F-2. Mores Creek Survey 2-6 Calculation Sheet.

Stream	Mores Creek	**Stream Segment Location**					
Section	Survey_2-6 – 1st Hwy 21 crossing to 10 mile Creek				Degrees	Minutes	Seconds
Date Collected	8/29/2006	Upstream	N		43	55	57.91
Field Crew	Darcy Sharp		W		-115	40	56.95
Data reduced by	Darcy Sharp	Downstream	N		43	54	29.23
Land Use	forest, mineral extraction		W		-115	41	56.9

Stream Bank Erosion Calculations

AVE. Bank Height:	1.2	ft
Total Inventoried Bank Length	4587	ft
Inv. Bank to Bank Length (LBB)	9174.0	ft
Erosive Bank Length	102	ft
Bank to Bank Eroding Seg. Length	204	ft
Percent eroding bank	0.02	%
Eroding Area	244.8	ft^2
Recession Rate	0.020	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.22	tons/year/sample reach
Erosion Rate (ER)	0.25	tons/mile/year
Feet of Similar Stream Type	446080	ft
Eroding Bank Extrapolation	20042.74	ft
Total Stream Bank Erosion	**21.65**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	2201.8	ft^2
Bank erosion over sampled reach (E)	2	tons/year/sample reach
Erosion Rate (ER)	2	tons/mile/year
Feet of Similar Stream Types	446080.00	ft
Eroding bank extrapolation	180266.80	ft
Total stream bank erosion	**194.7**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	1.0
Recession Rate	0.020

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
0.25	**21.65**	**2**	**194.7**	**0**

Table F-3. Mores Creek Survey 7 Calculation Sheet.

Stream	Mores Creek	**Stream Segment Location**				
Section	Survey_7 – 10 Mile Creek to Granite Creek			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	50	10.05
Field Crew	Darcy Sharp		W	-115	47	7.89
Data reduced by	Darcy Sharp	Downstream	N	43	49	48.7
Land Use	forest, mineral extraction		W	-115	47	34.66

Stream Bank Erosion Calculations

AVE. Bank Height:	3.6	ft
Total Inventoried Bank Length	3039	ft
Inv. Bank to Bank Length (LBB)	6078.0	ft
Erosive Bank Length	570	ft
Bank to Bank Eroding Seg. Length	1140	ft
Percent eroding bank	0.19	%
Eroding Area	4104.0	ft^2
Recession Rate	0.040	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	7.39	tons/year/sample reach
Erosion Rate (ER)	12.83	tons/mile/year
Feet of Similar Stream Type	34632	ft
Eroding Bank Extrapolation	14131.27	ft
Total Stream Bank Erosion	**91.57**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	4376.2	ft^2
Bank erosion over sampled reach (E)	8	tons/year/sample reach
Erosion Rate (ER)	14	tons/mile/year
Feet of Similar Stream Types	34632.00	ft
Eroding bank extrapolation	15168.00	ft
Total stream bank erosion	**97.6**	tons/year

Load Reduction Summary

Existing		Proposed		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
12.83	**91.57**	**14**	**97.6**	**0**

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0.5
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0.5
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	3.0
Recession Rate	0.040

Table F-4. Mores Creek Survey 8 Calculation Sheet.

Stream	Mores Creek	**Stream Segment Location**				
Section	Survey_8 – Granite Creek to Sawmill Creek			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	49	48.7
Field Crew	Darcy Sharp		W	-115	47	34.66
Data reduced by	Darcy Sharp	Downstream	N	43	49	35.15
Land Use	forest, mineral extraction		W	-115	47	55.88

Stream Bank Erosion Calculations

AVE. Bank Height:	4.8	ft
Total Inventoried Bank Length	2142	ft
Inv. Bank to Bank Length (LBB)	4284.0	ft
Erosive Bank Length	426	ft
Bank to Bank Eroding Seg. Length	852	ft
Percent eroding bank	0.20	%
Eroding Area	4089.6	ft^2
Recession Rate	0.055	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	10.12	tons/year/sample reach
Erosion Rate (ER)	24.95	tons/mile/year
Feet of Similar Stream Type	25078	ft
Eroding Bank Extrapolation	10827.00	ft
Total Stream Bank Erosion	**128.62**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	4112.6	ft^2
Bank erosion over sampled reach (E)	10	tons/year/sample reach
Erosion Rate (ER)	25	tons/mile/year
Feet of Similar Stream Types	25078.00	ft
Eroding bank extrapolation	10888.00	ft
Total stream bank erosion	**129.3**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	1
Bank Condition (0-3)	1
Vegetative/Cover on Banks (0-3)	0.5
Bank/Channel Shape - downcutting (0-3)	0.5
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	5.0
Recession Rate	0.055

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
24.95	**128.62**	**25**	**129.3**	**0**

Table F-5. Mores Creek Survey 9 Calculation Sheet.

Stream	Mores Creek	**Stream Segment Location**				
Section	Survey_9 – Sawmill Creek to Thorn Creek			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	48	31.43
Field Crew	Darcy Sharp		W	-115	52	5.89
Data reduced by	Darcy Sharp	Downstream	N	43	47	22.7
Land Use	forest, mineral extraction		W	-115	52	45.78

Stream Bank Erosion Calculations

AVE. Bank Height:	4.8	ft
Total Inventoried Bank Length	8373	ft
Inv. Bank to Bank Length (LBB)	16746.0	ft
Erosive Bank Length	2655	ft
Bank to Bank Eroding Seg. Length	5310	ft
Percent eroding bank	0.32	%
Eroding Area	25488.0	ft^2
Recession Rate	0.075	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	86.02	tons/year/sample reach
Erosion Rate (ER)	54.25	tons/mile/year
Feet of Similar Stream Type	20351	ft
Eroding Bank Extrapolation	18216.22	ft
Total Stream Bank Erosion	**295.10**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	16076.2	ft^2
Bank erosion over sampled reach (E)	54	tons/year/sample reach
Erosion Rate (ER)	34	tons/mile/year
Feet of Similar Stream Types	20351.00	ft
Eroding bank extrapolation	11489.60	ft
Total stream bank erosion	**186.1**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	1
Bank Condition (0-3)	0.5
Vegetative/Cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	0.5
Channel Bottom (0-2)	1.5
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	5.5
Recession Rate	0.075

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
54.25	**295.10**	**34**	**186.1**	**37**

Table F-6. Mores Creek Survey 10 Calculation Sheet.

Stream	Mores Creek	**Stream Segment Location**				
Section	Survey_10 – Thorn Creek to Grimes Creek			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	45	9.44
Field Crew	Darcy Sharp		W	-115	55	9.04
Data reduced by	Darcy Sharp	Downstream	N	43	44	49.02
Land Use	forest, mineral extraction		W	-115	55	21.72

Stream Bank Erosion Calculations

AVE. Bank Height:	2.4	ft
Total Inventoried Bank Length	2205	ft
Inv. Bank to Bank Length (LBB)	4410.0	ft
Erosive Bank Length	351	ft
Bank to Bank Eroding Seg. Length	702	ft
Percent eroding bank	0.16	%
Eroding Area	1684.8	ft^2
Recession Rate	0.035	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	2.65	tons/year/sample reach
Erosion Rate (ER)	6.35	tons/mile/year
Feet of Similar Stream Type	14737	ft
Eroding Bank Extrapolation	5393.78	ft
Total Stream Bank Erosion	**20.39**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	2116.8	ft^2
Bank erosion over sampled reach (E)	3	tons/year/sample reach
Erosion Rate (ER)	8	tons/mile/year
Feet of Similar Stream Types	14737.00	ft
Eroding bank extrapolation	6776.80	ft
Total stream bank erosion	**25.6**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0.5
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0.5
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	0.5
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	2.5
Recession Rate	0.035

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
6.35	**20.39**	**8**	**25.6**	**0**

Table F-7. Mores Creek Survey 11 Calculation Sheet.

Stream	Mores Creek	**Stream Segment Location**				
Section	Survey_11 – Grimes Creek to Mores Gaging Station			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	39	5.2
Field Crew	Darcy Sharp		W	-115	58	51.99
Data reduced by	Darcy Sharp	Downstream	N	43	38	56.85
Land Use	forest, mineral extraction		W	-115	59	11.87

Stream Bank Erosion Calculations

AVE. Bank Height:	2.4	ft
Total Inventoried Bank Length	1560	ft
Inv. Bank to Bank Length (LBB)	3120.0	ft
Erosive Bank Length	66	ft
Bank to Bank Eroding Seg. Length	132	ft
Percent eroding bank	0.04	%
Eroding Area	316.8	ft^2
Recession Rate	0.020	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.29	tons/year/sample reach
Erosion Rate (ER)	0.97	tons/mile/year
Feet of Similar Stream Type	47861	ft
Eroding Bank Extrapolation	4181.78	ft
Total Stream Bank Erosion	**9.03**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	1497.6	ft^2
Bank erosion over sampled reach (E)	1	tons/year/sample reach
Erosion Rate (ER)	5	tons/mile/year
Feet of Similar Stream Types	47861.00	ft
Eroding bank extrapolation	19768.40	ft
Total stream bank erosion	**42.7**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0.5
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	0.5
Deposition (0-1)	0.0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	1.0
Recession Rate	0.020

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
0.97	**9.03**	**5**	**42.7**	**0**

Table F-8. Grimes Creek Survey 1 Calculation Sheet.

Stream	Grimes Creek	**Stream Segment Location**				
Section	Survey_1 – Grimes Source to 1st road crossing			Degrees	Minutes	Seconds
Date Collected	8/9/2006	Upstream	N	43	58	46.42
Field Crew	Darcy Sharp		W	-115	42	27.22
Data reduced by	Darcy Sharp	Downstream	N	44	0	49.43
Land Use	forest, mineral extraction		W	-115	43	15.39

Stream Bank Erosion Calculations

AVE. Bank Height:	1.2	ft
Total Inventoried Bank Length	2892	ft
Inv. Bank to Bank Length (LBB)	5784.0	ft
Erosive Bank Length	0	ft
Bank to Bank Eroding Seg. Length	0	ft
Percent eroding bank	0.00	%
Eroding Area	0.0	ft^2
Recession Rate	0.020	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.00	tons/year/sample reach
Erosion Rate (ER)	0.00	tons/mile/year
Feet of Similar Stream Type	507816	ft
Eroding Bank Extrapolation	0.00	ft
Total Stream Bank Erosion	**0.00**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	1388.2	ft^2
Bank erosion over sampled reach (E)	1	tons/year/sample reach
Erosion Rate (ER)	2	tons/mile/year
Feet of Similar Stream Types	507816.00	ft
Eroding bank extrapolation	204283.20	ft
Total stream bank erosion	**220.6**	tons/year

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
0.00	**0.00**	**2**	**220.6**	**0**

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	0.0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	1.0
Recession Rate	0.020

Table F-9. Grimes Creek Survey 2 Calculation Sheet.

Stream	Grimes Creek	**Stream Segment Location**				
Section	Survey_2 – 1st road crossing to Cup Creek			Degrees	Minutes	Seconds
Date Collected	8/9/2006	Upstream	N	44	2	8.75
Field Crew	Darcy Sharp		W	-115	46	26.64
Data reduced by	Darcy Sharp	Downstream	N	44	2	31.56
Land Use	forest, mineral extraction		W	-115	47	11.52

Stream Bank Erosion Calculations

AVE. Bank Height:	2.7	ft
Total Inventoried Bank Length	1320	ft
Inv. Bank to Bank Length (LBB)	2640.0	ft
Erosive Bank Length	72	ft
Bank to Bank Eroding Seg. Length	144	ft
Percent eroding bank	0.05	%
Eroding Area	388.8	ft^2
Recession Rate	0.035	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.61	tons/year/sample reach
Erosion Rate (ER)	2.45	tons/mile/year
Feet of Similar Stream Type	298241	ft
Eroding Bank Extrapolation	32679.38	ft
Total Stream Bank Erosion	**138.97**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	1425.6	ft^2
Bank erosion over sampled reach (E)	2	tons/year/sample reach
Erosion Rate (ER)	9	tons/mile/year
Feet of Similar Stream Types	298241.00	ft
Eroding bank extrapolation	119824.400	ft
Total stream bank erosion	**509.6**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0.5
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	1.0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	2.5
Recession Rate	0.035

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
2.45	**138.97**	**9**	**509.6**	**0**

Table F-10. Grimes Creek Survey 2B Calculation Sheet.

Stream	Grimes Creek	**Stream Segment Location**				
Section	Survey_2B – Cup Creek to Buckskin Creek			Degrees	Minutes	Seconds
Date Collected	8/9/2006	Upstream	N	44	2	31.56
Field Crew	Darcy Sharp		W	-115	47	11.52
Data reduced by	Darcy Sharp	Downstream	N	44	2	36.52
Land Use	forest, mineral extraction		W	-115	47	52.65

Stream Bank Erosion Calculations

AVE. Bank Height:	1.3	ft
Total Inventoried Bank Length	3180	ft
Inv. Bank to Bank Length (LBB)	6360.0	ft
Erosive Bank Length	12	ft
Bank to Bank Eroding Seg. Length	24	ft
Percent eroding bank	0.00	%
Eroding Area	31.2	ft^2
Recession Rate	0.020	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.03	tons/year/sample reach
Erosion Rate (ER)	0.05	tons/mile/year
Feet of Similar Stream Type	42070	ft
Eroding Bank Extrapolation	341.51	ft
Total Stream Bank Erosion	**0.40**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	1653.6	ft^2
Bank erosion over sampled reach (E)	1	tons/year/sample reach
Erosion Rate (ER)	2	tons/mile/year
Feet of Similar Stream Types	42070.00	ft
Eroding bank extrapolation	18100.00	ft
Total stream bank erosion	**21.2**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	0.0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	1.0
Recession Rate	0.020

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
0.05	**0.40**	**2**	**21.2**	**0**

Table F-11. Grimes Creek Survey 3 Calculation Sheet.

Stream	Grimes Creek	**Stream Segment Location**				
Section	Survey_3 – Buckskin Creek to Granite Creek			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	57	24.4
Field Crew	Darcy Sharp		W	-115	51	32.38
Data reduced by	Darcy Sharp	Downstream	N	44	57	2.84
Land Use	forest, mineral extraction		W	-115	51	31.07

Stream Bank Erosion Calculations

AVE. Bank Height:	4.3	ft
Total Inventoried Bank Length	5631	ft
Inv. Bank to Bank Length (LBB)	11262.0	ft
Erosive Bank Length	366	ft
Bank to Bank Eroding Seg. Length	732	ft
Percent eroding bank	0.06	%
Eroding Area	3147.6	ft^2
Recession Rate	0.040	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	5.67	tons/year/sample reach
Erosion Rate (ER)	5.31	tons/mile/year
Feet of Similar Stream Type	40358	ft
Eroding Bank Extrapolation	5978.32	ft
Total Stream Bank Erosion	**46.27**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	9685.3	ft^2
Bank erosion over sampled reach (E)	17	tons/year/sample reach
Erosion Rate (ER)	16	tons/mile/year
Feet of Similar Stream Types	40358.00	ft
Eroding bank extrapolation	18395.60	ft
Total stream bank erosion	**142.4**	tons/year

Load Reduction Summary

Existing		Proposed		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
5.31	**46.27**	**16**	**142.4**	**0**

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0.5
Bank Condition (0-3)	0.5
Vegetative/Cover on Banks (0-3)	0.5
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	0.5
Total = Slight (0-4); Moderate (5-8); Severe (9+)	3.0
Recession Rate	0.040

Table F-12. Grimes Creek Survey 5 Calculation Sheet.

Stream	Grimes Creek	**Stream Segment Location**				
Section	Survey_5 – Granite Creek to Macks Creek			Degrees	Minutes	Seconds
Date Collected	9/12/2006	Upstream	N	43	46	46.7
Field Crew	Darcy Sharp		W	-115	58	40.52
Data reduced by	Darcy Sharp	Downstream	N	44	46	32.06
Land Use	forest, mineral extraction		W	-115	58	52.62

Stream Bank Erosion Calculations

AVE. Bank Height:	0.3	ft
Total Inventoried Bank Length	1800	ft
Inv. Bank to Bank Length (LBB)	3600.0	ft
Erosive Bank Length	0	ft
Bank to Bank Eroding Seg. Length	0	ft
Percent eroding bank	0.00	%
Eroding Area	0.0	ft^2
Recession Rate	0.020	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.00	tons/year/sample reach
Erosion Rate (ER)	0.00	tons/mile/year
Feet of Similar Stream Type	19944	ft
Eroding Bank Extrapolation	0.00	ft
Total Stream Bank Erosion	**0.00**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	216.0	ft^2
Bank erosion over sampled reach (E)	0	tons/year/sample reach
Erosion Rate (ER)	1	tons/mile/year
Feet of Similar Stream Types	19944.00	ft
Eroding bank extrapolation	8697.60	ft
Total stream bank erosion	**2.32**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	0.0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	1.0
Recession Rate	0.020

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
0.00	**0.00**	**1**	**2.3**	**0**

Table F-13. Grimes Creek Survey 6 Calculation Sheet.

Stream	Grimes Creek	**Stream Segment Location**				
Section	Survey_6 – Macks Creek to mouth			Degrees	Minutes	Seconds
Date Collected	8/9/2006	Upstream	N	43	46	32.06
Field Crew	Darcy Sharp		W	-115	58	52.62
Data reduced by	Darcy Sharp	Downstream	N	44	46	20.12
Land Use	forest, mineral extraction		W	-115	57	46.36

Stream Bank Erosion Calculations

AVE. Bank Height:	0.3	ft
Total Inventoried Bank Length	1500	ft
Inv. Bank to Bank Length (LBB)	3000.0	ft
Erosive Bank Length	0	ft
Bank to Bank Eroding Seg. Length	0	ft
Percent eroding bank	0.00	%
Eroding Area	0.0	ft^2
Recession Rate	0.020	ft/yr
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.00	tons/year/sample reach
Erosion Rate (ER)	0.00	tons/mile/year
Feet of Similar Stream Type	54058	ft
Eroding Bank Extrapolation	0.00	ft
Total Stream Bank Erosion	**0.00**	tons/year

Stream Bank Erosion Reduction Calculations

Eroding Area with Load Reductions	180.0	ft^2
Bank erosion over sampled reach (E)	0	tons/year/sample reach
Erosion Rate (ER)	1	tons/mile/year
Feet of Similar Stream Types	54058.00	ft
Eroding bank extrapolation	22223.20	ft
Total stream bank erosion	**6.0**	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	0
Bank Condition (0-3)	0
Vegetative/Cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	0
Channel Bottom (0-2)	1
Deposition (0-1)	0.0
Total = Slight (0-4); Moderate (5-8); Severe (9+)	1.0
Recession Rate	0.020

Load Reduction Summary

Existing		**Proposed**		
Erosion Rate (t/mi/y)	**Total Erosion (t/y)**	**Erosion Rate (t/mi/y)**	**Total Erosion (t/y)**	**Percent Reduction**
0.00	**0.00**	**1**	**6.0**	**#DIV/0!**

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Appendix G. Hydraulic Mine Gully Erosion Photos and Worksheets

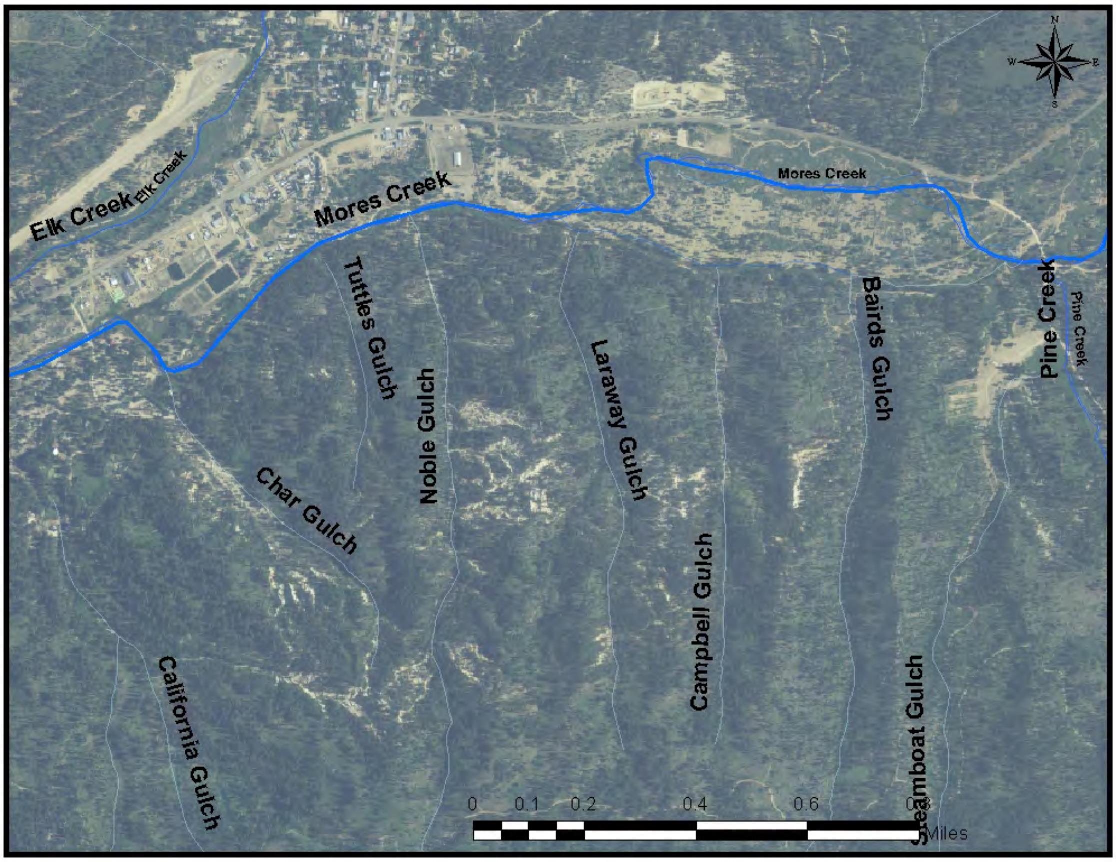

Figure G-1. Aerial Photograph of Hydraulically Mined Areas near Idaho City.

Figure G-2. Hydraulically Mined Area in Noble Gulch.

Figure G-3. Evidence of ditch constructed to convey water to hydraulically mined areas.

Figure G-4. Photo of Idaho City area in 1887.

Figure G-5. Hydraulic cannon being operated near Idaho City.

Figure G-6. Area used for calculation of stream erosion index (SEI) and Water Erosion Prediction Project (WEPP) model calibration.

Table G-1. Bairds Gulch Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**		
Section:	Bairds Gulch		*Upstream:*	43.81942	115.83145
Date Collected:		5/20/2008	*Downstream:*	43.82295	115.83275
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining	
Data Reduced By:	Same				

Streambank Erosion Calculations

Average Bank Height	47	ft
Total Inventoried Bank Length	963	ft
Inventoried Bank to Bank Length	1926	ft
Erosive Bank Length	963	ft
Bank to Bank Eroding Segment Length	1926	ft
Percent Eroding Bank	1	%
Eroding Area	90522	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	4182.1164	tons/year/sample reach
Erosion Rate (Er)	22929.984	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	1926	ft
Total Streambank Erosion	4182.1164	tons/year
Eroding Area (Acres)	2.078099174	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
22929.984	4182.1164	140	0.45458414	99.38944571

Streambank Erosion Reduction Calculations

Eroding Area	90522	ft^2
Eroding Area (sq Miles)	0.003247	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.4545841	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-2. Campbell Gulch Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**
Section:	Campbell Gulch		*Upstream:*
Date Collected:		5/20/2008	*Downstream:*
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**
Data Reduced By:	Same		Historic hydraulic mining

Streambank Erosion Calculations		
Average Bank Height	30	ft
Total Inventoried Bank Length	1069	ft
Inventoried Bank to Bank Length	2138	ft
Erosive Bank Length	1069	ft
Bank to Bank Eroding Segment Length	2138	ft
Percent Eroding Bank	1	%
Eroding Area	64140	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	2963.268	tons/year/sample reach
Erosion Rate (Er)	14636.16	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	2138	ft
Total Streambank Erosion	2963.268	tons/year
Eroding Area (Acres)	1.472451791	

Summary for Load Reductions				
Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
14636.16	2963.268	140	0.322098791	99.04346495

Streambank Erosion Reduction Calculations		
Eroding Area	64140	ft^2
Eroding Area (sq Miles)	0.0023007	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.3220988	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-3. Char Gulch Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Char Gulch		*Upstream:*	
Date Collected:		5/20/2008	*Downstream:*	
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining
Data Reduced By:	Same			

Streambank Erosion Calculations

Average Bank Height	44	ft
Total Inventoried Bank Length	1929	ft
Inventoried Bank to Bank Length	3858	ft
Erosive Bank Length	1929	ft
Bank to Bank Eroding Segment Length	3858	ft
Percent Eroding Bank	1	%
Eroding Area	169752	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	7842.5424	tons/year/sample reach
Erosion Rate (Er)	21466.368	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	3858	ft
Total Streambank Erosion	7842.5424	tons/year
Eroding Area (Acres)	3.896969697	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
21466.368	7842.5424	140	0.85246202	99.34781701

Streambank Erosion Reduction Calculations

Eroding Area	169752	ft^2
Eroding Area (sq Miles)	0.006089	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.852462	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-4. Gold Hill Survey Calculation Sheet.

Stream:	Elk Creek		**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Gold Hill		*Upstream:*	43.81942	115.83145
Date Collected:		5/20/2008	*Downstream:*	43.82295	115.83275
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining	
Data Reduced By:	Same				

Streambank Erosion Calculations

Average Bank Height	60	ft
Total Inventoried Bank Length	325	ft
Inventoried Bank to Bank Length	650	ft
Erosive Bank Length	325	ft
Bank to Bank Eroding Segment Length	650	ft
Percent Eroding Bank	1	%
Eroding Area	39000	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	1801.8	tons/year/sample reach
Erosion Rate (Er)	29272.32	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	650	ft
Total Streambank Erosion	1801.8	tons/year
Eroding Area (Acres)	0.895316804	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
29272.32	1801.8	140	0.195850528	99.52173248

Streambank Erosion Reduction Calculations

Eroding Area	39000	ft^2
Eroding Area (sq Miles)	0.0013989	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.1958505	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-5. Humbug Gulch Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Humbug Gulch		*Upstream:*	
Date Collected:		5/20/2008	*Downstream:*	
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining
Data Reduced By:	Same			

Streambank Erosion Calculations

Average Bank Height	36	ft
Total Inventoried Bank Length	1078	ft
Inventoried Bank to Bank Length	2156	ft
Erosive Bank Length	1078	ft
Bank to Bank Eroding Segment Length	2156	ft
Percent Eroding Bank	1	%
Eroding Area	77616	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	3585.8592	tons/year/sample reach
Erosion Rate (Er)	17563.392	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	2156	ft
Total Streambank Erosion	3585.8592	tons/year
Eroding Area (Acres)	1.781818182	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
17563.392	3585.8592	140	0.389772681	99.20288746

Streambank Erosion Reduction Calculations

Eroding Area	77616	ft^2
Eroding Area (sq Miles)	0.0027841	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.3897727	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-6. Noble Gulch Canyons Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Noble Gulch Canyons		*Upstream:* 43.81942	115.83145
Date Collected:		5/20/2008	*Downstream:* 43.82295	115.83275
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining
Data Reduced By:	Same			

Streambank Erosion Calculations		
Average Bank Height	83	ft
Total Inventoried Bank Length	4955	ft
Inventoried Bank to Bank Length	9910	ft
Erosive Bank Length	4955	ft
Bank to Bank Eroding Segment Length	9910	ft
Percent Eroding Bank	100	%
Eroding Area	822530	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	38000.886	tons/year/sample reach
Erosion Rate (Er)	40493.376	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	9910	ft
Total Streambank Erosion	38000.886	tons/year
Eroding Area (Acres)	18.88269054	

Summary for Load Reductions

Existing		Proposed		% reduction
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	
40493.376	38000.886	140	4.130588063	99.65426444

Streambank Erosion Reduction Calculations		
Eroding Area	822530	ft^2
Eroding Area (sq Miles)	0.0295042	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	4.1305881	tons/year

Recession Rate Calculation Worksheet

Slope Factor	**Rating**
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-7. Upper Noble Gulch Canyons Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Upper Noble Gulch Canyon		*Upstream:*	
Date Collected:		5/20/2008	*Downstream:*	
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining
Data Reduced By:	Same			

Streambank Erosion Calculations

Average Bank Height	42	ft
Total Inventoried Bank Length	1401	ft
Inventoried Bank to Bank Length	2802	ft
Erosive Bank Length	1401	ft
Bank to Bank Eroding Segment Length	2802	ft
Percent Eroding Bank	1	%
Eroding Area	117684	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2
Bank Erosion over Sampled Reach (E)	5437.0008	tons/year/sample reach
Erosion Rate (Er)	20490.624	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	2802	ft
Total Streambank Erosion	5437.0008	tons/year
Eroding Area (Acres)	2.701652893	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
20490.624	5437.0008	140	0.5909865	99.31676068

Streambank Erosion Reduction Calculations

Eroding Area	117684	ft^2
Eroding Area (sq Miles)	0.0042213	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.5909865	tons/sq mile/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-8. Noble Gulch Intermittent Stream Survey Calculation Sheet.

Stream:	Mores Creek		**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Noble Gulch		*Upstream:*	43.81942	115.83145
Date Collected:		5/20/2008	*Downstream:*	43.82295	115.83275
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	Historic hydraulic mining	
Data Reduced By:	Same				

Streambank Erosion Calculations

Average Bank Height	8.35	ft
Total Inventoried Bank Length	1425.6	ft
Inventoried Bank to Bank Length	2851.2	ft
Erosive Bank Length	792	ft
Bank to Bank Eroding Segment Length	1584	ft
Percent Eroding Bank	0.555555556	%
Eroding Area	13226.4	ft^2
Recession Rate	0.84	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	499.95792	tons/year/sample reach
Erosion Rate (Er)	1851.696	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	1584	ft
Total Streambank Erosion	499.95792	tons/year
Eroding Area (Acres)	0.303636364	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
1851.696	499.95792	666.61056	179.9848512	64

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	4761.504	ft^2
Erosion over sampled reach (with load reduction (20%)	179.98485	tons/yr/sample
Erosion Rate	666.61056	tons/mile/year
Feet of Similar Stream Type	0	ft
Eroding Bank Extrapolation (with reduction)	570.24	ft
Total Streambank Erosion	179.98485	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

Table G-9. Wet Creek Survey Calculation Sheet.

Stream:	Elk Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Wet Creek		*Upstream:*	
Date Collected:		5/20/2008	*Downstream:*	
Field Crew:	T. Herron, L Monnot		**Landuse and Notes:**	
Data Reduced By:	Same		Historic Hydraulic Mining	

Streambank Erosion Calculations

Average Bank Height	27	ft
Total Inventoried Bank Length	500	ft
Inventoried Bank to Bank Length	500	ft
Erosive Bank Length	500	ft
Bank to Bank Eroding Segment Length	500	ft
Percent Eroding Bank	1	%
Eroding Area	13500	ft^2
Recession Rate	0.84	
Bulk Density	110	lb/ft^2

Bank Erosion over Sampled Reach (E)	623.7	tons/year/sample reach
Erosion Rate (Er)	6586.272	tons/mile/year
Feet of similar stream type	0	ft
Eroding Bank Extrapolation	1000	ft
Total Streambank Erosion	623.7	tons/year
Eroding Area (Acres)	0.309917355	

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/sqmi/yr)	Total Erosion (t/yr)	% reduction
6586.272	623.7	140	0.067794413	97.87436656

Streambank Erosion Reduction Calculations

Eroding Area	13500	ft^2
Eroding Area (sq Miles)	0.0004842	mi^2
Erosion Rate	140	tons/sq mi/year
Total Erosion	0.0677944	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	3
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	15
Recession Rate	**0.84**

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Appendix H. Hydraulic Mined Areas WEPP Upland Erosion Calculation

Input used in the model to arrive at the sediment yield coefficients includes:

- Climate parameters at Idaho City
- Talmo sandy loam soils
- 50% slope, determined from GIS aerial photo interpretation
- GeoWEPP 25% vegetative cover high severity burn disturbed annually

With this input, the model simulates an annual average of precipitation (inches), runoff from rainfall (inches), runoff from snowmelt (inches), the upland erosion rate (tons/year) and the amount of sediment leaving the profile (tons/year). The acreages in each hydraulically-mined segment were determined from ArcGIS aerial photograph coverages.

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Appendix I. Watershed WEPP Upland Erosion Calculation

Input used in the model to arrive at the sediment yield coefficients includes:

- Climate parameters at Lucky Peak reservoir
- Sandy loam soils and moderate wind erodability group of 5, with 1 being most susceptible and 8 being least susceptible, according to SSURGO database for Boise-Mores watershed
- Average 19% (5º) slope from ArcGIS data
- “Disturbed WEPP” input
    - Mesic conifer forests covering 68% of the land area and xeric shrubland/bunchgrass community types covering 23% of the land area
    - Potential natural vegetation canopy cover for the watershed equaling 60% conifers, 20% tallgrass, and 20% bare ground for the mesic sites, and 25% shrubs, 25% tallgrass, and 50% bare ground for the xeric sites
    - Current canopy cover based on aerial photo interpretations equaling an average of 52% conifers, 30% short grass, and 18% bare ground on mesic sites, and 19% shrubs, 44% short grass, and 37% bare ground on xeric sites
    - Urban current canopy cover conditions for Placerville and Idaho City equaling 48% conifers, 8% short grass, and 44% bare ground
- “WEPP:Road” input
    - Dirt roads
        - Road at 4%, fill at 50%, and buffer at 25% gradient
        - Native road surface and low traffic level
        - Current condition is outsloped and rutted to simulate bare fill and ditches and background condition is outsloped and un-rutted to simulate vegetated, stabilized fill and buffer
    - Highway 21
        - Road at 2%, fill at 50%, and buffer at 25% gradient
        - Paved road surface and high traffic level
        - Current condition is outsloped and rutted to simulate bare fill and ditches and background condition is outsloped and un-rutted to simulate vegetated, stabilized fill and buffer

With this input, the model simulates an annual average of precipitation (inches), runoff from rainfall (inches), runoff from snowmelt (inches), the upland erosion rate (tons/year) and the amount of sediment leaving the profile (tons/year). The acreages in each land use were determined from ArcGIS data.

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Appendix J. Daily Sediment Loads

Daily Sediment Loads

Recently the Idaho Department of Environmental Quality has had to reevaluate TMDL targets and adjust targets to reflect daily loads. Historically, DEQ has assigned sediment loads and reductions on a yearly basis; however, recent guidance from EPA has focused on assigning daily loads.

It is well understood that pulses of pollutants, in this case sediment, occur during high discharge events. To better relate target sediment loads to this phenomenon, daily sediment loads were developed using stream flow data obtained from the United States Geological Survey (USGS). Stream flow information has been collected by the USGS on Mores Creek above Robie Creek near Arrowrock Reservoir, Idaho. USGS gauging station 13200000 has been collecting Mores Creek stream flow information since 1950. The Mores Creek hydrograph will be used to represent stream flows for the Mores and Grimes Creek watersheds for which this sediment TMDL was developed.

After determining the monthly flow average for the period of record, the percentage of flow occurring during each month throughout the year was calculated. The flow percentage for the months was then multiplied by the sediment load target and divided by the number of days in the month. The end result was a flow-based daily sediment load target for streams in the Boise-Mores Creek watershed.

Flows from March through June are the highest and consequently have the highest daily sediment load targets. Flows from August through October are the lowest as are the target sediment loads. Table J-1 outlines the daily sediment load targets by month.

Table J-1. Target Sediment Load (tons/day) for land use categories in the Mores Creek watershed.

	Percent flow	Forest	Urban	Unpaved Roads	Hwy 21	Mass Wasting	Stream Bank	Waste Water	Suction Dredge
Jan	0.0464	3.2212	0.0105	0.1929	0.0150	0.2797	3.2183	0.0120	2.4152
Feb	0.0684	5.2116	0.0169	0.3121	0.0242	0.4524	5.2067	0.0194	3.9075
Mar	0.1426	9.9115	0.0322	0.5936	0.0460	0.8605	9.9023	0.0368	7.4313
Apr	0.2645	18.9902	0.0617	1.1373	0.0882	1.6486	18.9726	0.0705	14.2382
May	0.2226	15.4661	0.0503	0.9262	0.0718	1.3427	15.4517	0.0574	11.5960
Jun	0.1183	8.4922	0.0276	0.5086	0.0394	0.7373	8.4844	0.0315	6.3672
Jul	0.0312	2.1681	0.0070	0.1298	0.0101	0.1882	2.1661	0.0081	1.6256
Aug	0.0119	0.8260	0.0027	0.0495	0.0038	0.0717	0.8252	0.0031	0.6193
Sep	0.0119	0.8535	0.0028	0.0511	0.0040	0.0741	0.8527	0.0032	0.6399
Oct	0.0175	1.2183	0.0040	0.0730	0.0057	0.1058	1.2172	0.0045	0.9134
Nov	0.0262	1.8777	0.0061	0.1125	0.0087	0.1630	1.8759	0.0070	1.4078
Dec	0.0386	2.6844	0.0087	0.1608	0.0125	0.2330	2.6819	0.0100	2.0127

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Appendix K. Distribution List

Bruce Baumhoff

Lynda Kuwahara

Cathie Nigro

Mark Rice

Oscar Baumhoff

Hana West, United States Forest Service BNF

Charlie Swearingen, United States Forest Service BNF

Russell Hicks, United States Forest Service BNF

Pam Elkovich, Trout Unlimited

Liz Woodruff, Idaho Rivers United

Butch Anderson, Water Treatment Plant Operator

Paul Drury ERO, Resources Water Resource Engineer

Terry Day, Boise County Commissioner

Russ Manwaring, West Central Highlands RC&D

John Roberts, Idaho Department of Lands

Leigh Woodruff, EPA

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Appendix L. Public Comments / Public Participation

All comments received during the 45 day Public comment period were provided by the U.S. Environmental Protection Agency.

Comment	Response	Page
Executive Summary		
Tables in the Executive Summary and Table 11 do not match the current 303d list.	Tables have been corrected to match the current 303d list	xxi-xxvi
Prior to finalizing the TMDLs we should confirm which AUs IDEQ believes are impaired for sediment and temperature. EPA would approve TMDLs for these waters, even if they are not currently included in the Idaho 303(d) list, but we would take no action on waters which IDEQ believes are not impaired, even though allocations have been established for them.	Added column in Table C to clarify water bodies that were impaired and those that were not impaired but were assigned load allocations due to their contribution to impaired waters.	xxi
Watershed Characterization		
Figure 15. This figure identifies problem culverts inventoried by the USFS. It would help if the text clarified whether inventories of blocked culverts has been conducted on State and private lands. If not, information in this figure might significantly underestimate the number of problem culverts in the watershed.	Clarified in the text that the only known culvert inventories were on U.S. Forest Service land. Also changed Figure 17 caption to reflect this.	31-33
Assessment Methods		
Turbidity. Only the single sample portion of the turbidity criteria is cited in the document (50 NTU above	Updated Table 14 and various places in text to include entire turbidity standard. Clarified at various places in the text that	44, Various

Comment	Response	Page
background). The portion of the criteria which specifies turbidity should not exceed background by more than 25 NTU for more than 10 consecutive days should also be described. Also, in many instances single measurements taken during BURP monitoring are used to evaluate compliance. Idaho's listing policy specifies that a minimum of two samples should be used for compliance purposes. Furthermore, BURP sampling is usually conducted at times when sediment levels are low. Fall and spring sampling are much more critical for turbidity levels. To determine whether turbidity criteria are being violated in the Mores Creek subbasin, we recommend more complete sampling during the late fall and spring.	compliance was not fully evaluated and recommended further sampling during high water periods in spring and fall.	
TSS. Similar comment as above – sampling during the summer is unlikely to identify TSS problems, which most commonly occur in the late fall and spring.	Clarified at various places in the text that compliance was not fully evaluated and recommended further sampling during high water periods in spring and fall.	Various
Chlorophyll a. Water column chlorophyll a has been sampled in a number of streams in the subbasin. This parameter is useful for evaluating nutrient and eutrophication issues in lakes and reservoirs, but is of limited value in free flowing streams. Instead, we recommend monitoring chlorophyll a in periphyton (algae attached to substrate) in streams as a more useful indicator of nutrient enrichment.	The water column chlorophyll a results were included because data was available although they may not be the most appropriate method. Periphyton samples are collected during BURP surveys. At this time, resources only allow lab processing of samples in areas where excess nutrients are a problem. There is no evidence of nuisance algae or macrophytes impairing beneficial uses in the subbasin.	Various
Assessment Methods		
E. coli criteria. In several places in the document the E.coli criteria are referred	Refined text at various places, removing MCL drinking water criteria.	Various

Comment	Response	Page
o as MCLs, which is a drinking water criterion, rather than a surface water quality criterion.	Added public swimming beach criteria to Table 14 and the section describing Lucky Peak.	
Bacteria - Reference is made to single sample E. coli concentrations of 406 cfu/100 ml and 576 cfu/100ml as being the criteria for primary and secondary contact recreation.	Refined text to explain these values were trigger pints for additional sampling to calculate a geometric mean and determine beneficial use support.	Various
Bacteria - An additional criteria in Idaho's standards of 235 cfu/100 ml applies to public swimming beaches, such as at Robie Creek.	Added public swimming beach criteria to Table 14 and the section describing Lucky Peak.	56
Bacteria - For all waters a 5 sample geometric mean criteria of 126 cfu/100ml applies.	Refined text and Table 14 to reflect this.	Various
Discussion of current §303(d) listed streams should reference the current, approved 2008 list (various places in text, and Table 11), rather than the previous 2002 list.	Corrected in Table 11 and various places in the text.	40, Various
Table 12 and Table B. Salmonid spawning is not identified as a designated or existing use for 1st and 2nd order Grimes Creek, but the document explains that it is an existing use,	Added Salmonid Spawning as an existing use for Grimes Creek in Table 12 and Table B.	xxi, 41, 93
Table 13. Drinking water is not identified as a designated or existing use for Elk Creek, but the document explains that it is an existing use, and the watershed has been designated as a public water supply by the Idaho Department of Environmental Quality (IDEQ) in the surface water quality standards.	Added Drinking Water Source as an existing use for Elk Creek in Table 13.	42
Section 2.3. The description of applicable water quality standards should also include turbidity, for which	WQS related to turbidity are described in Table 14. In addition, a discussion of the effects of turbidity on beneficial uses	44, 48

Comment	Response	Page
monitoring data is presented later in the document.	was added to Section 2.3, Pollutant/Beneficial Use Support Relationships.	
Lucky Peak Reservoir. E.coli data presented in T. 16 demonstrate that the geometric mean criteria (126 cfu/100 ml) was exceeded based on sample results from 6/13/06 – 7/18/06. The conclusion drawn is that these data do not warrant 303(d) listing, because bacteria levels are presumably the result of the presence of geese, and that E.coli levels "quickly" returned to safe levels. Regardless of the source, these data show that E.coli levels were elevated for nearly a five week period when the swimming area is actively used, including the 4th of July weekend which is usually the busiest of the year. At a minimum, this is clearly a public health risk to those using the area for swimming during that time, particularly infants and children. These levels should either be controlled, or actions taken to warn swimmers of the public health risk. Secondly, if geese are the source of elevated bacteria levels, the statement that "not due to human alteration of the natural system" should be further explained. The presence of significant goose numbers at the mouth of Robie Creek is likely due to the fact that a park with a lawn was constructed near the mouth of Robie Creek and Lucky Peak Reservoir. Habitat conducive to goose nesting was created by man's activities. While geese are known to nest on Mores Cr and other areas on Lucky Peak Reservoir, they are typically not in such concentrations as observed at the Robie Creek park. To conclude that E. coli numbers are not due to human activities appears	DEQ disagrees with your assertion that "human created habitat" is the cause of this exceedence. There are certainly no anthropogenic sources near the area and the tributary streams nearby showed no exceedences. It is also our understanding that signs have been posted during each incident. Additional data from 2007 and 2008 were obtained and added to this section. Coincidently, these annual exceedences occur during a proliferation of geese at the Robie Creek beach beginning about the middle of June. DEQ agrees that Lucky Peak Reservoir exceeded the criteria for primary contact recreation and we have included a Near Shore *E. coli* Bacteria TMDL. We also await any guidance EPA may have that would control this source of contamination.	56-58

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unfounded.		
Alternative means to control the source(s) may preclude the need to develop a TMDL, but in the mean time these data warrant inclusion of the waterbody in the next 303(d) list.	Lucky Peak Reservoir was found to not fully support primary contact recreation and DEQ has included a Near Shore *E. coli* Bacteria TMDL.	58
It is recommended that this information be shared with the Central District Health Department so that steps can be taken to protect swimmers during the upcoming summer.	This information was shared with the Central District Health Department and the beach is posted with signs at any time the WQS are violated.	56-58
Boise River. No BURP data are presented for Boise River AU 004_005. If data have not been collected we recommend that this AU be scheduled for BURP monitoring soon.	The need for large river BURP monitoring for AU 004_005 was added to this section and the Data Gaps table (Table 60)	69, 107
Thorn Creek. Discussion under Habitat Data indicates that a debris flow washed out parts of the road that parallels Thorn Creek. If the debris flow was in part a result of road construction or other human activities, it would not be appropriate to suggest that the sediment source is natural. The closed road which parallels the S.Fk. of Thorn Creek is being eroded by the creek, and continues to be a source of sediment loading to Thorn Cr.	We appreciate your concern and additional clarification was added to this section. The debris flow was caused by a historic rain-on-snow event, indicating this is a natural process. The road has been decommissioned by the BNF using proper BMPs. Surface fine data indicate that the area is recovering from the debris flow. We recommend that land management agencies continue erosion surveys to monitor this area and ensure beneficial uses are restored.	83-84
Granite Creek. AU 014_04 should be monitored using BURP protocols and should be assessed as a sediment source, due to the excessive bank erosion evident from the adjacent county road. Any available temperature data should be brought into the assessment, or if none has been collected, we recommended that continuous temperature monitoring be conducted in AU 014_04.	Language has been added to this section and the data gaps table (Table 60) recommending this AU for BURP sampling and continuous temperature monitoring.	105-107

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Data gaps. Table 60 Nutrients. For future sampling, we recommend periphyton chlorophyll a as a better measure of nutrient enrichment in streams rather than water column chlorophyll a, which is more commonly used in lakes and reservoirs. We also recommend that DEQ or BOR measure water column chlorophyll a in Arrowrock and Lucky Peak Reservoirs during critical summer months to evaluate eutrophication.	We currently collect periphyton samples but reserve allocation of resources for sample processing in areas where nutrients appear to be a concern. The need for processing was added to Table 60. Monitoring Chlorophyll a in Lucky Peak and Arrowrock Reservoirs was added to Table 60.	107
Data gaps. Table 60 Metals. Any data available on mercury concentrations in water should be brought into the assessment, due to its use in historic gold mining in the subbasin. Fish tissue sampling for mercury in major streams and Lucky Peak and Arrowrock reservoirs is recommended for the same reason.	All available data for heavy metals was included in this assessment. We understand your concern about legacy sources of heavy metal contamination. Action has been taken by DEQ Waste & Remediation staff where it is warranted. Future studies may include funding for more complete sampling. The need for water column and fish tissue sampling is stated in Table 60.	107
Pollutant Source Inventory		
Belshazaar mine. Sediment runoff from waste and tailings piles is discussed at the top of this page. Since these are point sources, they should be identified as sources in the sediment TMDL and assigned wasteload allocations.	The mine site was assessed by DEQ Waste & Remediation staff and a Preliminary Assessment has been submitted to EPA. A comprehensive erosion survey was not completed. Waste and Remediation staff that visited the site felt that sediment runoff was negligible.	109
NPDES facilities. Runoff from mine waste and tailings piles is considered to be a point source, and should receive a wasteload allocation.	See above response	110

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NPDES facilities. Should any new point source be proposed in the future, unless a wasteload allocation is included in the TMDL now, the TMDL will need to be modified to include a WLA for future facilities, including review and approval by EPA.	Temperature and sediment allocations were included in the TMDL for future waste water treatment facilities.	110
NPDES facilities. p. 113. Suggest rewording as follows: "It is anticipated that EPA issue a general NPDES permit for suction dredge operators …."	Changed as recommended.	112
Temperature. Timber harvest in the riparian zone on private, State and USFS lands, and grazing activity in selected locations is also a likely cause of riparian shade loss, and hence increased water temperature in the subbasin.	Text was revised to include this.	113
Flow and Habitat Alteration. The presence of flow diversions in the subbasin, such as in Elk Creek, also appear to be a factor causing impairment.	Text was revised to include this.	113
Data gaps. See comments above.	Text revised to include related items mentioned in Data Gaps (Table 60).	114
Sediment Total Maximum Daily Load		
Design conditions. Appropriate maintenance of road surfaces is another BMP which could reduce erosion from roads (last sentence, third paragraph).	This BMP was added.	122
Target selection. "The maximum threshold for natural condition stream bank stability potential is described as 80% or greater …" This statement is	Suggested changes were made.	122

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confusing as bank stability can be 100% naturally in some places. It might be appropriate to say that on average 80% bank stability is assumed to equate to natural conditions, based on Overton, 1995.		
80% bank stability. Where bank stability is >80% currently, current stability should be target. Suggesting it is okay for sediment to increases, given that the system will likely continue to be overloaded for decades, does not seem reasonable.	Clarified that for banks that currently have greater than 80% stability, then the target is to maintain existing stability. The 80% stability target accommodates natural disturbances that create temporarily unstable banks, such as large precipitation events or wildfires.	123, Various
Load Capacity, second paragraph. 80% bank stability is considered a target, but the load capacity would be the sediment load which results from 80% stable banks.	This section was revised for clarification.	123
The LC discussion should include an explanation of why natural background loading plus suction dredge loading would achieve WQS. Much of the discussion of p 133 about suction dredging should probably be included in the LC section in order to establish the rationale for LC.	Language was added to better explain the how the suction dredge allocation was calculated and why WQS will be met.	125
A table which quantifies the LC for the entire watershed, including suction dredge sources, should be included in this section to document the LC	Suction dredging was added to Table 62 to help clarify the total load capacity.	125
A target of natural background sediment is the concept suggested for establishing the load capacity. It would help if the document included a table which inventoried all the sediment sources, and included estimates of the natural loading, so that the overall sediment load for the subbasin, which represents the LC, is clear. This table could also be repeated (or expanded)	Suggested table (Table 67) was added in this section and another similar table including WLA was added at the end of the load capacity and sediment TMDL (Table 72).	123-130

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later in the document to show how the nonpoint source and point source allocations for each source will achieve the LC.		
"Natural background load estimates for stream bank erosion have been derived for each assessment unit in Mores Creek and Grimes Creek". How were estimates of natural background and current stream bank erosion determined for other streams in the subbasin?	Other streams in the basin were included through extrapolation of inventory erosion rates through the entire AU. Text was revised to clarify this.	124
How were stream bank erosion rates extrapolated to non-inventoried AU? Either extrapolate from similar AUs or explain the data gap and resulting underestimate of the sediment budget.	Bank erosion inventories were only completed in AUs that were thought to be impaired by sediment. DEQ recognizes that there is a data gap in the overall sediment budget by not including the sediment load contributed to Mores and Grimes Creeks by non-impaired AUs. In the future, other AUs may be inventoried for stream bank erosion as resources allow and all streams contributing sediment to listed AUs in the subbasin should meet the target of 80% bank stability.	124
Table 63 and accompanying text. Stream bank erosion LC values should be revised to reflect 80% or greater bank stability if current stability exceeds 80%.	Clarification was added. Please see above comment response.	126-129
Table 68. Some description of which roads or roads layer was used in the WEPP analysis would be helpful. It would also be helpful to know which roads were not included in the analysis, to put the results in perspective. Regarding WEPP analysis of road related sediment, did the analysis include private subdivision roads? It might not be practical to complete an analysis of all such roads, but it would	The description was revised in text to clarify this. GRAIP analysis results from Wilderness Ranch Subdivision are not yet available.	128-130

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be valuable to show such results for selected locations, since these roads may contribute high sediment loading, as suggested on p. 35. For example, Wilderness Ranch is in the process of completing a GRAIP analysis, and these results might be available to incorporate in the analysis.		
Road layer. Layer likely underestimates existing road network, especially private roads, based on experience working with USFS in that area. Should be explained in the document and could require larger MOS.	Additional information describing the road layer was added. A potential data gap is acknowledged.	128-130
Table 69. It's unclear how the stream bank erosion estimates in this table were derived, since they differ from values presented in Tables 61, 62.	Clarification of the load capacity and existing load estimates were added to the text. Erosion inventories from all AU's were added to the load capacity and allocation tables to account for all measured sources of streambank erosion sediment load.	129
The LA section should include specific numeric allocations to all non-point sediment sources in the watershed, including hydraulically mined areas.	The load allocation range from the WEPP and Stream Bank Erosion Inventory methods was replaced with the sediment load estimate from the WEPP erosion model.	133-134
The LA to roads should be discussed more thoroughly. They are the largest controllable source, although current estimate shows they contribute less than stream bank erosion.	Suggested discussion was added to the text.	134
Wasteload allocation. An allocation for sediment delivered from the Belshazaar mine should be included.	No waste load allocation can be made. See comments above.	130
Last sentence should be revised to reflect that dredge allocation results in a reduction in dredge days from 210 to	Made suggested changes to this paragraph and the WLA table.	138

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155. Suggest specifically state number of dredge days in the allocation table.		
Reference to natural background provisions in the second to last paragraph may not be appropriate in the sediment TMDL, since they reference temperature requirements.	Text was revised to correct the error.	130
Wasteload allocation for suction dredges mining. Second paragraph. This paragraph appears to have been copied from the SF Clearwater TMDL, where significant evaluation of suction dredge impacts has occurred over a number of years. If similar evaluation of impacts has not been conducted in the Mores Creek subbasin, this paragraph may need to be modified.	This paragraph was removed.	131
Since the LC of the TMDL is natural sediment loading, how does the loading from suction dredging fit within the LC? Having a table which lists all the sediment sources and their allocations showing how they sum to the LC would help.	Table 72 was added to show all sediment sources and allocations clearly.	137
Suction dredge loading calculated and allocated to Grimes Creek (1568 tons), and Elk Creek (471 tons) seem very high when compared to the overall natural load capacity of 2,711 tons for the subbasin (p. 136). Significant reductions in loading from suction dredging would appear to be needed to approach the LC. Elk Creek allocations seem particularly excessive, considering that Idaho City uses Elk Creek as a drinking water supply, and Idaho City must regularly impose boil water orders because their filters are incapable of adequately removing	Allocations were modified based upon suggestion of using SF Clearwater TMDL as a model.	131-135

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turbidity in source water. Wilderness Ranch also operates a surface water treatment facility drawing water directly from Mores Creek, just upstream from Robie Creek. Every consideration to minimize sediment input from all sources should be considered to protect these drinking water supplies.		
Another approach to developing allocations for Mores Creek may be to use the allocation structure from the SF Clearwater TMDL, where there is a reasonable understanding of suction dredge impacts, and use that information to derive flow proportional allocations for Mores Cr, Grimes Cr, and Elk Cr.	Allocations were modified based upon suggestion of using SF Clearwater TMDL as a model.	131-135
The time frame for allocations appears to conflict with periods of salmonid spawning. The spawning and incubation period for redband trout is Mar 15 – July 15, bull trout is September through October, whitefish are late fall spawners, and kokanee is September 1 – May 1 (IDEQ, 2002), although kokanee are known to migrate up Mores Creek by mid-August. We would recommend that the dredging allocations only apply during times when salmonid spawning and egg incubation does not occur. IDEQ may want to consider only allowing suction dredging between July 15 – August 15, a time window which has been established on the SF Clearwater to protect salmonid spawning and egg incubation.	It is recommended in this section that future dredging seasons avoid salmonid spawning and incubation periods based upon guidance from IDFG Regional fishery managers.	134

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The suction dredge seasons do not match critical season for salmonid spawning	Language was added to the load allocation table specifying the dates that discharge from suction dredging could enter the water body.	134
The formula at the top of the page should result in 157 tons rather than tons/day (units cancel out).	Changed as suggested.	132
Table 71. See comments above. Also, allocations should be expressed as tons, rather than tons/day. It might also help to show these in yd3, since these units relate more directly to how suction dredges are operated.	Changes made as suggested above. Loads were included in tons/year and also in yd3 to be consistent with other load allocations in the TMDL and be easily applied to suction dredges.	132-135
Margin of safety. Bank erosion from many streams may not have been accounted for in the TMDL, so it's unclear that bank erosion estimates contribute to the margin of safety.	These streams were accounted for through extrapolation of erosion rates throughout the AU.	136
Its not clear how including wasteload allocations in the TMDL is a margin of safety, since these sources currently exist, and proposed allocations may not be protective enough.	The reserve for future wastewater treatment facilities is a margin of safety.	140
Several elements of the MOS discussion are not actually MOS, but merely meeting beneficial uses. Also, given that roads and stream bank erosion are likely underestimated a greater margin of safety may be in order.	Removed these elements from the MOS discussion. Acknowledged the data gap and explained potential differences in load estimates.	140
Background. This paragraph indicates that natural background is 2,711 tons/year which is the goal of the TMDL. It is unclear where this estimate originates, and it appears that the sum of all the allocations exceeds this value.	The natural background sediment load stated in this paragraph was adjusted to include suction dredging and an upper limit to accommodate the range of sediment estimated load for hydraulic mining.	140

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Table 73 and 74 should be combined to list all nps LAs and ps WLAs, in order to clearly show how they sum to the LC as described in revised table in the LC section	Tables were combined as suggested.	141
Temperature Total Maximum Daily Loads		
Revised shade curves for most of the State have been developed by IDEQ and EPA. If there is sufficient time, these improved curves could be used to set targets in the current TMDL, rather than waiting to update the TMDL at the next 5 year TMDL review.	Revised shade curves were only recently developed by DEQ. The work for this TMDL was already complete. DEQ may update at the 5 year TMDL review if resources allow.	146
Load allocations. Major tributaries were evaluated and assigned target shade levels. We recognize that resources don't allow identifying shade targets for all tributaries, but in order to achieve natural stream temperatures in Mores Cr, all tributaries will need to achieve natural shade levels. To address this need, one approach is to include a narrative allocation stating that all other tributaries must also achieve natural riparian shade in order to achieve natural stream temperatures.	A narrative target for all tributaries is included in the text.	162
Wasteload allocation. Currently there are unpermitted point source discharges in the subbasin, including suction dredgers and mine tailings discharge at Belshazaar mine. The document would be more complete if it identified these sources, and explained why they are not receiving WLAs for temperature, for example, it could be explained that they are not expected to be a source of heat loading.	Language was added that these sources are not expected to be a source of heat loading.	164
Regarding future point source discharges, the TMDL will need to be	Language was added that creates a reserve for growth for future waste water	164

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re-opened in the future to accommodate new point sources, unless a reserve allocation is set aside for both temperature and sediment, and a process describing how the reserve will be assigned is included in the TMDL and approved by EPA. We would be glad to discuss details of a reserve allocation process prior to finalizing the TMDLs.	treatment facilities.	
Construction stormwater wasteload allocations. Construction stormwater and the federal permitting process for stormwater are discussed, but it is not clear what allocation has been assigned to this industry.	No numeric allocation was assigned. Construction stormwater discharge is considered in compliance with the TMDL so long as appropriate permits and BMP’s are applied.	168