Lolo Creek Tributaries Subbasin Assessment and Total Maximum Daily Load (HUC 17060306)

Final

Department of Environmental Quality
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Acknowledgments

The Idaho Department of Environmental Quality extends our sincere gratitude to the Lolo/Ford's Creek Watershed Advisory Group. Their participation was critical to the completion of this document. The result is a water quality improvement plan that allows for a focused and achievable cooperative implementation approach to meeting the goals and requirements of the Idaho State Water Quality Standards and the federal Clean Water Act.

The Idaho Department of Environmental Quality would also like to thank the Clearwater Soil and Water Conservation District, the Idaho Soil and Water Conservation Commission, the Idaho Department of Fish and Game, the Nez Perce Tribe and the Clearwater National Forest personnel. Watershed data and information made available through these agencies was critical to the development of the TMDLs. Mike Hoffman, formerly with the Idaho Soil and Water Conservation Commission and currently with the Clearwater SWCD, deserves our special thanks for all of his hard work implementing water quality improvement projects in the Lolo Creek Subbasin over the last 20 years.

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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

IASCD Idaho Association of Soil Conservation Districts

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

mi mile

mi^2 square miles

MBI Macroinvertebrate Biotic Index

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

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

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 standard

Executive Summary

The federal Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. Pursuant to Section 303 of the Clean Water Act, states and tribes 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 Clean Water Act 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. Idaho's list is called Section 5 of Idaho's Integrated Report 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 three water bodies with a combined five assessment units in the Lolo Creek watershed (HUC #17060306) that are water quality limited and listed in Section 5 of Idaho's 2008 Integrated Report as not supporting beneficial uses. This subbasin assessment (SBA) and TMDL analysis have been developed to comply with Idaho law and the federal Clean Water Act. The first part of this document, the SBA, describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions. The TMDLs quantify existing pollutant loads and allocate responsibility for load reductions needed to meet state water quality standards.

Subbasin at a Glance

Lolo Creek is a 6th-order tributary of the Clearwater River (HUC #17060306), and forms the boundary between Idaho and Clearwater Counties in north-central Idaho. The creek flows primarily southwest, from an elevation of 5,240 feet, just below the summit of Hemlock Butte, to 1,118 feet at the mouth where it enters the Clearwater River at river mile 54, near the town of Greer. It drains a watershed of approximately 156,000 acres (244 square miles). A 24-mile stretch of Lolo Creek, from the mouth to the Clearwater National Forest (CNF) boundary, flows through a steep, V-shaped canyon. The canyon is 1,500 feet deep in the lower portion and approximately half this depth at the Clearwater National Forest boundary. Most of the canyon is dominated by conifer forest, cliffs, rock outcrops, and talus slopes. Riparian vegetation is primarily limited to the mouth and the upper half of the canyon. The watershed above the canyon is comprised of open meadows interspersed with gently sloping, mostly forested upland.

In the western portion of the watershed, major tributary drainages include Jim Brown Creek, which flows into Musselshell Creek; eastern portion tributary drainages include Yoosa and Eldorado Creeks; and the major tributaries of the southern portion are Yakus and Crocker Creeks.

The Lolo Creek Subbasin is a sparsely populated area with no incorporated cities. The dominant land uses are and were historically forestry, road building, grazing, placer mining, and recreational activities. Land ownership varies throughout the watershed. The upper watershed is public land, managed by the CNF. The middle portion of the watershed is comprised of state endowment land managed by the Idaho Department of Lands and private land owned and managed by Potlatch Corporation. Various parcels of privately owned, non-industrial lands reside in the middle section of the subbasin as well. The lower watershed is primarily managed by the U.S. Bureau of Land Management, while smaller portions are owned by various private individuals (non-industry). The lower four miles of Lolo Creek is located within the current boundary of the Nez Perce tribal reservation (Figure A).

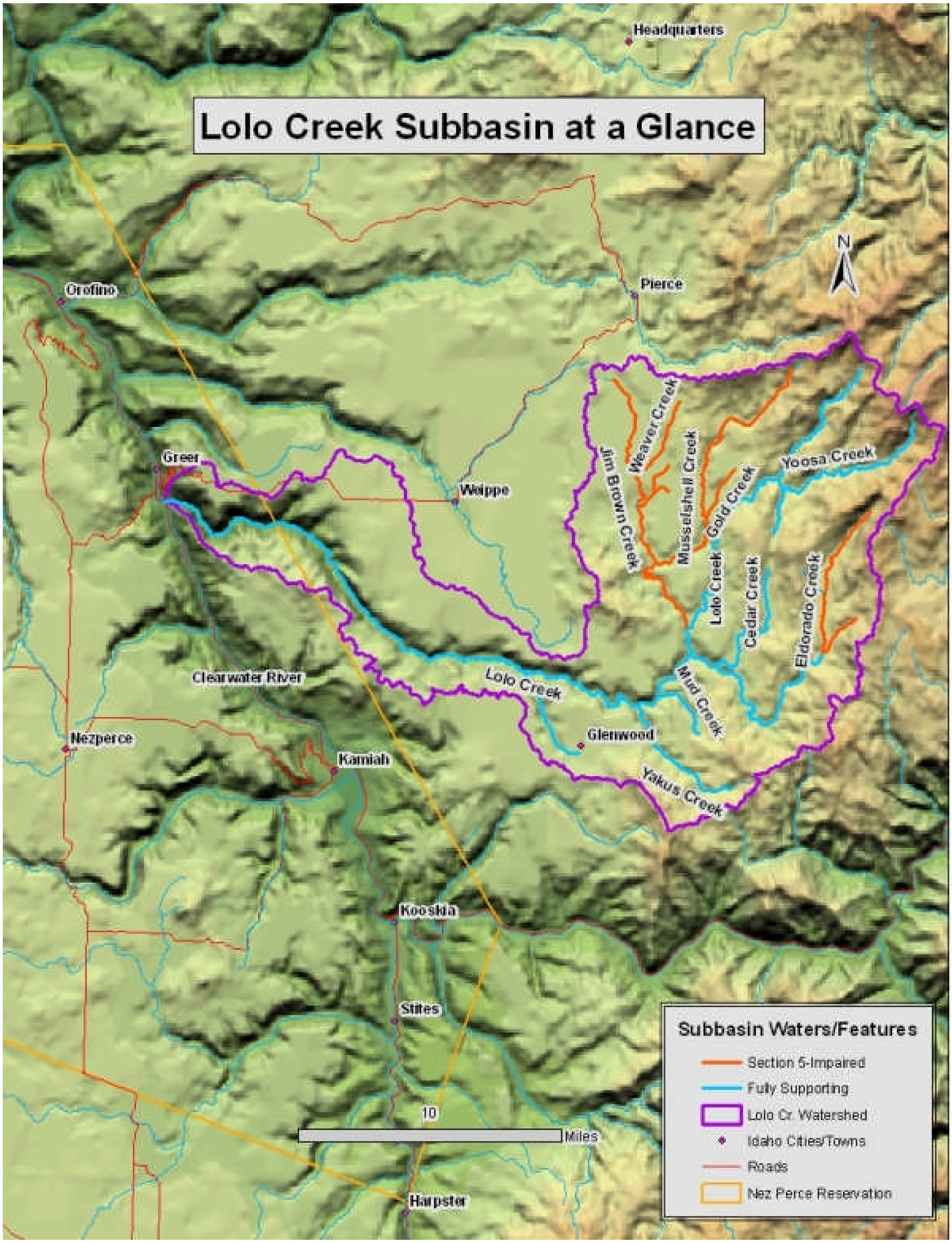

Figure A. Lolo Creek Subbasin at a Glance.

Key Findings

Three main tributaries to Lolo Creek—Eldorado Creek, Jim Brown Creek, and Musselshell Creek—show impairment and lack of support of their beneficial uses (Table A). This report focuses on the five assessment units on these three water bodies where Beneficial Use Reconnaissance Program (BURP) data indicate the biological assemblage and habitat have been degraded; or where ambient monitoring data collected during 2003-2004 show impairment by TMDL pollutants.

Table A. 2008 Integrated Report Section 5 waters.

Water Body Name	Assessment Unit ID Number	Listing	Pollutants	Listing Basis
Eldorado Creek	ID17060306CL029_02	2nd-order segments	Unknown	BURP data
Jim Brown Creek	ID17060306CL031_02 & 031_03	Headwaters to mouth	Bacteria, Nutrients, Sediment, Temperature	Carry Over From 1994 303(d)
Musselshell Creek	ID17060306CL032_02 & 032_03	Headwaters to mouth	Unknown	BURP data

Existing Beneficial Uses for Lolo Creek and its tributaries include cold water aquatic life, secondary contact recreation, and salmonid spawning (Table B). Water quality must be sufficiently maintained to provide for these uses.

Table B. Lolo Creek tributaries beneficial uses.

Stream Name	Listing	Assessment Unit	Beneficial Uses [a]	Type of Use
Eldorado Creek	Source to mouth	ID17060306CL029_02	COLD, SCR, SS	Existing
Jim Brown Creek	Source to mouth	ID17060306CL031_02 & 031_03	COLD, SCR, SS	Existing
Musselshell Creek	Source to mouth	ID17060306CL032_02 & 032_03	COLD, SCR, SS	Existing

[a] COLD – cold water aquatic life, SS – salmonid spawning, SCR – secondary contact recreation,

Starting in June 2003, DEQ water quality personnel initiated a year-long, routine water quality monitoring regimen which established monitoring stations in several AUs throughout the subbasin. Data collected at these monitoring stations was then analyzed against water quality standards in order to assess instream conditions and determine if TMDLs were necessary.

These monitoring stations were monitored every two weeks (as weather allowed) for the following parameters and pollutant concentrations: instantaneous stream temperature; total suspended solids (TSS); *E. coli* bacteria; dissolved oxygen, ammonia, nitrite+nitrate as nitrogen (NO_2+NO_3-N), and total phosphorus; instantaneous stream flow; and specific conductance.

To bolster the nutrient concentration data collected, 24-hour diurnal dissolved oxygen (DO) measurements were conducted on Jim Brown Creek and Musselshell Creek in August 2009.

E. coli and DO concentrations measured during the year-long sampling effort did not show that numeric criteria were exceeded. Where narrative criteria were used for sediment, the measured concentrations fell within ranges considered to support a good fishery. Where narrative criteria were used for nutrients, average nutrient concentrations were similar to eco-regional criteria recommendations reflective of reference conditions.

Instantaneous temperature measurements exceeded the salmonid spawning criteria, especially if the stringent bull trout requirements are applied. CNF reports show seven day running mean temperatures exceeded salmonid spawning criteria for short durations on upper and lower Eldorado Creek. Instantaneous temperature measurements taken during the monitoring regimen exceeded the maximum daily maximum temperature criterion during salmonid spawning and rearing season. Measurements of existing shade taken on seven stream segments in the subbasin showed that all the listed streams lack shade when compared to desired targets for their riparian vegetation types and bankfull widths. Dollar Creek, Eldorado Creek and Musselshell Creek have some relatively good quality segments with respect to shade and other segments that need improvement. Jim Brown Creek consistently lacks substantial shade.

A potential natural vegetation (PNV) temperature TMDL that calls for more shade on upper Eldorado Creek, Jim Brown Creek, and Musselshell Creek is included in section 5 of this document. Future restoration projects aimed at reducing stream temperature should help stabilize the banks and reduce direct access to the stream by cattle. These measures will help further reduce the amount of sediment, nutrients and *E. coli* conveyed to these streams. Table C shows the streams for which temperature TMDLs were developed.

Table C. Streams and pollutants for which TMDLs were developed.

Stream	Assessment Unit	Pollutant(s)
Eldorado Creek	ID17060306CL029_02	Temperature
Jim Brown Creek	ID17060306CL031_02 & 031_03	Temperature
Musselshell Creek	ID17060306CL032_02 & 032_03	Temperature

Table D presents the recommended changes that will be made to Section 5 of Idaho's Integrated Report (the 303(d) list) as a result of completing this SBA/TMDL. These changes will be incorporated during the creation of the next version of the Integrated Report which will become the current version at that time.

Table D. Summary of assessment outcomes.

Stream Name	Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Eldorado Creek	ID17060306CL029_02	Unknown	Temperature Yes	Move to Section 4a; remove unknown	SBA/TMDL completed:
Jim Brown Creek	ID17060306CL031_02 & 031_03	Temperature, Nutrients, Bacteria, Sediment	Temperature Yes	Move to Section 4a for Temperature; remove Nutrients, Sediment, Bacteria from the list	SBA/TMDL completed; Nutrients, Sediment and Bacteria meeting WQS
Musselshell Creek	ID17060306CL032_02 & 032_03	Unknown	Temperature Yes	Move to Section 4a; remove unknown	SBA/TMDL completed;

Public Participation

DEQ anticipates the finalization of this TMDL with the assistance of the Lolo/Ford's Creek Watershed Advisory Group (WAG). On a DEQ recommendation, the Clearwater Basin Advisory Group voted to allow the existing Jim Ford Creek WAG to provide advice and consultation on the Lolo Creek Tributaries SBA/TMDL. Members of the WAG represent agriculture, local government, federal government, the Nez Perce Tribe, recreation, forestry, environmental, mining, livestock and residential interests. Through the course of meetings and follow-up correspondence the WAG provided their consent to complete this TMDL.

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 water. 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. Idaho calls this list Section 5 of Idaho's Integrated Report. 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 TMDL addresses the three water bodies that together contain the five assessment units (AUs) in the Lolo Creek Subbasin that were listed as not meeting water quality standards in Idaho's 2008 Integrated Report (IDEQ 2008). The subbasin assessment and TMDL analysis have been developed to comply with Idaho law and the federal Clean Water Act. The TMDL describes the water quality data used to estimate loads, and identifies estimates of existing loads, allowable loads, and load reductions needed to meet Idaho water quality standards.

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 U.S. Environmental Protection Agency assumes the dominant role in defining and directing water pollution control programs across the country. The Department of Environmental Quality (DEQ) is responsible for compliance with the Clean Water Act in Idaho. The U.S. Environmental Protection Agency is responsible to ensure Idaho's water quality program complies with the Clean Water Act.

Section 303 of the Clean Water Act requires the Department of Environmental Quality to adopt water quality standards and to review those standards every three years. Idaho's water quality standards must be approved by the Environmental Protection Agency. The Department of Environmental Quality must monitor state waters to identify those that do not meet state water quality standards. For each water body that does not meet water quality standards, a total maximum daily load must be completed to restore the water body and comply with the standards.

This subbasin assessment identifies water quality status, pollutant sources, and control actions to date in the Lolo Creek watershed. While the subbasin assessment is not a requirement of the total maximum daily load, the Department of Environmental Quality performs the assessment to ensure the section 5 listing is up to date and accurate. A total maximum daily load is an estimate of the maximum amount of pollutants that the water body can absorb and still meet water quality standards. In practice, the term total maximum daily load has also come to mean the document in which this information is presented.

Idaho water quality standards are comprised of various beneficial uses designated for specific water bodies and corresponding numeric and narrative physical and chemical limits or criteria that must be met to allow the water body to support the uses. These beneficial uses are identified in the Idaho water quality standards. The standards include the designated use or uses for the water, the necessary criteria for protecting those uses, and the prevention of water quality degradation through antidegradation provisions.

The state may 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, salmonid spawning, seasonal cold water, warm water, 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 has not yet been classified (i.e., beneficial uses have not yet been explicitly designated for the water body), then cold water and primary contact recreation are used as additional default designated uses when water bodies are assessed.

Conducting 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., 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

Lolo Creek is a 6th-order tributary of the Clearwater River (part of hydrologic unit code [HUC[1]] 17060306), and forms the boundary between Idaho and Clearwater Counties in north-central Idaho. The creek flows primarily southwest, from an elevation of 5,240 feet, just below the summit of Hemlock Butte, to 1,118 feet at the mouth where it enters the Clearwater River at river mile 54, near the town of Greer. It drains a watershed of approximately 156,000 acres (244 square miles). The Lolo Creek mainstem is approximately 42 miles long. In the 24-mile stretch from the mouth to the Clearwater National Forest boundary, Lolo Creek flows through a steep, V-shaped canyon. The canyon is 1,500 feet deep in the lower portion of this stretch and approximately half this depth at the Clearwater National Forest boundary. Most of the canyon is dominated by conifer forest, cliffs, rock outcrops and talus slopes. Riparian vegetation is primarily limited to the mouth and the upper half of the canyon. The watershed above the canyon is comprised of open meadows interspersed with gently sloping, mostly forested upland.

In the western portion of the watershed, major tributary drainages include Jim Brown Creek, which flows into Musselshell Creek; eastern portion tributary drainages include Yoosa and Eldorado Creeks; and the major tributaries of the southern portion are Yakus and Crocker Creeks.

The Lolo Creek Subbasin is a sparsely populated area with no incorporated cities. The dominant land uses are and historically were forestry, road building, grazing, placer mining, and recreational activities. Land ownership varies throughout the watershed. The upper watershed is public land, managed by the Clearwater National Forest. The middle portion of the watershed consists mostly of state endowment land managed by the Idaho Department of Lands and private lands owned and managed by Potlatch Corporation (Potlatch Corp.). Various parcels of privately owned, non-industrial lands reside in the middle section of the subbasin as well. The lower watershed is primarily managed by the U.S. Bureau of Land Management (BLM), while smaller portions are owned by various private individuals (non-industry). The lower four miles of Lolo Creek is located within the current boundary of the Nez Perce tribal reservation (Figure 1).

[1] Although HUC stands for the *code* that identifies a hydrologic unit, it has also come to mean the hydrologic unit itself (e.g., a basin, watershed, subbasin, or subwatershed).

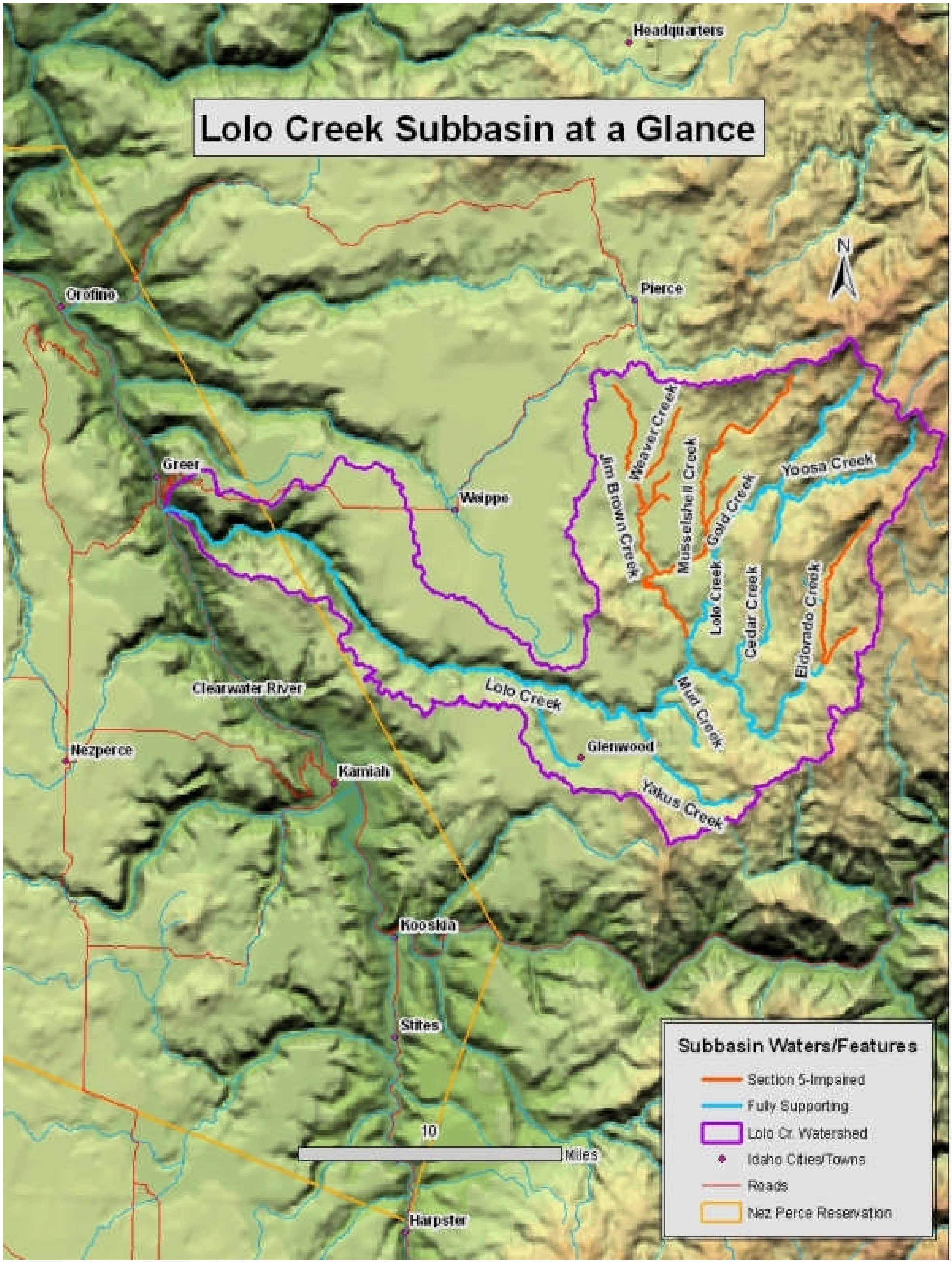

Figure 1. Lolo Creek Subbasin.

Climate

North-central Idaho is dominated by Pacific maritime air masses and prevailing westerly winds. Over 85% of the annual precipitation occurs during late fall, winter, and spring months. Cyclonic storms, consisting of a series of frontal systems moving east, produce long-duration, low-intensity precipitation during this period of the year. In winter and spring, this inland maritime regime is characterized by prolonged gentle rains, fog, cloudiness, and high humidity, with deep snow accumulations at higher elevations. Winter temperatures are often 15° to 25° F warmer than other continental locations of the same latitude.

Precipitation patterns change with elevation, with average precipitation ranging from 25 inches in Orofino (elevation 1,029ft.), to 43 inches at Pierce (elevation 3,188ft), to more than 70 inches at Hemlock Butte (elevation 6053 ft), just above the highest headwater segments in the subbasin.

Hydrology

Flow data from the USGS gage station located near the mouth of Lolo Creek is presented in Figure 2 and Figure 3. These figures illustrate how stream discharge follows the weather pattern, in which peak flows coincide with late winter and early spring precipitation and extremely low flows occur during the drier summer and fall seasons. During the year-long monitoring effort conducted on Lolo Creek (2003-04), flows recorded at the mouth peaked at 5300 cfs in February, and dropped to 17 cfs by September (USGS, http://waterdata.usgs.gov).

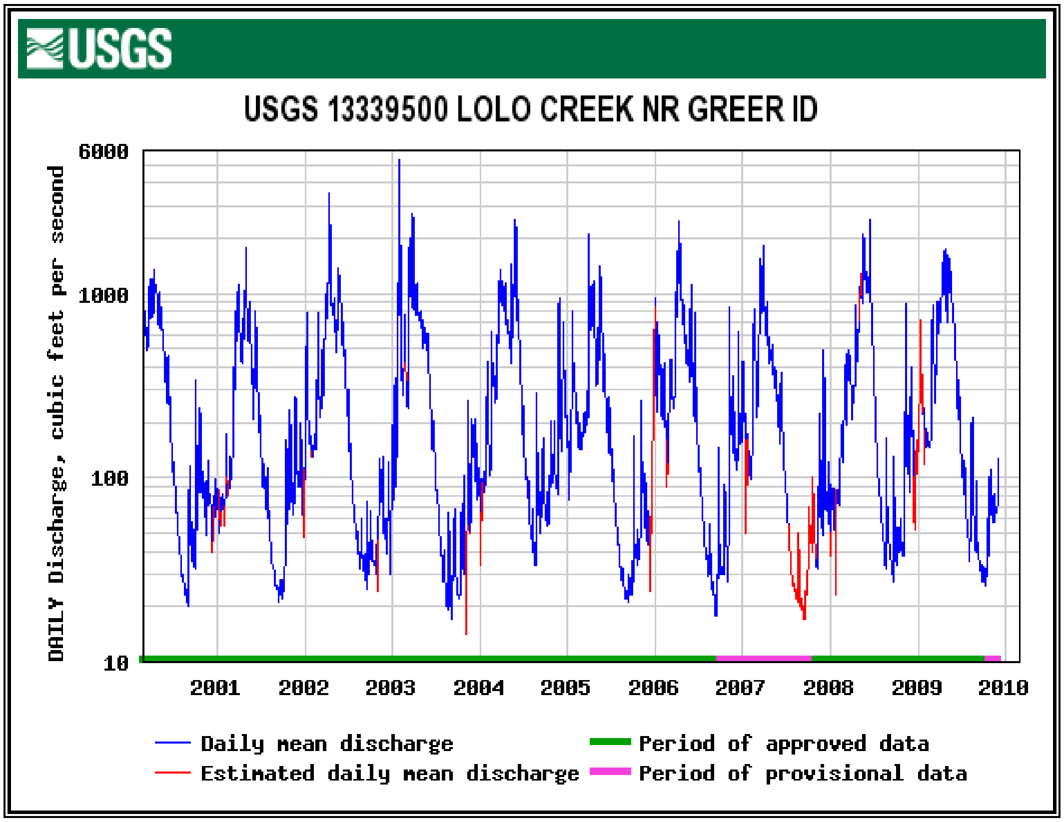

Figure 2. Daily Mean Discharge for Lolo Creek 2000-2010.

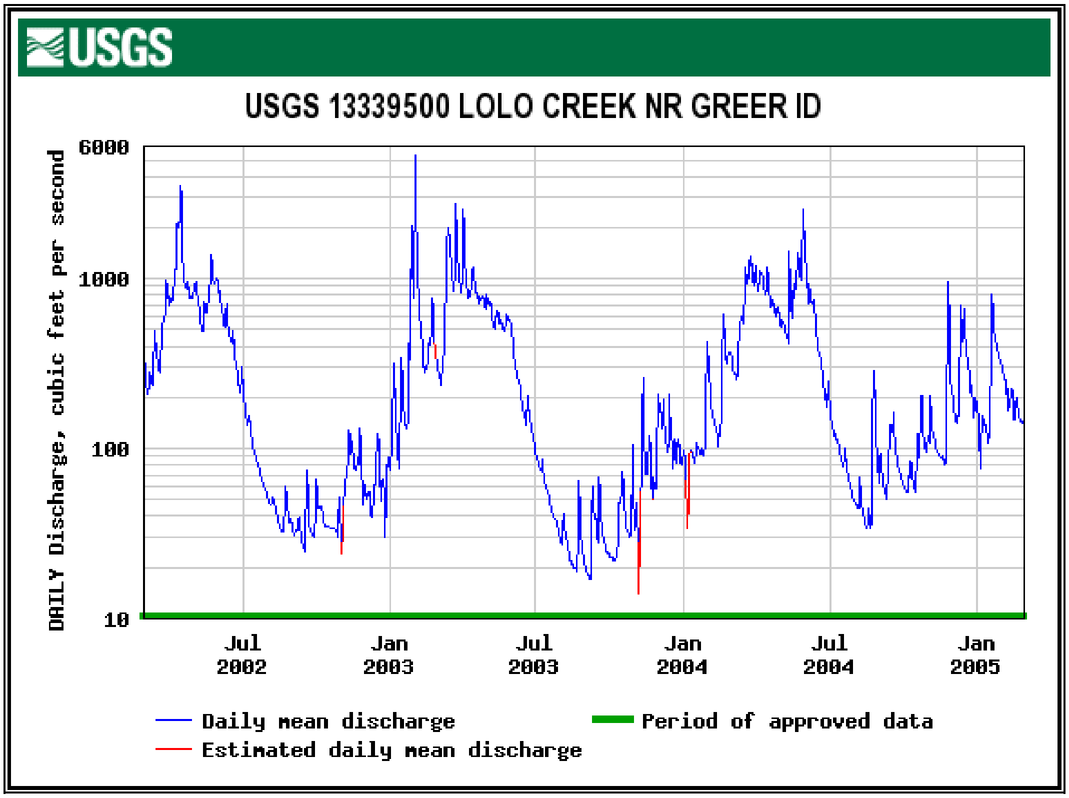

Figure 3. Daily Mean Discharge for Lolo Creek During DEQ Monitoring 2003-04

Topography, Geology and Soils

From its headwaters on Hemlock Butte to its mouth near the town of Greer, Idaho, elevations in the Lolo Creek Subbasin drop from 6,000 ft. to 1,100 ft. This descent in elevation follows the changes in landform topography from mountains, to plateaus, to breaklands. The headwaters flow over soils derived from the highly erodible granitic Idaho batholith. The lower portion of the subbasin originates from Grande Ronde basalt.

Soils in the subbasin are dominated by a silt-loam, loess cap over decomposed granitics. Most of the area is overlain by volcanic ash deposited approximately 6700 years ago during the eruption of Mount Mazama in southern Oregon. The ash layer is of silt loam texture, can be up to 20 inches in depth, and is extremely high in moisture and nutrient holding capacity. Depth and purity varies due to erosional processes the extent of colluvial activity and frost churning in the higher elevations (Lucas 2011). The area is typified by high, gently sloping uplands between deep, narrow canyon streams.

Vegetation

The dominant vegetation type in the upper subbasin, from the headwaters to the Clearwater National Forest (CNF) boundary, is mixed conifer forest made up of western red cedar, Englemann spruce, grand fir, Douglas fir, and mountain hemlock interspersed with lodgepole pine, white pine, western larch and subalpine fir. The drier south- and west-facing aspects of the middle and lower subbasin are typically open ponderosa pine and Douglas fir forests with a grass understory.

Grass species include several invasive pasture grasses and bromes, such as orchard grass and timothy. Native bunchgrass, bluebunch wheatgrass, and Idaho fescue are rare. The CNF Lochsa District inventoried noxious weeds such as spotted knapweed, Canada thistle, Dalmation toadflax and yellow hawkweed on CNF lands in the subbasin (CNF 2007). Weeds like yellow starthistle and spotted knapweed are common along the open hillsides of the lower section of the subbasin.

Riparian areas in the upper subbasin contain thinleaf alder, mallow ninebark, red osier dogwood, and Rocky Mountain maple. The steep canyon sides of the lower subbasin do not offer much floodplain for riparian vegetation, and consist of a thin band of shrubs intermixing with upland conifers (IDFG 1996).

Fisheries

Fisheries surveys carried out by the Nez Perce Tribe, BLM, Idaho Department of Fish and Game (IDFG), DEQ, and Clearwater BioStudies Inc. have confirmed that the Lolo Creek Subbasin is one of the major providers of spawning and rearing habitat for endangered anadromous salmonid species in the Clearwater Basin. The Nez Perce Tribe has identified Lolo Creek as one of their priority areas for fall Chinook salmon habitat restoration, and has successfully completed several projects.

Species native to the subbasin include: rainbow trout/steelhead, westslope cutthroat trout, Chinook salmon, sculpin, pacific lamprey, and mountain whitefish. Bull trout are rarely documented in the subbasin, and are not believed to be successfully spawning and rearing in Lolo Creek or its tributaries. But the cold water habitat provided by the upper subbasin streams may have supported bull trout in the past, and the subbasin was identified as critical bull trout habitat (BLM 2000). Introduced species include: coho salmon, brook trout, and smallmouth bass. Other species present in the subbasin include: northern pike minnow, redside shiner, speckled dace, and long nose dace.

Subwatershed and Stream Characteristics

The Lolo Creek Subbasin is a 5th-field HUC[2], consisting of the main Lolo Creek drainage and several subwatershed tributaries. In his widely quoted "A Classification of Natural Rivers," David L. Rosgen presents a system by which streams can be grouped together and described in terms of their morphology and common characteristics. By taking into account the landform, soils and fluvial features (i.e. pools and riffles) and describing the steepness, shape and sinuosity of the channel, one can apply Rosgen's classification system. When applied to the Lolo Creek tributaries, where the mainstem and tributaries drain more mountainous lands with relatively steep gradients, Rosgen "A" and "B" channels are represented. "A" channels are cascading, step-pool dominated streams flowing over erosional soils and bedrock. "B" channels have a more moderate gradient and are dominated by riffles and runs flowing over colluvial coble (Rosgen 1994).

In the upper subbasin, steep forested hillsides give way to plateaus and open meadows with much flatter gradients, and in these meadow segments Rosgen "C", "DA", "E", and "F" channels are prevalent. The "C", "DA", "E" and "F" channels are meandering, gentle gradient, riffle/pool types (Rosgen 1994).

Because of their steeper gradients and the channel stability created by their forms, "A" and "B" channels return to equilibrium more quickly following land use disturbances

[2] Although HUC stands for the *code* that identifies a hydrologic unit, it has also come to mean the hydrologic unit itself (e.g., a basin, watershed, subbasin, or subwatershed).

than do “C”, “DA”, “E”, and “F” channels (Rosgen 1994). These characteristics are exhibited in the upper Lolo Creek Subbasin, where “B” channels in stream segments of Eldorado Creek and Lolo Creek show full support of their beneficial uses, while the “C”, “DA”, “E”, and “F” channels in stream segments of Eldorado Creek, Jim Brown Creek, and Musselshell Creek show impairment and lack of support of their beneficial uses.

This report focuses on the five assessment units (AUs) on these three water bodies (Eldorado, Jim Brown, and Musselshell Creeks) where Beneficial Use Reconnaissance Program (BURP) data indicate that biological assemblages and habitat have been degraded, where CNF reports show that salmonid spawning temperature criteria were exceeded, or where ambient monitoring data collected during 2003-2004 show impairment by TMDL pollutants.

Eldorado Creek—ID17060306CL029_02

Eldorado Creek is a 3rd-order tributary of Lolo Creek, flowing predominantly south and then west from its headwaters below Austin Ridge (elevation 5,200 ft.) to its confluence with Lolo Creek just north of Lolo Creek campground (elevation 2,869 ft.). BURP data from the 2nd-order AU show it does not support its beneficial uses because of low habitat and biota ratings.

The entire Eldorado Creek watershed is within the Clearwater National Forest. Headwater tributaries to Eldorado Creek include Austin, Six Bit, and Dollar Creeks. Tributaries in the middle reaches include Two Bit, Four Bit, Lunch, Trout, and Fan Creeks. Brick, Kate, Panther, Linda, Cedar, Opal, Eva, and Dora Creeks flow into the lower segment.

An ecosystem assessment performed by the Clearwater National Forest (CNF) in 2003 found that wide, meandering C-type channels are prevalent in the watershed, especially in frost pockets and mountain meadow segments where the gradient decreases and the channel is less confined. These lower-gradient stream segments have a natural tendency to accumulate sediment rather than carrying it further downstream.

Large wildfires consumed riparian vegetation along the meadow segments of the upper Eldorado Creek watershed, which contributed to the buildup of sediment in stream beds and exposed the creeks to more solar heat load. Starting in the 1950’s, timber harvest activities and their associated network of roads, combined with post-harvest grazing, also contributed to the destabilization of Eldorado Creek and further removed riparian vegetation, especially in the 2nd-order “C” and “E” type channels. Significant habitat restoration projects, road work, and best management practices have been implemented in the watershed. As the CNF Ecosystem Assessment states, “Management practices have improved since the 1970’s, but instream conditions still show the effects of past activities” (CNF 2003).

Jim Brown Creek ID17060306CL031_02 and 031_03

Jim Brown Creek is a 3rd-order tributary flowing into Musselshell Creek. It flows from north to south, starting at an elevation of approximately 3,400 feet and drops to approximately 3,100 feet where it meets Musselshell Creek. The majority of the watershed is privately owned, and the lowlands around the creek have been extensively logged and grazed. The majority of Jim Brown Creek's channel is a low-gradient, meandering meadow stream which has been denuded of riparian vegetation and opened for direct access by cattle. Subsequently, the banks and channel have become unstable, the creek has become over-widened, and more solar heat load is reaching the stream. The 2nd-order AU of Jim Brown Creek does not support its beneficial uses, but BURP data from the most recent survey in 2008 show the 3rd-order AU is fully supporting its beneficial uses. DEQ monitoring data generated during 2003-2004 was also considered when assessing Jim Brown Creek. These data show that it is unlikely the 3rd order segment of Jim Brown Creek can meet the temperature criteria to support salmonid spawning, and should receive a TMDL aimed at reducing temperature. TMDL implementation projects have been completed on Jim Brown Creek, but voluntary landowner participation is needed on a wider scale to restore the most degraded segments.

Musselshell Creek—ID17060306CL032_02 and 032_03

Musselshell Creek is a 3rd-order tributary to Lolo Creek, flowing south and west from its headwaters on Dan Lee Ridge (elevation 5,000 ft.) to its confluence with Jim Brown Creek (elevation 3,100 ft.). Musselshell Creek then makes a large meander and turns east and south to its mouth at Lolo Creek, between Lolo Creek mile 26 and mile 27. Both the 2nd- and 3rd-order AUs do not support their beneficial uses because of low habitat and biota ratings.

The majority of the Musselshell Creek watershed is owned by the CNF, with the 3rd-order segment flowing through land owned by Potlatch Corp. and state endowment land managed by Idaho Department of Lands (IDL). Alder Creek and Dewey Creek are headwater tributaries of Musselshell Creek. Gold Creek is the major tributary in the middle segment, and Jim Brown and Blonde Creeks flow into the lower segment.

As in the 2nd-order segment of Eldorado Creek, fires, timber harvests, roads, grazing, and mining have degraded Musselshell Creek until it no longer supports its beneficial uses. The Musselshell Creek watershed is also similar to Eldorado Creek in that the C- and E-type channel segments continue to show the effects of past activities. The low-gradient, meadow reaches of Musselshell Creek and its tributaries have denuded riparian areas, unstable banks, over-wide width to depth ratios, and are exposed to more solar heat load. Land use activities that contributed to the degradation of the Musselshell watershed have changed. Habitat restoration projects and best management practices have been implemented in the watershed, especially on CNF lands.

1.3 Cultural Characteristics

The Nez Perce Tribe traditionally inhabited the Lolo Creek area, making use of the summer climate and hunting grounds. They erected lodges, fished, hunted, and dug camas root in the surrounding area. In 1805, Lewis and Clark had their first encounter with the Nez Perce on the Weippe Prairie, not far from the present Weippe townsite. Soon after the Corps of Discovery’s expedition through the region, the fur trading industry came to Idaho. Then gold was discovered in 1860 by E.D. Pierce, bringing a rush to the area in 1861. The Homestead Act brought many families to the region and Weippe grew.

Timber harvesting on Potlatch Corp. land in the upper watershed began in the 1930s, and timber harvest on the CNF began in earnest in the 1950s. The extensive forest road network associated with timber extraction continued to expand throughout the watershed until the late 1980s. Grazing continues in the subbasin on CNF allotments, and on state endowment land managed by IDL, Potlatch Corp., or privately owned land. Recreation activities like hunting, fishing, off-road vehicle use, hiking, biking, and touring the historical Lewis and Clark motorway continue to draw enthusiasts to the area.

The Nez Perce Tribe and CNF have completed projects designed to restore the Chinook salmons runs in the subbasin to their former numbers, creating habitat, restoring critical stream reaches, re-sizing and replacing inadequate road culverts, de-commissioning and obliterating old logging roads, and operating hatcheries to augment wild populations.

Cultural Features, Land Use and Ownership

Land use within the subbasin is 91% forest, 5% non-irrigated cropland, and 4% pasture and rangeland (BLM 1993). The Lolo Creek Subbasin is sparsely populated, lacking any incorporated towns or cities. Land ownership changes throughout the subbasin, with private landowner holdings at the mouth and then scattered upstream from stream mile 7 to the CNF boundary. Private ownership is predominant in the Jim Brown Creek subwatershed. The BLM owns the Lolo Creek canyon corridor from stream mile 0.5 upstream to mile 7.5. From the BLM boundary to the CNF boundary, IDL and Potlatch Corp. own and manage land holdings. The entire subbasin lies within the lands originally ceded to the Nez Perce Tribe, with the last 4 stream miles within the current reservation boundary (Figure 4).

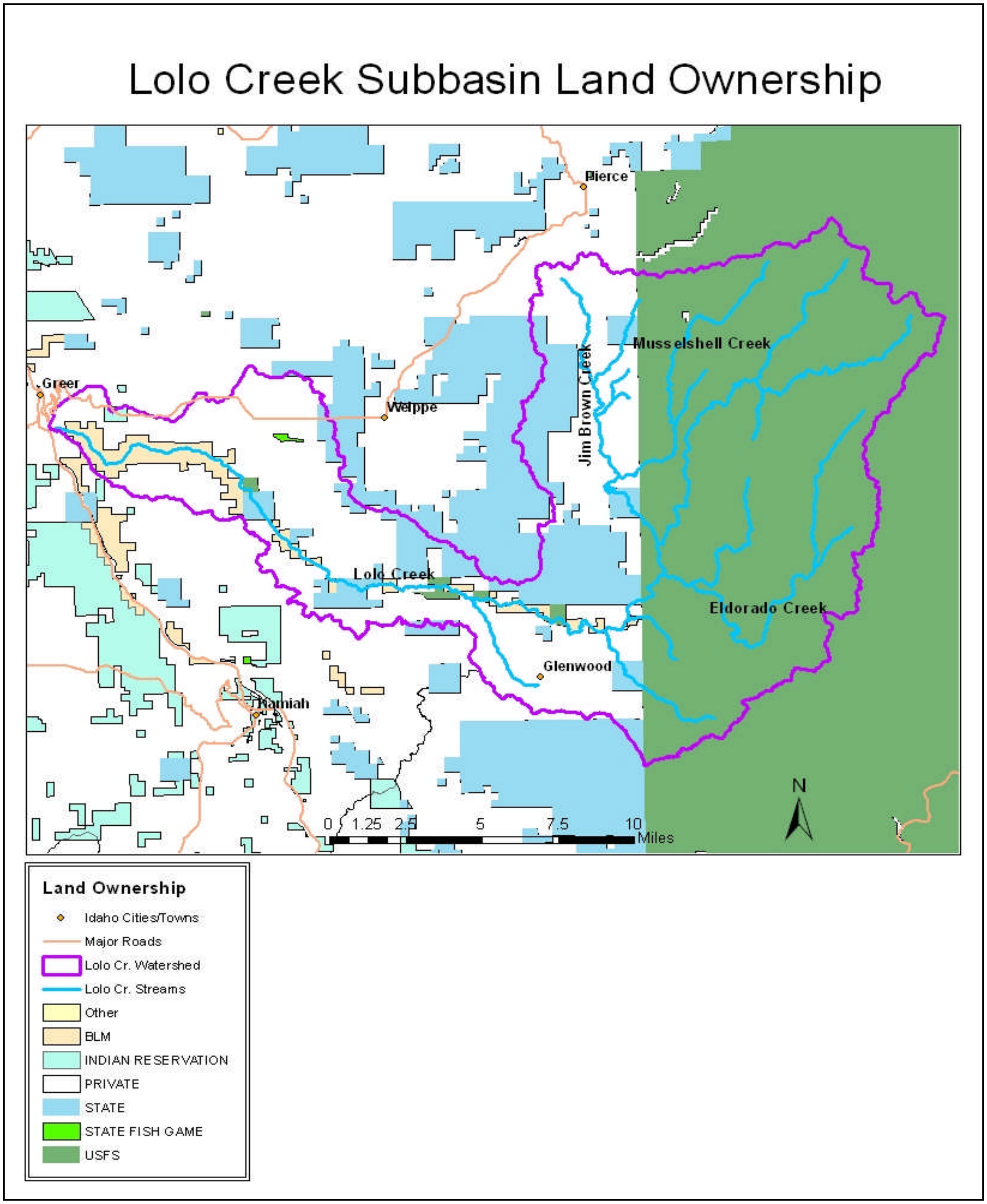

Figure 4. Land Ownership in the Lolo Creek Subbasin

2. Subbasin Assessment – Water Quality Concerns and Status

This section identifies the applicable water quality standards (WQS) for the water-quality-limited assessment units (AUs) in the Lolo Creek Subbasin. Lolo Creek is in the Lower Clearwater hydrologic unit (HUC 17060306).

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 Water Body Assessment Guidance, second edition (WBAG II; Grafe et al. 2002).

An AU is a group of similar streams or stream segments that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs. Although ownership and land use might change significantly, the AU would remain the same.

Using AUs to describe water bodies offers many benefits, the primary benefit being that all the waters of the state are now defined consistently. In addition, using AUs fulfills the fundamental requirement of DEQ's reporting obligation under section 305(b) of the Clean Water Act, wherein states must report on the condition of all the waters of the state. Because AU identification numbers are extensions of water body identification numbers (WBIDs), and WBIDs are used to identify water bodies and the water quality standards for them, 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 stream segments subsequently added to the list were for the entire stream, 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 (identified with 4th-field, 8-digit HUCs), so that all the waters in a drainage are, and since 1994 have been, considered for TMDL purposes.

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 any 1998 listed segment were carried forward to the 2002 303(d) listings, which made 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 2002 303(d) list (Section 5 of the 2002 Integrated Report).

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 water quality listing and de-listing.

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

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

This report focuses on the five AUs on three water bodies in the Lolo Creek Subbasin (Eldorado, Jim Brown, and Musselshell Creeks) where Beneficial Use Reconnaissance Program data indicate the biological assemblage and habitat have been degraded, or where ambient monitoring data collected during 2003-2004 show impairment by TMDL pollutants (Table 1, Figure 5).

Both the 2nd-and 3rd-order AUs on Jim Brown Creek, ID17060306CL031_02 and 031_03 are listed in Section 5 of Idaho's Integrated Report for temperature, nutrients, bacteria, and sediment. Assessments of BURP data from both the 2nd-and 3rd-order AUs on Jim Brown Creek concluded that these AUs failed to support their beneficial uses. Assessments of the two most recent BURP surveys conducted on reaches in the 3rd-order AU in 2008 conclude that one stream reach near the mouth is supporting, and the other is not supporting beneficial uses. Data generated during 2003-2004 must also be considered when assessing Jim Brown Creek. These data show that it is unlikely the 3^{rd} order segment of Jim Brown Creek can meet the temperature criteria to support salmonid spawning, and should receive a TMDL aimed at reducing stream temperature.

The 2nd-order AU of Eldorado Creek, ID17060306CL029_02, was listed as not supporting beneficial uses because of a low habitat rating and a low biota rating. Both the 2nd-and 3rd-order AUs of Musselshell Creek were listed as not supporting beneficial uses due to low habitat and biota ratings.

Section 303(d) of the 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.

Listed Waters

Table 1 shows the pollutants listed and the basis for listing for each Section 5 listed AU in the subbasin. Figure 5 shows the streams with AUs listed in the 2008 Idaho Integrated Report Section 5.

Table 1. Waters Listed in 2008 Integrated Report Section 5.

Water Body Name	Assessment Unit Id Number	Listing	Pollutants	Listing Basis
Eldorado Creek	ID17060306CL029_02	2nd-order segments	Unknown	BURP data
Jim Brown Creek	ID17060306CL031_02 & 031_03	Headwaters to mouth	Bacteria, Nutrients, Sediment, Temperature	Carry Over from Original 303(d)
Musselshell Creek	ID17060306CL032_02 & 032_03	Headwaters to mouth	Unknown	BURP data

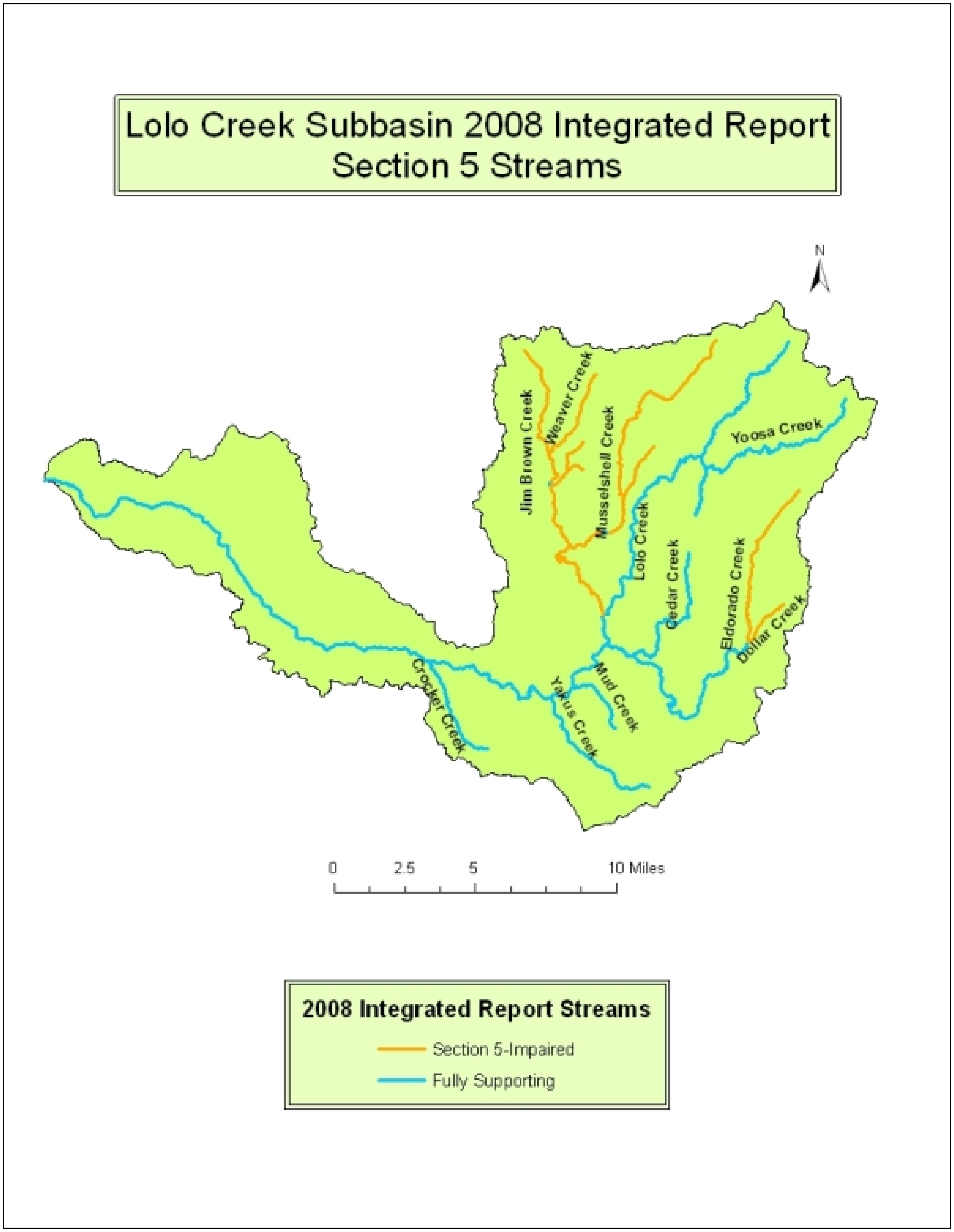

Figure 5. Idaho Integrated Report Section 5 Streams

2.2 Applicable Water Quality Standards

Idaho WQS address various beneficial uses designated or presumed for specific water bodies. The WQS define the corresponding numeric and narrative, physical and chemical limits, or criteria, needed to support these uses. These beneficial uses are identified in the Idaho water quality standards, IDAPA 58.01.02, and include the following:

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

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 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 waterbody on or after November 28, 1975, whether or not they are included in the water quality standards." The existing instream 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 water body 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, then because of the requirement to protect levels of water quality for existing uses, the numeric criteria for salmonid spawning would also apply (e.g., intergravel dissolved oxygen, temperature). However, if cold water aquatic life, for example, is not found to be an existing use, a use designation to that effect would be needed before some other aquatic life criteria (such as seasonal cold) could be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01). For the Lolo Creek tributaries, no beneficial uses have been designated; existing uses are listed in Table 2.

Table 2. Lolo Creek tributaries beneficial uses.

Stream Name	Listing	Assessment Unit	Beneficial Uses [a]	Type of Use
Eldorado Creek	Source to Mouth	ID17060306CL029_02	COLD, SCR, SS	Existing
Jim Brown Creek	Source to Mouth	ID17060306CL031_02 & 031_03	COLD, SCR, SS	Existing
Musselshell Creek	Source to Mouth	ID17060306CL032_02 & 032_03	COLD, SCR, SS	Existing

[a] COLD – cold water aquatic life, SS – salmonid spawning, SCR – secondary contact recreation,

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 3).

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 3 includes the most common numeric criteria used in TMDLs.

Figure 6 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

Table 3. 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	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
			Seasonal Cold Water: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	
Turbidity			Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days.	
Ammonia			Ammonia not to exceed calculated concentration based on pH and temperature.	
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

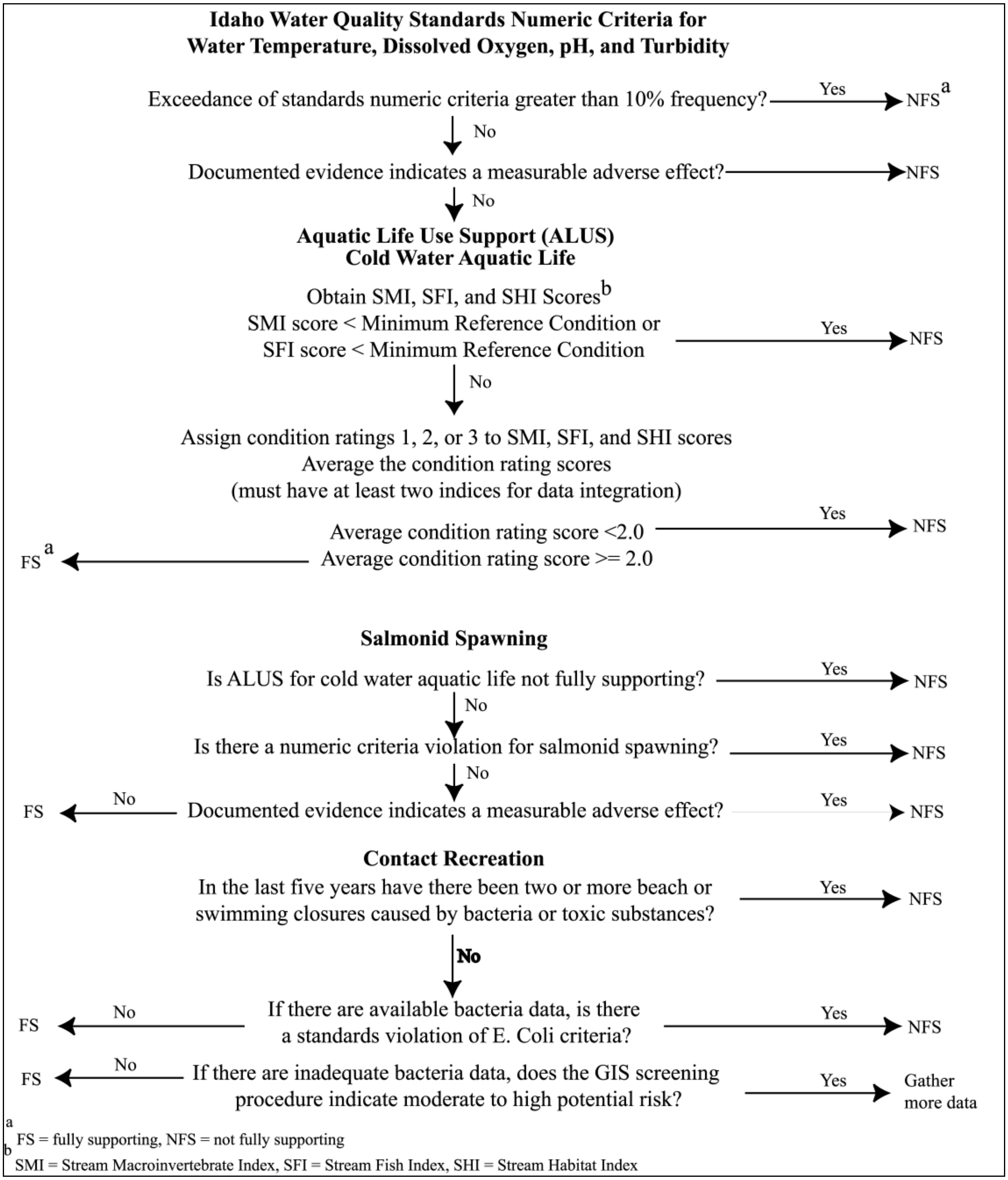

Figure 6. Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: *Water Body Assessment Guidance*, Second Edition (Grafe *et al*. 2002)

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in streams are naturally occurring stream characteristics that have been altered by humans. That is, streams naturally have sediment, nutrients, and the like, but when human activities 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 result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or coldwater aquatic community is present. Many factors, natural and human-influenced, 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 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. An oxygen sag will typically occur each night once photosynthesis stops 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 instream 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 instream 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 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.

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, indicator bacteria which are often associated with pathogens, but which generally occur in higher concentrations and are thus more easily measured, are assessed.

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 human 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 phosphorous 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, more than 90% of the TP present is typically 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 7.0 are indicative of a phosphorus-limited system while those ratios less than 7.0 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 either the sediments 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 phosphorous 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. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced. This results in a reduction of the nitrogen oxides (NO_x) that are being 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 sources of sediment 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 low flow velocity areas, 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 on 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 nutrients (phosphorus), nuisance algae, DO, and pH.

2.4 Summary and Analysis of Existing Water Quality Data

Starting in June 2003, DEQ water quality personnel initiated a year-long, routine water quality monitoring regimen which established monitoring stations in several AUs throughout the subbasin. Data collected at these monitoring stations was then analyzed against WQS in order to assess instream conditions and determine if TMDLs were necessary.

These monitoring stations were monitored every two weeks (as weather allowed) for the following parameters and pollutant concentrations: instantaneous stream temperature; total suspended solids (TSS); *E. coli* bacteria; DO, ammonia, nitrite+nitrate as nitrogen (NO_2+NO_3-N), and TP; instantaneous stream flow; and specific conductance.

To bolster the nutrient concentration data collected, 24-hour diurnal dissolved oxygen measurements were conducted on Jim Brown Creek and Musselshell Creek in August 2009.

In addition to the USGS gaging station at the mouth of Lolo Creek, the CNF operated stream flow gaging stations on upper Lolo Creek and the 3rd-order AU of Eldorado Creek during the monitoring year 2003-04. The CNF also collected total suspended solids samples from Eldorado Creek. Reported results from continuous stream temperature data collected by the CNF exceed State temperature standards for short durations (CNF 2003).

Beneficial Use Reconnaissance surveys were conducted on selected streams in the subbasin in the summers of 1995, 2001, 2002, and 2008. These surveys provide data on habitat conditions, stream macroinvertebrates, and fish. IDFG provided data on the general spawning and incubation periods for salmonid species in the subbasin and the Nez Perce Tribe has data on salmonid density and distribution.

Flow Characteristics

Flow data from the USGS gage station located near the mouth of Lolo Creek, during the year-long monitoring effort by DEQ in 2003-04, is presented in Figure 7 (and Figure 3). This figure illustrates stream discharge—where peak flows coincide with late winter and early spring precipitation and extremely low flows occur during the drier summer and fall seasons. As noted earlier, during the 2003-04 monitoring effort, flows recorded at the mouth peaked at 5300 cubic feet per second (cfs) in February, and dropped to 17 cfs by September (USGS, http://waterdata.usgs.gov).

Data from the CNF gaging stations on Eldorado Creek and upper Lolo Creek, along with the instantaneous flows measured by DEQ at the monitoring sites follow the same flashy pattern. In 2003, the peak flow measured on the 3rd-order AU of Eldorado Creek was over 500 cfs in February, and the minimum measured flow was 16 cfs in October (Figure 7). In 2003-04, DEQ measured instantaneous flows at the mouth of Musselshell Creek that ranged from a maximum of 77 cfs in May to a minimum of below 1 cfs in August. The flow pattern in Jim Brown Creek was similar, with the maximum instantaneous flow measured at 60 cfs in May and the minimum below 0.5 cfs in August.

Precipitation events causing stream discharge to increase rapidly account for the highest sample concentrations of TMDL pollutants measured. For example, the highest *E. coli* and total phosphorous concentrations measured in Jim Brown Creek were in samples collected in November during a rain-on-snow event. Heavy rains from an August thunderstorm caused flows on Musselshell Creek to increase from around 5 cfs to 25 cfs, and *E. coli* concentrations measured during that event were higher than in previous samples.

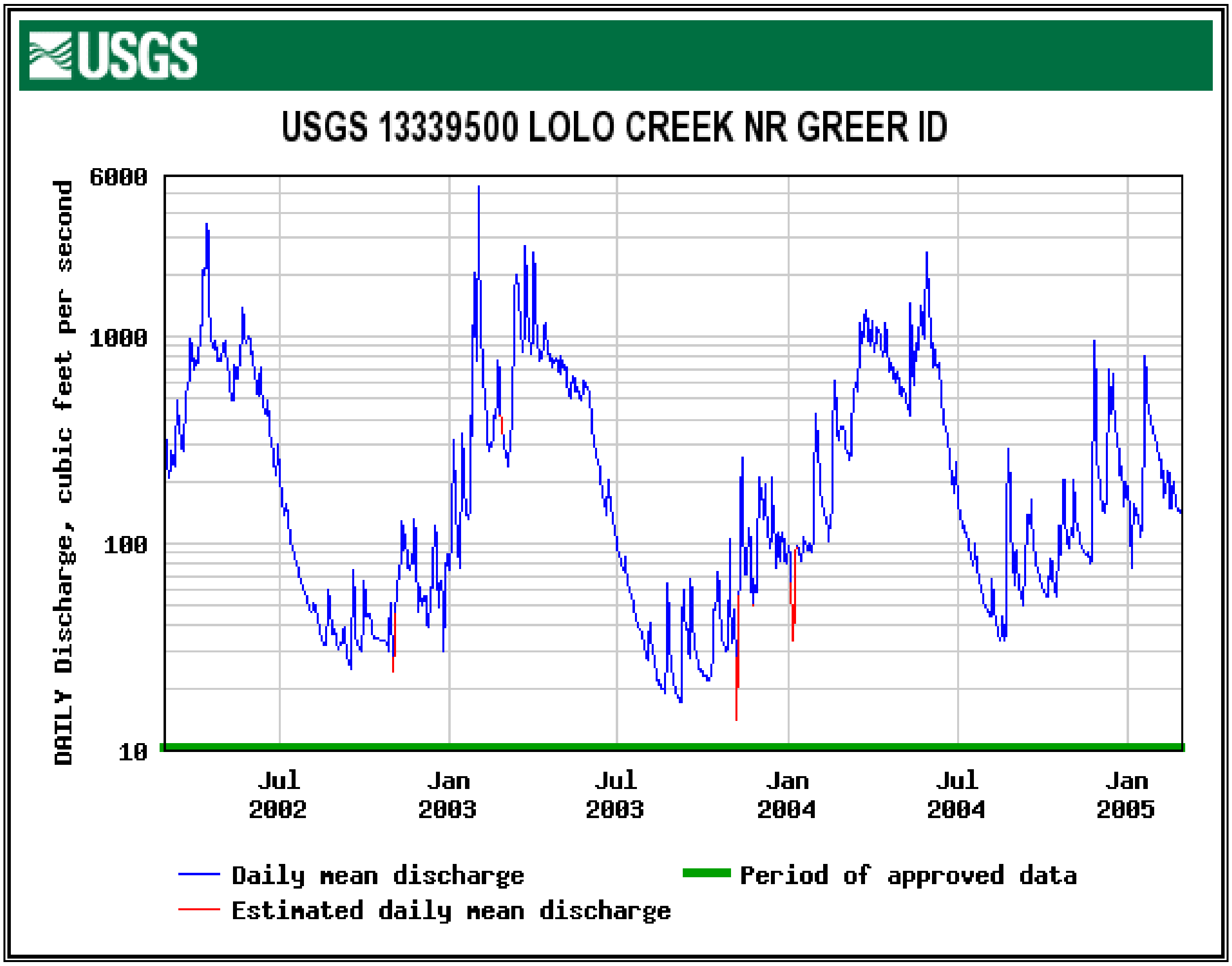

Figure 7. Daily mean discharge for Lolo Creek during DEQ monitoring 2003-04.

Water Column Data

Data generated during the aforementioned year-long routine monitoring effort will be used in the analysis to follow, and can be found in Appendix B.

Temperature

Lolo Creek and Jim Brown Creek were listed on the 1998 303(d) list for temperature pollution. Later, in 2008, Eldorado Creek and Musselshell Creek were listed in Section 5 of the Integrated Report (the 303(d) list) for reasons associated with combined biota and habitat assessments, which showed that neither creek was supporting its existing beneficial uses. The pollutant causing beneficial use impairment was listed as unknown.

As noted earlier, stream temperatures in the subbasin have likely been affected by events such as wildfires, timber harvest activities, and post-harvest grazing. Large wildfires consumed riparian vegetation along the meadow segments of upper Eldorado Creek and Musselshell Creek, which contributed to the buildup of sediment in stream beds and exposed the creeks to more solar heat load. Starting in the 1950s, timber harvest activities and their associated network of roads, combined with post-harvest grazing, also contributed to the destabilization of Jim Brown Creek, Musselshell Creek and Eldorado Creek, further removing riparian vegetation along the C- and E-type channels.

The Eldorado Creek Ecosystem Assessment at the Watershed Scale, 2003, summarizes stream temperature data measured by the CNF in the Eldorado Creek watershed from 1991through 1998. The CNF reports recording a 7-day running mean maximum temperature of 17.4 °C at the mouth of Eldorado Creek, and a 7-day running mean maximum of 16.2 °C in upper Eldorado Creek, both in1998 (CNF 2003). These streams have salmonid spawning as a documented existing beneficial use, and the Lolo Creek Subbasin is considered critical habitat for bull trout. The temperature criteria for supporting salmonids like steelhead, cutthroat and brook trout are as follows: 13 °C maximum daily maximum temperature, 9°C average daily maximum temperature during spawning and incubation periods. The bull trout criteria are: 13°C weekly maximum temperature over the warmest 7-day period during June through August; not to exceed 9 °C daily average in September and October. General periods of salmonid spawning and incubation are listed in Table 4 (Brindza, 2004).

Table 4. General salmonid spawning and incubation periods.

Estimated Spawning and Incubation Period												
Salmonid Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A-run Steelhead Rainbow		✓	✓	✓	✓							
Westslope Cutthroat				✓	✓	✓						
Bull Trout									✓	✓	✓	✓
Brook Trout									✓	✓	✓	
Spring Chinook Salmon								✓	✓	✓	✓	✓
Fall Chinook Salmon										✓	✓	
Coho Salmon										✓	✓	✓

DEQ recorded instantaneous temperature readings in excess of the maximum daily maximum temperature (MDMT) salmonid spawning criterion, at the monitoring stations on Jim Brown and Musselshell Creeks, beginning in June 2003. Although instantaneous temperature readings do not provide enough data to calculate daily averages or weekly mean temperatures, if a single measurement exceeds the MDMT limit it is known that the daily maximum is no less than that single measurement and therefore the criterion is exceeded. 21 separate instantaneous temperature measurements were taken at established monitoring stations on Eldorado, Jim Brown and Musselshell Creeks during the monitoring year. Musselshell Creek exceeded the MDMT criterion 12 times, Eldorado Creek exceeded the MDMT criterion 10 times, and Jim Brown Creek exceeded the MDMT criterion 14 times. Instantaneous temperature measurements were highest from June through September. As Table 4 shows, westslope cutthroat, bull trout, brook trout and spring Chinook could be affected by these warmer stream temperatures. Therefore, Jim Brown and Musselshell Creeks are not supporting their salmonid spawning beneficial uses.

In the summer of 2007, DEQ personnel conducted a survey of existing effective shade on the AUs addressed in this SBA/TMDL. Measurements of existing shade taken on seven stream segments in the subbasin showed that all the listed streams lack shade when compared to desired targets for their riparian vegetation types and bankfull widths. Dollar Creek (a tributary to Eldorado Creek), Eldorado Creek and Musselshell Creek have some relatively good quality segments with respect to shade and other segments that need improvement. Jim Brown Creek consistently lacks substantial shade.

A potential natural vegetation (PNV) temperature TMDL that calls for more shade on upper Eldorado Creek, Jim Brown Creek, and Musselshell Creek is included in Section 5 of this document. Projects designed to increase shade may also have a positive impact on channel and stream bank restoration, which can eliminate certain sources of pollution, reduce multiple pollutant concentrations, and improve habitat, while simultaneously reducing stream temperature.

Dissolved Oxygen

Waters designated for cold water aquatic life must sustain dissolved oxygen concentrations of 6.0 milligrams per liter (mg/L) or greater at all times (IDAPA 58.01.02.250.02.a). For the salmonid spawning beneficial use, the Idaho state criterion for dissolved oxygen in the water column is a one-day minimum of not less than 6.0 mg/L or 90% (ninety percent) of saturation, whichever is greater (IDAPA 58.01.02.250.02.f.2.a).

No instantaneous violations of the State standard were recorded during routine monitoring. 48-hour diurnal DO measurements were recorded during two days in August of 2009 on both Jim Brown Creek and Musselshell Creek. No violations of the State standard were measured (Figure 8 and Figure 9).

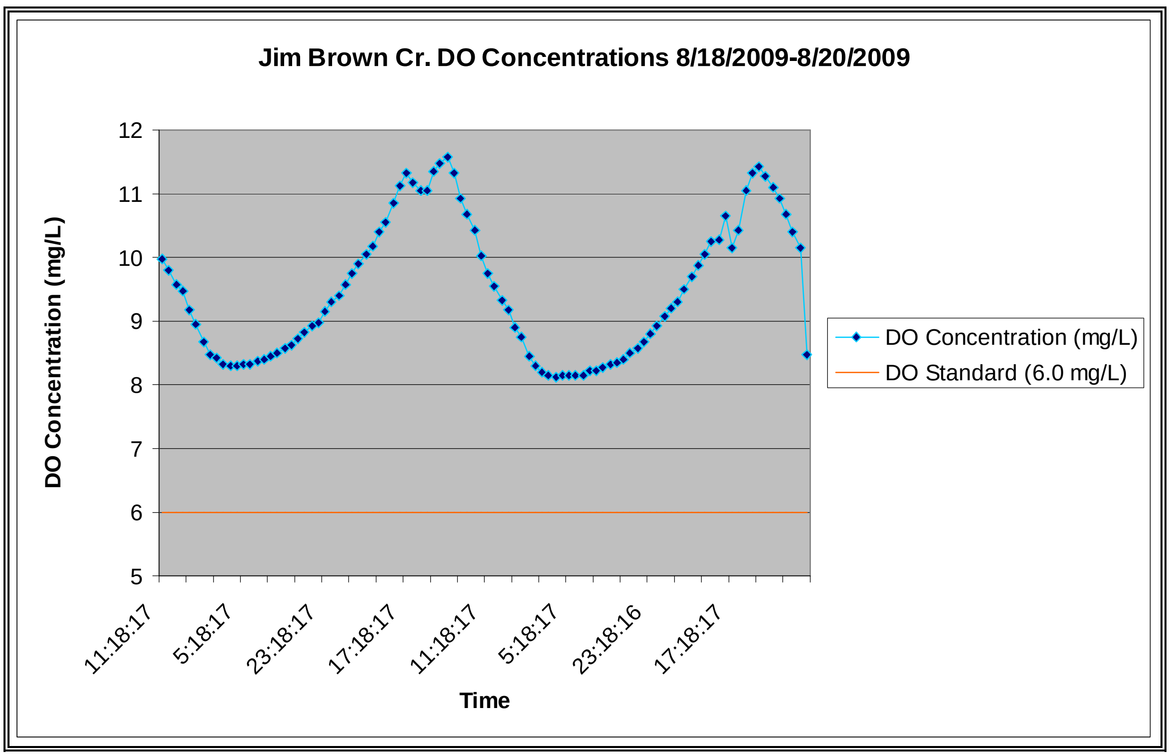

Figure 8. Jim Brown Creek 48-Hour Diurnal DO Concentrations Measured August 18-20, 2009

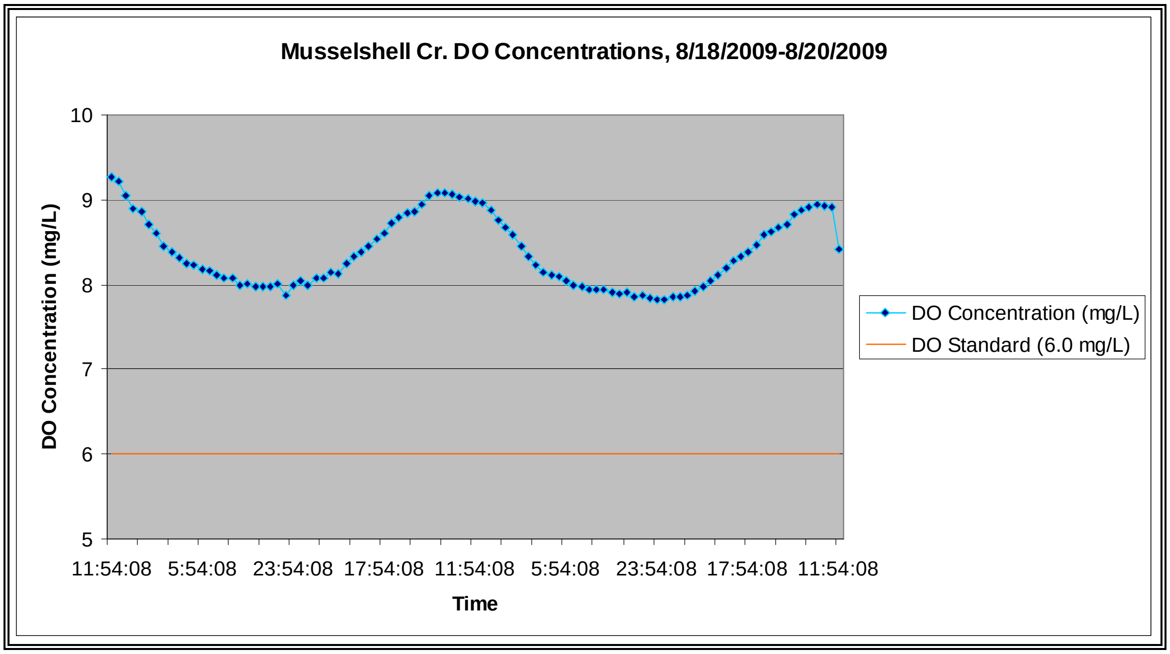

Figure 9. Musselshell Creek 48-Hour Diurnal DO Concentrations Measured August 18-20, 2009

Sediment

Sediment criteria found in Idaho Water Quality Standards (IDAPA 58.01.02) is narrative, meaning there is not a numeric value to assess whether a water body is in compliance with standards; instead, Idaho has a requirement that states sediment shall be limited to a quantity that does not impair beneficial uses.

The most available water column sediment data for application in this TMDL are reported in terms of total suspended solids (TSS). A total suspended solids target for sediment has been taken from the *Guide to Selection of Sediment Targets for Use in Idaho TMDLs* and set at a level such that sediment will not exceed the estimated load capacity supportive of a good fishery (DEQ 2003).

The effects of sediment on the most sensitive designated beneficial use, aquatic life, are dependent on concentration and duration of exposure (DEQ 2003). Guidance developed by DEQ for application of the narrative sediment criteria for protection of aquatic life beneficial uses suggests that a sediment target incorporate both concentration and duration of exposure, not only to properly protect aquatic life, but also to allow for episodic spikes that can occur naturally with spring runoff or heavy precipitation events.

A target range of a monthly average of 25 mg/L total suspended solids (TSS) with a maximum daily limit of 50 mg/L to allow for natural variability has been selected and applied to the concentrations measured in 2003-04. The average monthly target and the maximum daily limit are within the range identified as supporting a good fishery by the European Inland Fisheries Advisory Commission and the Committee on Water Quality

Criteria from the Environmental Studies Board of the National Academy of Science and National Academy of Engineers (DEQ 2003).

When TSS concentrations collected in the Lolo Creek Subbasin tributaries are compared with this target range, none of the measured concentrations exceed the target. As with *E. Coli* bacteria and nutrient concentrations, the maximum measured TSS concentrations occurred during runoff and precipitation events, and represent 10% or less of the dataset DEQ generated in 2003-04 (Table 5). The most common measured concentration on all three streams was below the detection limit. Ambient TSS monitoring data indicate the current sediment load being contributed to Eldorado, Musselshell and Jim Brown Creeks does not warrant TMDLs aimed at further reductions and allocations. While current sediment loading is being controlled, it is the residual sediment load that continues to affect these streams.

BURP habitat and macroinvertebrate data confirm that the "C" and "E" type channels have accumulated excess sediment in their streambeds. Human land use practices and historical wildfires are the most likely causes of this excess accumulation. However, land use practices have changed significantly, especially on the CNF-owned lands in the Musselshell and Eldorado Creek subwatersheds. Examples of these land use changes in the form of pollution prevention and control efforts implemented in the subbasin are summarized in Section 4 of this document. Future restoration projects aimed at reducing stream temperature, like the establishment of riparian buffers; the replanting of red cedar, Englemann spruce, and white pine along the meadow segments; and the active recruitment of woody debris will also have a positive impact on further reducing and controlling sediment while providing more shade and reducing stream temperature.

Table 5. Measured TSS Concentrations 2003-04.

Water Body	Max. TSS Concentration (mg/L)	Min. TSS Concentration (mg/L)
Eldorado Creek	28	Non Detectable
Jim Brown Creek	10	Non Detectable
Musselshell Creek	34	Non Detectable

E. coli Bacteria

The State of Idaho criteria for *E. coli* is that bacteria are not to exceed 126 colony forming units per 100 milliliters of solution (cfu/100 ml) as a 30-day geometric mean. Also, there are single sample maximum limits of 406 cfu/100 ml for primary contact recreation (PCR) uses and 576 cfu/100 ml for secondary contact recreation (SCR) uses. Depending on the use, if either single sample maximum is exceeded, five additional samples must be taken every 3 to 7 days over a month's time to determine the geometric mean concentration and compare it to the standard (IDAPA 58.01.02.251.01 & 02).

Primary contact use applies when the ingestion of small quantities of water is likely to occur. Such activities include, but are not restricted to, swimming, water skiing, or skin diving. Secondary contact applies for recreation uses not included in the primary contact category. These activities may include fishing, boating, wading, infrequent swimming, and other activities where ingestion of raw water is not likely to occur.

E. coli samples taken on Eldorado Creek in 2003-04 did not exceed the single sample maximum of 406 cfu/100ml for PCR, or 576 cfu/100ml for SCR. The highest concentration from Musselshell Creek above the mouth of Jim Brown creek did not exceed the SCR single sample maximum—a concentration of 548 cfu/100ml, sampled November 12, 2003, during a rain-on-snow event. *E. coli* concentrations in one sample each from the 2nd- and 3rd-order AUs of Jim Brown Creek exceeded the recreation single sample value on the same sample date, during the same November precipitation event. A sample from the 2nd-order AU of Jim Brown Creek also registered a concentration of 579 cfu/100ml in August 2004 during heavy thundershowers.

In November 2007, geometric mean monitoring, using 5 *E. coli* bacteria samples collected at evenly–spaced time intervals within 30 days, was conducted at the monitoring stations on Jim Brown Creek and Musselshell Creek. Samples were taken in November to coincide with the month during which the original sample concentrations were highest. The maximum measured single sample *E. coli* concentration taken during November 2007 was 142 cfu/100ml in the 2nd-order AU of Jim Brown Creek, and the corresponding calculated geometric mean concentrations were far below the standard of 126 cfu/100ml (Table 6).

Table 6. Measured instream *E. coli* bacteria geometric mean concentrations.

WBID & AU #	Water Body Name	*E. coli* Geometric Mean Concentration (cfu/100 ml)
ID17060306CL031_02	Jim Brown Creek	55
ID17060306CL031_03	Jim Brown Creek	34
ID17060306CL032_03	Musselshell Creek	39

E. coli concentrations in samples collected from the 3rd-order AUs of Jim Brown and Musselshell Creeks exceeded contact recreation single sample maximum values one time each out of 20 sampling events, or 5 percent of the dataset. *E. coli* concentrations in two samples exceeded contact recreation single sample maximum values in the 2nd-order AU of Jim Brown Creek, representing 10 percent of the dataset. All of the samples with levels that exceeded contact recreation single sample maximum values correspond with precipitation events. The sampled and calculated geometric-mean concentrations do not violate the standard for *E. coli*. Therefore, TMDLs calling for reductions in *E. coli* bacteria are not necessary for these streams. Rather, it is DEQ's recommendation that the implementation of best management practices like riparian fencing and off-site watering should continue in both the Musselshell and Jim Brown Creek subwatersheds.

Nutrients

Idaho's narrative standard for nutrients 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" (IDAPA 58.01.02.200.06). Excessive nutrients affect dissolved oxygen and impair aquatic life beneficial uses due to the growth and decomposition cycle of algae feeding on the nutrients and the biochemical oxygen demand as ammonia is transformed to nitrate-nitrogen. An instream dissolved oxygen concentration of 6.0 mg/L is required by Idaho's water quality standards for protection of aquatic life beneficial uses.

As mentioned above, Jim Brown Creek, the only stream in this subbasin that is 303(d)-listed for nutrients, showed no violations of the State's DO standard. No visible slime growths were observed while monitoring. The average total phosphorous (TP) concentration measured during routine monitoring was 0.03 mg/L, which coincides with EPA criteria recommendations that represent the 75^{th} percentile of all streams sampled in the Eco-region. Two samples had concentrations greater than this recommended concentration, both collected during the precipitation events described earlier. Only one sample showed a nitrate + nitrite (NO_2+NO_3 mg/L**)** concentration above the method detection limit, and that sample occurred during the same precipitation event. All the other nitrogen samples had nitrate + nitrite concentrations below the detection limit.

The EPA criteria recommendations represent reference conditions for the Eco-regions they describe. All measured concentrations that exceeded this recommendation occurred during run-off events and no violation of the numeric DO standard was recorded. Therefore, based on the assessment of the data collected, Jim Brown Creek does not show impairment by excess nutrients and does not require a nutrient TMDL in order to support its beneficial uses.

Biological and Other Data

The BURP monitoring protocol provides three types of data: macroinvertebrates, fish, and habitat. A stream macroinvertebrate index (SMI) is generated from seven different qualities of the macroinvertebrates found, including: species diversity, richness of species diversity, species guilds, and pollutant tolerance. A stream fish index (SFI) is developed based on species present, abundance of the different species, and the presence/absence of juveniles. A stream habitat index (SHI) uses both quantitative and qualitative measures of stream habitat including substrate composition, channel structure, streamside vegetation, and stream bank condition. Index scores (condition ratings) from the monitoring samples are compared with statistical reference index scores, and used along with available physical and chemical data to determine whether an AU supports its beneficial uses.

The WBAG II (Grafe *et al.* 2002) describes DEQ's method for evaluating biological data and determining beneficial use support of Idaho water bodies. Assessing a water body involves analyzing and integrating multiple types of data to determine the degree of beneficial use support and biological integrity. The WBAG II considers data most relevant to support status determinations to be data less than five years old.

Idaho's WBAG II provides for use of a multimetric index score that incorporates SMI, SFI, and SHI scores (condition ratings). A multimetric index score of 2.0 or greater indicates that biological characteristics support beneficial uses, meaning the stream passes the assessment; a score of less than 2.0 indicates that biological characteristics do not support beneficial uses and the stream fails the assessment. Multimetric index scores, their averages, and the grand average of all scores for BURP surveys completed on the Lolo Creek Subbasin tributaries are shown in Table 7.

Both this SBA/TMDL(s) report and the 2008 Integrated Report relied on data generated prior to 2008. Therefore, the support status established by a BURP survey on the 3rd order AU of Jim Brown Creek in 2008 had not affected its listing. When existing temperature data, the monitoring data and BURP data are assessed, it becomes apparent that the 3rd order AU of Jim Brown is impaired by temperature. The temperature TMDL(s) in Chapter 5 of this document are meant to deal with the original temperature listings and restore the support of the existing salmonid spawning beneficial use.

Table 7. BURP Multimetric Index Scores.

Assessment Unit	Stream Name	Year Sampled	SMI Condition Rating	SFI Condition Rating	SHI Condition Rating	Grand Average*	Beneficial Use Support**
ID17060306 CL029_02	Eldorado Cr	1995	0	–	2	0	NFS
	Dollar Cr	1995	3	2	3	2.67	
	Eldorado Cr	2001	1	1	1	1.0	
	Dollar Cr	2001	3	2	3	2.67	
ID17060306 CL031_02	Jim Brown Cr	1995	1	–	2	1.50	NFS
ID17060306 CL031_03	Jim Brown Cr	1995	1	1	1	1.0	NFS(1995)
		2008	3	–	3	3.0	AVERAGE= FS (2008)
		2008	2	1	2	1.67	
ID17060306 CL032_02	Musselshell Cr	1995	0	1	2	0	NFS
	Gold Cr	1995	1	2	3	2.0	
	Musselshell Cr	2001	3	2	2	2.33	
	Musselshell Cr	2002	2	1	1	1.33	
	Musselshell Cr	2002	2	1	1	1.33	
ID17060306 CL032_03	Musselshell Cr	1995	1	1	1	1.00	NFS
		2001	3	1	1	1.67	

*If >=3 BURP sites the Grand Average of BURP score averages,
If <= 2 BURP sites then lowest BURP score average,
If any BURP score average is 0, then score is 0 (does not meet minimum thresholds),.
** If score >=2 then Full Support (FS), < 2, then Not Full Support (NFS).

In the fall of 2006, DEQ collected macroinvertebrate samples from Jim Brown Creek and had them analyzed, along with data representing the original 1995 BURP macroinvertebrate samples, in an attempt to determine what type of pollutants may be impairing beneficial uses. The presence of macroinvertebrates belonging to pollutant-tolerant taxa, and the proportion of them that belong to certain taxa, is a good indicator of what type of pollutants are affecting overall stream conditions. The macroinvertebrate samples were collected from the same locations as the 1995 BURP sites, using standard DEQ field methods. EcoAnalysts Inc. provided the sorting and taxonomic identification, along with a narrative summary report describing ecological information pertaining to the most abundant taxa in each sample. In general, the dominant taxa represented were riffle beetles and ephemerellid mayflies. According to Brett Marshall, senior aquatic entymologist for EcoAnalysts Inc.:

> Riffle beetles occur in most western streams—from pristine to moderately degraded sites. They often feed on closely attached biofilms of diatoms and bacteria, but can also ingest organic sediments as deposits begin adhering to benthic substrata. In addition to their tolerance to some

> sedimentation, they may facultatively reside among refuge provided by filamentous algae and aquatic vegetation. Sometimes they are even associated with submerged woody debris, where they may gouge the rotting surface as xylophages. Because of their primary mode of feeding (scraping biofilms), they are usually considered scrapers when functional feeding groups are calculated and thus, they may improve IBIs, like the Idaho SMI, by elevating scraper abundance, scraper richness, clinger richness, and clinger abundance. Yet, they may also indicate impairment because they sometimes benefit from enrichment (Marshall 2007).

Marshall describes ephemerellid mayflies and their tolerance as follows:

> Unlike many mayfly species, the larvae of this taxon are not especially sensitive to sediment because they are armored and have modified structures protecting their gills from abrasion. This taxon is both a collector-gatherer and a climber. It is often found among aquatic mosses, some algae, detritus, and water cress, where it searches for accumulations of fine organic particles, upon which it feeds (Marshall 2007).

Aquatic mosses, detritus and submerged woody debris are common in the lower gradient segments of Jim Brown Creek. The macroinvertebrates found share a tolerance for sediment, which coincides with the legacy excess sediment loads still found in the streambeds of the “C” and “E” type channels. The lack of cold water taxa, combined with the fact that several taxa described in the analysis show a tolerance for higher stream temperatures also supports the conclusions drawn in the SBA—temperature is the most likely cause of impairment in these tributaries.

Status of Beneficial Uses

In addition to the BURP data and WBAG assessments, TMDL monitoring data is used in making support status determinations. Table 8 illustrates the most current support status determinations for the Lolo Creek Subbasin tributaries, and the pollutant for which TMDLs have been written, based on available data. Low SFI and SHI ratings, multiple instantaneous temperature measurements in excess of the MDMT criterion and 7 day average temperatures reported by CNF in 2003 all point to temperature as the main pollutant impairing upper Eldorado Creek, Jim Brown Creek, and Musselshell Creek. The existing salmonid spawning beneficial use is not being fully supported in these tributaries, due to temperature.

Table 8. Beneficial use support status and TMDL pollutants.

Stream Name	Extent	AU#	Aquatic Life Uses		Recreation Uses	Pollutant
			SS	COLD		
Eldorado Creek	2nd-order AUs	ID17060306CL029_02	NFS	NFS	FS	Temp
Jim Brown Creek	Source to Mouth	ID17060306CL031_02 & 031_03	NFS	NFS	FS	Temp
Musselshell Creek	Source to Mouth	ID17060306CL032_02 & 032_03	NFS	NFS	FS	Temp

SS=salmonid spawning, COLD=cold water aquatic life , NFS=not fully supporting beneficial uses, FS=fully supporting beneficial uses, Temp=Temperature

Conclusions

Data collected on the tributaries of the Lolo Creek Subbasin listed in Section 5 of the Integrated Report (303(d)-listed) focused on the suite of TMDL pollutants associated with the listings. *E. coli* and DO concentrations measured during the year-long sampling effort did not show that numeric criteria were exceeded. Where narrative criteria were used for sediment, the measured concentrations fell within target ranges supportive of a good fishery. Where narrative criteria were used for nutrients, average nutrient concentrations were similar to eco-regional criteria recommendations reflective of reference conditions. A potential natural vegetation (PNV) temperature TMDL that calls for more shade to reduce stream temperatures on upper Eldorado Creek, Jim Brown Creek, and Musselshell Creek is included in Chapter 5 of this document.

2.5 Data Gaps

All available data generated in the future, where applicable, will be used to review and reevaluate the subbasin assessment and TMDLs. Any new listings in Section 5 of the Integrated Report or carry-overs will also be addressed in the next review cycle.

3. Subbasin Assessment–Pollutant Source Inventory

This section identifies and discusses sources of pollutants affecting water quality in the Lolo Creek Subbasin. Sources may occur as point sources, regulated by National Pollutant Discharge Elimination System (NPDES) permits, and as nonpoint sources which are not subject to any permitting program. Point sources convey pollutants directly into waters through a pipe, ditch or other identifiable point of discharge. Nonpoint sources have no exact point of discharge to receiving waters, conveying their associated pollutants over the landscape. To the best knowledge of DEQ, the Lolo Creek Subbasin tributaries receive pollutants from nonpoint sources only, which are discussed in more detail below.

3.1 Sources of Pollutants of Concern

Point Sources

There are no known point sources that discharge directly to the Lolo Creek Subbasin tributaries addressed in this report. Suction dredge operators who wish to mine these streams are now required to apply for and receive an EPA permit which requires specific management practices designed to lessen impacts to the stream and riparian area. Permit provisions for endangered anadromous salmonid species and bull trout critical habitat waters should restrict suction dredging in the Lolo Creek Subbasin. No waste load allocations are given for suction dredge operations.

Nonpoint Sources

Nonpoint sources of pollution in the Lolo Creek Subbasin include: timber harvest activities, roads, grazing, agriculture, mining, recreational off-road vehicle use, and septic tanks. Timber harvest on CNF lands has been reduced and road maintenance and obliteration has helped control sediment transport. Potlatch Corp. and IDL continue to extract timber from their lands in the subbasin, using best management practices (BMPs) prescribed by Forest Practices Act (FPA) guidelines. Grazing continues on CNF, BLM, IDL, and Potlatch Corp. lands, as well as on private lands. Implementation projects like riparian fencing and off-site watering of cattle have improved stream banks and habitat on Jim Brown and Musselshell Creeks.

3.2 Data Gaps

Authoritative water quality evaluations to discern instream load contributions from and among the various nonpoint sources found within the watershed are not possible from this data. More specific identification of pollutant loads attributable to known nonpoint sources located within the delineated watershed areas should be completed by the appropriate designated management agency to ensure effective and efficient load reductions are achieved if deemed necessary.

Nonpoint Sources

The potential natural vegetation TMDL found in section 5 of this document makes it clear which stream segments have been the most affected or disturbed by riparian plant removal, channelization, and wildfire. The lack of shade found in each stream segment illustrates both where and how excess solar radiation is reaching the stream and warming the water. Completion of the PNV temperature TMDL has resulted in the quantification of nonpoint source solar heat loading to the Lolo Creek Subbasin tributaries.

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

This chapter presents a brief summary of efforts specifically implemented to control pollutants, enhance instream habitat, and improve water quality in the Lolo Creek Subbasin. In some cases, federal agencies, the Nez Perce Tribe, state agencies, private landowners, and local communities mentioned here have coordinated efforts to restore habitat and control certain pollutants throughout the watershed. Other agencies and organizations mentioned will become involved in pollution control activities during the implementation phase of this TMDL. The type of restoration/pollutant control activities and the agencies and individuals undertaking these measures vary with land use and ownership.

4.1 Federal/Tribal Efforts

Bureau of Land Management

The U.S. Bureau of Land Management (BLM) considers the lands they manage in the lower Lolo Creek Subbasin a high priority restoration watershed. BLM applies management strategies aimed at protection, active and passive restoration, and rehabilitation of aquatic and riparian ecological functions. Recent activities have focused on road closures and securing conservation easements along the lower 8 miles of Lolo Creek.

Clearwater Focus Program

The purpose of the Clearwater Focus Program is to coordinate staff and funding resources for projects to enhance and restore fish and wildlife habitats in the Clearwater River Basin. The Office of Species Conservation and the Nez Perce Tribal Watershed Division co-coordinate the program on behalf of the State of Idaho and the Nez Perce Tribe.

Projects have been conducted on private, state, federal, and tribal lands and partnerships have been developed for all Clearwater Focus Program projects. In addition to the commission and the Tribe, frequent project partners include the U.S. Forest Service, Natural Resources Conservation Service, soil and water conservation districts, private landowners, Idaho Department of Fish and Game (IDFG), and the BLM. Projects have focused on riparian fencing, plantings, road obliterations, revegetation, grassed waterways, culvert replacement, and agricultural ponds.

Natural Resources Conservation Service

The Natural Resources Conservation Service provides technical assistance to the Clearwater Soil and Water Conservation District and its landowners and administers costsharing programs on private lands. These programs are largely voluntary on the part of private landowners, and include:

- Environmental Quality Incentive Program
- Wildlife Habitat Incentive Program
- Wetland Reserve Program
- Conservation Reserve Program
- Continuous Conservation Reserve Program

US Forest Service, Clearwater National Forest

The Clearwater National Forest manages its lands within the watershed using guidelines and policies specified in the Clearwater National Forest Plan. The plan utilizes strategies designed to protect habitats and populations of fish. The plan contains a monitoring requirement designed to insure Idaho State Water Quality Standards are met on the forest. On-site monitoring will be conducted to establish a baseline, guide implementation, and track the effectiveness compliance of best management practices (BMPs). Instream monitoring will be conducted to address the effect of land disturbance activities on water quality and fish habitat.

Over the past five years, the watershed restoration program has become a high priority on the forest. The CNF, along with the Nez Perce Tribe, who is an integral partner in the funding and implementation of various projects, has implemented projects to improve watershed conditions. Today, the focus of the watershed restoration efforts basically involves two main components: road decommissioning projects and aquatic passage improvement projects. Meadow restoration projects are currently scheduled to occur in the Musselshell Creek subwatershed.

United States Fish and Wildlife Service

The United States Fish and Wildlife Service administers two grant programs: the Partners for Wildlife Program and the Private Stewardship Grant Program. The Partners for Wildlife Program provides cost-share opportunities for projects aimed at enhancing fish and wildlife habitat, with an emphasis on the restoration of riparian areas, wetlands, and native plant communities. The Private Stewardship Grant Program provides grants and assistance to groups engaged in private, voluntary conservation efforts targeted at benefiting endangered/threatened species.

Nez Perce Tribe

The Nez Perce Tribe manages a number of departments and divisions responsible for protecting, enhancing, and restoring tribal resources. The Tribe developed the 1998 Unified Watershed Assessment and Watershed Restoration Priorities plan, which identifies watersheds containing tribal fee and trust lands and tribal usual and accustomed fishing places. The plan sets out priorities for restoration. The Tribe Water Resources Division implements restoration work in watersheds within the Reservation upon completion of TMDLs that have been developed under a tri-party agreement with the

Tribe, EPA, and DEQ. In addition, the 1996 Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes sets adult anadromous return targets for each subbasin in the Columbia Basin and makes recommendations for restoration activities and fish release and production programs.

Since 1996, the Nez Perce Tribe Department of Fisheries Resource Management, Watershed Division has led a cooperative effort to enhance fish habitat, reduce sediment delivery and protect riparian areas from excessive grazing. The Tribe has partnered with the CNF on national forest lands and with Potlatch Corporation on their privately owned lands. As of 2006, the cooperative was responsible for installing 19 miles of riparian fencing, obliterating 59 miles of roads, planting 8,000 native-species riparian trees and shrubs, and replacing 14 culverts (McRoberts 2006). The majority of this work was done on the Jim Brown, Musselshell, and Eldorado Creeks watersheds.

4.2 State Agency Efforts

Idaho Department of Fish and Game

The Idaho Department of Fish and Game works to preserve, protect, perpetuate, and manage all wildlife. The agency has created several management plans and policies relevant to fish and wildlife and their habitat in the Clearwater subbasin. The staff assists in working with volunteer landowners to improve habitat through incentive programs.

Idaho Conservation Data Center

The Idaho Conservation Data Center is the central repository for information related to the state's rare plant and animal populations. The staff is involved with rare plant and natural area surveys and the development of conservation strategies. These activities assist government agencies and private organizations to identify unique areas for protection against disturbance and development.

Idaho Soil and Water Conservation Commission

The Idaho Soil and Water Conservation Commission staff provides technical and administrative support to the 51 conservation districts in Idaho. The staff helps to provide funding with grants and loans through the Resource Conservation and Rangeland Development Program and financial incentives through the Water Quality Program for Agriculture. The programs are intended to improve rangeland and riparian areas and contribute to protection and enhancement of water quality. The commission also administers the Idaho Agricultural Pollution Abatement Plan, which is the implementing action for all nonpoint source agricultural sector activities in the state.

Idaho Department of Lands

The Idaho Department of Lands administers the following laws and acts: the Idaho Forestry Act Fire Hazard Reduction programs, the Idaho Forestry Practices Act, the

Idaho Lake Protection Act, surface mining laws, placer mining laws, and navigable waters provisions. The Department also administers the state Stewardship Program, which provides cost-share dollars to perform forestry practices and assists private landowners in developing timber management plans with site-specific BMPs designed to protect riparian areas and water quality.

Idaho Department of Water Resources

The Department of Water Resources enforces the Stream Channel Protection Act, requiring permits for in-channel work or developments, and manages Idaho's water rights program, reserving the authority to establish minimum stream flows to protect a variety of instream uses.

University of Idaho

Faculty and students from the University of Idaho College of Agricultural and Life Sciences, College of Natural Resources, and College of Science have been directly involved in activities related to fish, wildlife, and water quality issues. The Cooperative Extension Service provides assistance in public outreach and education.

4.3 Local/Community Efforts

Clearwater Soil and Water Conservation District

The Clearwater Soil and Water Conservation District provides guidance and assistance to citizens with land use and natural resource needs. Their Resource Conservation Plan facilitates sustainable management of natural resources by outlining procedures and methods, prioritizing current needs, and identifying expectations. The district's goal is to ensure that the land, water, and wildlife resources under its care will remain viable and sustainable in the future.

In the mid-1990s, the CSWCD staff successfully recruited private land owner cooperation to install BMPs like riparian fencing, armored stream access ramps, and woody vegetation plantings along degraded stream segments of Jim Brown Creek. BMP effectiveness monitoring undertaken by the CSWCD did show improvements in habitat, bank and channel stability where BMPs were installed.

Highway Districts

Both the Clearwater and Idaho County Highway Districts administer BMPs to control erosion and sediment transport from county road construction projects.

Potlatch Corporation

Potlatch Corporation uses comprehensive methods to control sediment transport from their harvesting, planting, and road building activities in the Lolo Creek Subbasin. They follow FPA guidelines for BMPs and also use their own refined procedures to ensure their impact on water quality is minimal and their forests remain sustainable.

5. Total Maximum Daily Load(s)

A TMDL prescribes an upper limit 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 waste load allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA).

Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load that is 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 that 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.

This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a load analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a load 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 a TMDL is protective under critical conditions, it 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 on the surface.

A pollutant 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.

5.1 Instream Water Quality Targets

For the Lolo Creek tributaries temperature TMDLs we utilize a potential natural vegetation (PNV) approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) which establishes that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered to be a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and the natural level of shade and channel width become the target of the TMDL. The instream temperature that results from attainment of these conditions is consistent with the water quality standards, even though it may exceed numeric temperature criteria. 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 Shumar and De Varona (2009). For a more complete discussion of shade and its effects on stream water temperature, the reader is referred to the *South Fork Clearwater Subbasin Assessment and TMDLs* (IDEQ, 2004) and *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and De Varona, 2009).

Potential Natural Vegetation for Temperature TMDLs

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 the factors influencing shade that are most likely to have been influenced by human activities, and that can be most readily 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 enjoys in a number of ways. Effective shade, which is the shade provided by all objects (not just vegetation) that intercept the sun as it makes its way across the sky, can be measured in a given spot with a solar pathfinder or with 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 the stream's aspect. In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream, and it can either be measured using a densiometer or estimated visually either on site or in aerial photographs. All of these methods tell us information about how much of the stream is covered and how much of it is exposed to direct solar radiation.

Potential natural vegetation (PNV) along a stream is that riparian plant community that could grow to an overall mature state, although some level of natural disturbance is usually included in our development and use of shade targets. The PNV can be removed either by natural disturbance (wildfire, disease/old age, wind-blown, wildlife grazing) or by human activities and influences (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, (with the exception of natural levels of disturbance and age distribution), results in the stream heating up from human-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, flood, or other natural disturbance will be at less than PNV and require their own time to recover. Streams that have been disturbed by human activity may require additional restoration above and beyond natural recovery.

Existing shade was estimated for the Lolo Creek tributaries from visual observations of aerial photos (2009 NAIP imagery). 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 by analyzing vegetation communities most likely to have populated the streams and comparing that to a shade curve developed for similar vegetation communities. 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 wide streams. As the vegetation gets taller, the plant community is able to provide more shade at any given channel width.

Existing and PNV shade values were converted to solar load values based on solar load data recorded on flat plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations that collect these data. In this case, the Missoula, Montana station was used. This solar load data is collected on flat plate collectors under full sun. 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 (IDAPA 58.01.02.200.09). 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 human-caused sources of heat in the watershed), and are thus considered to be consistent with the Idaho water quality standards, even though they may exceed numeric criteria by more than 0.3°C.

Pathfinder Methodology

The solar pathfinder is a device that allows one to trace the outline of shade-producing objects on specialized charts called solar path charts. These charts are further specialized by month and called monthly solar path charts. The percentage of the sun’s path covered by these shade-producing 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 location where a tracing is made, the solar pathfinder should be placed in the middle of the stream about the bankfull water level. The manufacturer's instructions for making traces should be followed—this includes making sure the pathfinder is level and is oriented to the south. To choose ten locations without biasing the locations, systematic sampling is easiest. To do this, the person making the tracings would start at a unique location such as 50 to 100 m from a bridge or fence line and then proceed upstream or downstream, stopping to take additional traces at fixed intervals (e.g., every 50m, every 50 paces, etc.). The person could instead randomly locate the specific spots for making tracings by generating random numbers and using them as interval distances.

It is a good idea to measure bankfull widths and take notes while taking solar pathfinder traces, and to photograph the landscape of the stream at several unique locations. Special attention should 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 person can take readings with a convex and/or concave densiometer at the same locations as they make solar pathfinder traces. This provides the information that would be needed to develop relationships between canopy cover (densiometer) and effective shade (solar pathfinder) measurements for a given stream.

Aerial Photo Interpretation Methodology

Expectations of effective shade based on plant type and density are determined for stream segments that have similar natural vegetation density and these are marked out on a 1:100K or 1:250K hydrography. Each segment is assigned a single value that represents an entire 10% interval in effective shade percentage (a shade class). Each 10% interval is represented by the lowest value in that interval. These shade classes and their representative values are described below (*adapted from the CWE process, IDL, 2000*). For example, if we estimate that shade for a particular stretch of stream is somewhere between 50% and 59%, we assign the value of 50% 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. Streams where the banks and water are clearly visible on an aerial photograph are usually are in low-shade classes (10 to 30%). Streams with dense forest or heavy brush where no portion of the stream is visible usually are in high-shade classes (70 to 90%). More open canopies where portions of the stream may be visible usually fall into moderate classes (40 to 60%).

It is important to note that the visual estimates made from 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 such as the shade provided by steep canyon walls. We assume that canopy coverage and effective shade are similar based on research conducted by Oregon DEQ. The visual estimates of shade in this TMDL should be field-verified with a solar pathfinder. The pathfinder measures effective shade and takes into consideration 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 by interpreting 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 stream 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 smaller percentage of the water surface in wider streams, and widened streams can also have less vegetative cover if shoreline vegetation has been eroded away.

Stream width (i.e., NSDZ or Bankfull Width) may not be discernable by aerial photo interpretation described previously. Accordingly, this parameter must be estimated from available information. For the major basins in Idaho, we use regional curves, with data compiled by Diane Hopster of Idaho Department of Lands (Figure 1), to estimate natural bankfull width.

For each stream evaluated in the load analysis, natural bankfull width was estimated based on the Clearwater River basin curve (Table 9, Figure 10). Although estimates from other curves were examined (i.e. Spokane, Kootenai, Pend Oreille), the Clearwater curve was ultimately chosen because of its proximity to the Lolo Creek watershed. Additionally, existing width data should be evaluated and compared to these curve estimates if such data are available. However, for these watersheds, only a few BURP-surveyed and pathfinder-measured sites exist and bankfull width data from those sites represents only spot data (three to five measured widths in a reach only several hundred meters long) that are not always representative of the stream as a whole. In general, we found BURP bankfull width values to be greater than bankfull width estimates from the Clearwater basin curve and chose not to make the natural widths used in this analysis any different than these Clearwater basin curve-based estimates. For every stream segment in the load analysis tables, there is a natural bankfull width and an existing bankfull width based on the bankfull width values presented in Table 9.

Table 9. Bankfull Width Estimates Based on Drainage Area and Existing Measures.

Location	area (sq mi)	Spokane (m)	Kootenai (m)	PendOreille (m)	Clearwater (m)	Existing (m)*
Dollar Creek @ mouth	2.66	4	3	4	3	
Dollar Creek @ 4030ft	0.65	2	2	2	1	4.7, 4.5
Eldorado Creek @ mouth	42.4	15	13	11	12	
Eldorado Creek ab Cedar Creek	33.2	13	12	10	11	15.7
Eldorado Creek ab Fan Creek	24	12	10	9	9	
Eldorado Creek ab Dollar Creek	11.7	8	7	7	6	9.5
Eldorado Creek @ 3660ft	3.86	5	4	4	3	5.8 @3600ft
Jim Brown Creek @ mouth	29.6	13	11	10	10	7.2, 9.6, 9.8
Jim Brown Creek ab Mosquito Cr	20.8	11	9	9	8	
Jim Brown Creek ab Weaver Creek	10.3	8	7	6	6	4.7
Jim Brown Creek ab Sourdough Cr	2.77	4	3	4	3	
Musselshell Creek @ mouth	55.2	17	15	13	14	16.6
Musselshell Creek ab Jim Brown Cr	19	10	9	8	8	7.4
Musselshell Creek ab Gold Creek	12.1	8	7	7	6	8
Musselshell Creek ab Alder Creek	7.1	6	5	6	5	
Musselshell Creek ab Cole Creek	2.86	4	3	4	3	

* The existing widths shown here are measurements made either during BURP surveys or during monitoring with solar pathfinders.

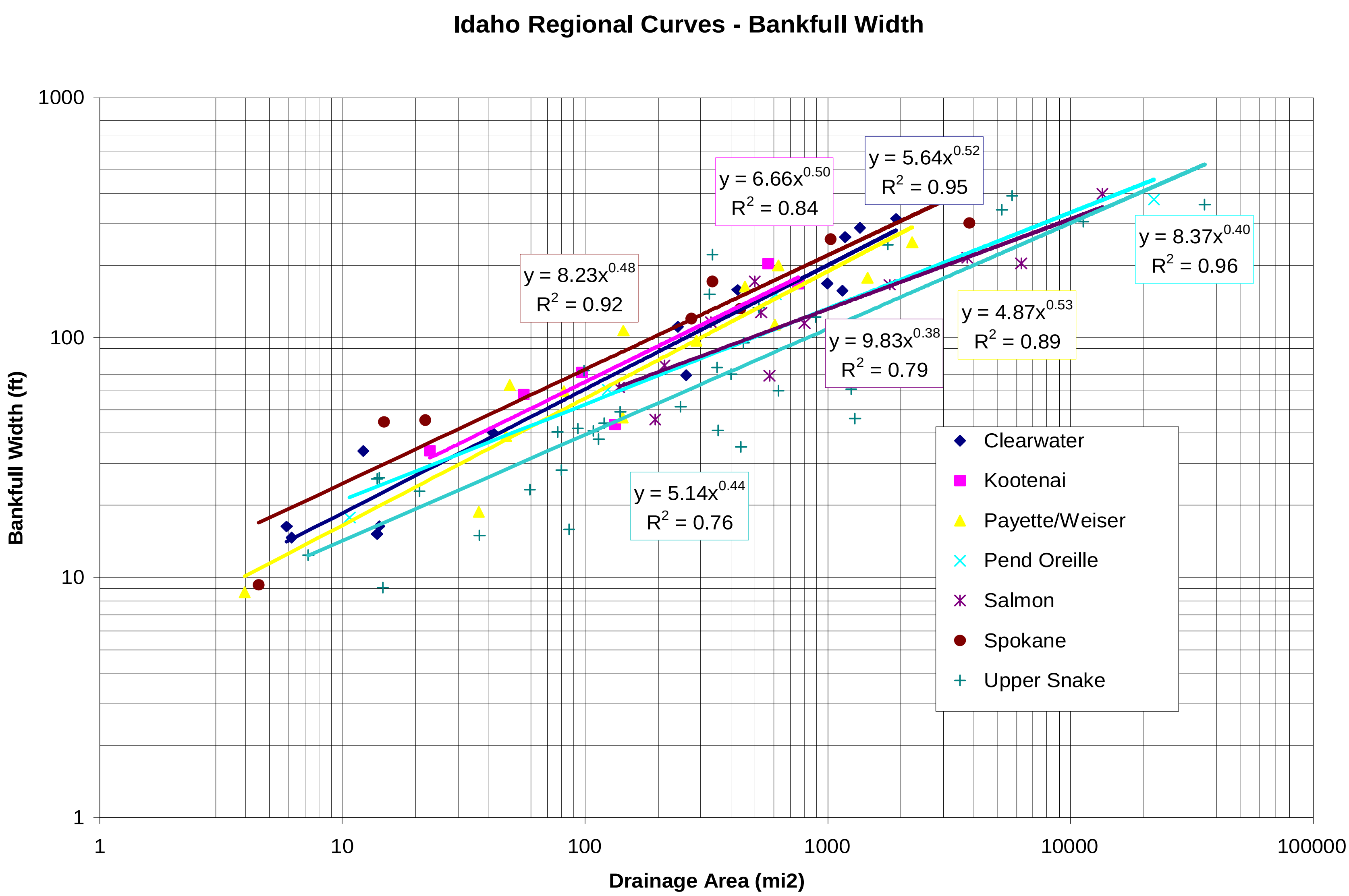

Figure 10. Bankfull Width as a Function of Drainage Area for Major River Basins.

Design Conditions

The upper portion of the Lolo Creek watershed is within the Clearwater Mountains and Breaks Level 4 Ecoregion of the Northern Rockies Level 3 Ecoregion of McGrath et al. (2001). This region is exposed to substantial maritime influence resulting in moist coniferous forests that are transitional in species composition between northern Idaho Panhandle forests and the drier forests of the southern Idaho Batholith.

The Clearwater National Forest identifies three broad groups of forest type based on their landtype associations classification system. These groups are:

- Breaklands – forests on steep slopes at lower elevations, with warmer temperature regimes.
- Uplands – forests generally above the breaklands in elevation, which have more rolling topography. They tend to be cooler and more mesic than breaklands.
- Subalpine – the setting above the uplands elevationally, with mixed topography and generally colder temperatures.

The shade curves (described below) provide shade values to be used as targets for PNV type temperature TMDLs in Idaho and were developed by DEQ and EPA from information about these landtype groups (see Shumar and De Varona, 2009).

Target Selection

To determine potential natural vegetation shade targets for the Lolo Creek tributaries, effective shade curves from the Clearwater National Forest (CNF) section of DEQ's PNV TMDL Procedures Manual (Shumar and De Varona, 2009) were examined. These curves were produced using vegetation community modeling of Idaho plant communities. 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 Lolo Creek tributaries, the curve for the most similar vegetation type was selected for each shade target determination.

First, an overlay of CNF landtypes grouped as breaklands, uplands, and subalpine areas was placed over the stream being examined. The upper portions of these streams were predominantly in the upland type although there were occasional sections of stream in the breakland type. As streams progress downstream they leave the forest groups and enter a region where other non-forest landtypes occur. Visual observations of these regions reveal that stream valleys were widening and alder communities tended to dominate the streamside vegetation and the forest was further away from the stream. A similar situation occurs with streams throughout the Panhandle region of Idaho. For that region we have developed non-forest shade curves based on hardwood vegetation that is applied as targets using a stream order and gradient approach (see Shumar and De Varona, 2009). A similar situation did not exist for the Clearwater region, therefore, we have developed a new shade curve for this region that is based on the CNF upland forest type and the mountain alder (*Alnus incana*) non-forest community as described in Shumar and De Varona (2009). We split the 41m buffer width in the model such that the first five zones adjacent to the stream are based on the mountain alder community dimensions (55% canopy cover and 5.1m weighted average height), and the four remaining zones furthest from the stream utilize the CNF uplands forest dimensions (81% canopy cover and 21m weighted average height). The resulting shade curve we refer to as the CNF Upland-Alder Mixed curve can be seen in Appendix C of this document. This shade curve is used for shade targets on those portions of streams in this TMDL where the valley has widened and the forest no longer dominates the stream-edge vegetation.

Monitoring Points

The accuracy of shade values based on the aerial photo interpretations was field-verified with a solar pathfinder at seven sites. Although limited, we were able to use the results of these pathfinder measurements to re-calibrate our estimates by re-examining the original aerial photo interpretations of existing shade. The pathfinder-measured values in Table 10 revealed that the original photo interpretations underestimated shade by an average of 3% ± 4.8 (mean ± 95% C.I.).

Table 10. Pathfinder Results for Seven Sites on the Lolo Creek Tributaries.

Aerial photo-based shade class	Pathfinder-measured actual shade value	Pathfinder measurement-based shade class	Difference (delta)	
90	86.9	80	10	Dollar
10	19.9	10	0	Eldorado
10	22.6	20	-10	Jim Brown – mouth
10	19.4	10	0	Jim Brown
40	69.3	60	-20	Musselshell –upper
20	26.6	20	0	Musselshell
50	50.8	50	0	Musselshell –mouth
			-3	average
			9.51	standard deviation
			4.81	95% CI

To determine accuracy of effective shade estimates, monitoring can be conducted on any reach throughout the Lolo Creek watershed the measured shade values can be compared to estimates of existing shade seen on Figure 11 and Figure 14, and described in Table 11 through Table 14. Those areas with the largest disparity between existing shade estimates and shade targets should be monitored with solar pathfinders to verify or adjust the existing shade levels and to determine progress toward meeting shade targets. It is important to note that many existing shade estimates have not been field-verified and may require adjustment during the TMDL implementation process. The lengths of the different stream segments determined as having the same effective shade level vary because they depend 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. Ten equally-spaced solar pathfinder measurements taken within one segment and averaged together should suffice to determine a new shade levels in the future for that segment.

5.2 Load Capacity

The load capacity for a stream under PNV is essentially the solar load allowed by the target shade levels specified for the reaches within that stream. These loads are determined by determining the solar load recorded on flat plat collector (under full sun/no shade) as described earlier, for a given period of time, which is the amount of solar load with 0% shade (full sun). That load is then multiplied by the amount of solar radiation that is not blocked by shade (i.e., the “percent open”, which is equal to 100% minus the percentage of shade). In other words, if a shade target is 60% (or 0.6), then the solar load that would reach the stream at that target level of shade is 40% of the load recorded on the flat plate collector under full sun.

DEQ obtains solar load data recorded on flat plate collectors from National Renewable Energy Laboratory (NREL) weather stations near by. In this case, data from the Missoula, Montana station was used. The solar loads used in this TMDL are spring/summer averages; therefore, we used the average load for just the six-month period from April through September. These months coincide with the time of year when stream temperatures are increasing and deciduous vegetation is in leaf, and extend into early fall spawning time. Table 11 through Table 14 and Figure 11 and Figure 14 show the PNV shade target levels (identified as Target or Potential Shade) and their corresponding potential summer load (on an area basis in $kWh/m^2/day$ and as total load in kWh/day) that serve as the load capacities for the streams.

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 spring and fall salmonids spawning and when cold water aquatic life criteria 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 later on in the summer, but solar loads affect salmonids spawning temperatures in spring and fall. Thus, solar loading in these streams is evaluated from spring (April) to early fall (September).

5.3 Estimates of Existing Pollutant Loads

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)). An estimate must be made for each point source; however, there are no point sources known to DEQ in this subbasin. Nonpoint sources are typically estimated based on the type of source (land use) and area (such as a subwatershed), but may be aggregated by type of source or land area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. Like target shade, existing shade levels were converted to solar load values by multiplying the fraction of open stream by the solar radiation recorded on a flat plate collector at the Missoula, Montana NREL weather station. Existing shade values are presented in Table 11 through Table 14 and Figure 12 and Figure 15. Like load capacities (potential loads), existing loads in Table 11 through Table 14 are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day).

Total existing loads or total potential loads, in kWh/day, can be summed for the entire stream or portion of stream examined in a single load analysis 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 section on load allocation.

Table 11. Existing and Potential Solar Loads for Dollar Creek.

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)	Lack of Shade (%)	**Dollar Creek**
AU# ID17060306CL029_02														
740	0.9	0.55	0.99	0.055	-0.495	1	1	740	407	740	40.7	-366.3	-9	CNF upland
250	0.8	1.1	0.99	0.055	-1.045	1	1	250	275	250	13.75	-261.25	-19	forest
400	0.9	0.55	0.99	0.055	-0.495	1	1	400	220	400	22	-198	-9	
70	0.7	1.65	0.99	0.055	-1.595	1	1	70	115.5	70	3.85	-111.65	-29	
90	0.9	0.55	0.99	0.055	-0.495	1	1	90	49.5	90	4.95	-44.55	-9	
80	0.6	2.2	0.99	0.055	-2.145	2	1	160	352	80	4.4	-347.6	-39	
170	0.9	0.55	0.99	0.055	-0.495	2	1	340	187	170	9.35	-177.65	-9	
90	0.6	2.2	0.99	0.055	-2.145	2	1	180	396	90	4.95	-391.05	-39	
340	0.9	0.55	0.99	0.055	-0.495	2	1	680	374	340	18.7	-355.3	-9	
100	0.6	2.2	0.98	0.11	-2.09	3	2	300	660	200	22	-638	-38	
240	0.8	1.1	0.98	0.11	-0.99	3	2	720	792	480	52.8	-739.2	-18	
80	0.7	1.65	0.98	0.11	-1.54	3	2	240	396	160	17.6	-378.4	-28	
1080	0.8	1.1	0.98	0.11	-0.99	4	2	4320	4752	2160	237.6	-4514.4	-18	
560	0.9	0.55	0.96	0.22	-0.33	3	3	1680	924	1680	369.6	-554.4	-6	
180	0.8	1.1	0.96	0.22	-0.88	3	3	540	594	540	118.8	-475.2	-16	
160	0.7	1.65	0.74	1.43	-0.22	3	3	480	792	480	686.4	-105.6	-4	upland-alder
120	0.6	2.2	0.74	1.43	-0.77	3	3	360	792	360	514.8	-277.2	-14	mix
460	0.3	3.85	0.74	1.43	-2.42	3	3	1380	5313	1380	1973.4	-3339.6	-44	
							Total	**12,930**	**17,391**	**9,670**	**4,116**	**-13,275**	**-20**	

Table 12. Existing and Potential Solar Loads for Eldorado Creek.

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)	Lack of Shade (%)	**Eldorado Creek**
AU# ID17060306CL029_02														
3300	0.9	0.55	0.94	0.33	-0.22	2	2	6600	3630	6600	2178	-1452	-4	CNF breakland
400	0.7	1.65	0.74	1.43	-0.22	3	3	1200	1980	1200	1716	-264	-4	upland-alder
380	0.9	0.55	0.96	0.22	-0.33	3	3	1140	627	1140	250.8	-376.2	-6	CNF upland
260	0.7	1.65	0.74	1.43	-0.22	3	3	780	1287	780	1115.4	-171.6	-4	upland-alder
420	0.5	2.75	0.74	1.43	-1.32	3	3	1260	3465	1260	1801.8	-1663.2	-24	mix
350	0.2	4.4	0.74	1.43	-2.97	4	3	1400	6160	1050	1501.5	-4658.5	-54	
920	0.5	2.75	0.61	2.145	-0.605	4	4	3680	10120	3680	7893.6	-2226.4	-11	
120	0.8	1.1	0.94	0.33	-0.77	4	4	480	528	480	158.4	-369.6	-14	CNF upland
120	0.4	3.3	0.61	2.145	-1.155	4	4	480	1584	480	1029.6	-554.4	-21	upland-alder
340	0.7	1.65	0.61	2.145	0.495	4	4	1360	2244	1360	2917.2	673.2	0	mix
290	0.8	1.1	0.94	0.33	-0.77	5	4	1450	1595	1160	382.8	-1212.2	-14	CNF upland
380	0.5	2.75	0.61	2.145	-0.605	5	4	1900	5225	1520	3260.4	-1964.6	-11	upland-alder
200	0.7	1.65	0.92	0.44	-1.21	5	5	1000	1650	1000	440	-1210	-22	CNF upland
850	0.4	3.3	0.52	2.64	-0.66	5	5	4250	14025	4250	11220	-2805	-12	upland-alder
170	0.1	4.95	0.52	2.64	-2.31	6	5	1020	5049	850	2244	-2805	-42	mix
180	0.3	3.85	0.52	2.64	-1.21	6	5	1080	4158	900	2376	-1782	-22	
110	0.1	4.95	0.52	2.64	-2.31	6	5	660	3267	550	1452	-1815	-42	
120	0.7	1.65	0.52	2.64	0.99	7	5	840	1386	600	1584	198	18	
320	0.2	4.4	0.52	2.64	-1.76	7	5	2240	9856	1600	4224	-5632	-32	
480	0.4	3.3	0.46	2.97	-0.33	7	6	3360	11088	2880	8553.6	-2534.4	-6	
550	0.6	2.2	0.46	2.97	0.77	7	6	3850	8470	3300	9801	1331	0	
290	0.3	3.85	0.46	2.97	-0.88	8	6	2320	8932	1740	5167.8	-3764.2	-16	
120	0.4	3.3	0.46	2.97	-0.33	8	6	960	3168	720	2138.4	-1029.6	-6	
60	0.1	4.95	0.46	2.97	-1.98	8	6	480	2376	360	1069.2	-1306.8	-36	
270	0.4	3.3	0.46	2.97	-0.33	9	6	2430	8019	1620	4811.4	-3207.6	-6	
210	0.2	4.4	0.46	2.97	-1.43	9	6	1890	8316	1260	3742.2	-4573.8	-26	
250	0.1	4.95	0.41	3.245	-1.705	9	7	2250	11137.5	1750	5678.75	-5458.75	-31	
170	0.4	3.3	0.41	3.245	-0.055	9	7	1530	5049	1190	3861.55	-1187.45	-1	
450	0.3	3.85	0.41	3.245	-0.605	9	7	4050	15592.5	3150	10221.75	-5370.75	-11	
300	0.2	4.4	0.41	3.245	-1.155	9	7	2700	11880	2100	6814.5	-5065.5	-21	
290	0.3	3.85	0.41	3.245	-0.605	9	7	2610	10048.5	2030	6587.35	-3461.15	-11	
520	0.2	4.4	0.41	3.245	-1.155	10	7	5200	22880	3640	11811.8	-11068.2	-21	
130	0.4	3.3	0.41	3.245	-0.055	10	7	1300	4290	910	2952.95	-1337.05	-1	
510	0.2	4.4	0.37	3.465	-0.935	10	8	5100	22440	4080	14137.2	-8302.8	-17	
110	0.4	3.3	0.37	3.465	0.165	10	8	1100	3630	880	3049.2	-580.8	0	

Table 12 (cont.). Existing and Potential Solar Loads for Eldorado Creek.

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)	Lack of Shade (%)	**Eldorado Creek**
190	0.2	4.4	0.37	3.465	-0.935	10	8	1900	8360	1520	5266.8	-3093.2	-17	
110	0.3	3.85	0.37	3.465	-0.385	10	8	1100	4235	880	3049.2	-1185.8	-7	
170	0.2	4.4	0.37	3.465	-0.935	10	8	1700	7480	1360	4712.4	-2767.6	-17	
410	0.3	3.85	0.37	3.465	-0.385	11	8	4510	17363.5	3280	11365.2	-5998.3	-7	
400	0.4	3.3	0.37	3.465	0.165	11	8	4400	14520	3200	11088	-3432	0	
470	0.3	3.85	0.37	3.465	-0.385	11	8	5170	19904.5	3760	13028.4	-6876.1	-7	
460	0.7	1.65	0.76	1.32	-0.33	11	9	5060	8349	4140	5464.8	-2884.2	-6	CNF upland
380	0.5	2.75	0.76	1.32	-1.43	11	9	4180	11495	3420	4514.4	-6980.6	-26	forest
840	0.6	2.2	0.76	1.32	-0.88	12	9	10080	22176	7560	9979.2	-12196.8	-16	
70	0.5	2.75	0.76	1.32	-1.43	12	9	840	2310	630	831.6	-1478.4	-26	
AU# ID17060306CL029_03														
290	0.5	2.75	0.76	1.32	-1.43	12	9	3480	9570	2610	3445.2	-6124.8	-26	
680	0.4	3.3	0.76	1.32	-1.98	12	9	8160	26928	6120	8078.4	-18849.6	-36	
500	0.3	3.85	0.72	1.54	-2.31	13	10	6500	25025	5000	7700	-17325	-42	
380	0.2	4.4	0.72	1.54	-2.86	13	10	4940	21736	3800	5852	-15884	-52	
150	0.4	3.3	0.72	1.54	-1.76	13	10	1950	6435	1500	2310	-4125	-32	
370	0.3	3.85	0.72	1.54	-2.31	13	10	4810	18518.5	3700	5698	-12820.5	-42	
650	0.1	4.95	0.31	3.795	-1.155	13	10	8450	41827.5	6500	24667.5	-17160	-21	upland-alder
420	0.2	4.4	0.31	3.795	-0.605	14	10	5880	25872	4200	15939	-9933	-11	mix
330	0.3	3.85	0.31	3.795	-0.055	14	10	4620	17787	3300	12523.5	-5263.5	-1	
150	0.4	3.3	0.31	3.795	0.495	14	10	2100	6930	1500	5692.5	-1237.5	0	
140	0.3	3.85	0.31	3.795	-0.055	14	10	1960	7546	1400	5313	-2233	-1	
280	0.4	3.3	0.31	3.795	0.495	14	10	3920	12936	2800	10626	-2310	0	
400	0.3	3.85	0.31	3.795	-0.055	14	10	5600	21560	4000	15180	-6380	-1	
440	0.5	2.75	0.28	3.96	1.21	15	11	6600	18150	4840	19166.4	1016.4	0	
180	0.3	3.85	0.28	3.96	0.11	15	11	2700	10395	1980	7840.8	-2554.2	0	
810	0.2	4.4	0.28	3.96	-0.44	15	11	12150	53460	8910	35283.6	-18176.4	-8	
210	0.1	4.95	0.28	3.96	-0.99	15	11	3150	15592.5	2310	9147.6	-6444.9	-18	
160	0	5.5	0.28	3.96	-1.54	15	11	2400	13200	1760	6969.6	-6230.4	-28	
430	0.1	4.95	0.28	3.96	-0.99	16	11	6880	34056	4730	18730.8	-15325.2	-18	
570	0.2	4.4	0.28	3.96	-0.44	16	11	9120	40128	6270	24829.2	-15298.8	-8	
420	0.3	3.85	0.68	1.76	-2.09	16	11	6720	25872	4620	8131.2	-17740.8	-38	CNF upland
470	0.2	4.4	0.68	1.76	-2.64	16	11	7520	33088	5170	9099.2	-23988.8	-48	forest
530	0.4	3.3	0.26	4.07	0.77	16	12	8480	27984	6360	25885.2	-2098.8	0	upland-alder
410	0.4	3.3	0.64	1.98	-1.32	16	12	6560	21648	4920	9741.6	-11906.4	-24	CNF upland
480	0.3	3.85	0.64	1.98	-1.87	16	12	7680	29568	5760	11404.8	-18163.2	-34	forest
540	0.2	4.4	0.26	4.07	-0.33	16	12	8640	38016	6480	26373.6	-11642.4	-6	upland-alder
							Total	**263,860**	**955,174**	**202,360**	**553,073**	**-402,101**	**-16**	

Table 13. Existing and Potential Solar Loads for Jim Brown Creek.

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)	Lack of Shade (%)	**Jim Brown Creek**
AU# ID17060306CL031_02														
310	0.7	1.65	0.92	0.44	-1.21	1	1	310	511.5	310	136.4	-375.1	-22	CNF upland alder mix
390	0.8	1.1	0.92	0.44	-0.66	1	1	390	429	390	171.6	-257.4	-12	
710	0.7	1.65	0.87	0.715	-0.935	2	2	1420	2343	1420	1015.3	-1327.7	-17	
150	0.5	2.75	0.87	0.715	-2.035	2	2	300	825	300	214.5	-610.5	-37	
1590	0.2	4.4	0.74	1.43	-2.97	3	3	4770	20988	4770	6821.1	-14166.9	-54	
440	0.6	2.2	0.74	1.43	-0.77	3	3	1320	2904	1320	1887.6	-1016.4	-14	
200	0.5	2.75	0.61	2.145	-0.605	4	4	800	2200	800	1716	-484	-11	
270	0.6	2.2	0.61	2.145	-0.055	4	4	1080	2376	1080	2316.6	-59.4	-1	
290	0.4	3.3	0.61	2.145	-1.155	4	4	1160	3828	1160	2488.2	-1339.8	-21	
550	0.3	3.85	0.61	2.145	-1.705	4	4	2200	8470	2200	4719	-3751	-31	
140	0.4	3.3	0.61	2.145	-1.155	4	4	560	1848	560	1201.2	-646.8	-21	
590	0.2	4.4	0.52	2.64	-1.76	5	5	2950	12980	2950	7788	-5192	-32	
AU# ID17060306CL031_03														
630	0.1	4.95	0.52	2.64	-2.31	5	5	3150	15592.5	3150	8316	-7276.5	-42	
210	0.3	3.85	0.52	2.64	-1.21	5	5	1050	4042.5	1050	2772	-1270.5	-22	
290	0.1	4.95	0.46	2.97	-1.98	6	6	1740	8613	1740	5167.8	-3445.2	-36	
340	0.2	4.4	0.46	2.97	-1.43	6	6	2040	8976	2040	6058.8	-2917.2	-26	
900	0.1	4.95	0.46	2.97	-1.98	6	6	5400	26730	5400	16038	-10692	-36	
30	0	5.5	0.46	2.97	-2.53	6	6	180	990	180	534.6	-455.4	-46	
150	0.1	4.95	0.41	3.245	-1.705	7	7	1050	5197.5	1050	3407.25	-1790.25	-31	
530	0.2	4.4	0.41	3.245	-1.155	7	7	3710	16324	3710	12038.95	-4285.05	-21	
790	0.1	4.95	0.41	3.245	-1.705	7	7	5530	27373.5	5530	17944.85	-9428.65	-31	
590	0.2	4.4	0.37	3.465	-0.935	8	8	4720	20768	4720	16354.8	-4413.2	-17	
1560	0	5.5	0.37	3.465	-2.035	8	8	12480	68640	12480	43243.2	-25396.8	-37	
440	0.1	4.95	0.33	3.685	-1.265	9	9	3960	19602	3960	14592.6	-5009.4	-23	
470	0	5.5	0.33	3.685	-1.815	9	9	4230	23265	4230	15587.55	-7677.45	-33	
150	0.2	4.4	0.33	3.685	-0.715	9	9	1350	5940	1350	4974.75	-965.25	-13	
800	0.1	4.95	0.33	3.685	-1.265	9	9	7200	35640	7200	26532	-9108	-23	
230	0	5.5	0.31	3.795	-1.705	10	10	2300	12650	2300	8728.5	-3921.5	-31	
80	0.1	4.95	0.31	3.795	-1.155	10	10	800	3960	800	3036	-924	-21	
300	0	5.5	0.31	3.795	-1.705	10	10	3000	16500	3000	11385	-5115	-31	
70	0.2	4.4	0.31	3.795	-0.605	10	10	700	3080	700	2656.5	-423.5	-11	
230	0.1	4.95	0.31	3.795	-1.155	10	10	2300	11385	2300	8728.5	-2656.5	-21	
90	0.2	4.4	0.31	3.795	-0.605	10	10	900	3960	900	3415.5	-544.5	-11	
							Total	**85,050**	**398,932**	**85,050**	**261,989**	**-136,943**	**-25**	

Table 14. Existing and Potential Solar Loads for Musselshell Creek.

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)	Lack of Shade (%)	**Musselshell Creek**
17060306CL032_02														
870	0.9	0.55	0.95	0.275	-0.275	1	1	870	478.5	870	239.25	-239.25	-5	CNF breakland
3190	0.9	0.55	0.96	0.22	-0.33	3	3	9570	5263.5	9570	2105.4	-3158.1	-6	CNF upland
1060	0.8	1.1	0.94	0.33	-0.77	4	4	4240	4664	4240	1399.2	-3264.8	-14	forest
1100	0.7	1.65	0.94	0.33	-1.32	4	4	4400	7260	4400	1452	-5808	-24	
340	0.9	0.55	0.92	0.44	-0.11	5	5	1700	935	1700	748	-187	-2	
700	0.8	1.1	0.92	0.44	-0.66	5	5	3500	3850	3500	1540	-2310	-12	
290	0.9	0.55	0.92	0.44	-0.11	5	5	1450	797.5	1450	638	-159.5	-2	
340	0.7	1.65	0.92	0.44	-1.21	5	5	1700	2805	1700	748	-2057	-22	
390	0.4	3.3	0.92	0.44	-2.86	5	5	1950	6435	1950	858	-5577	-52	
180	0.6	2.2	0.92	0.44	-1.76	6	5	1080	2376	900	396	-1980	-32	
140	0.5	2.75	0.92	0.44	-2.31	6	5	840	2310	700	308	-2002	-42	
190	0.6	2.2	0.92	0.44	-1.76	6	5	1140	2508	950	418	-2090	-32	
170	0.8	1.1	0.92	0.44	-0.66	6	5	1020	1122	850	374	-748	-12	
450	0.7	1.65	0.52	2.64	0.99	6	5	2700	4455	2250	5940	1485	0	CNF upland
960	0.5	2.75	0.52	2.64	-0.11	6	5	5760	15840	4800	12672	-3168	-2	alder mix
620	0.4	3.3	0.46	2.97	-0.33	7	6	4340	14322	3720	11048.4	-3273.6	-6	
210	0.5	2.75	0.46	2.97	0.22	7	6	1470	4042.5	1260	3742.2	-300.3	0	
790	0.4	3.3	0.46	2.97	-0.33	7	6	5530	18249	4740	14077.8	-4171.2	-6	
140	0.6	2.2	0.46	2.97	0.77	7	6	980	2156	840	2494.8	338.8	0	
720	0.4	3.3	0.46	2.97	-0.33	7	6	5040	16632	4320	12830.4	-3801.6	-6	
280	0.6	2.2	0.46	2.97	0.77	8	6	2240	4928	1680	4989.6	61.6	0	
100	0.4	3.3	0.46	2.97	-0.33	8	6	800	2640	600	1782	-858	-6	
180	0.6	2.2	0.46	2.97	0.77	8	6	1440	3168	1080	3207.6	39.6	0	
680	0.5	2.75	0.46	2.97	0.22	8	6	5440	14960	4080	12117.6	-2842.4	0	
390	0.4	3.3	0.46	2.97	-0.33	8	6	3120	10296	2340	6949.8	-3346.2	-6	
260	0.3	3.85	0.41	3.245	-0.605	8	7	2080	8008	1820	5905.9	-2102.1	-11	
120	0.5	2.75	0.41	3.245	0.495	8	7	960	2640	840	2725.8	85.8	0	
940	0.4	3.3	0.41	3.245	-0.055	8	7	7520	24816	6580	21352.1	-3463.9	-1	
530	0.1	4.95	0.41	3.245	-1.705	8	7	4240	20988	3710	12038.95	-8949.05	-31	
410	0.2	4.4	0.41	3.245	-1.155	8	7	3280	14432	2870	9313.15	-5118.85	-21	
1740	0.2	4.4	0.37	3.465	-0.935	8	8	13920	61248	13920	48232.8	-13015.2	-17	
240	0.1	4.95	0.37	3.465	-1.485	8	8	1920	9504	1920	6652.8	-2851.2	-27	
180	0.2	4.4	0.37	3.465	-0.935	8	8	1440	6336	1440	4989.6	-1346.4	-17	
230	0.1	4.95	0.37	3.465	-1.485	8	8	1840	9108	1840	6375.6	-2732.4	-27	
90	0.2	4.4	0.37	3.465	-0.935	8	8	720	3168	720	2494.8	-673.2	-17	
200	0.1	4.95	0.37	3.465	-1.485	8	8	1600	7920	1600	5544	-2376	-27	
820	0.2	4.4	0.37	3.465	-0.935	8	8	6560	28864	6560	22730.4	-6133.6	-17	
17060306CL032_03														
560	0.1	4.95	0.33	3.685	-1.265	9	9	5040	24948	5040	18572.4	-6375.6	-23	
3600	0.2	4.4	0.45	3.025	-1.375	12	11	43200	190080	39600	119790	-70290	-25	CNF breakland
170	0.1	4.95	0.26	4.07	-0.88	13	12	2210	10939.5	2040	8302.8	-2636.7	-16	upland-alder
600	0.2	4.4	0.4	3.3	-1.1	14	13	8400	36960	7800	25740	-11220	-20	CNF breakland
280	0.4	3.3	0.4	3.3	0	15	13	4200	13860	3640	12012	-1848	0	forest
1700	0.5	2.75	0.38	3.41	0.66	16	14	27200	74800	23800	81158	6358	0	
							Total	**208,650**	**701,113**	**190,230**	**517,007**	**-184,105**	**-14**	

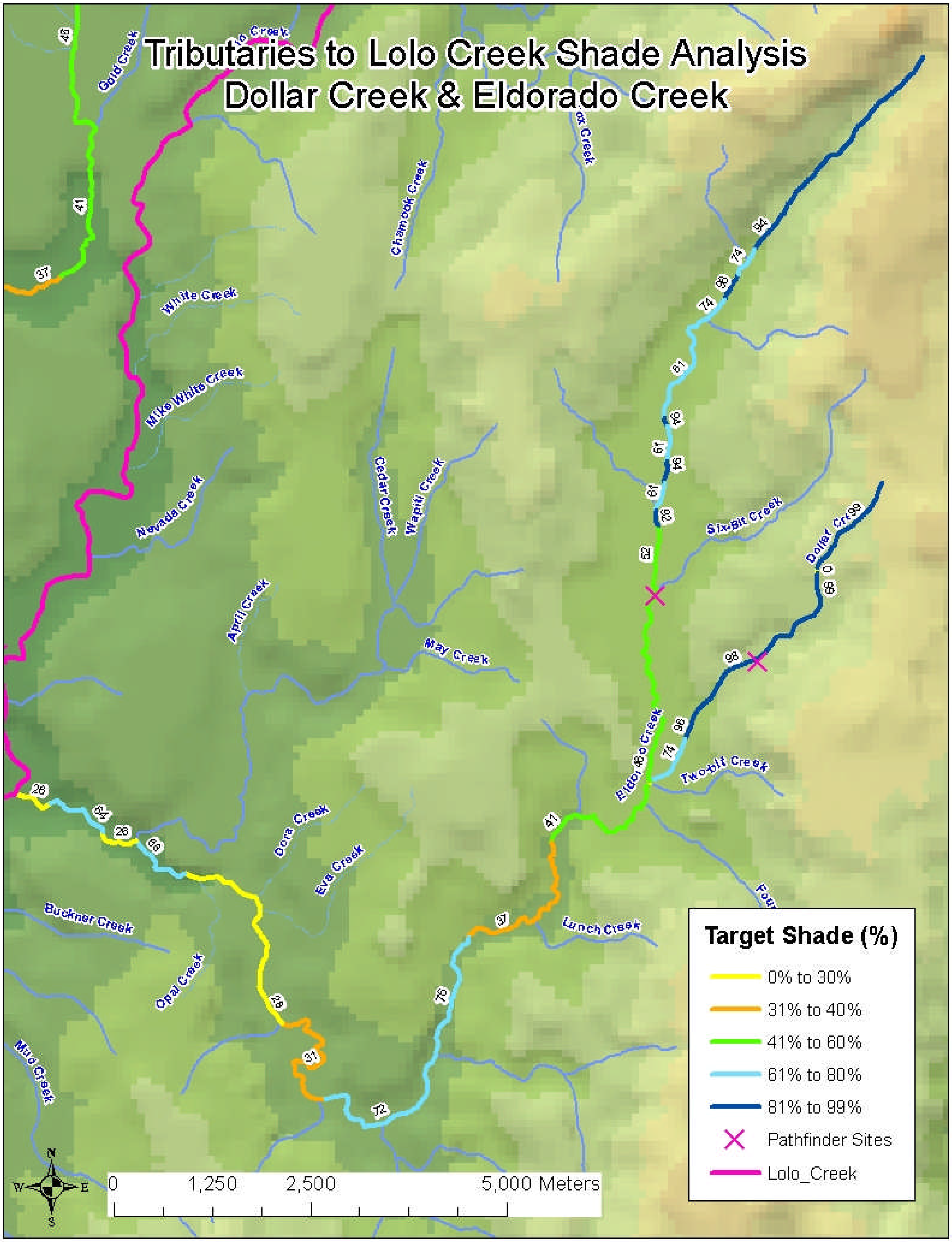

Figure 11. Target Shade for Dollar Creek and Eldorado Creek.

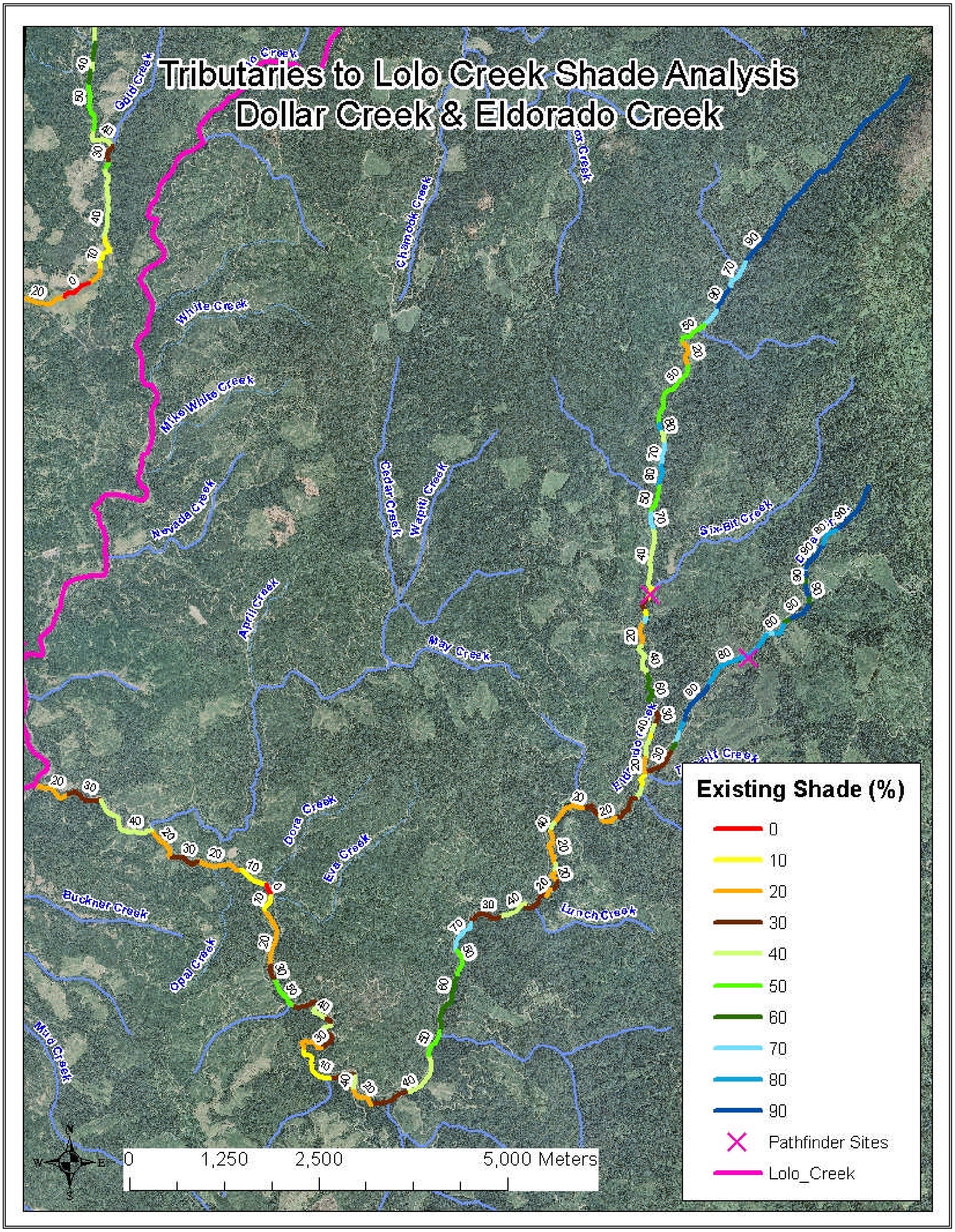

Figure 12. Existing Shade Estimated for Dollar Creek and Eldorado Creek by Aerial Photo Interpretation.

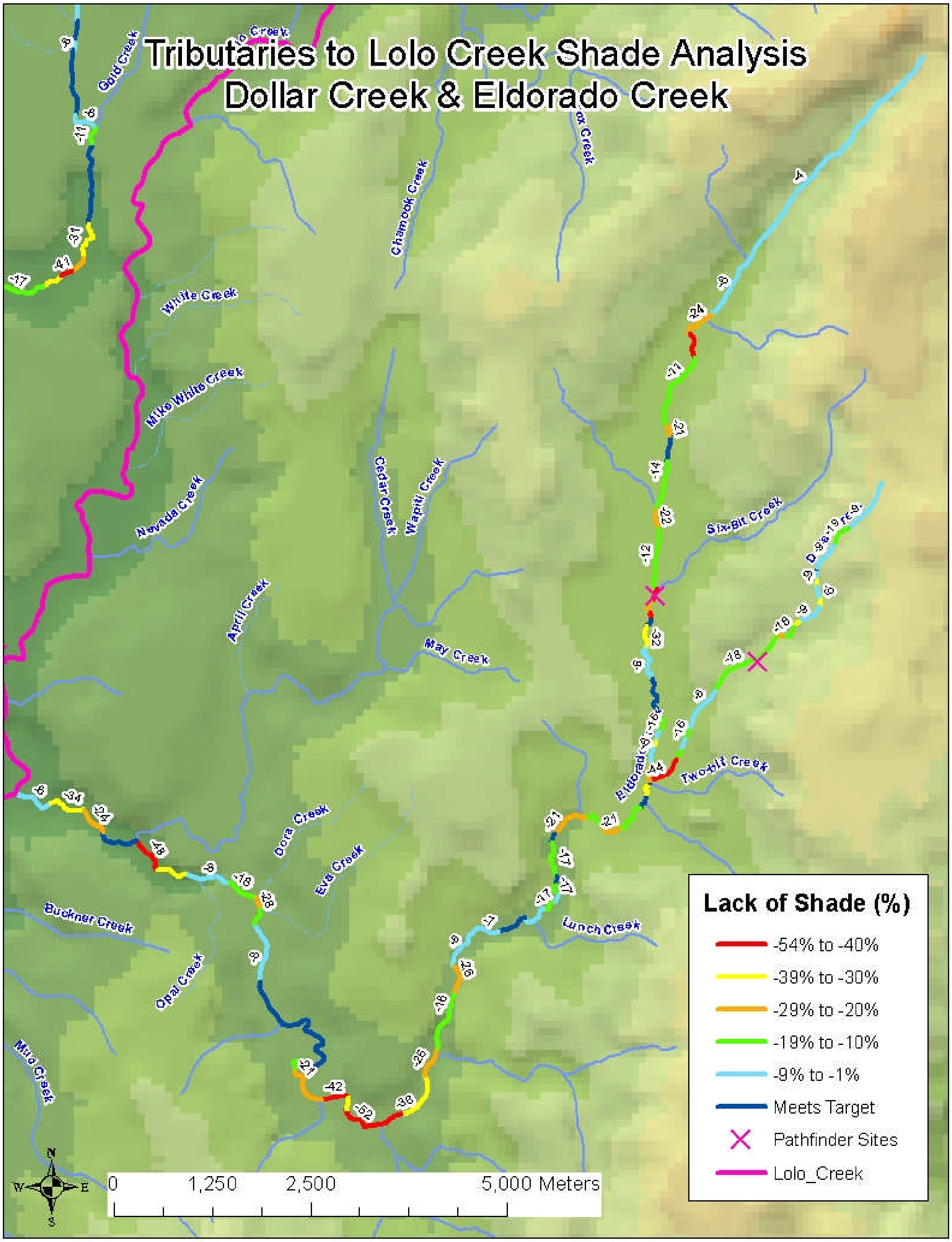

Figure 13. Lack of Shade (Difference Between Existing and Target) for Dollar Creek and Eldorado Creek.

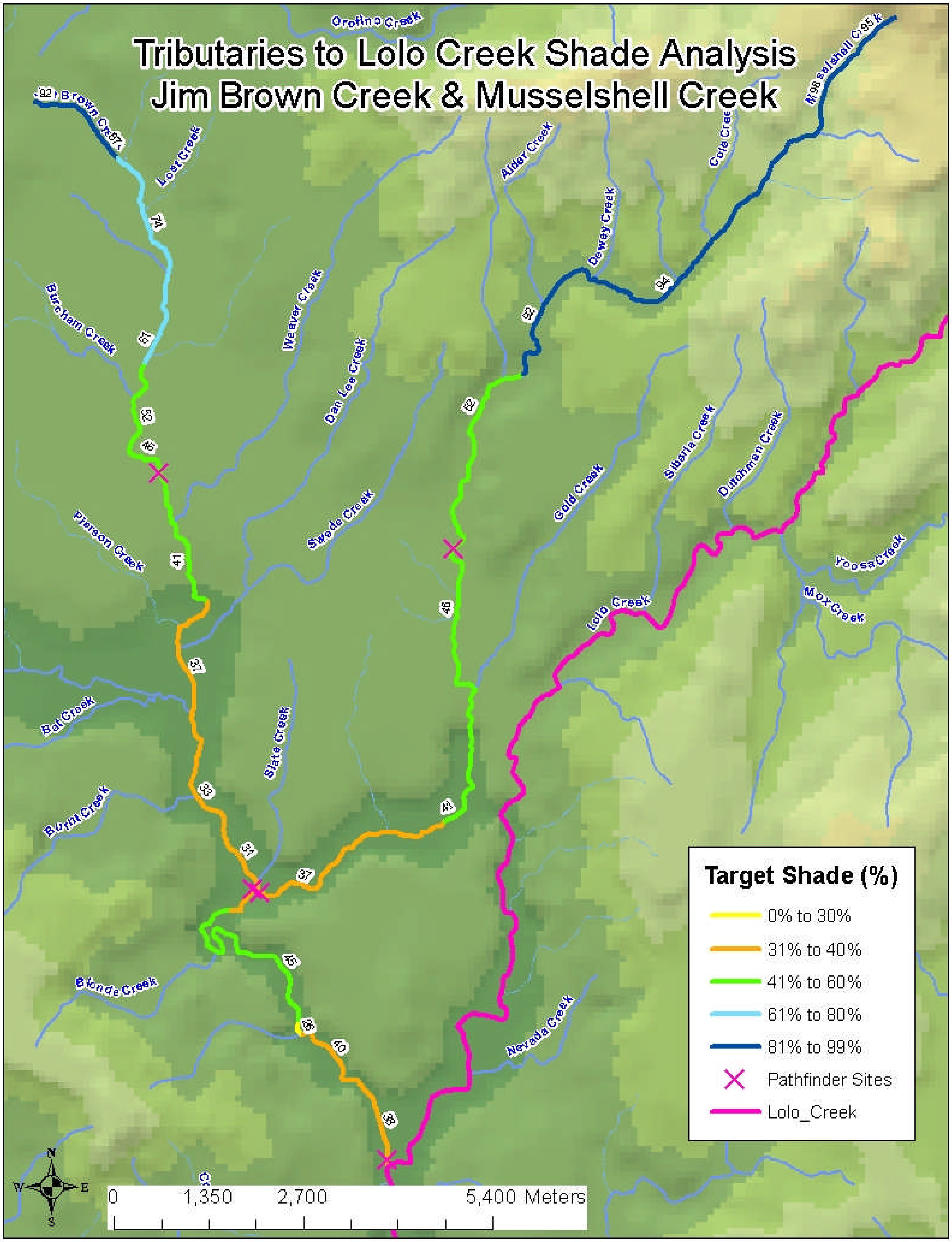

Figure 14. Target Shade for Jim Brown Creek and Musselshell Creek.

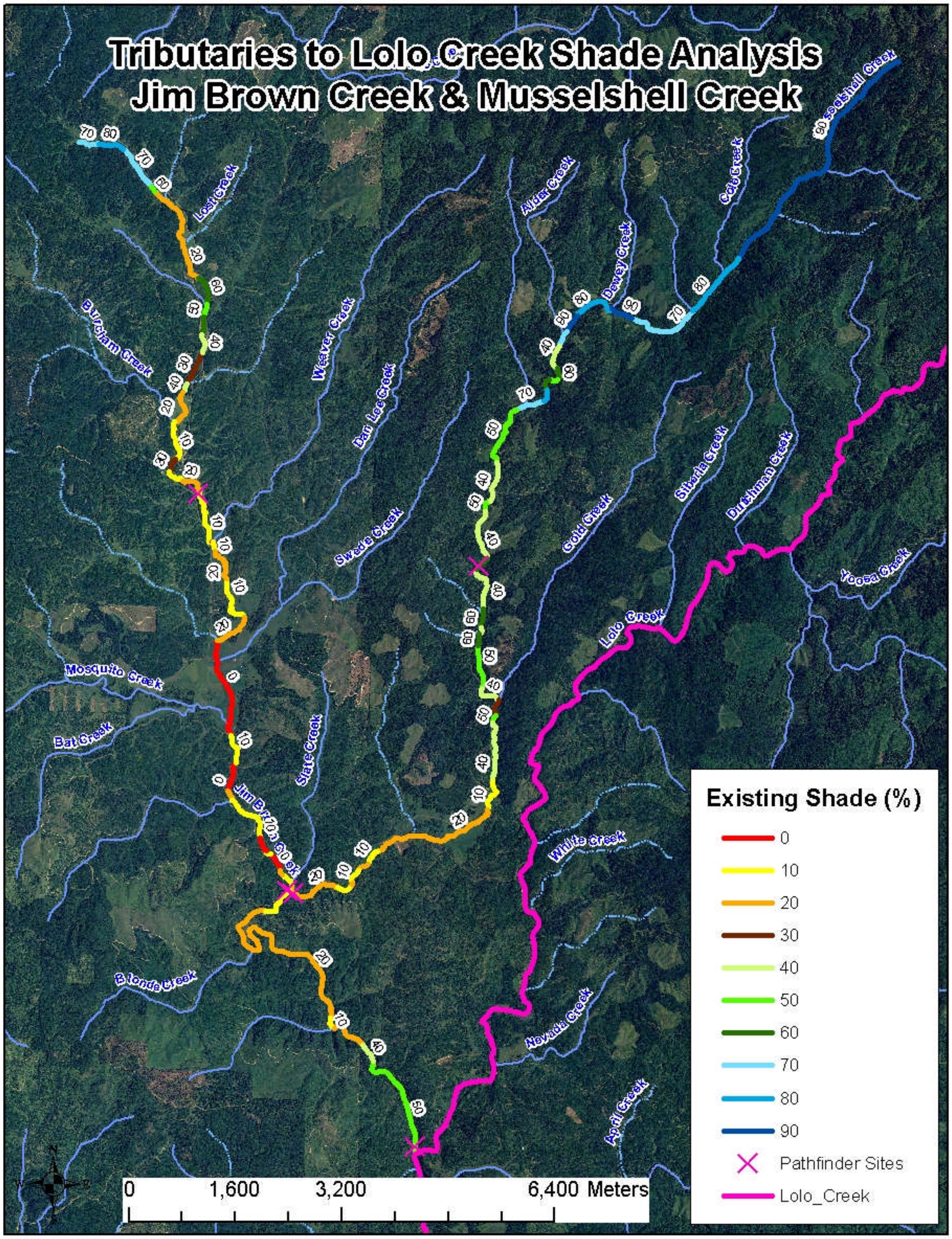

Figure 15. Existing Shade Estimated for Jim Brown Creek and Musselshell Creek by Aerial Photo Interpretation.

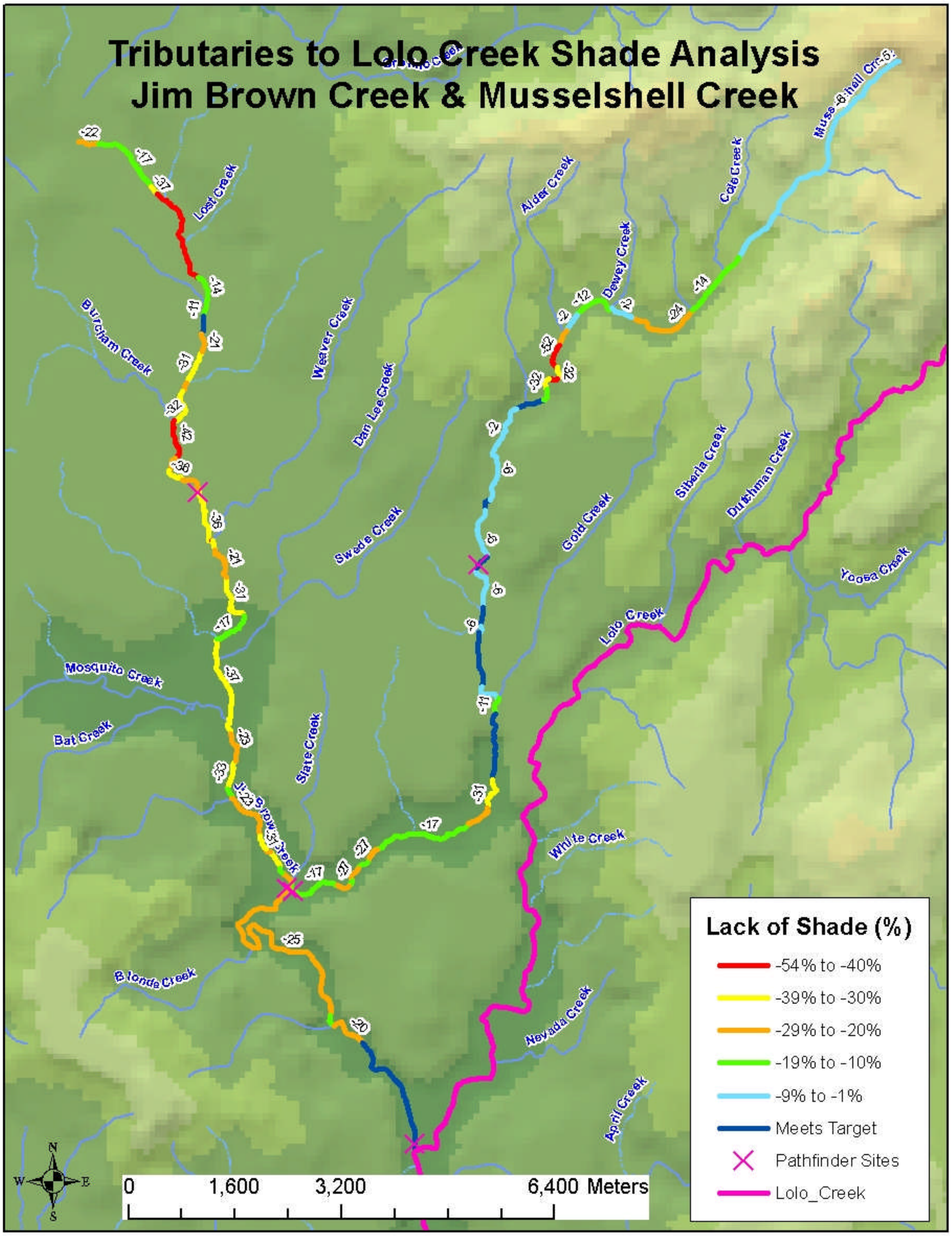

Figure 16. Lack of Shade (Difference Between Existing and Target) for Jim Brown Creek and Musselshell Creek.

5.4 Load Allocation

Because this TMDL is based on potential natural vegetation, under which solar loading would be equivalent to background loading, the load allocation essentially expresses 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. Tables 11 through 15 show the target or potential shade which is converted to a potential summer load by multiplying the percent-open (100% minus the shade percentage) by the average load recorded on a flat plate collector (at the nearest NREL weather station with such data) for the months of April through September. That is the load capacity of the stream and it is necessary to maintain the load at or below this capacity to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without causing this load capacity to be exceeded. Additionally, because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the waters examined here need to be in natural conditions in order to prevent excess heat loads to the system.

Table 15 shows the total existing, total target, and total excess heat load (kWh/day) as well as average lack of shade 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 15 lists the tributaries in order of their excess loads from highest to lowest. Therefore, large tributaries tend to be listed first and small tributaries are listed last.

Although the following analysis focuses 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 13 and Figure 16 that show Lack of Shade, are the key to successfully restoring these waters to achieving WQS. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should key in on locations with the largest differences between existing and target shade as locations where implementation efforts should be prioritized. Each load analysis table contains a final column that lists the lack of shade on the stream. It is derived from subtracting the target shade from the existing shade for each segment. Thus, stream segments with the largest lack of shade are in the worst shape. The average lack of shade listed at the bottom of that last column in each loading table is also listed in the table below and represents a general level of condition for comparison among streams (Table 15).

Table 15. Total Solar Loads and Average Lack of Shade for All Waters.

Water Body	Total Existing Load (kWh/day)	Total Target Load (kWh/day)	Excess Load (kWh/day)	Proportion Excess/ Existing (%)	Average Lack of Shade (%)
Eldorado Creek	955,174	553,073	402,101	42	16
Musselshell Creek	701,113	517,007	184,107	26	14
Jim Brown Creek	398,932	261,989	136,943	34	25
Dollar Creek	17,391	4,116	13,275	76	20

All streams lacked shade. Eldorado Creek and Musselshell Creek are similar in size with total target loads greater than 500,000 kWh/day. Eldorado Creek appears to be in worse condition with a greater amount of existing load in excess of its target. Jim Brown Creek is about half the size of Musselshell Creek with respect to target load, and with a similar proportion of excess load. Dollar Creek has small loads in comparison to the other three streams. And, as is typical of small streams, a similar level of shade loss results in a much larger proportion of excess load.

Figure 13 shows that the majority of Dollar Creek is either within the same shade class as its target (lack of shade is between 9% and 1%) or lacks shade by less than 20%. There is one segment near the mouth of Dollar Creek where the existing shade level is substantially lower than its target level, which may be the result of past activities or a natural meadow that does not match the target vegetation type. This section should be more thoroughly investigated during the implementation phase. Eldorado Creek has sections that either meet shade targets or are within the same class; but it also has sections where there is a substantial lack of shade. Likewise for Musselshell Creek (Figure 16) where headwaters and mid reaches are in good condition and other sections lack appreciable shade. Jim Brown Creek consistently lacks considerable shade in excess of 20%.

There may be a variety of reasons that individual reaches do not meet shade targets, including natural phenomena (beaver ponds, springs, wet meadows, past natural disturbances) and/or historic land use activities (logging, grazing, mining, etc.). It is important that each reach be field-verified to determine if differences in existing shade and target shade levels are real, result from activities, and are controllable. Information within this TMDL (maps and load analysis tables) should be used to guide and prioritize implementation investigations. It is recognized that the information within this TMDL may need further adjustment to reflect new information and conditions in the future.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the loading analysis. Because existing shade is reported as a single value from the bottom of each 10% shade class level but target shade is a unique integer, there is usually a difference between them. For example, say a particular stretch of stream has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that stretch of stream were at target level, it would be recorded as 80% existing shade in the load analysis because it falls into the 80 – 89% existing shade class. There would be an automatic difference of 6% which could be attributed to the margin of safety.

Wasteload Allocation

There are no known NPDES-permitted point sources in the affected watersheds. Thus, there are no wasteload allocations either. If a new point source were 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) should be involved.

Margin of Safety

The margin of safety in this 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 represented by the value at the bottom of the class interval, (55% shade equals 50%), which likely underestimates actual shade in the load analysis. Although the load analysis used in this TMDL involves gross estimations that are likely to have large variances, load allocations are applied to the stream and its riparian vegetation rather than specific NPS activities, and can be adjusted as more information is gathered from the stream environment.

Seasonal Variation

This 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 April through June when spring salmonid spawning is occurring, July and August when maximum temperatures exceed cold water aquatic life criteria, and September when fall salmonid spawning is most likely to be affected by higher temperatures. 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.

Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

The Clean Water Act 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. TMDLs that don't 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 best management practices.

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 best management practices 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 General Construction Permit, unless local ordinances have more stringent and site-specific standards that are applicable.

5.5 Implementation Strategies

Implementation strategies for TMDLs produced using potential natural vegetation-based shade and solar load values should incorporate the load analysis tables presented in this TMDL. These tables need to be updated, first to field–verify (or adjust) the existing shade levels (those that have not yet been field–verified), and second to monitor progress toward achieving 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 between field-verified shade levels and reported existing shade levels used in the load analysis 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 toward achieving desired reductions in solar loads.

Streamside vegetation and channel morphology are factors influencing shade which have been changed by anthropogenic activities, and which can be the most readily corrected. If implemented successfully, projects designed to increase shade may also have a positive impact on channel and stream bank restoration, which can eliminate certain sources of pollution and reduce other pollutant concentrations in the subbasin while simultaneously reducing stream temperature.

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

A schedule for implementation of best management practices, pollution control strategies, assessment reporting dates, and evaluation of progress will be developed with appropriate designated management agencies and the Lolo/Ford's Creek Watershed Advisory Group. Based on such assessments and evaluations, implementation strategies for TMDLs may need to be modified if monitoring shows that the water quality standards are not being met.

Approach

The TMDLs presented in this chapter focus on excess heat loading to the tributaries of Lolo Creek, and express this excess load as a lack of riparian shade along these streams. Nonpoint source best management practices designed to reduce excess heat loading to the Lolo Creek tributaries should be applied within the watershed by the designated management agencies responsible for such activities. Cattle grazing allotments on the CNF, IDL, and private forest lands should be evaluated to determine the full extent of their cumulative effect on the water quality of the Lolo Creek Subbasin. Restoration projects designed to increase riparian shade, restore stream banks, and discourage direct access to these streams by cattle should be undertaken, especially along Jim Brown Creek.

The Lolo/Ford's Creek Watershed Advisory group will play a valuable role in identifying private landowners within the watershed who wish to voluntarily participate in restoration projects aimed at reducing temperature and restoring altered stream segments.

Responsible Parties

Idaho Code 39-3612 states designated management agencies are to use TMDL processes for achieving water quality standards. The Department of Environmental Quality will rely on the designated management agencies to implement pollution control measures or best management practices for pollutant sources they identify as priority.

The Department of Environmental Quality also recognizes the authorities and responsibilities of local city and county governments as well as applicable state and federal agencies, and will enlist their involvement and authorities for protecting water quality through implementation of Idaho Administrative Procedures Act 58.01.02 and Clean Water Act Section 401.

The designated state agencies listed below are responsible for assisting and providing technical support for the development of specific implementation plans and other appropriate support to water quality projects. General responsibilities for Idaho designated management agencies are:

- Idaho Soil and Water Conservation Commission: grazing and agriculture.
- Idaho State Department of Agriculture: aquaculture and animal feeding operations.

- Idaho Transportation Department: public roads.
- Idaho Department of Lands: timber harvest, oil and gas exploration, and mining.
- Idaho Department of Water Resources: stream channel alteration activities.
- Department of Environmental Quality: all other activities.

Monitoring Strategy

Idaho Code 39-3611 requires the Department of Environmental Quality to review and evaluate each Idaho TMDL, supporting assessment, implementation plan, and all available data periodically, at intervals no greater than five years. Such reviews are to be conducted using the Beneficial Use Reconnaissance Program protocol and the Water Body Assessment Guidance methodology to determine beneficial use attainability and status, and whether state water quality standards are being achieved.

Permanent water quality monitoring stations should be established at the mouth and at the assessment unit boundary of TMDL streams. These would be used for long term monitoring to assess trends in cumulative pollutant loading identified by this TMDL. Beneficial use support status monitoring and assessment will be conducted within each assessment unit of the watershed and evaluated using the Water Body Assessment Guidance for compliance with Idaho state water quality standards.

Idaho Code 39-3621 requires designated agencies, in cooperation with the appropriate land management agency, ensure best management practices are monitored for their effect on water quality. The monitoring results should be presented to the Department of Environmental Quality on a schedule agreed to between the designated agency and the Department. The designated management agency should report the effectiveness of the measures or practices implemented to the Department in the form of load reductions applicable to the TMDL.

Pollutant load reductions gained by the application of pollutant controls and BMPs will be monitored by the Department of Environmental Quality through reports provided by designated management agencies. Information reported will be compiled and tracked over time to determine measurable pollutant load reductions relative to the TMDL allocations.

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.

5.6 Conclusions

E. coli and DO concentrations measured during the year long sampling effort did not show that numeric criteria were exceeded. Where narrative criteria were used for sediment, the measured concentrations fell within ranges considered to support a good fishery. Where narrative criteria were used for nutrients, average nutrient concentrations were similar to eco-regional criteria recommendations reflective of reference conditions.

Instantaneous temperature measurements exceeded the salmonid spawning criteria, especially if the stringent bull trout requirements are applied. Continuous temperature data collected by the CNF also exceeded salmonid spawning criteria for short durations, and were the most likely source of the original temperature listings in the subbasin. Measurements of existing shade taken on seven stream segments in the subbasin showed that all the listed streams lack shade when compared to desired targets for their riparian vegetation types and bankfull widths. Dollar Creek, Eldorado Creek and Musselshell Creek have some relatively good quality segments with respect to shade and other segments that need improvement. Jim Brown Creek consistently lacks substantial shade (Table 16).

Table 16. Summary of assessment outcomes.

Stream Name	Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List (Integrated Report sections)	Justification for Recommended Change
Eldorado Creek	ID17060306CL029_02	Unknown	Temperature Yes	Move to Section 4a; remove unknown	SBA/TMDL completed
Jim Brown Creek	ID17060306CL031_02 & 031_03	Temperature, Nutrients, Bacteria, Sediment	Temperature Yes	Move to Section 4a for Temperature, remove for Nutrients, Sediment, Bacteria	SBA/TMDL completed
Musselshell Creek	ID17060306CL032_02 & 032_03	Unknown	Temperature Yes	Move to Section 4a; remove unknown	SBA/TMDL completed

The Potential Natural Vegetation (PNV) temperature TMDLs presented in this chapter call for more shade on upper Eldorado Creek, Jim Brown Creek, and Musselshell Creek. Future restoration projects aimed at reducing stream temperature should also help stabilize the banks and reduce direct access to the stream by cattle, which should further reduce the amount of sediment, nutrients, and *E. coli* conveyed to these streams. A growth reserve is not included in the total maximum daily loads. Unless the load capacity is increased, future sources will need to acquire a load allocation from existing allocations.

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GIS Coverage

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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.
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 4^{th} 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 6^{th} 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.

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 micron 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.

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.

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. Lolo Creek Tributaries Monitoring Data 2003-2004

Table B-1. Monitoring parameters, protocols, and reporting units.

Monitoring Parameter	Monitoring Protocol	Reporting Units
Dissolved Oxygen (DO)	Hach HQ 40 DO Probe	Milligrams/Liter (mg/L)
Escherichia Coli (*E. coli*)	SM 9223 B (MPN)	Colony Forming Units/100 ml
Ammonia (NH_3)	EPA 353.2 & EPA 350.1	mg/L
Nitrogen (NO_3+NO_2)	EPA 353.2 & EPA 350.1	mg/L
Total Phosphorus	EPA 365.4	mg/L
Instantaneous Temperature	Hach HQ 40 Temp Probe	°C
Turbidity	EPA 180.1	Nephelometric Units (NTU)
Total Suspended Solids (TSS)	EPA 160.2 - TSS	mg/L
Conductance	Hach HQ 40 Conductivity Probe	micromhos
pH	Standard Buffer (4, 7, 10)	pH
Instantaneous Discharge	March-McBirney Model 2000 or Price Current Meter	Cubic Feet/Second (cfs)

Table B2. Eldorado Creek Monitoring Data

Date	Time	D.O. (mg/L)	Temp (°C)	Cond (μS)	TSS (mg/L)	NO_2+NO_3 (mg/L)	NH_3 (mg/L)	TP (mg/L)	E. Coli (cfu/100mL)	Flow From CNF gage(cfs)
6/10/2003	15:40	ND	15.1	27.6	5	BDL	BDL	0.031	65	51.5
6/25/2003	12:30	ND	12.4	29.6	BDL	BDL	BDL	0.063	13	28
7/14/2003	13:15	ND	18.4	29.4	BDL	BDL	BDL	0.028	31	15
7/21/2003	13:30	7.56	21.2	33.3	BDL	BDL	BDL	0.031	160	12
8/5/2003	12:30	7.85	17.8	33.7	BDL	BDL	BDL	0.034	38	11
8/18/2003	ND	6.94	17.6	35.1	BDL	BDL	BDL	0.036	34	7.4
9/2/2003	12:45	ND	16.2	34.2	BDL	BDL	BDL	0.034	6	7
9/16/2003	14:25	12.6	10.8	29.7	BDL	BDL	BDL	0.027	1	9
9/30/2003	13:40	10.12	10.9	30.1	BDL	BDL	BDL	0.02	2	7.8
10/14/2003	12:15	11.69	6.3	26.8	BDL	BDL	BDL	0.021	12.4	13.3
10/27/2003	13:45	ND	5.1	26.2	BDL	BDL	BDL	BDL	2	9.2
11/12/2003	13:00	10.68	0.1	ND	9	BDL	BDL	0.045	228.2	16.6
11/24/2003	14:15	12.94	0.2	ND	BDL	BDL	BDL	0.019	38.4	6.8
12/10/2003	13:30	12.39	0.6	Nd	BDL	BDL	BDL	0.012	ND	6.3
5/5/2004	18:30	10.1	9	22.2	BDL	BDL	BDL	0.02	6.1	152.4
5/19/2004	14:00	11.4	7.5	24.3	BDL	BDL	BDL	0.015	NS	177
6/3/2004	12:00	8.2	8.7	24.1	BDL	BDL	BDL	0.024	16.1	212.9
6/14/2004	15:10	7.8	7.3	25.7	BDL	BDL	BDL	0.026	3.1	132.9
6/30/2004	10:15	7.1	14.6	ND	BDL	BDL	BDL	0.029	26.9	38.3
7/14/2004	9:00	8.4	15	ND	BDL	BDL	BDL	0.026	53.7	20.9
7/27/2004	17:05	6.3	18.3	ND	BDL	BDL	BDL	0.032	31.4	15
8/11/2004	11:30	6.8	15.6	ND	BDL	BDL	BDL	0.027	21.8	12.3
8/25/2004	14:00	6.2	12.2	ND	28	BDL	BDL	0.086	307.6	75.7

Table B3. Upper Jim Brown Creek Monitoring Data

Date	Time	D.O. (mg/L)	Temp (^oC)	Cond (μS)	TSS (mg/L)	NO_2+NO_3 (mg/L)	NH_3 (mg/L)	TP (mg/L)	E-Coli (cfu/100mL)	Flow (cfs)
6/10/2003	13:45	ND	19.7	60.4	BDL	BDL	BDL	0.03	6	1.30
6/24/2003	17:00	ND	14.2	68.2	6	BDL	BDL	0.04	14	1.99
7/8/2003	10:30	ND	18	74.2	BDL	BDL	BDL	0.03	190	0.80
7/21/2003	12:40	8.21	24.8	73	BDL	BDL	BDL	0.04	54	0.50
8/6/2003	11:00	7.54	19.3	69.3	4	BDL	BDL	0.04	ND	0.67
8/18/2003	11:00	6.81	16.5	65.2	BDL	BDL	0.11	0.03	5	0.18
9/2/2003	12:30	ND	16.1	65.2	7	BDL	BDL	0.04	2	0.28
9/16/2003	12:00	12.48	11.9	56.8	BDL	BDL	BDL	0.03	4	0.56
9/30/2003	11:00	9.64	9.5	49.2	BDL	BDL	BDL	0.02	3.1	0.28
10/13/2003	14:10	10.78	7.8	46.4	BDL	BDL	BDL	0.03	17.8	1.88
10/27/2003	12:00	12.39	3.8	38.4	BDL	BDL	BDL	BDL	<1	0.92
11/12/2003	10:30	10.08	0.1	ND	6	0.12	BDL	0.12	2419	Ice
11/25/2003	12:00	11.7	0.1	ND	BDL	BDL	BDL	0.03	ND	Ice
5/18/2004	14:15	8.3	11	37.3	7	BDL	BDL	0.04	20.3	17.43
6/2/2004	18:10	8.4	14.7	38.8	BDL	BDL	BDL	0.02	7.4	16.85
6/16/2004	10:50	7.8	12.3	50.3	BDL	BDL	BDL	0.03	38.4	5.76
6/30/2004	16:15	6.7	21.3	ND	BDL	BDL	BDL	0.04	28.1	1.68
7/14/2004	7:00	4.9	16	ND	BDL	BDL	BDL	0.03	86.2	1.95
7/29/2004	13:30	6.4	20.4	ND	BDL	BDL	BDL	0.03	16	1.02
8/10/2004	9:30	6	14.6	ND	BDL	BDL	BDL	0.04	8.5	1.06
8/24/2004	15:30	6.2	13.4	ND	BDL	BDL	BDL	0.07	579	3.9

Table B4. Jim Brown Creek at Mouth Monitoring Data

Date	Time	D.O. (mg/L)	Temp (°C)	Cond (μS)	TSS (mg/L)	NO_2+NO_3 (mg/L)	NH_3 (mg/L)	TP (mg/L)	E-Coli (cfu/100mL)	Flow (cfs)
6/10/2003	12:00	ND	14.4	58.9	4	BDL	BDL	0.027	21	4.43
6/25/2003	10:00	ND	ND	ND	BDL	BDL	BDL	0.023	37	4.41
7/8/2003	11:30	ND	19.6	67.3	BDL	BDL	BDL	0.021	41	1.85
7/22/2003	9:45	7.91	19.4	67.3	BDL	BDL	BDL	0.034	11	0.21
8/5/2003	14:00	8.49	21.3	68.2	BDL	BDL	BDL	0.031	30	0.82
8/21/2003	12:00	6.9	18.2	68.3	BDL	BDL	BDL	0.029	10	0.12
9/4/2003	12:30	ND	15.7	63.1	BDL	BDL	BDL	0.03	7	0.229
9/16/2003	12:45	15.54	13	54.5	BDL	BDL	BDL	0.027	46	0.754
9/30/2003	11:50	10.44	10.6	48.9	BDL	BDL	BDL	0.019	6.3	0.758
10/13/2003	15:00	11.15	9.1	47.5	BDL	BDL	BDL	0.025	65.9	3.609
10/28/2003	13:30	13.72	6.3	64.2	BDL	BDL	BDL	BDL	32.4	2.78
11/12/2003	11:20	10.06	0.1	ND	10	0.16	BDL	0.12	1733	Ice
11/25/2003	12:50	11.7	0.1	ND	BDL	BDL	BDL	0.027	ND	2.15
5/6/2004	12:20	8.5	14.6	ND	BDL	BDL	BDL	0.028	1	7.93
5/18/2004	14:50	8.1	11	34.9	BDL	BDL	BDL	0.018	17.1	59.92
6/3/2004	13:40	8	13.3	36.7	BDL	BDL	BDL	0.023	7.4	45.03
6/16/2004	14:00	7.9	13.7	44.8	BDL	BDL	BDL	0.032	35.4	21.89
6/30/2004	15:00	7	22.7	ND	BDL	BDL	BDL	0.034	160.7	9.11
7/14/2004	14:30	6	21.3	ND	BDL	BDL	BDL	0.03	21.6	7.9
7/29/2004	11:30	7	21	ND	BDL	BDL	BDL	0.033	24.3	4.99
8/10/2004	10:30	6.4	16.2	ND	BDL	BDL	BDL	0.028	46.2	2.36
8/24/2004	12:30	6	13.7	ND	4	BDL	BDL	0.062	298.7	14.96

Table B5. Upper Musselshell Creek Monitoring Data

Date	Time	D.O. (mg/L)	Temp (^oC)	Cond (μS)	TSS (mg/L)	NO_2+NO_3 (mg/L)	NH_3 (mg/L)	TP (mg/L)	E-Coli (cfu/100mL)	Flow (cfs)
6/10/2003	12:30	ND	17.6	24.6	BDL	BDL	BDL	0.018	1	17.29
6/25/2003	10:30	ND	12.2	28.4	BDL	BDL	BDL	0.014	56	13.28
7/8/2003	11:45	ND	18.5	25.2	BDL	BDL	BDL	0.019	31	6.95
7/22/2003	10:15	8.18	19.4	30.3	BDL	BDL	BDL	0.023	31	2.84
8/5/2003	14:30	7.66	21.2	31.4	BDL	BDL	BDL	0.028	79	2.3
8/21/2003	12:20	6.4	18.3	30.9	BDL	BDL	BDL	0.025	130	0.94
9/4/2003	12:00	ND	16.1	28.9	BDL	BDL	BDL	0.017	26	0.947
9/16/2003	13:00	14.06	12.6	27.8	BDL	BDL	BDL	0.017	6	1.706
9/30/2003	12:30	10.15	10.9	28.8	BDL	BDL	BDL	0.013	8.5	1.447
10/13/2003	15:30	10.95	6.2	23.5	BDL	BDL	BDL	0.014	23.8	4.068
10/28/2003	14:00	ND	6.5	39.3	BDL	BDL	BDL	BDL	8.7	3.137
11/12/2003	12:15	10.5	0.1	ND	6	0.11	BDL	0.039	547.5	Ice
11/25/2003	13:30	11.5	0.1	ND	BDL	BDL	BDL	0.012	ND	Ice
5/6/2004	12:45	10.3	9.1	22.2	5	BDL	BDL	0.019	4.1	42.01
5/18/2004	15:20	8.5	8.2	24.5	BDL	BDL	BDL	0.022	4.1	73.49
6/7/2004	14:15	8.7	10.2	23.8	4	BDL	BDL	0.022	9.8	77.23
6/16/2004	14:35	8.3	11.3	25.9	4	BDL	BDL	0.021	10.9	38.65
6/30/2004	15:30	6.9	19.3	ND	4	BDL	BDL	0.023	34.1	29.25
7/14/2004	15:00	7.8	18.8	ND	BDL	BDL	BDL	0.022	23.5	23.62
7/29/2004	ND	6.7	19.4	ND	BDL	BDL	BDL	0.022	82	16.22
8/10/2004	11:15	6.6	16.1	ND	BDL	BDL	BDL	0.02	34.5	4.57
8/25/2004	12:00	6.5	13.1	ND	BDL	BDL	BDL	0.031	285.1	25.65

Table B6. Musselshell Creek at Mouth Monitoring Data

Date	Time	D.O. (mg/L)	Temp (^oC)	Cond (μS)	TSS (mg/L)	NO_2+NO_3 (mg/L)	NH_3 (mg/L)	TP (mg/L)	E-Coli (cfu/100mL)	Flow (cfs)
6/11/2003	12:15	ND	16.8	35.2	BDL	BDL	BDL	0.019	20	23.04
6/24/2003	16:00	ND	15.2	39	BDL	BDL	BDL	0.017	16	19.51
7/8/2003	12:20	ND	20.1	41.4	BDL	BDL	BDL	0.024	43	8.74
7/22/2003	11:00	9.33	19	41.3	BDL	BDL	BDL	0.018	42	4.58
8/6/2003	ND	7.88	22.2	47.1	BDL	BDL	BDL	0.023	ND	3.5
8/21/2003	13:30	ND	20.5	49.8	BDL	BDL	BDL	0.018	17	2.12
9/4/2003	13:00	ND	16.8	45.8	BDL	BDL	BDL	0.026	32	1.637
9/18/2003	10:00	12.7	10.5	34.9	BDL	BDL	BDL	0.02	ND	17.377
10/2/2003	10:00	10.77	8.8	48.2	BDL	BDL	BDL	0.014	9.8	2.918
10/14/2003	11:45	11.9	6.5	35.7	BDL	BDL	BDL	0.018	25.4	10.983
10/29/2003	11:00	ND	5.6	52.5	34	BDL	BDL	0.087	200.5	35.001
11/12/2003	12:40	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/30/2004	12:00	6.9	19.5	ND	BDL	BDL	BDL	0.028	39.3	ND
7/14/2004	12:30	6.2	18.5	ND	BDL	BDL	BDL	0.021	37.9	17.09
7/29/2004	10:00	7	20.1	ND	BDL	BDL	BDL	0.023	21.1	17.24
8/11/2004	15:00	7	21.4	ND	BDL	BDL	BDL	0.021	20.6	7.61
8/25/2004	13:00	6.4	13.5	ND	6	BDL	BDL	0.044	209.8	46.28

Table B7. Upper Jim Brown Creek Geometric Mean E-coli Concentration

Date	E-Coli cfu/100ML	
11/12/2003	2419	trigger
11/15/2007	142.1	
11/20/2007	22.3	
11/26/2007	4.1	
11/28/2007	17.1	
	55.727	Geometric mean

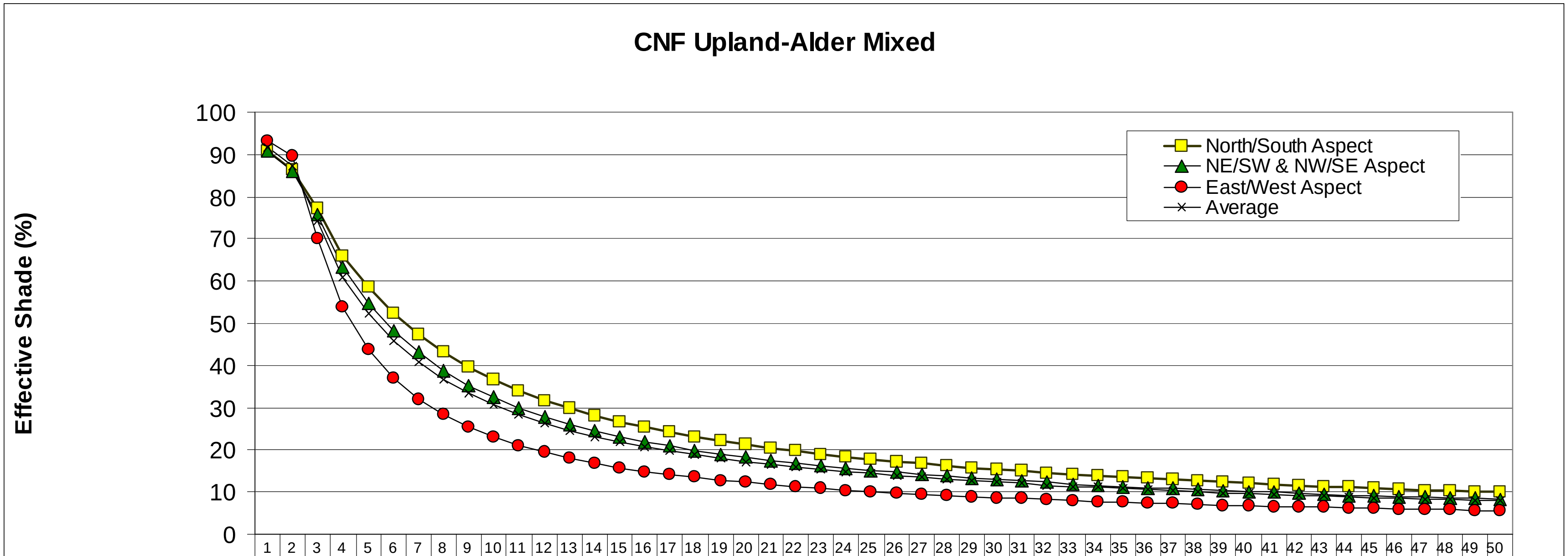
Table B8. Jim Brown Creek at Mouth Geometric Mean E-coli Concentration

Date	E-Coli cfu/100ML	
11/12/2003	1732.4	trigger
11/15/2007	101.4	
11/20/2007	18.7	
11/26/2007	7.4	
11/28/2007	2	
	34.4634	Geometric mean

Table B9. Upper Musselshell Creek Geometric Mean E-coli Concentration

Date	E-Coli cfu/100ML	
11/12/2003	548	trigger
11/15/2007	108.1	
11/20/2007	29.2	
11/26/2007	17.5	
11/28/2007	3	
	39.0508	geomean

Appendix C. New Shade Curves



"Vegetation" Channel Width (meters)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
North/South Aspect	91	86	77	66	59	52	47	43	40	37	34	32	30	28	27	25	24	23	22	21	21	20	19	18	18
NE/SW & NW/SE Aspect	91	86	76	63	55	48	43	39	35	32	30	28	26	25	23	22	21	20	19	18	18	17	16	16	15
East/West Aspect	93	90	70	54	44	37	32	28	25	23	21	19	18	17	16	15	14	13	13	12	12	11	11	10	10
Average	92	87	74	61	52	46	41	37	33	31	28	26	25	23	22	21	20	19	18	17	17	16	15	15	14

"Vegetation" Channel Width (meters)	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
North/South Aspect	17	17	16	16	15	15	15	14	14	13	13	13	13	12	12	12	12	11	11	11	11	10	10	10	10
NE/SW & NW/SE Aspect	15	14	14	13	13	13	12	12	12	11	11	11	11	10	10	10	10	10	9	9	9	9	9	8	8
East/West Aspect	10	9	9	9	9	8	8	8	8	8	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6
Average	14	13	13	13	12	12	12	11	11	11	11	10	10	10	10	9	9	9	9	9	9	8	8	8	8

"Vegetation" Channel Width (meters)

Figure C-1. Shade Curve for the CNF Upland Forest – Alder Mixed Community Type.

Appendix D. Distribution List

Distribution List

Department of Environmental Quality - Lewiston Regional Office, 1118 F Street, Lewiston, Idaho 83501

Department of Environmental Quality - State Office, 1410 North Hilton, Boise, Idaho 83706

US Environmental Protection Agency - Idaho Operations Office, 1435 North Orchard, Boise, Idaho 83706

Clearwater Basin Advisory Group Members

Lolo/Ford's Creek Advisory Group Members

Appendix E. Public Comments

Public Comments

A 30 day public comment period was provided for the draft of the Lolo Creek Tributaries SBA/TMDL from July 29 through August 29, 2011. Notice was provided to the general public through the Lewiston Morning Tribune and the document was made available through the Lewiston and State Offices of the Department of Environmental Quality, the Lewiston City Library, and through DEQ's website at www.deq.idaho.gov/public/comment.cfm.

The received comments and DEQ's responses are recorded in this appendix.

Name: William C. Stewart, Environmental Specialist

Address: United States Environmental Protection Agency

1435 N. Orchard

Boise, ID 83706

Affiliation: Federal

Comment EPA 1) After a thorough review of this document, I have no comments at this time.

DEQ response: Thank you for taking the time to review the document.

Name: Jim Clapperton

Address: Kamiah, Idaho

Affiliation: Maggie Creek Area Manager, Idaho Department of Lands

Comment IDL 1) In the TMDL document, state land is identified throughout as "IDL ownership." IDL manages state endowment land, but does not own it. We request that the document refer to IDL-managed state ownership throughout the document as "State of Idaho Endowment Land."

DEQ response: Thank you for helping to make the document more clear, concise and accurate. These changes have been made throughout. We will also apply this nomenclature to future reports where endowment lands are mentioned.