Salmon Falls Creek Subbasin Assessment and Total Maximum Daily Loads

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Cover photo by Clyde Lay.

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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

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

AU assessment unit

AWS agricultural water supply

BLM United States Bureau of Land Management

BMP best management practice

BOD biochemical oxygen demand

BURP Beneficial Use Reconnaissance Program

C Celsius, Centigrade

CAFO Confined Animal Feeding Operation

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

cfs cubic feet per second

CFU colony forming units

cm centimeters

CW cold water

CWA Clean Water Act

CWE cumulative watershed effects

DEQ Department of Environmental Quality

DO dissolved oxygen

DWS domestic water supply

E. coli Esherichia coli

EPA United States Environmental Protection Agency

ESA Endangered Species Act

F Fahrenheit

FDI Flow Duration Interval

GIS Geographical Information Systems

gpm/ft Gallons per minute per foot

HUC Hydrologic Unit Code

IASCD Idaho Association of Soil Conservation Districts

I.C. Idaho Code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDL Idaho Department of Lands

km kilometer

km^2 square kilometer

$kwh/m^2/day$ Kilowatt per hour per square meter per day

LA load allocation

LC load capacity

LDI Load Duration Interval

m meter

m^3 cubic meter

m^3/s cubic meter per second

mi mile

mi^2 square miles

MBI macroinvertebrate index

mg/L milligrams per liter

mg/m^2 milligram per square meter

mm millimeter

MOS margin of safety

N Nitrogen

n.a. not applicable

NO_x General symbol for nitrite and nitrate in a solution

NA not assessed

NB natural background

nd no data (data not available)

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NTU nephlometric turbidity unit

P Phosphorus

PCR primary contact recreation

ppm part(s) per million

QA quality assurance

QC quality control

SBA subbasin assessment

SCR secondary contact recreation

SFI DEQ's stream fish index

SMI DEQ's stream macroinvertebrate index

SSC Suspended Sediment Concentration

STATSGO State Soil Geographic Database

TFRO Twin Falls regional Office

TKN total Kjeldahl nitrogen

TMDL total maximum daily load

TN Total nitrogen

TP total phosphorus

TSI Trophic State Index

TSS total suspended solids

t/y tons per year

U.S. United States

USC United States Code

USDA United States Department of Agriculture

WLA wasteload allocation

WQS water quality standard

Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to §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. §303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. This document addresses the Assessment Units (AU) in the Salmon Falls Creek Subbasin that have been placed on what is known as the "§303(d) list". This is found in the current integrated report:

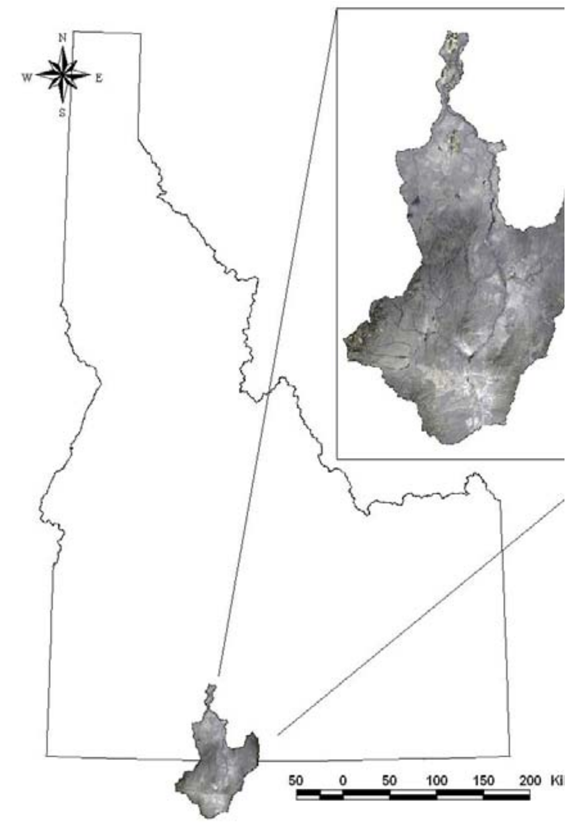
http://www.deq.state.id.us/water/data_reports/surface_water/monitoring/integrated_report.cfm.

The Salmon Falls Creek Subbasin Assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the Salmon Falls Creek Subbasin (Figure 1), located in south central Idaho.

The first part of this document, the SBA, is an important first step in leading to the TMDL. The starting point for this assessment was Idaho's current 2002 integrated report of water quality limited water bodies. Currently 17 Assessment Units (Figure 2) or segments of the Salmon Falls Creek Subbasin are listed. The SBA examines the current status of §303(d) listed waters and defines the extent of impairment and causes of water quality limitation throughout the listed waters of the subbasin. The TMDL loading analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

This subbasin assessment (SBA) and TMDL analysis has been developed to comply with Idaho's TMDL schedule. The basis for Idaho's TMDL schedule was the 1998 §303(d) list, which included eight stream segments and one reservoir occurring within the region designated as the Salmon Falls Creek Subbasin. These same segments are incorporated in the 2002 integrated report within the respective Assessment Units, although nearly 149 miles of stream systems were added. *The Salmon Falls Creek Subbasin Assessment and Total Maximum Daily Load(s)* (SBA-TMDL) for surface waters of hydrological unit code 17040213 describes those 17 Assessment Units and pollutant combinations that are listed on the 2002 §303(d) list prepared by the state of Idaho. The listed Assessment Units, in some cases, include numerous water bodies that are considered "water quality limited" if one stream system within the Assessment Unit fails to meet water quality standards. The SBA also provides information pertaining to existing and designated beneficial uses. The information in the SBA includes those pollutants and the sources of pollutants that are affecting these beneficial uses in other as-yet-to-be listed water bodies such as Salmon Falls Creek Reservoir. The information was obtained from a variety of sources, including monitoring efforts of the Department of Environmental Quality (DEQ) and other agencies and individuals. The public has also been involved in the development of the SBA-TMDL through a variety of venues. Most notably, public meetings were held in conjunction with the Mid Snake Watershed Advisory Group (Mid Snake WAG).

Subbasin at a Glance



Hydrologic Unit Code	17040213
Subbasin Drainage size	2,234 km^2 in Idaho 5,393 km^2 Total
Total stream km	4,085 km
Listed stream km	349 km
Applicable Water Quality Standards	▪ IDAPA 58.01.02.200-General Surface Water Quality Criteria ▪ IDAPA 58.01.02.250-Surface Water Quality Criteria for Aquatic Life Use Designations
Beneficial Uses Affected	▪ Cold water aquatic life ▪ Salmonid spawning ▪ Secondary Contact Recreation
Listed Pollutants of Concern	▪ Sediment Siltation ▪ Thermal Modification ▪ Flow Alteration ▪ Excess Nutrients ▪ Bacterial Contamination
Affected Communities	Castleford, Rogerson, Hollister, Three Creek, Jackpot, and Twin Falls

Figure 1. Salmon Falls Creek Subbasin and Vital Statistics.

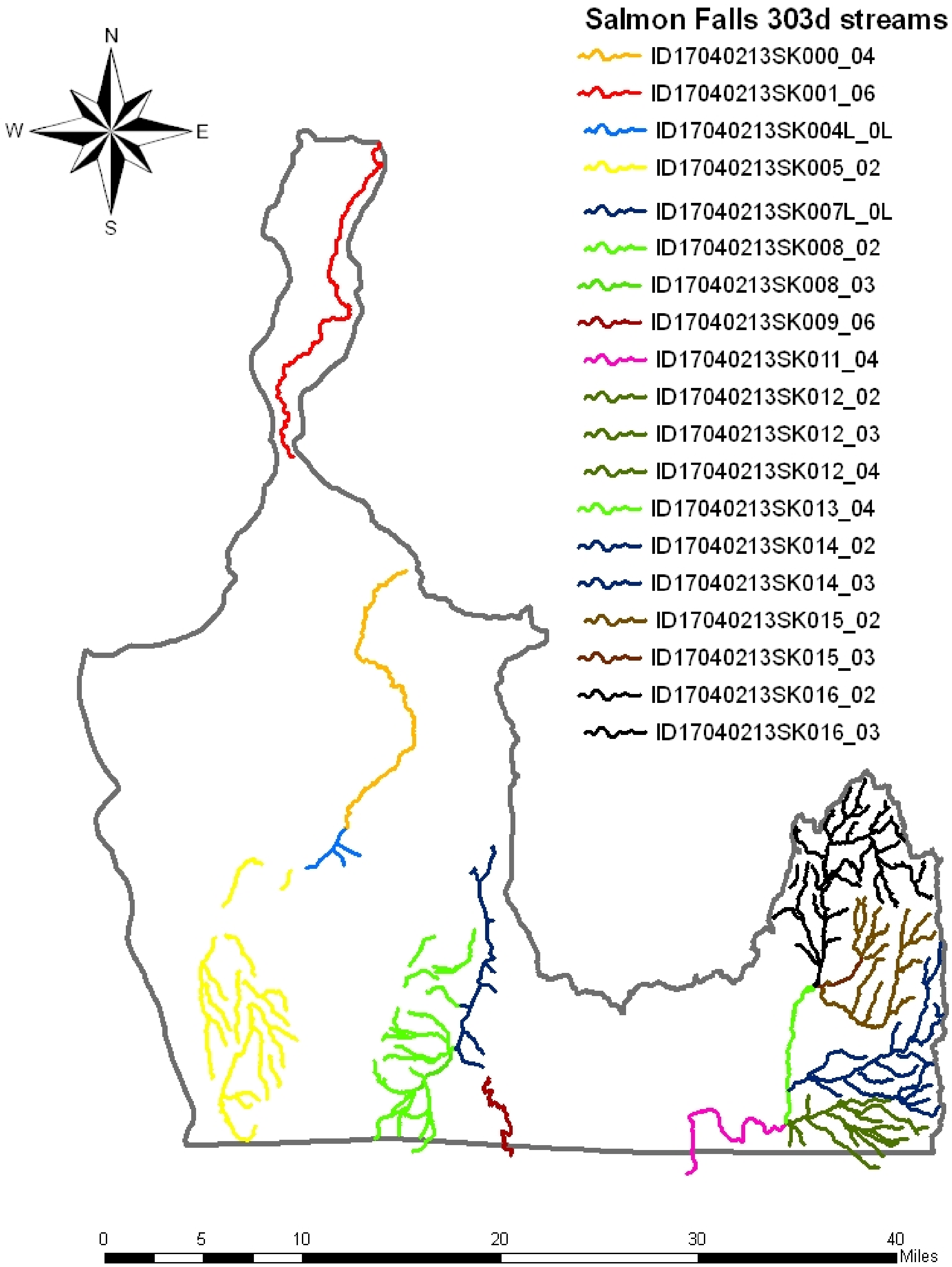


Figure 2. 2002 §303(d) Listed Assessment Units of the Salmon Falls Creek Subbasin.

Table 1. Assessment Unit descriptions and water quality impaired segments.

Assessment Unit	Assessment Unit name	Assessment Unit description	Water quality limited water body description
ID17040213SK000-04	UNCLASSIFIED WATERS	4th order segments of Cedar Creek	Cedar Creek from Cedar Creek Reservoir to Salmon Falls Creek
ID17040213SK001-06	Salmon Falls Creek and Tributaries	6th order segments of Salmon Falls Creek	Salmon Falls Creek Devil Creek to Snake River
ID17040213SK004-L	Cedar Creek Reservoir	Cedar Creek Reservoir	Cedar Creek Reservoir
ID17040213SK005-02	House Creek	2nd order segments of House Creek	House Creek to Cedar Creek Reservoir
ID17040213SK007-L	Salmon Falls Creek Reservoir	Salmon Falls Creek Reservoir	Salmon Falls Creek Reservoir
ID17040213SK008-02	China Creek and Tributaries	2nd order segments of China Creek	China Creek, Player Creek, Browns Creek, Whiskey Slough, and Corral Creek
ID17040213SK008-03	China Creek and Tributaries	3rd order segments of China Creek	China Creek to Salmon Falls Creek Reservoir
ID17040213SK009-06	Salmon Falls Creek and Tributaries	6th order segments of Salmon Falls Creek	Salmon Falls Creek Idaho/Nevada border to Salmon Falls Creek Reservoir
ID17040213SK011-04	Shoshone Creek and Tributaries	4th order segments of Shoshone Creek	Shoshone Creek from Hot Creek to Idaho/Nevada Border
ID17040213SK012-02	Hot Creek and Tributaries	2nd order segments of Hot Creek	Hot Creek Idaho/Nevada Border to Shoshone Creek
ID17040213SK012-03	Hot Creek and Tributaries	3rd order segments of Hot Creek	Hot Creek to Shoshone Creek
ID17040213SK013-04	Shoshone Creek and Tributaries	4th order segments of Shoshone Creek	Shoshone Creek from Cottonwood Creek to Hot Creek
ID17040213SK014-02	Big Creek and Tributaries	2nd order segments of Big Creek	Big Creek Headwaters to
ID17040213SK014-03	Big Creek and Tributaries	3rd order segments of Big Creek	Big Creek to Shoshone Creek

Assessment Unit	Assessment Unit name	Assessment Unit description	Water quality limited water body description
ID17040213SK015-02	Cottonwood Creek and Tributaries	2nd order segments of Cottonwood Creek	Cottonwood Creek Headwaters to Shoshone Creek
ID17040213SK015-03	Cottonwood Creek and Tributaries	3rd order segments of Cottonwood Creek	Cottonwood Creek to Shoshone Creek
ID17040213SK016-02	Shoshone Creek and Tributaries	2nd order segments of Shoshone Creek	Shoshone Creek Headwaters to Cottonwood Creek
ID17040213SK016-03	Shoshone Creek and Tributaries	3rd order segments of Shoshone Creek	Shoshone Creek Headwaters to Cottonwood Creek

Key Findings

In general, the impacts to the beneficial uses were determined by assessing the biological communities and the water chemistry data available. When these two data sets were in agreement with one another, appropriate actions, such as completing a TMDL or delisting the stream, were undertaken.

The water quality of the Salmon Falls Creek Subbasin, in general, is of good to moderate quality. Sediment, nutrients, and temperature are the most common listed pollutants in the Salmon Falls Creek Subbasin.

However, Salmon Falls Creek Reservoir is one of the few water bodies within the state with mercury contamination identified.

Phosphorus Findings

In most of the listed assessment units, it was determined that total phosphorus (TP) was a limiting nutrient. However, in the Big Creek and Cottonwood Creek watersheds it was determined that TP was in excess and may be impacting the beneficial uses of Shoshone Creek. While the majority of streams systems appear to have little impact from excess nutrients, the same cannot be said for the two reservoir systems. Both Cedar Creek and Salmon Falls Creek Reservoirs contained excess nutrients that lead to nuisance aquatic vegetation blooms. TMDLs are proposed for the tributary systems that feed these two reservoirs.

In most watersheds, phosphorus compounds were not in excess of EPA "Gold Book" recommendations (*Water Quality Criteria 1986.* (EPA 1986)). Background TP concentrations at a Nevada sampling site of Salmon Falls Creek averaged 0.093 milligrams per liter (mg/L) annually, while concentrations near the end of the reach averaged 0.102 mg/L annually. (See Appendix A for unit conversion.) Only nonpoint sources and natural soil-associated phosphorus contribute to this increase in TP concentration, as there are no point sources located within the watershed.

In the Salmon Falls Creek Reservoir, annual TP concentrations averaged 0.114 mg/L while in Cedar Creek Reservoir annual TP concentrations averaged 0.100 mg/L. TP concentrations in the China Creek watershed have averaged 0.185 mg/L annually. Natural background levels in the subbasin were determined to be between 0.02-0.035 mg/L TP.

The EPA Gold Book has set guidelines for TP concentrations in rivers flowing into lakes and reservoirs at 0.05 mg/L. As such, Salmon Falls Creek, China Creek, Cedar Creek and House Creek TP concentration targets are set at 0.05 mg/L.

For lakes and reservoirs, the EPA Gold book has set guidelines for TP concentrations at 0.025 mg/L. As a result, the Salmon Falls and Cedar Creek Reservoir TP concentration targets are set at 0.025 mg/L.

Reductions in TP will be required for nonpoint sources within the four watersheds in order to meet these targets within the Salmon Falls Creek and Cedar Creek Reservoirs. The other listed streams and pollutants in the subbasin, in general, were below the nutrient standard or guideline established for the protection of beneficial uses.

Nitrogen Findings

In most watersheds, nitrogen compounds were not in excess of Redfield Ratio (i.e.16:1 N to P). The Redfield Ratio provides a measure of the natural balance of nutrients found within plant tissues and thus not considered excessive in the environment. However, in the lower section of Salmon Falls Creek, where ground water plays a significant role in the hydrology of that system, it was determined that nitrogen was, in fact, in excess and could lead to nuisance aquatic vegetation growths.

Flow and Habitat Alternation Findings

It is EPA policy that flow and habitat alterations are *pollution* and not specific *pollutants*, and TMDLs are not required. However, streams found to be impacted by these forms of pollution will remain on the §303(d) list. Cedar Creek below the Cedar Creek Reservoir falls into this category.

Listed on the Idaho 1998 303d list for temperature pollution were Salmon Falls Creek, Nevada/Idaho border to Salmon Falls; Shoshone Creek, Nevada/Idaho border to Magic Hot Springs; and Shoshone Creek, Cottonwood Creek to Big Creek. The Environmental Protection Agency (EPA) also added streams to Idaho's 1998 303d list of impaired waters that exceeded Idaho's temperature criteria. In the Salmon Falls Creek Subbasin, Hot Creek, headwaters to mouth, was among those EPA additions. Additionally, major tributaries to Salmon Falls Creek and Shoshone Creek were added to the analysis as potential sources of heat loading. These tributaries include the South Fork Shoshone Creek, Pole Camp Creek, Cottonwood Creek, Langford Flat Creek, Big Creek, Hannah's Fork, and Horse Creek in the Shoshone Creek drainage. In the Salmon Falls Creek drainage, Devil Creek, Cedar Creek, House Creek, Little House Creek, Whiskey Slough, Browns Creek, China Creek, Player Creek, and the North Fork Salmon Falls Creek were examined. All streams examined require load reductions as a result of lack of shade.

Mercury Findings

Although not currently listed on the integrated report, Salmon Falls Creek Reservoir was examined due to a fish consumption advisory placed on the water body in 2001. Fish tissues were collected in October of 2006. Mercury concentrations found in fish at that time averaged 0.779 mg/kg, well above DEQ's fish tissue criterion of 0.30 mg/kg. In order to achieve the water quality standard, mercury levels would need to be reduced by 69 percent.

Summaries of Assessments

Tables 2 and 3 summarize the assessment outcomes for each assessment unit and the proposed TMDLs and reductions to be completed. The tables identify which assessment units will be retained on subsequent §303(d) lists as a result of data gaps or policy issues concerning flow alteration.

Table 2. Summary of assessment outcomes.

Water Body Segment/ Assessment Unit	Listed Pollutants	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cedar Creek Lower ID17040213SK000_04	Flow Alteration Temperature Sediment	Yes	Retain for Flow Alteration TMDLs completed move to Section 4A and 4C upon approval	Existing Shade Bank Stability
Salmon Falls Creek Lower ID17040213SK001_06 ID17040213SK003_06	Temperature Nutrients Sediment	Yes	TMDLs completed move to Section 4A upon approval. Delist Bacteria and Dissolved Oxygen (DO)	Existing Shade Excess TP Excess TN Excess TSS
Devil Creek ID17040213SK002_03 ID17040213SK002_04	Temperature	Yes	Add, TMDL Completed move to section 4A upon approval	Existing Shade

Water Body Segment/ Assessment Unit	Listed Pollutants	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cedar Creek Reservoir ID17040213SK004_L ID17040213SK004	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval.	Existing Shade Bank Stability Excess TP
House Creek ID17040213SK005	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval. Delist Bacteria	Existing Shade Bank Stability Excess TP
Cedar Creek Upper ID17040213SK006	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval.	Existing Shade Bank Stability Excess TP
China Creek, Corral Creek, Whiskey Slough ID17040213SK007_02	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TP
Salmon Falls Creek Reservoir ID17040213SK007_L	Mercury Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Fish Tissue Excess TP
China Creek ID17040213SK008_03	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TP
Salmon Falls Creek ID17040213SK009_06	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TSS Excess TP
North Fork Salmon Falls Creek ID17040213SK010	Temperature	Yes	Add, TMDLs completed move to Section 4A upon approval	Existing Shade
Shoshone Creek ID17040213SK011_04 ID17040213SK013_04 ID17040213SK016_04	Temperature Sediment	Yes	TMDLs completed move to Section 4A upon approval. Delist Bacteria	Existing Shade Bank Stability
Hot Creek ID17040213SK012_03A ID17040213SK012_04	Temperature	Yes	TMDLs completed move to Section 4A upon approval. Delist sediment	Existing Shade
Big Creek ID17040213SK014	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TP

Water Body Segment/ Assessment Unit	Listed Pollutants	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cottonwood Creek ID17040213SK015	Temperature Sediment Nutrients Bacteria	Yes	TMDLs completed move to Section 4A upon approval. Delist DO	Existing Shade Bank Stability Excess TP Excess *E. coli*.

Table 3. Pollutants and Required Reductions.

Water Body Segment/ Assessment Unit	Pollutants	Required Reductions
Cedar Creek ID17040213SK000_04	Flow Alteration	None
	Temperature	45 percent
	Sediment	56 percent
Salmon Falls Creek Lower ID17040213SK001_06 ID17040213SK003_06	Temperature	20
	Nutrients	TP 54 percent TN 67 percent
	Sediment	TSS 39 percent
Devil Creek ID17040213SK002_03 ID17040213SK002_04	Temperature	33 percent
Cedar Creek Reservoir ID17040213SK004_L ID17040213SK004 ID17040213SK005 ID17040213SK006	Temperature	41 percent
	Sediment	17 percent
	Nutrients	60 percent
China Creek, Corral Creek, Whiskey Slough ID17040213SK007_02	Temperature	36 percent
	Sediment	14 percent
	Nutrients	86 percent
Salmon Falls Creek Reservoir ID17040213SK007_L	Mercury	69 percent
China Creek ID17040213SK008_03	Temperature	47 percent
	Sediment	10 percent
	Nutrients	86 percent
Salmon Falls Creek	Temperature	12 percent

Water Body Segment/ Assessment Unit	Pollutants	Required Reductions
ID17040213SK009_06	Sediment	TSS 90 Bank Stability 90
	Nutrients	80 percent
North Fork Salmon Falls Creek ID17040213SK010	Temperature	55 percent
Shoshone Creek ID17040213SK011_04 ID17040213SK013_04 ID17040213SK016_04	Temperature	40 percent
	Sediment	65 percent
Hot Creek ID17040213SK012_03A ID17040213SK012_04	Temperature	40 percent
Big Creek/ ID17040213SK014	Temperature	38 percent
	Sediment	64 percent
	Nutrients	65 percent
Cottonwood Creek ID17040213SK015	Temperature	46 percent
	Sediment	86 percent
	Nutrients	77 percent
	Bacteria	88 percent

1. Subbasin Assessment – Watershed Characterization

1.1 Introduction

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

This document addresses the water bodies in the Salmon Falls Creek Subbasin that have been placed on Idaho's current §303(d) list. Also included is a summary of the water body assessment outcomes for the unlisted water bodies assessed for the integrated report and 303(d) listing cycle.

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

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 and continue to change, as experience and perceptions of water quality have changed.

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

Some conditions that impair water quality do not receive TMDLs. The EPA considers certain unnatural conditions, such as flow alteration, a lack of flow, or habitat alteration, that are not the result of the discharge of specific pollutants as “pollution.” TMDLs are not required under the CWA for water bodies impaired by pollution, but not by specific pollutants. A TMDL is only required when a pollutant can be identified. However, often a stream will be found to be impaired by several pollutants as well as pollution. In those cases the best management practices (BMP) used to complete the required load reductions for the specified pollutants will likely also address the effects of pollution. In most circumstances, the BMPs for many pollutants and pollution are one and the same. In effect creating the desired effect of restoring beneficial uses impaired by pollution. In those cases, a de facto TMDL for pollution is then created by the TMDLs for specific pollutants.

However, in some rare cases, such as Cedar Creek, flow alteration is the only factor impairing the beneficial uses. In these circumstances the stream is retained on the 303(d) list until such time as pollution can be addressed or a Use Attainability Analysis can be completed.

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

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

- Aquatic life support – cold water, seasonal cold water, warm water, salmonid spawning, modified

- Contact recreation – primary (swimming), secondary (fishing or boating)

- Water supply – domestic, agricultural, industrial

- Wildlife habitats, aesthetics

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

In the Salmon Falls Creek Subbasin, only four assessment units or stream segments have been so designated. These designated assessment units include: Salmon Falls Creek from Nevada/Idaho border to Salmon Falls Creek Reservoir; Salmon Falls Creek Reservoir; and Salmon Falls Creek from Salmon Falls Creek Reservoir to the Snake River (two assessment units). The remainder of the water bodies within the Salmon Falls Creek Subbasin are unclassified.

A 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.

- When water bodies are not attaining water quality standards, determine the causes and extent of the impairment.

1.2 Physical and Biological Characteristics

The characterization of the Salmon Falls Creek Subbasin (Figure 3) will be based on its physical and biological features and how they interplay with ecoregional and hydrological traits. The Salmon Falls Creek Subbasin is complex in its characterization, principally due to a plurality of land types within the Idaho portion of the subbasin. There are highly accessible areas where agricultural, pastureland, and row crop activities dominate the land use. Adjacent to these lands, and predominating the subbasin, are the low mountainous and sage-steppe areas from which the majority of water in the subbasin comes and rangeland land use activities dominate.

Additionally, there are many sources of water in the subbasin. Much of the water for the smaller streams (e.g. Cottonwood Creek and Big Creek) comes from snowpack and rainfall in the mountain ranges in the eastern portion of the subbasin. However, many of the smaller feeder streams along the western portion of the subbasin arise from springs (e.g. China Creek, and House Creek).

To further complicate the analysis, some of the streams within the subbasin gain a portion of their water from thermal sources (e.g. Hot Creek, Salmon Falls Creek, and Shoshone Creek) and hydrological modifications have essentially dewatered at least two of the streams located within the subbasin. Both Cedar Creek and Salmon Falls Creek have been disconnected from their natural headwaters and must rely on seep water or springs to regenerate any significant flow below their respective dams. In the case of Cedar Creek, these water sources do not exist and the stream has been dry since the construction of the dam in 1912. Unlike Cedar Creek, Salmon Falls Creek (built in 1906) gains water throughout the lower portion of its watershed from water seeping around the dam and from numerous springs and irrigation returns.

Adding to the subbasin complexity is the issue of nonpoint source pollution within the watersheds. Many factors influence the type and rate of nonpoint source pollution, such as soil characteristics, climate, vegetation, and topography, as well as land use and population centers.

Land use in the subbasin is predominantly rangeland (89 percent). Irrigated agriculture also exists in the lower elevation, northern portion of the subbasin where water is either pumped from the ground or diverted from Salmon Falls Creek Reservoir or Cedar Creek Reservoir. The subbasin is somewhat unique in that (in the Idaho portion) the major population centers impacting the basin are outside of the subbasin. The cities and towns of Twin Falls, Rogerson, and Hollister are where the majority of landowners, recreationists, and land managers reside. Within the Idaho portion of the subbasin most of the row crop agricultural areas are near the community of Castleford. Other communities within the subbasin include Jackpot and Contact, Nevada.

The subbasin contains three different water sources. The first of these is runoff from the snowpack and other precipitation events in the mountainous region to the south and west. The second is the Salmon Falls/Rock Creek Aquifer below the northern portion of the subbasin (Crosthwaite 1969). Salmon Falls Creek is the southern-most border between the Eastern Snake River Plain Aquifer and the Western Snake River Plain Aquifer (Garabedian 1992). The final source is a geothermal aquifer layer that feeds several geothermal springs along the ecoregional boundary. These sources affect water quality to varying degrees. Water from the geothermal aquifer may affect water quality significantly in some portions of the subbasin, Hot Creek in particular.

The subbasin land forms, vegetation, topography, and precipitation can be defined by two ecoregions. The predominant ecoregion of the subbasin is the Northern Basin and Range. The Northern Basin and Range ecoregion is predominantly sage-steppe-juniper mountain lands. Most of the surface streams are intermittent or ephemeral in nature due to low annual precipitation and high seasonal evaporation. Consequently, limited riparian habitat exists within the subbasin. Those streams that remain perennial usually form from spring sources in the more mountainous regions of the subbasin. Along these stream courses some riparian habitats persist.

Sediment, nutrients, and temperature were the most common listed pollutants in the subbasin in 2004. These pollutants were listed on the most of the 2004 §303(d) listed Assessment Units within the subbasin (Figure 4). Other listed pollutants and stressors (pollution) included flow alteration, bacteria, organic enrichment, and mercury. The SBA portion of the SBA-TMDL determines the current amount of a particular pollutant in each of the watersheds of the §303(d) listed assessment units. The SBA also determines what impact to the beneficial uses each pollutant may have.

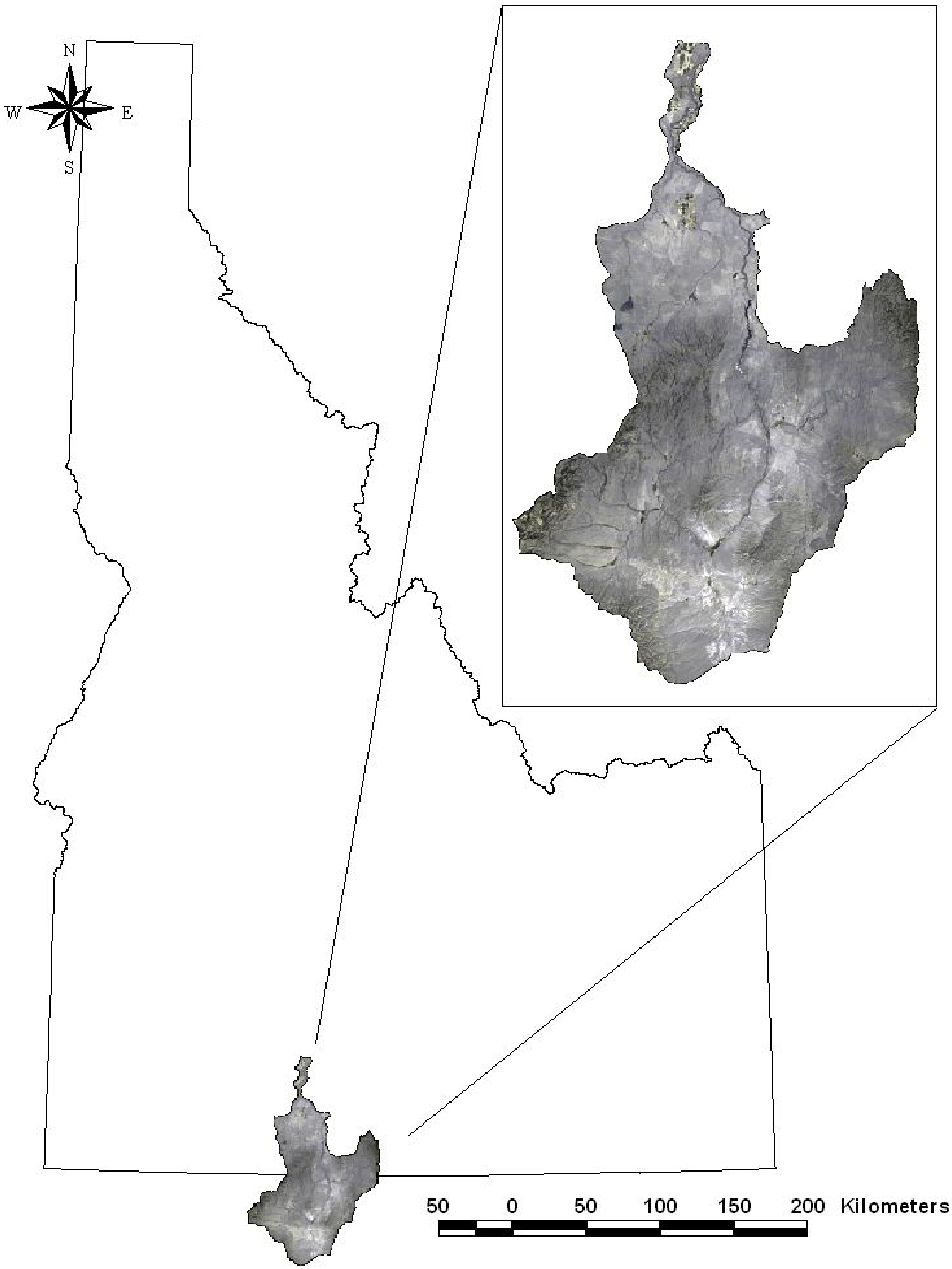


Figure 3. Salmon Falls Creek Subbasin in Relationship with the State of Idaho.

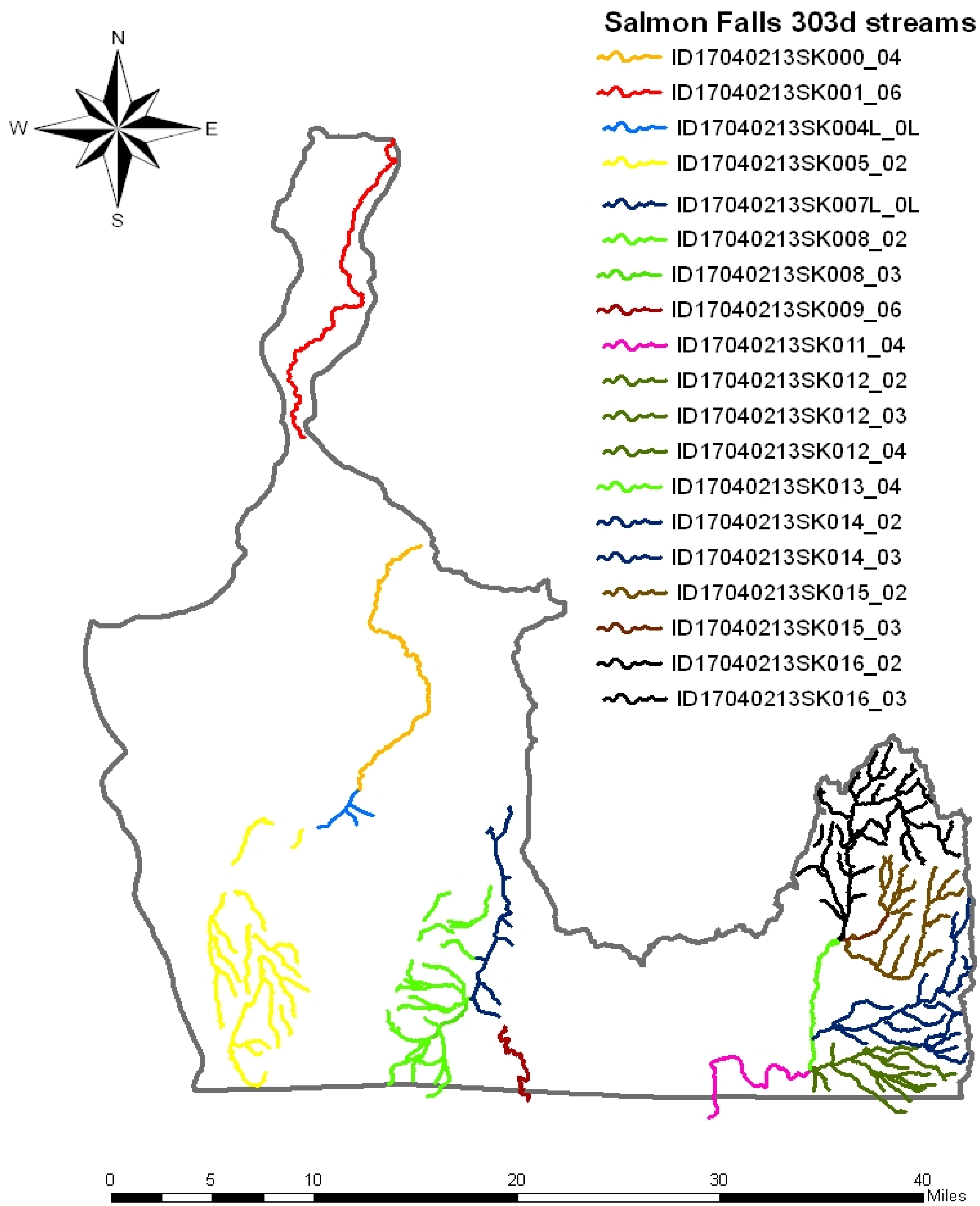


Figure 4. 2002 §303(d) Listed Assessment Units.

Climate

The Salmon Falls Creek Subbasin begins in the mountains and highlands located along the southern and western boundaries of the subbasin and reaches northward to the lowlands of the Snake River Basin/High Desert ecoregion in the northern edges of the subbasin. The pronounced differences in climate from the mountains to the Snake River Plain are due to the elevation difference across the subbasin. Precipitation varies from 10.1 (in)/year in the lower elevations at Castleford to 20.9 to 38.2 in/year on the mountain summits (See Appendix A for unit conversion factors).

Using the Koeppen system of climate classification (Figure 5), the majority of the subbasin is considered cold steppes (Bsk) with localized areas of Humid Continental areas with precipitation being evenly distributed and warm short summers (Dfb) to precipitation concentrated during the winter with warm short summers (Dsb) (See http://www.met.tamu.edu/class/metr324/Slide56-57.pdf for more detail in determining Koeppen climate classification.)

Three climate stations (Jackpot NV 264016, Hollister, ID 104295, and Castleford ID 101551) from the Western Regional Climate Center (www.wrcc.dri.edu 2004) are available near the subbasin to characterize the watershed. Because the majority of the climate stations are outside of the subbasin, there are few data sets available to characterize the bulk of the subbasin. As noted, nearly all the perennial flow in this watershed comes from the mountainous areas of the subbasin, which do not have climate station data.

The town of Jackpot NV is in the southern portion of the subbasin near the Idaho border. The town is at approximately 5,248 feet (ft) in elevation. The climate is arid with an annual precipitation of less than 9.8 inches. Approximately 40 percent of the precipitation falls in the spring (March to May). The average snow depth in the winter months is 1 inch, except in January, which averages approximately 2 inches. This indicates that precipitation in the form of snow does not accumulate to provide for a spring snowmelt runoff in the lower southern portions of the subbasin. The wettest months of the year are April, May, and June (1.1, 2.0, and 1.4 inches respectively), while the driest months are December (0.5 in) February (0.4 in), and July (0.4 in). However, for the remainder of the year, outside of the wettest and driest three, average precipitation is near 0.6 inch per month. The monthly average precipitation is approximately 0.8 inch a month due in part to the relatively moist average conditions in May. The average annual maximum temperature for the Jackpot area is 60.4 $^{\circ}$F, with the average annual minimum temperatures of 32.4 $^{\circ}$F.

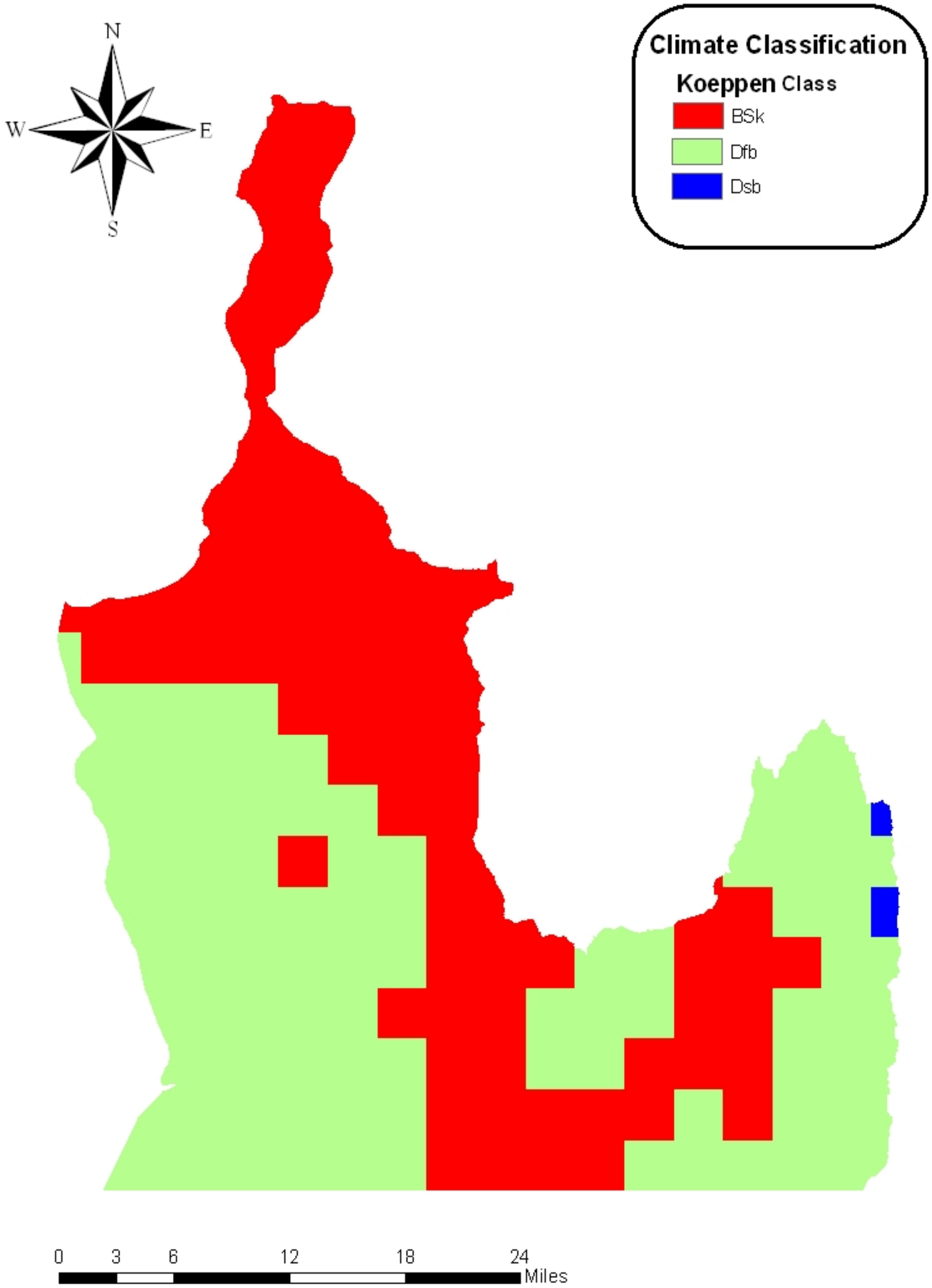


Figure 5. Koeppen Climate Classification of the Salmon Falls Creek Subbasin. Bsk, cold steppes; Dfb Humid Continental, evenly distributed precipitation, and warm short summers; Dsb, concentrated winter precipitation and warm short summers.

The town of Hollister is approximately 27 miles (km) north of the NV/ID border in the Snake River Basin Ecoregion. Hollister lies at 4,513 ft elevation. It is an arid climate, with an annual mean precipitation of just under 10.1 inches. Approximately 30 percent of the precipitation falls in the spring (March to May) and approximately 20 percent falls during each of the other seasons. The average snow depth in the winter months is effectively zero. This indicates that precipitation in the form of snow does not accumulate to provide for a spring snowmelt runoff in the lower middle portions of the subbasin. The wettest months of the year are January, May, and June (1.0, 1.4, and 1.2 inches respectively), while the driest months are February (0.6 inch), July (0.5 inch), and August (0.5 inch). Annual average monthly precipitation is 0.8 inch per month. The average annual maximum temperature for the Hollister area is 94.8 °F, with the average annual minimum temperatures of 34.9 °F.

The town of Castleford is in the northern portion of the subbasin, it is also located in the Bsk cold steppe climate area, and is well within the Snake River Basin Ecoregion. Castleford lies at 3,864 ft elevation. It is an arid climate, with an annual mean precipitation of just under 10.1 inches. Typical of cold steppe climates, most of the precipitation that falls in the Castleford area falls in the winter while the summer months are some of driest. Approximately 30 percent of the precipitation falls in the spring (March to May) and another 30 percent falls during the winter months. The average snow depth in the winter months is 0.7 inch. This indicates that precipitation in the form of snow may accumulate to provide for some spring snowmelt runoff in the northern portions of the subbasin. The wettest months of the year are January, May, and December (1.2, 1.2, and 1.1 inches respectively), while the driest months are July (0.2 inch), August (0.4 inch), and September (0.5 inch). Annual average monthly precipitation is 0.8 inch per month. The average annual maximum temperature for the Castleford area is 62.4 °F, with the average annual minimum temperatures of 35.4 °F.

Four SNOTEL sites can be used to determine snow pack and to make runoff predictions for the water-year. Two of these sites are in Idaho and are Wilson Creek located at 7,120 feet in the North Fork of Salmon Falls Creek Watershed and Magic Mountain at 6,880 feet in the Rock Creek Watershed of the Upper Snake-Rock Creek Subbasin and also includes the watershed of Shoshone Creek in the Salmon Falls Creek Subbasin.

The Nevada SNOTEL sites include Pole Creek Ranger Station at 8,330 feet in the Canyon Creek Watershed of the Salmon Falls Creek Subbasin, Draw Creek at 7,200 feet in the South Fork of Salmon Falls Creek Watershed of the Salmon Falls Creek Subbasin. Information from these SNOTEL sites can be found at http://www.wcc.nrcs.usda.gov/snotel/Nevada/nevada.html and http://www.wcc.nrcs.usda.gov/snotel/Idaho/idaho.html.

Monthly and yearly averages from the four sites are presented in Tables 4 and 5.

Table 4. Monthly Average Precipitation (inches).

MONTH	WILSON CREEK	MAGIC MOUNTAIN	POLE CREEK	DRAW CREEK	MONTHLY AVERAGE
1	3.16	4.13	2.00	2.67	2.99
2	2.54	3.55	1.88	2.24	2.55
3	2.73	3.56	2.37	1.90	2.64
4	4.03	3.62	2.30	1.58	2.88
5	2.89	3.17	2.62	1.80	2.62
6	1.94	1.73	1.67	1.07	1.60
7	0.66	0.82	1.03	0.68	0.80
8	0.64	0.74	0.77	0.50	0.66
9	0.97	1.05	1.03	0.67	0.93
10	1.34	1.75	1.17	1.06	1.33
11	2.92	4.10	2.15	2.63	2.95
12	3.08	4.58	2.15	2.38	3.05

Table 5. Annual Average SNOTEL Precipitation (inches).

YEAR	WILSON CREEK	MAGIC MOUNTAIN	POLE CREEK	DRAW CREEK
1981				18.7
1982		31.4		28.9
1983		36.7		30.3
1984		51	23.7	28.5
1985		41	16.9	19.5
1986		29.1	19.3	21.3
1987		33.7	16.1	19.3
1988		25.9	18.4	18.8
1989		34	15.2	16.5
1990		22	18.1	20.6
1991	28.8	29.6	16.5	21.6
1992	20.6	25.1	17	16.4
1993	29.9	32.4	18.5	20.4
1994	26.8	31.8	15.6	21.4
1995	33.5	40.2	22.8	26.2
1996	30.8	43.9	28	24.1
1997	28.1	30.3	18.2	21.2
1998	30.5	41.1	26.4	27.6
1999	24.1	28.4	17.8	18
2000	25.8	30.3	18.7	16.6
2001	23.3	30	21.1	16.6

YEAR	WILSON CREEK	MAGIC MOUNTAIN	POLE CREEK	DRAW CREEK
2002	22.2	24.1	14.3	16.6
2003	25.5	29.1	20.3	17.7
Annual Average	26.92	32.78	20.91	19.15

It is apparent from these tables that appreciably more precipitation falls in the mountains than in the lowland where the weather stations are located. Also notable is that more precipitation falls in the mountains of Idaho than those in the Nevada region. As a result, the streams fed by the Cassia Mountains should provide for more perennial streams such as Big Creek, Cottonwood Creek and Shoshone Creek. Were as, the streams from the Nevada portion should be expected to be intermittent or ephemeral if they rely solely on runoff from precipitation falling in the mountains. Examples of these would be Player Creek, Cottonwood Creek (a tributary stream of Salmon Falls Creek not Shoshone Creek, located solely in Nevada), Corral Creek, and Whiskey Slough.

Subbasin Characteristics

Water in the Salmon Falls Creek Subbasin moves through a variety of pathways. Generally, the natural hydrology of an area is the result of its climactic regime, topography, and geology. Topography seems to play the most significant role in determining the location of perennial water within the subbasin as the other two factors are fairly uniform throughout the subbasin. Most of the perennial streams have some origin in the mountainous areas of the subbasin. Mountainous areas are located principally in the southwest portion and southeastern portions of the subbasin (Figure 6). In the southwestern portion the Browns Bench (China and House assessment units), the Bad Lands in Nevada, and Granite Range also in Nevada (Salmon Falls and North Fork of Salmon Falls assessment units) provide snowpack and groundwater for much of the perennial watersheds. The mountainous region to the southeast serves as the headwater areas of Big Creek, Hot Creek and Shoshone Creek assessment units. In general, the Salmon Falls Creek and Shoshone Creek routes dominate the subbasin. Except for these two major drainages, most of the surface channels are intermittent or ephemeral tributaries.

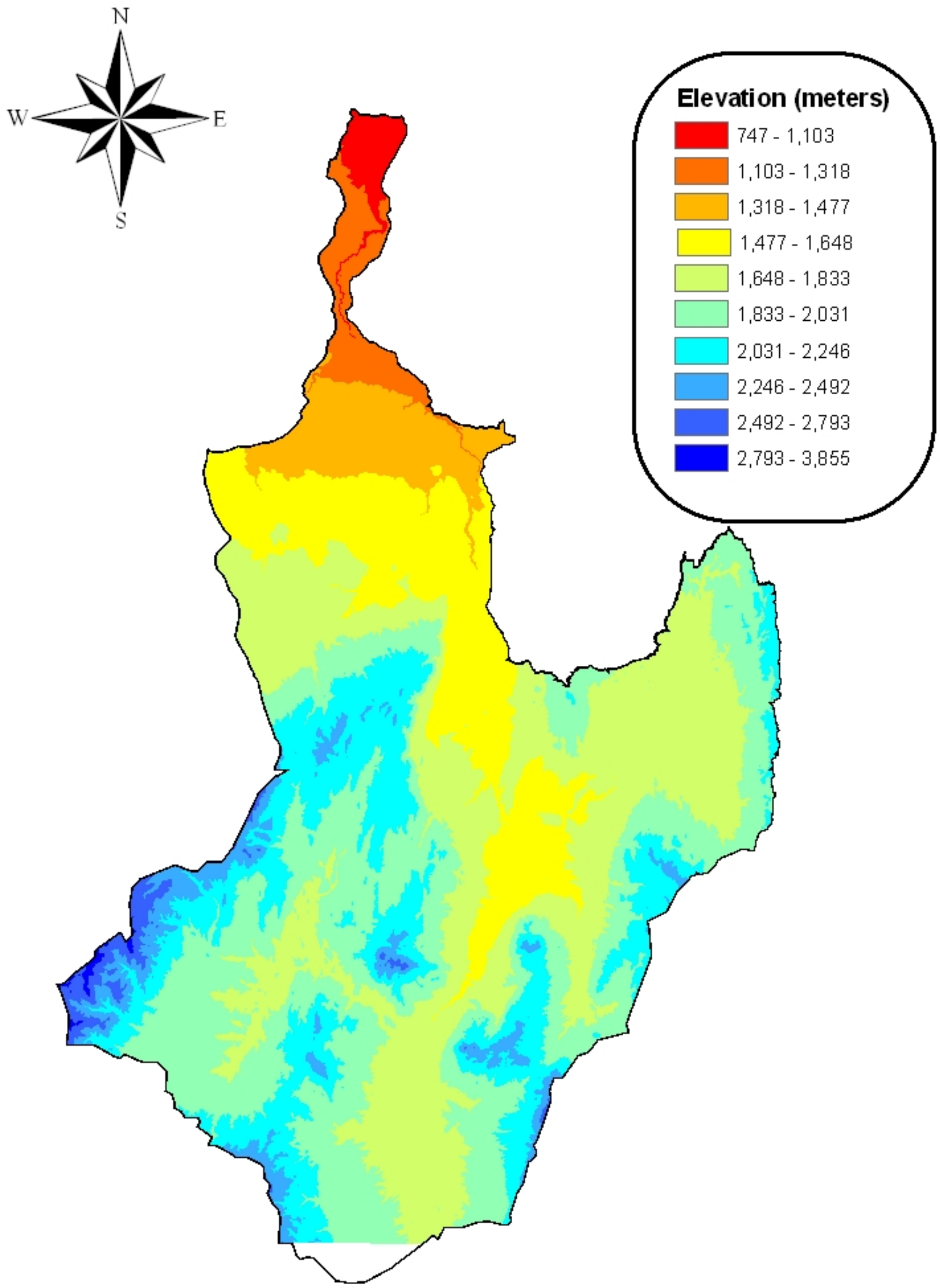


Figure 6. Elevation of the Salmon Falls Subbasin.

Stream Characteristics

The EPA reach file identifies numerous streams as perennial within the subbasin. Further investigations, ground-truthing, and cross-referencing with United States Geological Service (USGS) topographic maps were required to determine if a stream is currently perennial. The reach file identified thirty streams as perennial including the ones assessed in this document that are contained in the various assessment units on the §303(d) list. Some of these streams will be included in assessment units assessed in upcoming years. Future iterations of the SBA-TMDL will include new streams not meeting their beneficial uses. Many of the remaining streams have had Beneficial Use Reconnaissance Program (BURP) data collected on them. Updated assessment guidance is available in the Water Body Assessment Guidance II (WBAG II) (Grafe et al. 2002), and will be used on these streams with BURP data collected in years following the SBA-TMDL initiation. These streams with BURP data will be assessed for the next §303(d) list. Table 6 contains a list all subbasin "perennial" streams from the NHD database and a determination if they actually have perennial water through DEQ personnel observations. This list is for those interested parties that might have data on these streams. The BURP data and any other data gathered on these streams will be used to assess streams and rivers for future §303(d) lists. Subsequently, those streams added to the §303(d) list would be included in future iterations of the Salmon Falls Creek SBA-TMDL.

The geology of the subbasin exerts its most dominant control of the hydrology of the subbasin through the interplay with groundwater. Seasonally, ground water plays an unknown but significant role in the hydrology of several streams and rivers of the subbasin. Discussions of the hydrology of each stream will follow much later in this document.

Table 6. Streams under consideration as perennial streams.

Stream Name	Observed Status	Boundaries
Big Creek	Perennial	Headwaters to Mouth
Browns Creek	Intermittent	Headwaters to Mouth
Cedar Creek	Perennial	Headwaters to Reservoir
Cedar Creek	Intermittent	Reservoir to Mouth
China Creek	Perennial	Headwaters to Mouth
Corral Creek	Intermittent	Headwaters to Mouth
Cottonwood Creek	Perennial	Headwaters to Mouth
Devil Creek	Intermittent	Headwaters to Mouth
Diamond Creek	Unknown	Headwaters to Mouth
Eagle Spring Creek	Unknown	Headwaters to Mouth
Electric Spring Creek	Unknown	Headwaters to Mouth
Hanna's Creek	Perennial	Headwaters to Mouth
Hot Creek	Perennial	Headwaters to Mouth
House Creek	Perennial	Headwaters to Mouth

Stream Name	Observed Status	Boundaries
Jack Creek	Unknown	Headwaters to Mouth
Langford Flat Creek	Intermittent	Headwaters to Mouth
Little House Creek	Perennial	Headwaters to Mouth
Lost Creek	Unknown	Headwaters to Mouth
Middle Fork Hanna's Creek	Perennial	Headwaters to Hanna's Fork
Middle Fork Shoshone Creek	Perennial	Headwaters to Shoshone Creek
Mule Creek	Unknown	Headwaters to Mouth
North Fork Salmon Falls Creek	Perennial	Headwaters to Salmon Falls Creek
Player Creek	Perennial	Player Spring to China Creek
Player Creek	Intermittent	Headwaters to Player Spring
Pole Camp Creek	Intermittent	Headwaters to Shoshone Creek
Salmon Falls Creek	Perennial	Headwaters to Reservoir
Salmon Falls Creek	Perennial	Reservoir to Mouth
Shoshone Creek	Perennial	Headwaters to State Line
South Fork Hanna's Creek	Unknown	Headwaters to Hanna's Fork
South Fork Shoshone Creek	Perennial	Headwaters to Salmon Falls Creek
Twin Springs	Perennial	Headwaters to Mouth
West Fork Devil Creek	Unknown	Headwaters to Mouth
Wilson Creek	Unknown	Headwaters to Mouth

Salmon Falls Creek Reservoir supplies water for irrigation in the northern portions of the subbasin and to areas outside of the subbasin. The reservoir discharges into a main canal, which then splits into two feeder canals, one on the east side of the valley and one on the west side. Data is available from the USGS on discharge from the reservoir through the canal since 1922. From this data, DEQ estimates that during the irrigation season about 345 ft^3/s on average are diverted from the reservoir during the irrigation season. Monthly and daily discharge rates vary throughout the irrigation season. Typically, peak discharge is in July and averages 386 ft^3/s.

Cedar Creek Reservoir also supplies irrigation water to the Northern portion of the subbasin and surrounding areas. The reservoir discharges into Cedar Creek and uses the existing creek channel for 4 miles. At that point the water is siphoned into the Cedar Mesa Canal and routed to the Cedar Mesa Reservoir prior to delivery to the irrigated farmlands near Castleford. Discharge information for Cedar Creek Reservoir is estimated to average approximately 80 ft^3/s during the irrigation season.

Ground water

Ground water in the Salmon Falls Creek Subbasin is an important aspect of the water quality and quantity of some streams. Typically, the spring fed streams lie within the boundary layers of the various volcanic periods, such as between the Banbury and Idavada volcanic layers. For example, in the China Creek area, springs and dissolved materials in the ground water have a great impact on water quality. In this system it is chiefly total phosphorus (TP) from groundwater which affects water quality. However, for the most part springs are limited in the subbasin. Additionally, some of the springs within the area are warm or hot springs (arising from the Idavada volcanic layer) which may influence stream temperatures although, the impact from these geothermal sources is unknown at this time. The Salmon Falls Creek-Rock Creek Aquifer (part of the Eastern Snake River Plain Aquifer) lies beneath the northern portion of the subbasin (Figure 7). The elevation of ground water in the Salmon Falls area was estimated to be near 1,036 to 3,040 feet (ft) above sea level in 1993 (Bendixson 1993). Wells in the Twin Falls subarea range in depth from 62 to 1,289 ft. In the Rogerson area, water table depth of several wells ranged between 259-499 ft. However, for most wells in the area, pumping lifts are ordinarily near 400 ft (Young and Newton 1989). The specific capacity of wells studied in the Blue Gulch area of the subbasin within the Salmon Falls Creek-Rock Creek aquifer was estimated at 34-290 gallons per minute per foot (gpm/ft) of drawdown (Chapman and Ralston 1970). In some areas of the aquifer the transmissivity can be very high, such as in the Quaternary basalts. However, in fine-grained sediments and older tertiary rhyolite the transmissivity is much lower. These factors indicate that time of travel in the lower Salmon Falls Creek-Rock Creek area can be very short while in the upper rhyolitic volcanics and sedimentary alluvium areas, time of ground water travel is much longer. Furthermore, typical water movement in the area is from recharge areas in the mountains down gradient north west towards the Snake River. The Salmon Falls Creek Canyon forms a ground water movement barrier that prevents water movement East/West within the aquifer.

Some ground water level monitoring was done in the Salmon Falls Creek-Rock Creek area (1960 to 1993) as a result of the Blue Gulch area being listed as a critical Groundwater area (see Bendixon 1993). Most of the monitored wells in the subbasin show a seasonally steady decrease in ground water level up to the mid 1980s. This indicates that over the period of record to 1980s, that ground water withdrawals exceeded recharge. However, most wells in the study area have shown steady increases following this period. In general Bendixson (1993) estimated that ground water declines of up to 29.5 ft had occurred between 1960 and the mid 1980s. Following the establishment of large tracts of farmlands in the Conservation Reserve Program (≈80 percent of the Blue Gulch area) in the 1980s groundwater levels have increased to near predrafting conditions (Bendixon 1993). In the aquifer system analysis done by Chapman and Ralston (1970), they estimated that 34,000 acre/feet per year was discharged from the system via underflow and from irrigation withdrawals. This estimate was made during somewhat substantial groundwater level declines in the study area. While during the recharge years Bendixon (1993) refined those estimates to be closer to 18,500 acre-feet per year to ground water pumping and 7,300 acre-feet discharged to Salmon Falls Creek. In addition, it was estimated that between 10,000 and 35,000 acre-feet per year would recharge the area from precipitation events in the spring and winter, entering the aquifer through the fractured basalt beds of the local ephemeral stream systems. Ralston and Chapman (1970) indicated that a minimal amount is lost due to low evapotranspiration in the non-irrigated lands of the area base solely on the depth to groundwater in the area.

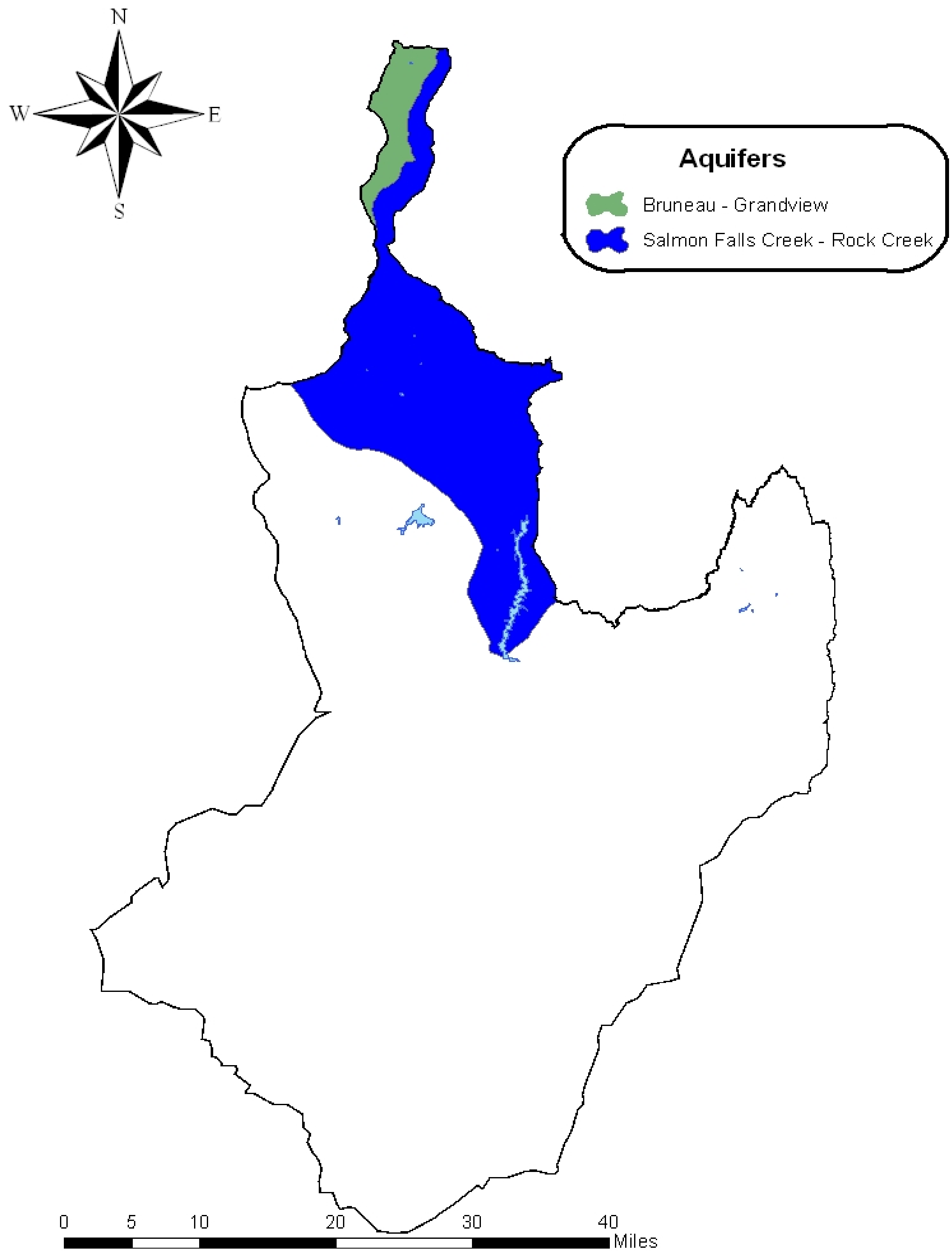


Figure 7. Portions of the Bruneau-Grandview and Salmon Falls Creek Rock Creek Aquifers in Relationship to the Subbasin and Reservoirs.

Soils/Geology/K-Factor

Local soils can be conceptualized as four soil provinces: the clayey and loamy soils of volcanic areas, the loamy soils of the fluvial canyons, the highly stratified alluvial soils of the area near the farming center of Castleford, and the alpine glacial soils of the Cassia Mountain province.

The average slope provides a gauge of potential soil erosion, or risk erodibility. GIS shapefiles indicate that slopes of the subbasin are generally low (1.2-5.6 percent) on the agricultural plains, moderately steeper in the areas forming the watersheds surrounding the stream networks in the Shoshone Basin (5.7-12.4 percent), and slopes increase appreciably as one approaches the bordering mountain ranges and into Nevada. The slopes are fairly steep in the Nevada Portion of the Subbasin, ranging from 22-45.9 percent (Figure 8). The overall percentage of the subbasin within five slope classes are presented in Table 7.

Table 7. Percent of Subbasin within Five Slope Classes.

SLOPE CLASS	PERCENT OF SUBBASIN AREA
1 to 2 percent	22.37
2 to 5 percent	33.55
5 to 10 percent	32.25
10 to 22 percent	11.15
22 to 46 percent	0.68

The “K-factor” is the soil erodibility factor in the Universal Soil Loss Equation (Wischmeier and Smith 1965). The factor is comprised of four soil properties: texture, organic matter content, soil structure, and permeability. The K-factor values range from 1.0 (most erosive) to 0 (nearly non-erosive). K-factors for the Salmon Falls Creek Subbasin were calculated from the STATSGO soil information and range from 0.08 in the Salmon Falls Creek Canyon bottom, 0.34 in the Brown’s Bench area, to a high of 0.42 in the eastern hills of the Cassia Mountains bordering the Shoshone Basin. Those portions of the subbasin in Nevada range from 0.2 to 0.32, while the agricultural lands of the subbasin range from 0.19 to 0.32. This indicates that the soils in the subbasin are relatively stable with the highest K-factor at nearly the bottom third between highly erodible and nonerosive. Soils on the flat slope of the plains and agricultural areas have the low to moderately erodible soils. The K-factors range from 0.1 to 0.26 on the soils of the main rangeland areas, such as in the Salmon Falls Reservoir area and Shoshone Basin. Table 8 shows the percentage of the subbasin within five K-factor classes. Figure 9 presents the area weighted K-factors of the Salmon Falls Creek Subbasin soils.

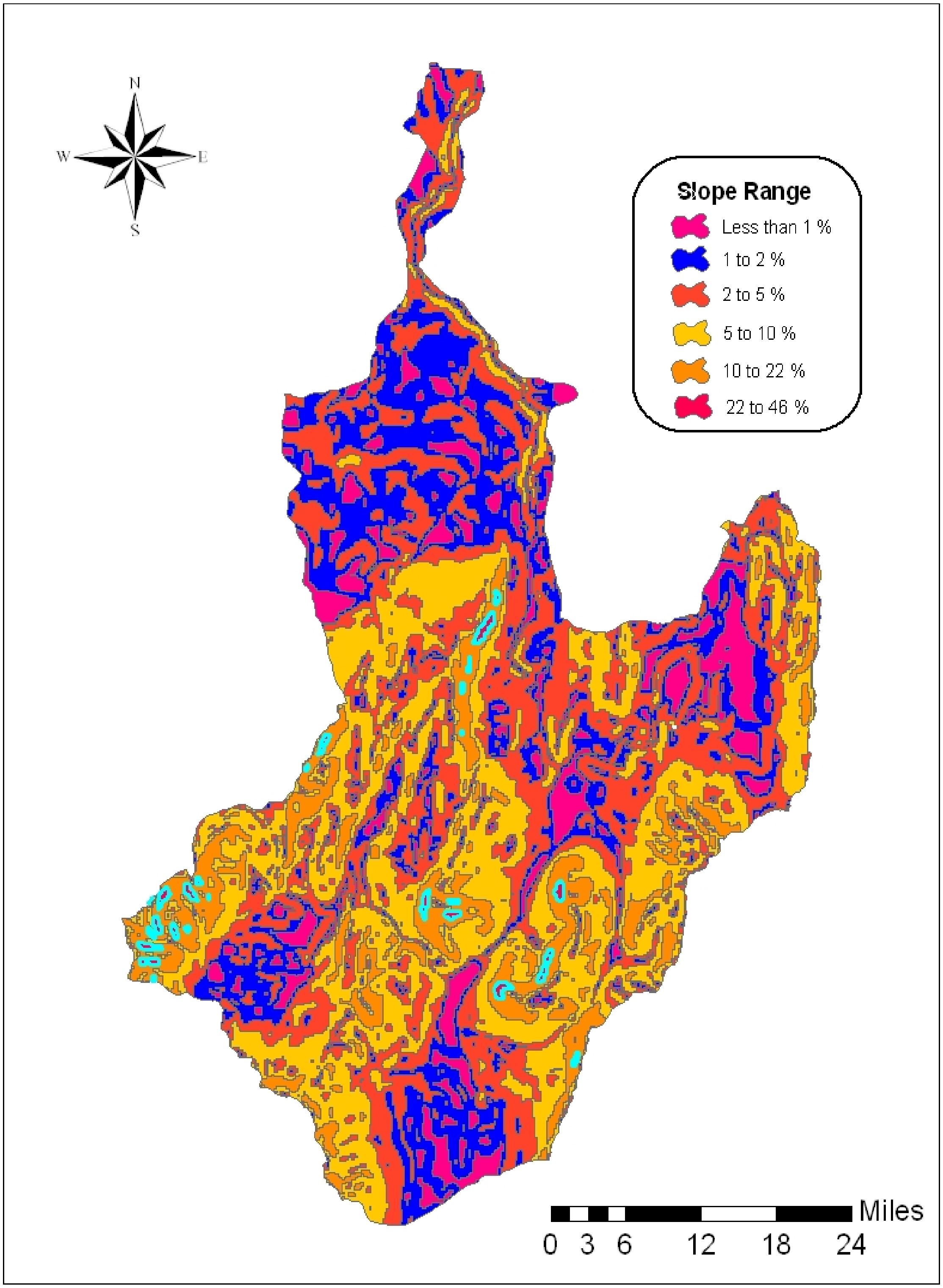


Figure 8. Slope classes of the Salmon Falls Creek Subasin.

Table 8. Percentage of Subbasin within Five K-factor Classes.

K-FACTOR CLASSES	PERCENTAGE OF SUBBASIN AREA
0.08 to 0.15	1.8
0.15 to 0.22	27.50
0.22 to 0.29	31.68
0.29 to 0.36	32.22
0.36 to 0.43	6.80

In general, the K-factors indicate that the rangelands have low soil erosion potentials. Because of this, the amount of sediment from rangelands entering streams is also low. Due to the low erosion potential from the uplands, the Salmon Falls Creek Subbasin Assessment and following Total Maximum Daily Loads (TMDL) will focus on valley bottom and channel sources of sediment for those streams on the 1998 §303(d) list with sediment as a pollutant.

The overall geologic structure of the area is within the southern extent of the Northern Basin and Range ecoregion. The Basin and Range is an area of faulted metamorphic and sedimentary rocks uplifted into mountains, separated by basins deeply filled with alluvium and colluvium (Figure 10). In addition, areas of the Salmon Falls Creek Subbasin that lie within the Northern Basin and Range contain granitic intrusions in scattered locations chiefly in Nevada. Also prominent in the ecoregion, beside the volcanic geology common to southern Idaho, are the Pliocene and Miocene lake and stream deposits through which Salmon Falls, and House Creeks flow (Figure 11).

The Snake River Basin/High Desert ecoregion crosscuts the Salmon Falls Creek Subbasin in the north. Locally thick deposits of loess (wind-blown silt) overlie these rocks, particularly in the volcanic Snake River Plain (Alt and Hyndman 1989). The Snake River Plain is a deep, wide, structural basin filled with a veneer of volcanic basalt deposits overlying rhyolite. The rocks in the Snake River Plain decrease in age, from west to east, due to the migration of a magma source that has migrated to present-day Yellowstone National Park.

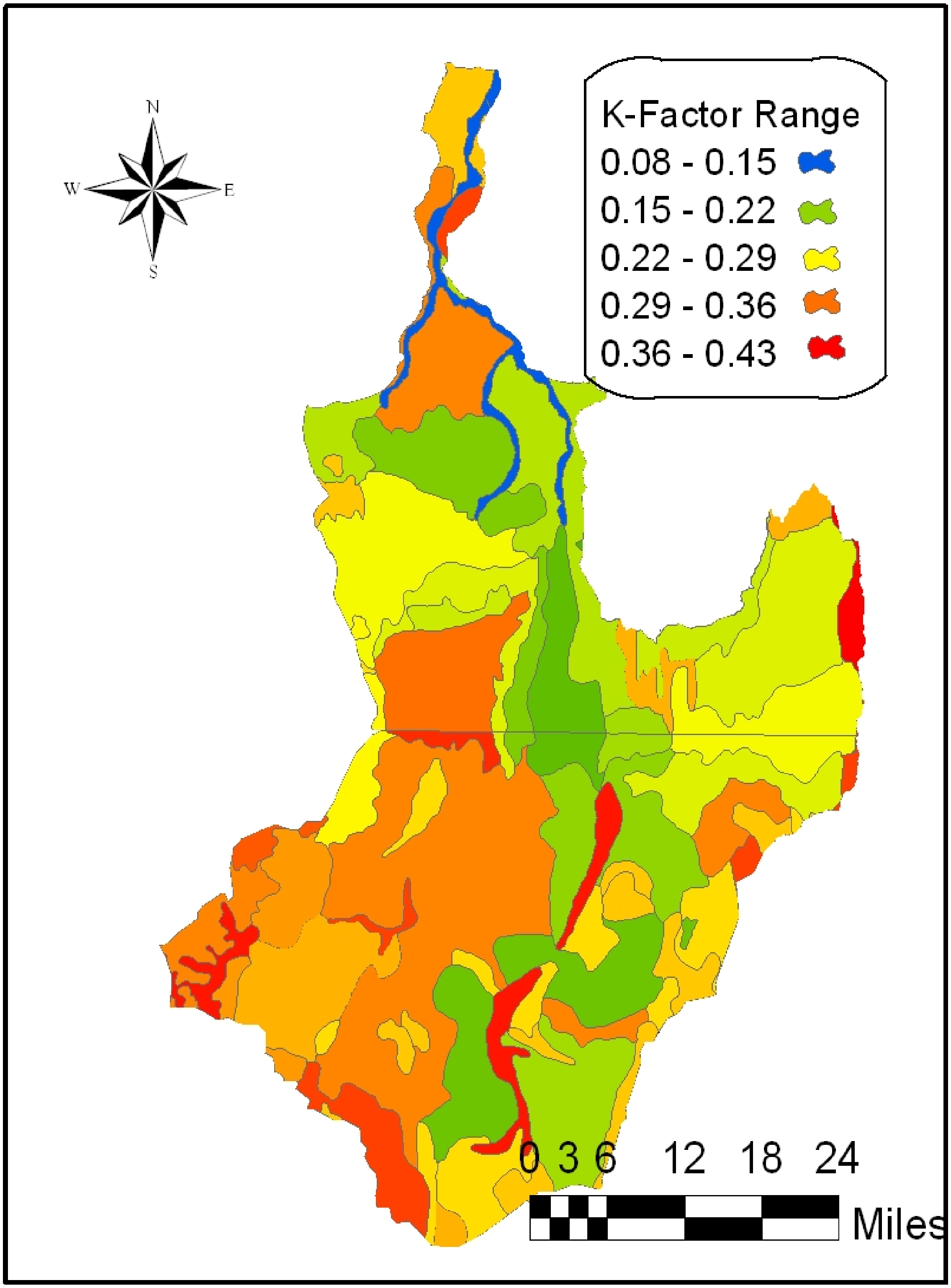


Figure 9. Soil erosion index and location of water quality limited streams within the subbasin.

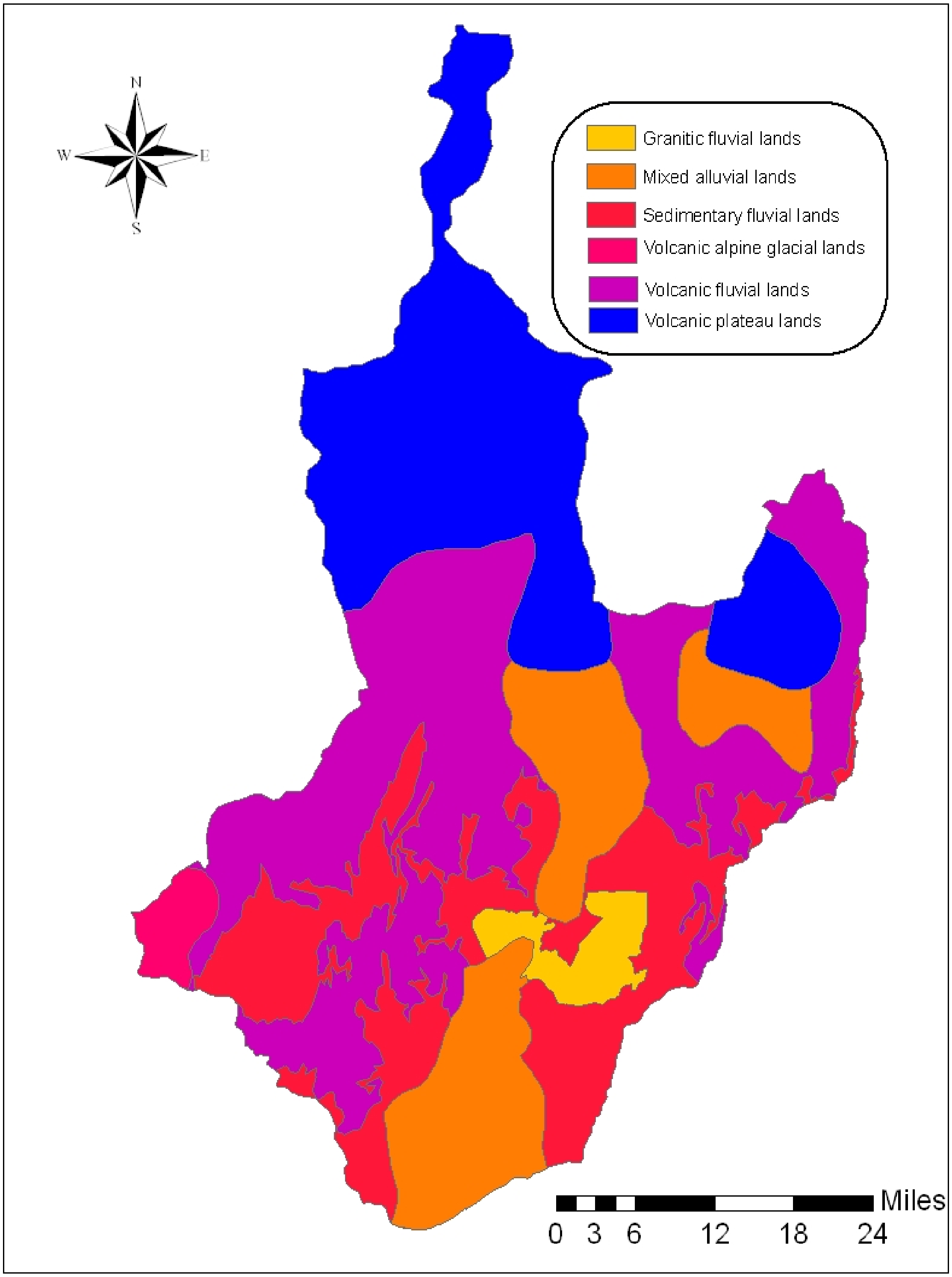


Figure 10. Major geological subdivisions of the Salmon Falls Creek Subbasin.

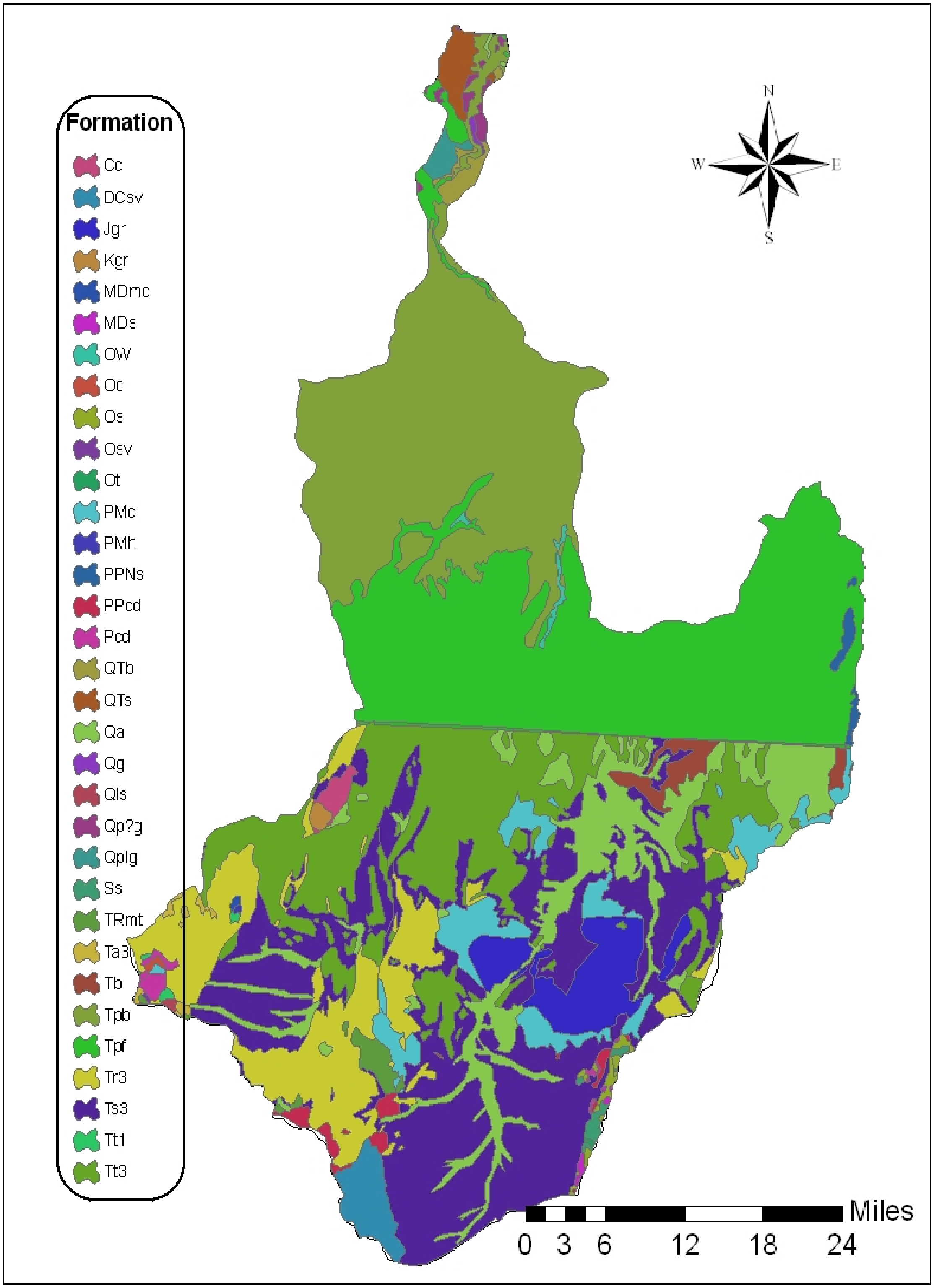


Figure 11. Geological formations within the Salmon Falls Creek Subbasin.

Table 9. Geologic Description for Select Formations.

Formation	Salmon Falls Creek Subbasin Geologic Descriptions	Percent of Subbasin
Tpb	Pliocene and upper Miocene Basalt	33.1
Tpf	Pliocene and upper Miocene felsic volcanic rocks	21.9
QTb	Quaternary Basalt	10.0
Qplg	Volcanic breccias, tuffs, and volcanic rocks older than Tertiary age	7.8
Jgr	Quaternary to Tertiary-age volcanic flows Rhyolite	4.8
Tr3	Tertiary tuffacious rocks and sediments	3.0
Qa	Quaternary alluvial deposits	3.0
QTs	Pleistocene and Pliocene stream and Lake Deposits	1.1
Tt3	Pleistocene glacial outwash	1.0
Ts3	Intrusive and metamorphic rocks	0.9

*GIS coverage changes at state lines due to different state descriptions for geological types. Various agencies are working to have the descriptions the same for all areas.

The geomorphology of the subbasin can be divided into six geological subsections (Figure 10). Within each of these subsections, locally distinct geological formations can be found. The majority of the subbasin (92.0 percent including the Nevada portions) lies within the Volcanic plateau lands subsection. Each geological subsection contributes sediment to the streams in various volumes. From Figures 6 and 7 it can be seen that the volcanic plateau subsection likely does not contribute significant sediment loads to the streams and rivers as its slopes are usually less than 5 percent and it is below Salmon Falls Creek Reservoir. Therefore, only three geological subsections play any factor in water quality in the Salmon Falls Creek Subbasin.

For a more detailed view of the geology of the Salmon Falls Creek Subbasin that may affect water quality, see Figure 11 and Table 9.

Topography

The region is cartographically covered by 1:24,000-scale and higher USGS topographic quadrangle maps. The total vertical relief in the area is 6,737 ft, from an elevation of 3,431 ft at the Snake River to 10,168 ft at Gods Pocket Peak Nevada in the Jarbidge Mountains. Slopes in the agricultural and most grazing areas are quite gentle (less than 5 percent) with considerably steeper slopes in the foothills and mountains (5-46 percent) (Figure 8).

The topography is an expression of the geologic structure and historical glacial and volcanic processes. Chiefly the faulted, linear mountain chains of the Northern Basin and Range ecoregion, which are bordered by the Snake River Plain to the north are the basis for most of the topography. The mountainous areas of the subbasin can be generally broken into several provinces. The first of these are high volcanic/glacial mountains in the Jarbidge area. Second is the western edge of the Cassia Mountains locally known as the South Hills from which spring sources dominate and form Big Creek and Cottonwood Creek. Third are the granitic intrusions located in Nevada near Contact. The final province would be the basalts and quaternary detritus, which form the fertile agricultural Snake River Plain area (Figure 10).

The Salmon Falls Creek and Shoshone Creek streams bisect the subbasin North-South in the case of Salmon Falls Creek and East-West in the case of Shoshone Creek. Each flow through large open valleys or basins before entering into deeply incised canyons in the volcanic plateau region of the subbasin. Alluvial terraces rise above these streams along their courses through the open basins.

The Salmon Falls Creek Subbasin covers approximately 2,103 square miles (mi^2) in total area. Nearly 871 mi^2, or 41 percent of the subbasin, lies within the state of Idaho. The elevation range within the Idaho portion of the subbasin is from 3,431 to 7,829 ft. Overall, the subbasin has a northeast aspect. The stream channels and mainstem rivers follow a dendritic drainage pattern throughout the subbasin as a result of the topography.

Vegetation

The Salmon Falls Creek Subbasin is predominantly within the Northern Basin and Range ecological region (97.46 percent of the subbasin) as described by Omernik and Gallant (1986) and Omernik (1986), with limited Snake River Basin/High Desert to the north. These two ecoregions are further divided into ecozones (Figure 12).

Basin and Wyoming Sagebrush is the dominant vegetation type throughout the region (over 54 percent of the Idaho portion of the subbasin). Other shrub brush communities such as Mountain big sage, rabbitbrush, and bitterbrush combine to make up over 90 percent of the Idaho portion of the subbasin. Streamside vegetation is generally the same as the surrounding regional vegetation due to the intermittent or ephemeral nature of most streams. Where perennial flow does occur, dense stands of sedges and forbs line the riparian zone. In perennial streams with moderate annual flow, woody vegetation consists of alder, willow, cottonwood, clematis, rose, and mock orange.

Most of the Northern Basin and Range ecoregion is used as rangeland. Where access by livestock is concentrated loss or reduction of streamside vegetation is severe, causing stream bank erosion and sedimentation. Water withdrawal for pasture irrigation or stock water can result in completely dry channels downstream from diversions.

Variability in the makeup of natural vegetation in the Salmon Falls Creek Subbasin is minimal. Shrubland vegetation predominate the entire subbasin (90.73 percent in the Idaho portion) with limited riparian vegetation (0.63 percent of the Idaho portion of the subbasin) in the mainstem streams and rivers. Following the construction of irrigation canals and irrigation return drains, some of the natural sage-grass areas have been changed to support agricultural crops, pasture grasses, hay, and riparian vegetation (Figure 13 and Table 10), which cover approximately 5.77 percent of the Idaho portion of the subbasin.

Fish and Wildlife

Within the Salmon Falls Creek Subbasin, several state and federal agencies list species of special concern; candidate species; or endangered, threatened, and sensitive species. The United States Fish and Wildlife Service (USFWS) is the main (non-anadromous, nonmarine species) listing agency. The USFWS lists 24 animals and 4 plants as endangered, threatened, or as candidate species within the state of Idaho (http://ecos.fws.gov/tess_public/StateListingAndOccurrence.do?state=ID). However, in Twin Falls County there are only seven endangered or threatened species (Table 11). Of these species, five are aquatic and one, the Bald Eagle, frequents aquatic habitats. The aquatic animals are Snake River snails, which are found only in the mainstem of the Snake River and as such may be greatly influenced by activities within the Salmon Falls Creek Subbasin. Decreases in the sediment and nutrient delivery from the Salmon Falls Creek Subbasin should positively impact the snails of the Snake River system. In addition to the downstream effects of improving water quality on the listed snails, other federally listed or candidate plants and animals that may be influenced by the Subbasin Assessment (SBA) or TMDL are the spotted frog (*Rana luteiventris*) and potentially slickspot peppergrass (*Spiranthes diluvalis*). The slickspot peppergrass has the potential to be found in bare slickspot soils within Wyoming sagebrush habitat and has been found in nearby Owyhee County. The spotted frog is an aquatic animal found in and near streams, lakes, marshes, and ponds. The spotted frog frequents these aquatic habitats in mixed coniferous forests, subalpine forests, grasslands, and sage and rabbitbrush shrublands (Stebbins 1985). Management decisions, because of the SBA-TMDL, will need to address these two species. Management decisions because of the SBA-TMDL may affect upland species as well. These will need to be addressed in any implementation plans developed by state and federal land management agencies.

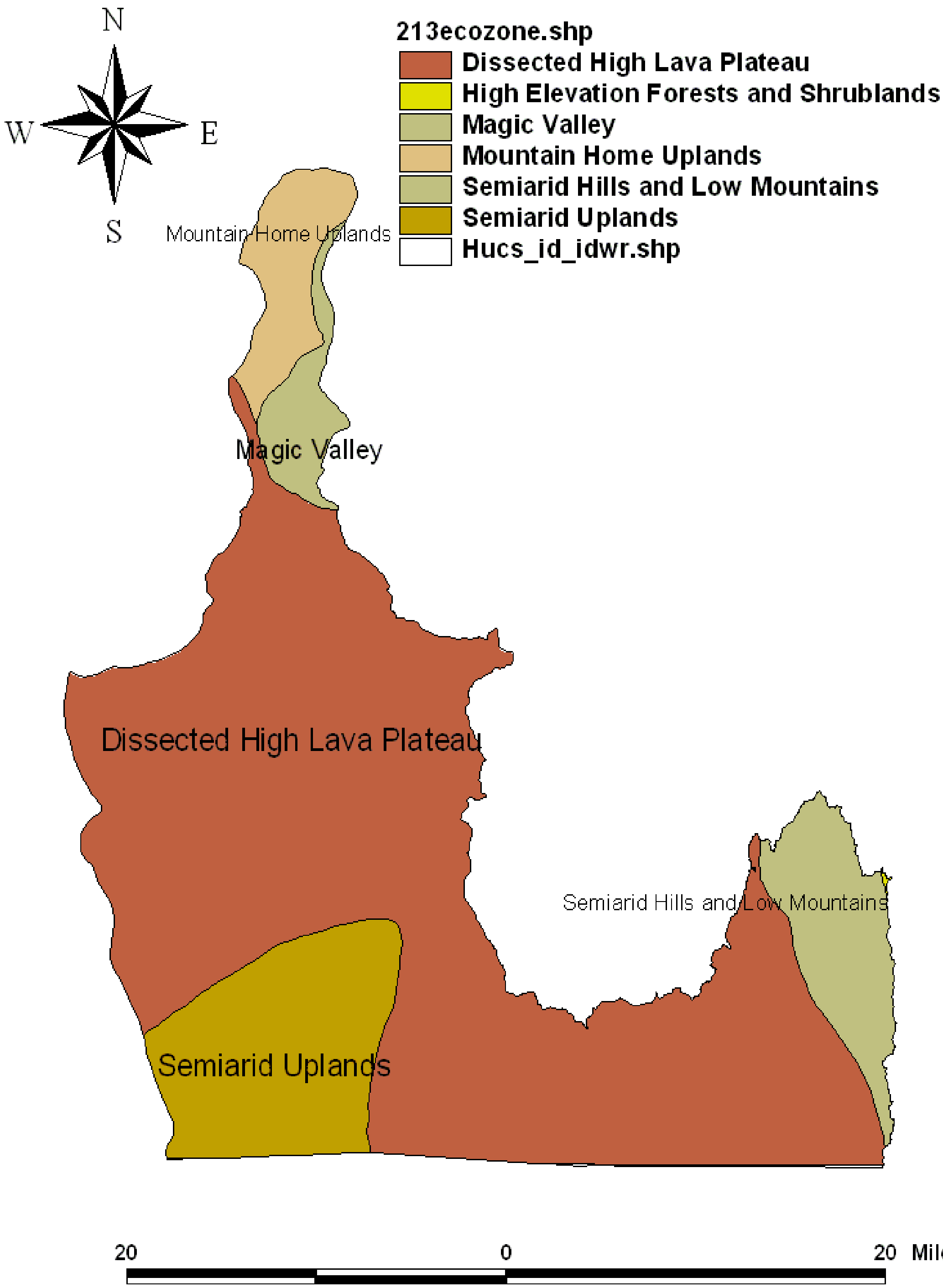


Figure 12. The Ecozone regions of the Salmon Falls Creek Subbasin (Idaho Portion Only).

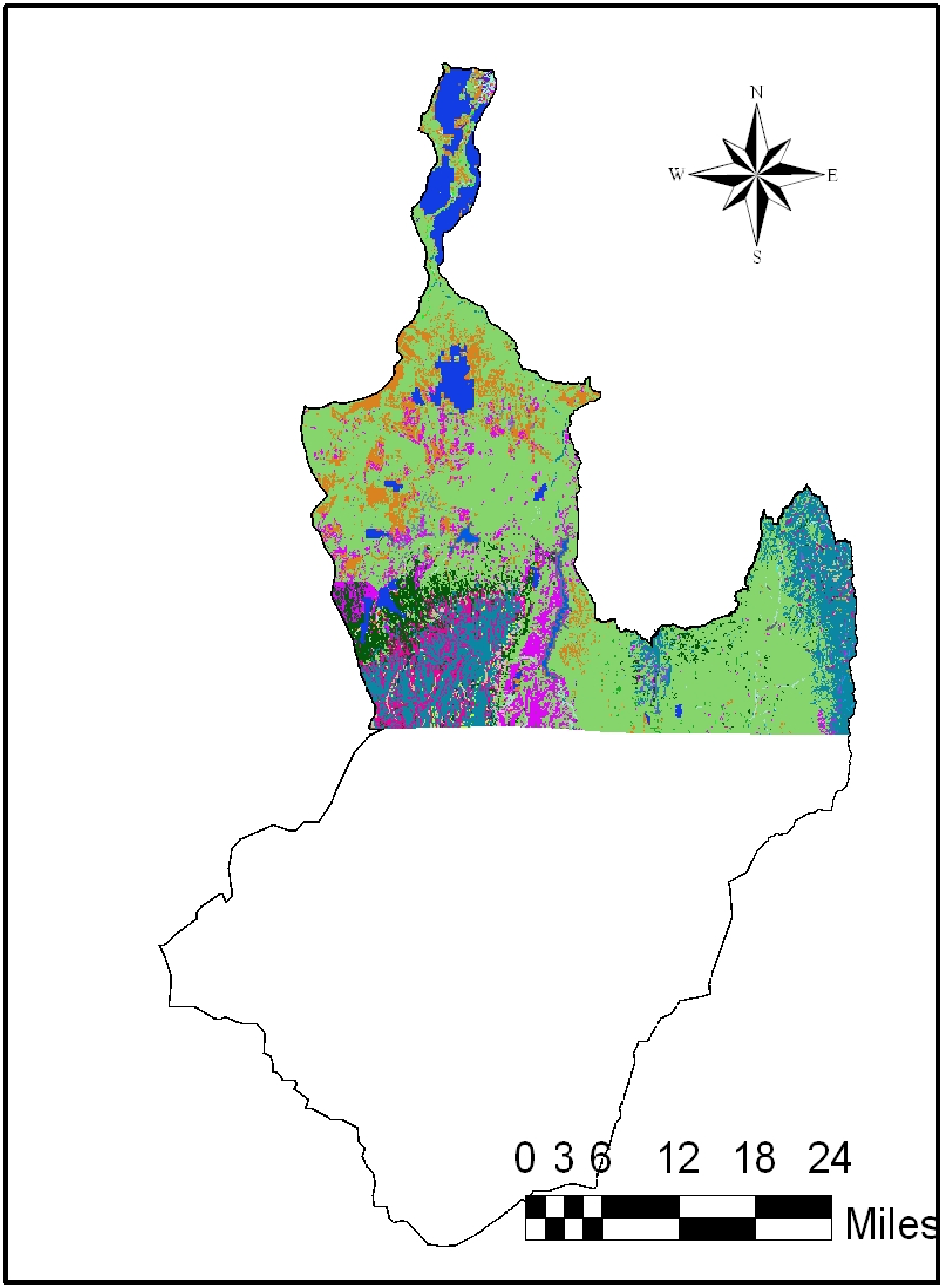


Figure 13. Vegetation Classes within the Idaho Portion of the Salmon Falls Creek Subbasin.

Table 10. Vegetation Cover Classes.

The Idaho Department of Fish and Game (IDFG) maintains a statewide list of species of special concern. Many of the species on this list are duplicates of those listed by the USFWS and other federal agencies. However, the list does not contain plant species.

Table 11 displays the federally listed threatened, endangered, and federal species of special concern found within the Salmon Falls Creek Subbasin. A list of the Idaho Department of Fish and Game's species of special concern can be found at http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_pdf/appendix%20b.pdf

Table 11. Threatened, endangered, and other species of federal concern in the Salmon Falls Creek Subbasin.

Species Common Name	Scientific Name	Comments
Bald Eagle	*Haliaeetus leucocephalus*	First protected in 1966 by the Endangered Species Preservation Act. Listed in 1973 under the Endangered Species Act. Down listed from endangered to threatened in 1995. Removed from the list of threatened and endangered species on June 28, 2007.
Banbury Spring Limpet	*Lanx sp*	Listed as endangered in 1992.
Bliss Rapids Snail	*Taylorconcha serpenticola*	Listed as threatened in 1992.
Canada Lynx	*Lynx canadensis*	Proposed for listing as threatened.
Gray Wolf	*Canus lupus*	Currently listed as endangered.
slickspot peppergrass	*Lepidium papilliferum*	Proposed for listing as endangered.
Snake River Physa Snail	*Physa natricina*	Listed as endangered in 1992.
Spotted Frog	*Rana lateiventris*	Considered the Great Basin sub-populations of the Columbian spotted frog. Determined that listing was warranted 1993. Currently a candidate species.

Fisheries

There are many species of fishes in the streams and reservoirs of the Salmon Falls Creek Subbasin (Table 12). The various fish species found within the basin include, rainbow trout, brown trout, brook trout, cutthroat trout, cutthroat/rainbow trout hybrid, kokanee salmon, sculpin species, shiners, long nose dace, speckled dace, and sucker species such as Utah, mountain, and blue head suckers.

Table 12. Fish species and pollution tolerance in the Salmon Falls Creek Subbasin

Species	Scientific name	Tolerance to pollution
rainbow trout	*Oncorhynchus mykiss*	II
brown trout	*Salmo trutta*	MI
kokanee salmon	*Oncorhynchus nerka*	II
sculpin	*Cottus sp.*	
Utah sucker	*Catostomus ardens*	TT
mountain sucker	*Catostomus platyrhychus*	MT
shiners	*Richardsonius sp.*	
longnose dace	*Rhinichthys cataractae*	MI
specked dace	*Rhinichthys osculus*	MI
walleye	*Stizostedion vitreum*	MT
black crappie	*Pomoxis nigromaculatus*	
smallmouth bass	*Micropterus dolomieu*	
northern pikeminnow	*Ptychocheilus oregonensis*	II
mountain whitefish	*Prosopium williamsoni*	

From: 1996 Water Body Assessment Guidance, A Stream to Standard Process (DEQ 1996)
Tolerance Value: II = Highly intolerant, MI = Moderately intolerant, MT = Moderately tolerant, TT = High tolerant

In addition, DEQ has recently developed a fish index for assessing water bodies for upcoming §303d lists. The stream fish index (SFI) is part of the Water Body Assessment Guidance, second edition (WBAG II) (Grafe et al. 2002) document, and uses the fish community to determine the support status of cold water aquatic life. The individual metrics within the index are slightly different depending upon which ecoregion the stream falls within. For the rangeland type streams, the metrics used were percent cold water individuals, Jaccard's community similarity coefficient, percent omnivores and herbivores, percent cyprinids as longnose dace, percent of fish with abnormalities, and catch per unit effort.

Macroinvertebrates

DEQ has developed two multi-metric indices for macroinvertebrate communities over the past decade. Both share many of the same metrics as well as metrics unique to each. The first of these was developed in 1996 as part of the original WBAG. It was called the Macroinvertebrate Biotic Index (MBI), and was intended to be used as an indicator of stream health (DEQ 1996).

Following the development of WBAG II, a new multi-metric tool was used to assess the aquatic life beneficial uses of wadeable streams in Idaho (Grafe et al. 2002). DEQ staff and Tetra Tech, a private consulting firm often employed by the EPA, developed the new tool. The new macroinvertebrate tool is called the Stream Macroinvertebrate Index (SMI). Within the index nine metrics are used: total taxa, Ephemeroptera taxa, Plecoptera taxa, Trichoptera taxa, percent Plecoptera, Hilsenhoff Biotic Index, percent five dominant taxa, scraper taxa, and clinger taxa. Further descriptions of scoring and breakpoint determinations can be found in WBAG II (Grafe et al. 2002). Theoretically, the SMI yields scores that range from 0 to 100. Break points used to assign rating conditions were based on reference conditions found in desert basin streams. These break points and condition ratings allow DEQ to integrate the scores from other indices into one final score for a given stream. The condition ratings range from 0, the minimum threshold, to 3, the maximum rating a stream can receive. The condition ratings from all indices used in an assessment are averaged to determine the final assessment outcome. For the desert basin ecoregions a SMI score greater than or equal to 51 yields a condition rating value of 3. For scores less than 33 a condition rating value of 0 is given. In General, if a stream receives an average condition rating of 2 or more it would be considered fully supporting its beneficial uses.

For the Salmon Falls Creek SBA, DEQ assessed the macroinvertebrate communities using both multi-metric indices in conjunction with other biological communities and water chemistry. These other data sources will augment any perceived shortcomings of the MBI and SMI in assessing the status of aquatic life beneficial uses in streams in the Salmon Falls Creek Subbasin. Moreover, the use of the macroinvertebrate community will lend further weight to fishery and water chemistry assessments made in previous and following sections. The assessment of the macroinvertebrate information will be based on the WBAG II and the best professional judgment of DEQ staff involved with the collection and assessment of this type of data and as corroborating information from other sources.

Aquatic Vegetation

Throughout the spring and summer of 2006, DEQ conducted water quality monitoring on the §303(d) listed assessment units within the Salmon Falls Creek Subbasin. During these monitoring events, DEQ made other water quality observations. These included the number and type of fishes observed and the approximate dates the various streams in the subbasin went dry. In addition to these observations, DEQ has noted the distribution of aquatic plants in the streams. Most locations are completely devoid of aquatic plant mats that would indicate excessive aquatic growths due to excess nutrients. In other locations the aquatic plants are localized and do not cover large portions of the streambeds. In addition, DEQ has not received any complaints concerning aquatic vegetation within the subbasin.

1.3 Cultural Characteristics

The cultural characteristics of the Salmon Falls Creek Subbasin have changed only slightly over the past century since the area was first settled by cattlemen in the late 1800s. The area’s first European inhabitants arrived in the middle to late 1860s. Prior to that, the area was a major crossroads for the Shoshone and Piaute Indians traveling through southern Idaho and Northern Nevada. Brown’s Bench may have been a significant source for quality tool stone. Ignimbrite quarries have been located in the area and the stone is supposed to have been used by native Americans from considerable distances away (http://www.centerfirstamericans.com/mt.php?a=50). Early visitors included trappers searching for new beaver trapping areas. Ramsey Cook traveled through the area in 1811 followed by Peter Ogden’s Hudson Bay Trappers in 1826. Neither group stayed long as there was not sufficient beaver in the area (Idaho State Historical Society 1981).

Following the early establishment of coach and mail lines between Salt Lake City, Utah and The Dalles, Oregon in 1864 was the establishment of the Camp Reed in Shoshone Basin (Varley 2004). The Army was charged with searching for marauding Indians, who were thought to be stealing livestock and horses from the stage lines. By 1866, Camp Reed was abandoned.

A short gold rush along the Snake River, from Minidoka to below the Thousand Springs area, brought yet more people to the area in the 1870s (Varley 2004). As the gold was isolated to gravel bars within the river, and of such fine particle size, many abandoned their efforts. Those with some remaining capital began buying up ranches along the streams in the Salmon Falls, Shoshone Basin, and Twin Falls areas.

The largest operator at the time was Andrew Harrel, who trailed over 3,000 head of cattle into the region. In subsequent years, he added more livestock to his herd. These huge cattle operations ran in the area between Goose Creek to the East, the Bruneau River to the West, and the Snake River to the North. For the most part, the cattle were turned out to the range in the spring and collected at various points for shipment and sale in the late fall. As such, it was the beginning of the widespread degradation of water quality throughout the region as there was little control of the cattle along the riparian areas.

Large free-range operations thrived until the late 1890s, when several harsh winters drove many out of business. Included were the notorious ranchers in the Browns Bench area, who, wanting a rail line spur from the Delaplain area in Nevada, hired Chinese laborers to build the spur. Upon completion of the line, the ranchers did not have the money to pay for the construction. When the laborers came to the ranchers for their pay, the laborers were hung in the area of China Creek, hence the name of this creek in the Salmon Falls Creek Subbasin.

In the following years, several hundred people were living in the area, homesteading, farming, and ranching. Meanwhile, water projects, such as the Milner Dam and the Minidoka Dam were beginning to be built in surrounding communities. These large water projects assured the surrounding areas of a steady supply of water in areas where water was limited. Consequently, the communities flourished.

In 1909, developers from the east decided to build a dam in the Salmon Falls area. The idea of a steady flow of water was appealing, and it was estimated that the dam would provide water for 120,000 to 150,000 acres of land (Idaho State Historical Society 1981). However, the water quantity stored by the dam did not live up to its original billing. In 1911, only 19,000 acres were irrigated, causing many to abandon their farms while the remaining farmers bought up the shares and learned to conserve water. By 1918, only 35,000 acres of the originaly-estimated 150,000 acres were being watered with Salmon River Canal water (Idaho State Historical Society 1981).

By the 1920s, with a rail line from Twin Falls to Rogerson, the development of a highway system in the area, and increased reliance on automobiles, the small farming towns of Berger, Amsterdam, and Hollister began to fade away. Only very small communities exist in Rogerson and Hollister today. Population estimates in 2005 are as follows: Hollister, ID 236; Castleford, ID 277; Rogerson, ID 230 (www.city-data.com); Jackpot, NV 1,281 (http://gov.state.nv.us/pr/2004/PDF/PR-attachment.pdf). Cattle ranching and farming remain the way of life for most of the subbasin residents in Idaho, while the gaming industry is the major employer in the Jackpot, Nevada area.

Land Use

As seen in Figure 14 and Table 13, approximately 85 percent of the lands within the subbasin are classified as rangelands. 5.28 percent of the remaining lands are in the open agricultural areas, which are classified as irrigated agriculture. In addition, 9.35 percent of the subbasin is classified as forested, of which most is used as rangeland. The remaining 0.43 percent of the subbasin consists of urban area, wetlands, bare rock, etc. The urban areas are scattered in the agricultural areas and are made up of many small town sites that range in size from Jackpot (population 1,281) to Berger (population 1-10).

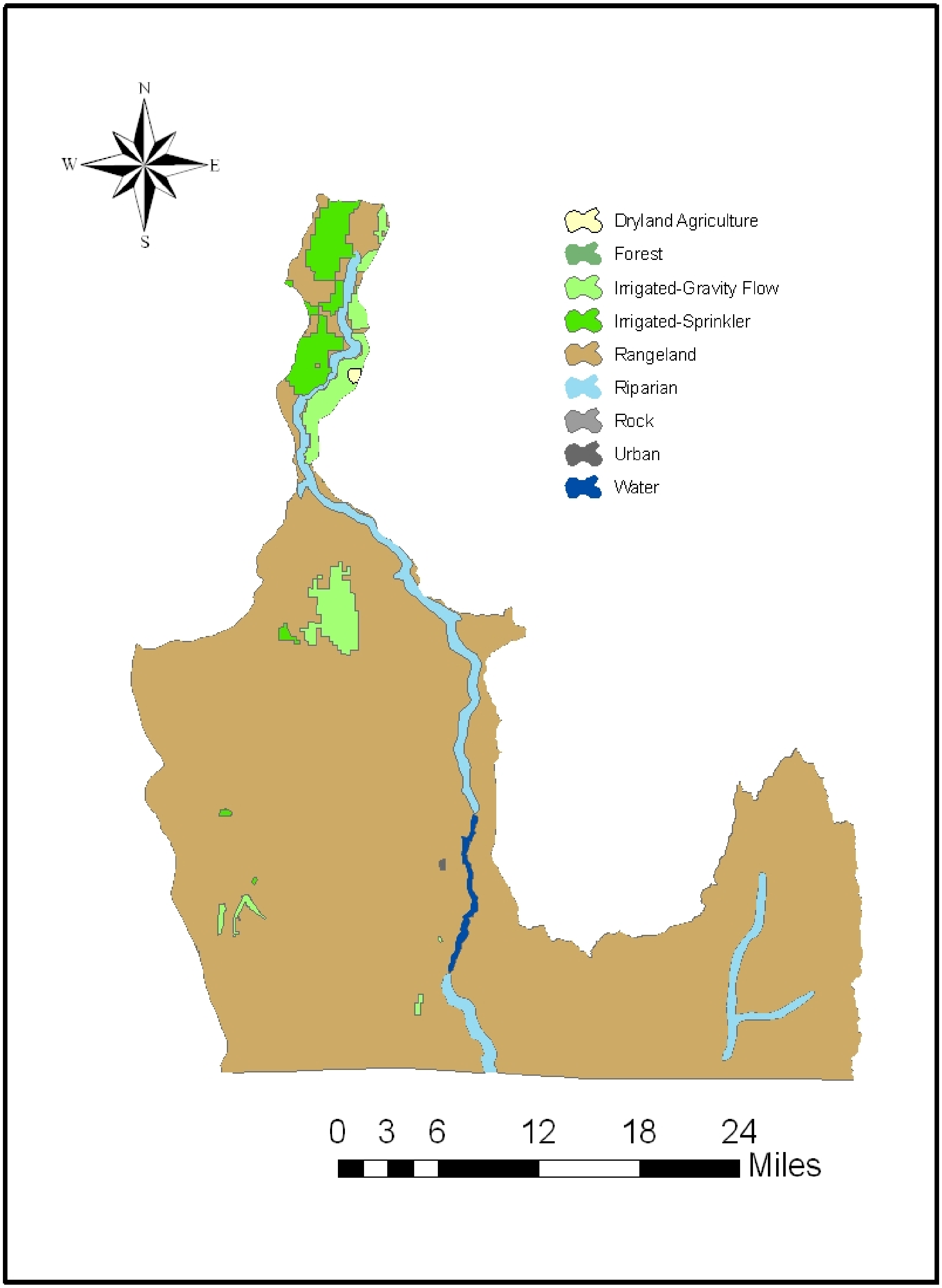


Figure 14. Land Use in the Salmon Falls Creek Subbasin (Idaho Portion Only).

Table 13. Land Use in the Salmon Falls Creek Subbasin (Idaho Portion Only).

LAND USE TYPE	AREA, $MILES^2$	PERCENT OF TOTAL AREA
Range	1,787	84.94
Forest	197	9.35
Irrigated Agriculture	111	5.28
Urban	0.8	0.03
Other	8.2	0.43
Total	2,103	100.00

Highway 93 is the main road through the subbasin. This highway bisects the subbasin and heads north/south through the central portion of the subbasin. The only other paved roads in the subbasin are those that connect Highway 93 with the small towns in and around the area, such as the Three Creek Road, as well as the section roads leading to the Snake River and other communities from Castleford. The remainder of the subbasin is covered with numerous dirt and gravel roads, most of which are not maintained (Figure 15).

The subbasin contains portions of Twin Falls County, Idaho; Owyhee County, Idaho; and Elko County, Nevada (Figures 16-17 and Table 14). Privately owned lands (17.62 percent of the entire subbasin) are essentially the same lands that are used for agriculture. The majority of the remainder (80.21 percent of the subbasin) is managed by the federal government—United States Bureau of Land Management (BLM) 71.48 percent and USFS 8.73 percent. Scattered state endowment lands (sections 16 and 36), under the management of each state's respective department of lands comprise 1.90 percent of the subbasin, of which almost all belongs to the State of Idaho (Table 15). Nevada's current policy regarding endowment lands has been to sell these lands to private landowners. As a result, approximately 27 acres of Nevada state lands exist within the subbasin.

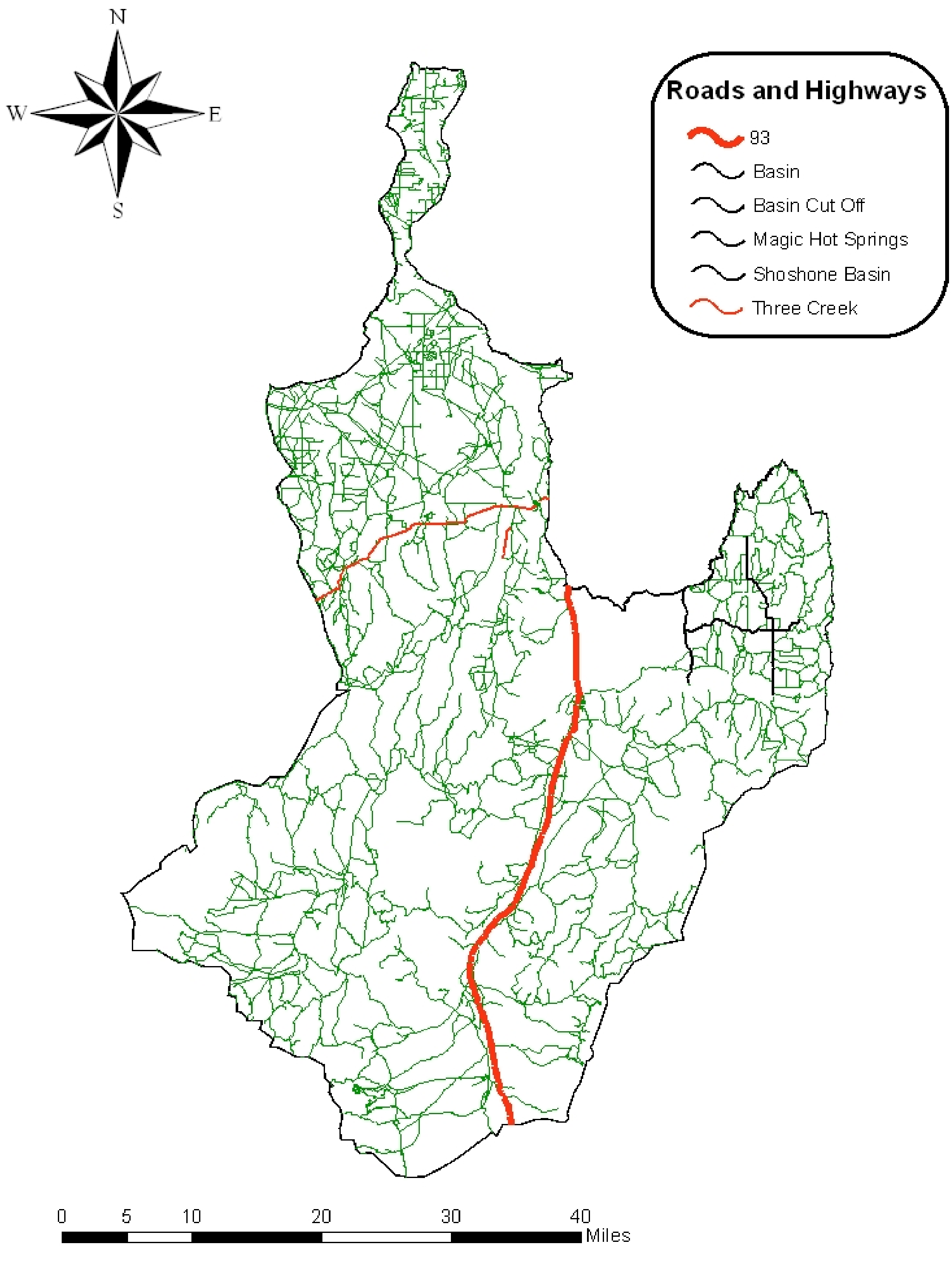


Figure 15. Major Roads and Highways of the Salmon Falls Creek Subbasin.

Land Ownership, Cultural Features, and Population

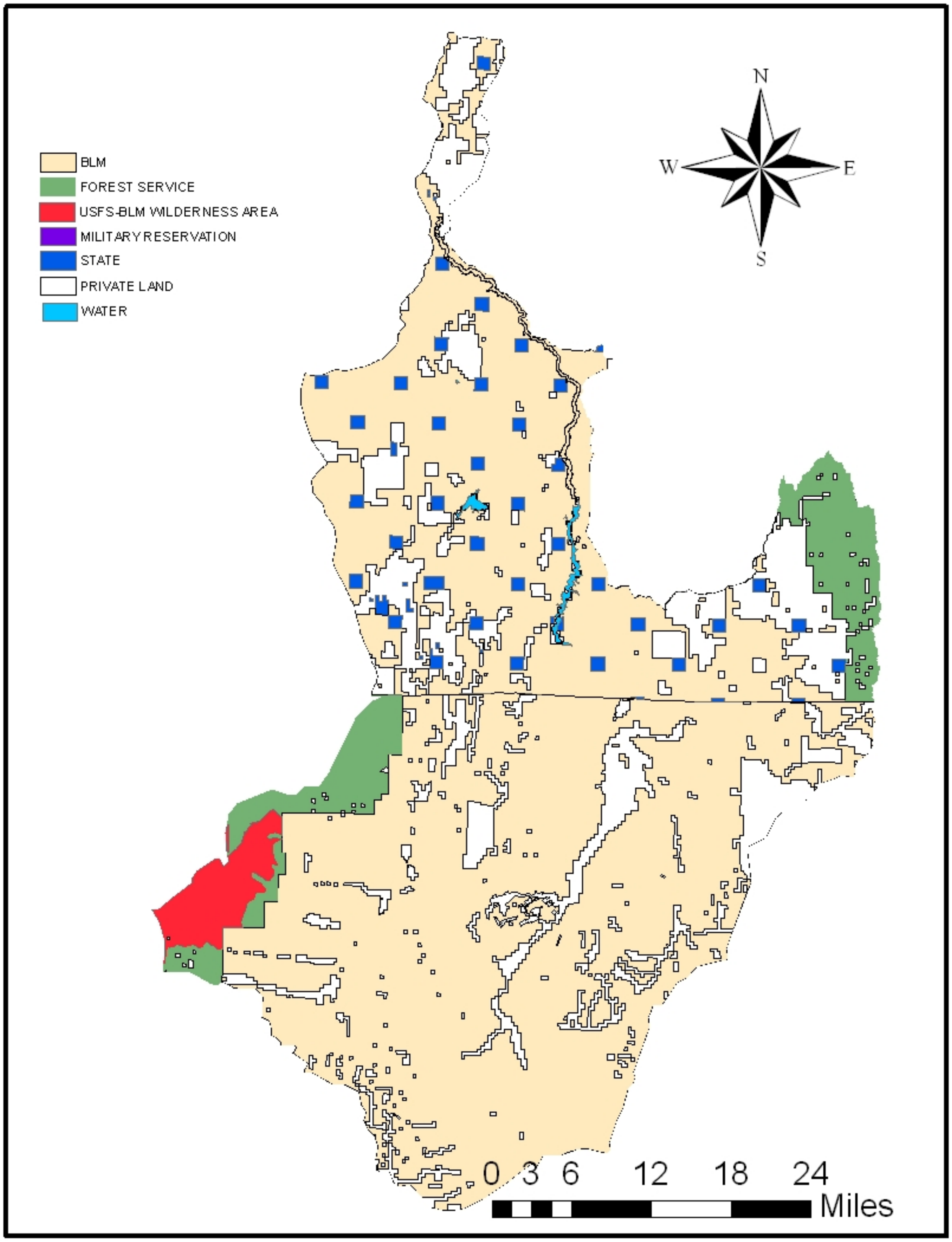


Figure 16. Land Ownership of the Salmon Falls Creek Subbasin.

Table 14. County area of the subbasin.

County	Area, Miles^2	Percent of Total Area
Elko County Nevada	1,232	58.57
Twin Falls County Idaho	802	38.14
Owyhee County Idaho	69	3.29
Total	2,103	100.00

Table 15. Land ownership in the Salmon Falls Creek Subbasin.

Land Owner	area (acres)	Area (Miles^2)	Percent
BLM Nevada	603,925	953	45.32
BLM Idaho	348,549	550	26.16
USFS Idaho	44,239	70	3.32
USFS Nevada	44,275	67	3.17
Wilderness USFS Nevada	29,788	47	2.24
Private Idaho	130,252	206	9.77
Private Nevada	104,555	165	7.85
State Land Idaho	25,271	40	1.90
State Land Nevada	27	0.04	0.00
Reservoirs	3,645	5.9	0.27
Military	8	0.01	0.00
Total	1,334,534	2103	100.00

The 2005 population estimate for Twin Falls County was 69,419 (www.idoc.state.id.us 2006) and it was 64,349 in 2000. The majority of the county population lives outside of the subbasin. For example, the population of several of the cities near the subbasin (Twin Falls, Buhl, and Filer) was 44,413 in 2005. Most of the towns in the subbasin and their populations have been listed previously within the SBA. The underlying foundation for economic activity in the area is agriculture, which consists of ranching and farming.

Recreation is an important water-related industry of the Salmon Falls Creek Reservoir and Cedar Creek Reservoir, although water delivery for irrigation is the principle use for these reservoirs' waters. These impoundments provide for recreational experiences throughout the year, most notably fishing for trout and walleye. In addition to fishing, personal watercraft use and water skiing occur on a limited basis on both water bodies.

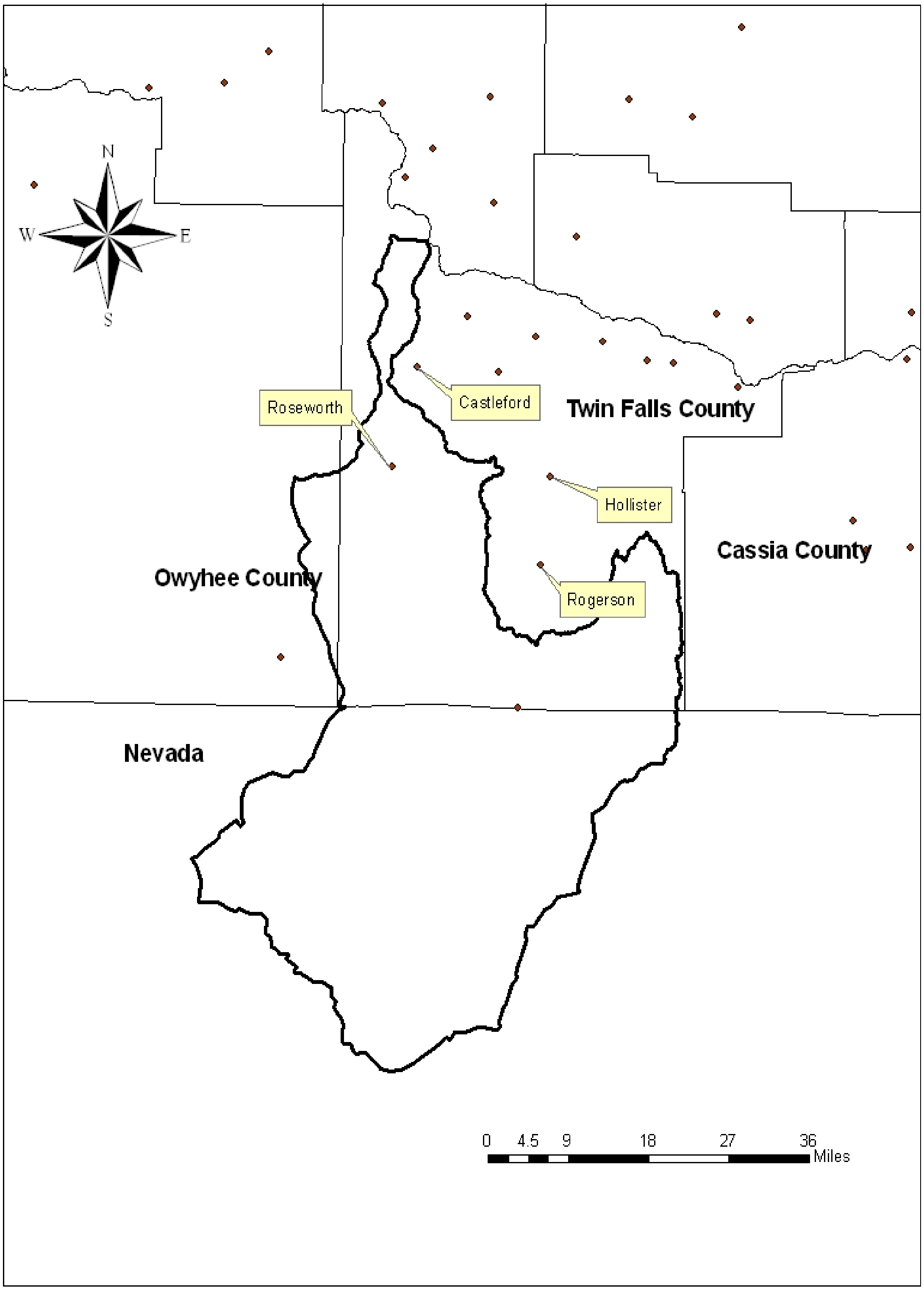


Figure 17. State and county boundaries and the location of several small towns and communities within the Salmon Falls Creek Subbasin.

History and Economics

The principal economic activity within the Salmon Falls Creek Subbasin is agriculture. In the lower portion of the subbasin, below Salmon Falls Creek Reservoir, row crop agriculture dominates. Potatoes, sugar beets, corn, and hay are the primary crops. A potato processing plant is located in the nearby Twin Falls area, as is a sugar processing plant, and, there are numerous dairies located within the area that require a steady stream of feed. Consequently, the farmers find a ready market for their products. In recent years, more large industrial dairies and cheese plants have begun to locate in the south-central Idaho region increasing the demand for hay and corn.

In the upper portion of the subbasin, cattle and sheep ranching are the dominant economic activities. However, recreation plays a significant role as well. Hunting and fishing opportunities bring many people into the subbasin throughout the year.

In some areas of the subbasin, hydrologic modifications to the tributaries and mainstem rivers have been extensive. Salmon Falls Creek Reservoir was started in 1906 and virtually dewatered Salmon Falls Creek below the dam once the dam was completed. However, many springs and seepage through the fractured basalts restore much of the river to a perennial water body as the stream proceeds to the confluence with the Snake River. Similar dewatering of the Cedar Creek system occurs below the dam as well. Specifically, most of Cedar Creek is dry below the Cedar Mesa Canal siphon throughout the year. Cedar Creek Reservoir was initiated in December of 1907 with land sales and construction to begin later that year (Twinfallspubliclibrary.org 2006).

Many other streams are also diverted for agricultural purposes and are dry for significant portions of the year. Furthermore, most of the water bodies have control structures or pumps fully capable of removing all the water from the stream. However, most of these structures and pumps are the result of water rights that predate the CWA and will be considered as part of the subbasin characteristics in any water quality plan (see IDAPA 58.01.02.050.01).

2. Subbasin Assessment – Water Quality Concerns and Status

This section describes the water quality concerns and status of the 303(d)-listed water bodies in the Salmon Falls Creek Subbasin (Figure 18). Included in the discussion are the following:

- A description of the 303(d)-listed Assessment Units and the justification for their 303(d) listing.
- An overview of the water quality data used in the subbasin assessment to analyze and compare the different listed water bodies. The data presented illustrate which water bodies within each 303(d)-listed Assessment Unit are truly impaired and require a TMDL to improve water quality, and which water bodies are not in need of a TMDL because beneficial uses are being met.
- Various characteristics of the 303(d) water bodies.
- Recommendations for each 303(d)-listed Assessment Unit.

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

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. The 1998 §303(d) list for the state of Idaho (DEQ 2001a) included nine segments occurring within the region designated as the Salmon Falls Creek Subbasin (Table 16 and Figures 3 and 4). Other segments will be addressed in this document due to current and past monitoring efforts identifying water quality problems, and additions to the §303(d) list made as a result of the 2002 integrated report. These water bodies will not be added to the next §303(d) list if TMDLs are needed due to the TMDLs being completed through this Subbasin assessment and TMDL effort. These segments are therefore included in the SBA-TMDL process and will be described below and in Table 16 as if they were part of a §303(d) list.

About Assessment Units

AUs now define all the waters of the state of Idaho (see Figure 4). These units and the methodology used to describe them can be found in the WBAG II (Grafe et al 2002). Assessment units (AUs) are groups of similar streams 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 can change significantly, the AU remains the same.

Using assessment units 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 he fundamental requirement of EPA’s 305(b) report, a component of the Clean Water Act wherein states report on the condition of all the waters of the state. Because AUs are a subset of water body identification numbers, there is now a direct tie to the water quality standards for each AU, so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

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

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

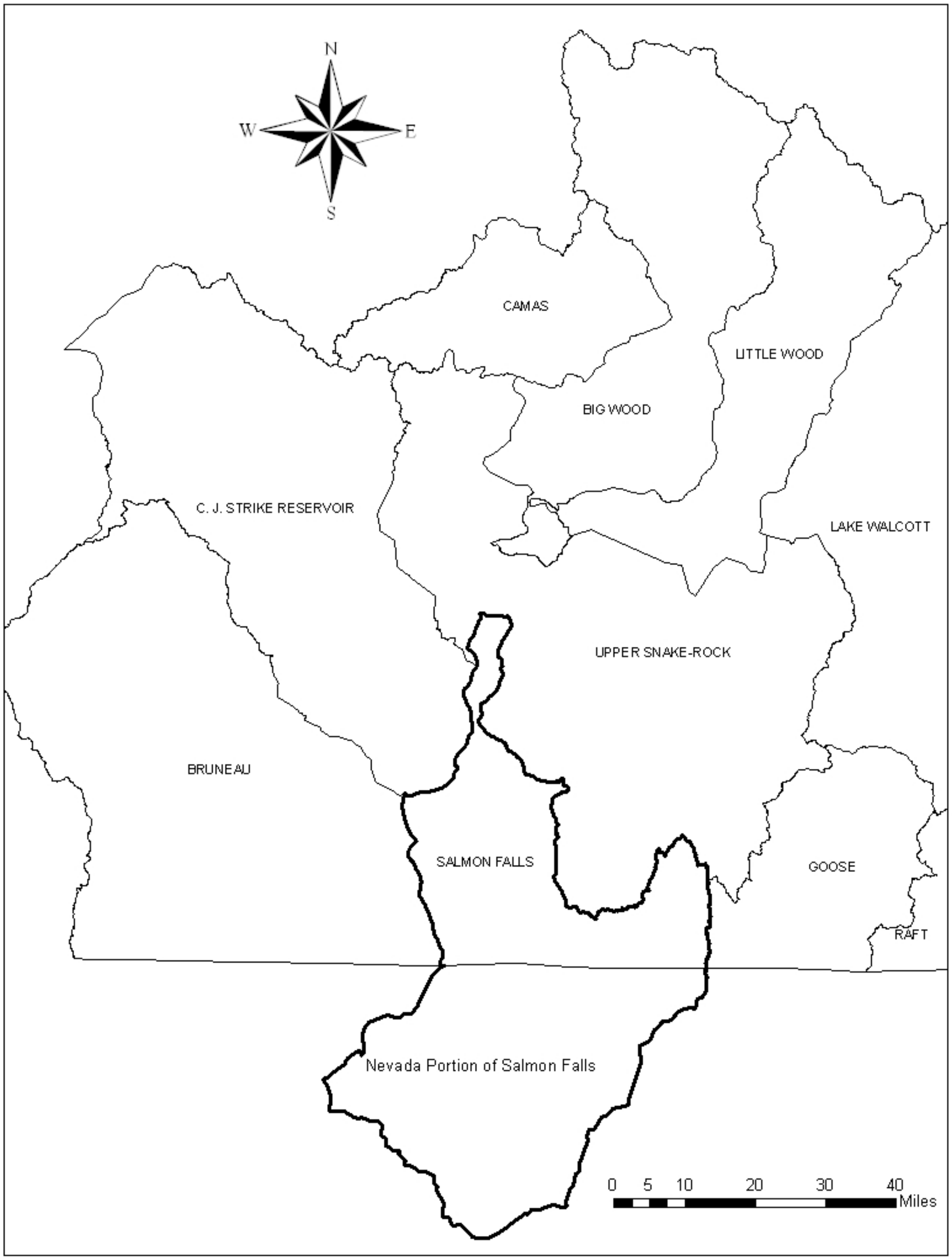


Figure 18. Salmon Falls Creek and Surrounding Subbasins.

Listed Waters

Table 16. 2002 §303(d) Assessment Units and Water Quality Segment Boundaries in the Salmon Falls Creek Subbasin.

WATER BODY NAME	1998 §303(D)[1] BOUNDARIES	ASSESSMENT UNIT	ASSESSMENT UNIT DESCRIPTION
Cedar Creek	Cedar Creek Reservoir to Snake River	ID17040213SK000_04	4th Order segment of Cedar Creek and Other Unclassified Waters in Subbasin
Cedar Creek Reservoir		ID17040213SK004_0L	Cedar Creek Reservoir
Cottonwood Creek	Headwaters to Shoshone Creek	ID17040213SK015_02 ID17040213SK015_03	1st and 2nd Order Tributaries of Cottonwood Creek, and the 3rd Order segment of Cottonwood Creek
Shoshone Creek	Headwaters to Shoshone Creek	ID17040213SK016_02	1st and second order tributaries to Shoshone Creek.
Hot Creek	Headwaters to Salmon Falls Creek	ID17040213SK012_02 ID17040213SK012_03 ID17040213SK012_03A	1st and 2nd order tributaries to Hot Creek. 3rd Order segment of Hot Creek
Salmon Falls Creek	State line to Lower Salmon Falls Creek Reservoir	ID17040213SK009_06	6th Order segment of Salmon Falls Creek From Nevada border to reservoir
Salmon Falls Creek	Bluegill Lake to Snake River	ID17040213SK001_06	6th Order segment of Salmon Falls Creek from Devil Creek to Snake River
Shoshone Creek	Cottonwood Creek to Big Creek	ID17040213SK013_04	4th Order segment of Shoshone Creek
Shoshone Creek	Magic Hot Springs to Nevada	ID17040213SK011_04	4th Order segment of Shoshone Creek
Salmon Falls Creek Reservoir	Not Listed in 1998	ID17040213SK007_L	Salmon Falls Creek Reservoir
Big Creek	Not Listed in 1998	ID17040213SK014_02	1st and 2nd Order Tributary streams of Big Creek
Big Creek	Not Listed in 1998	ID17040213SK014_03	3rd Order segment of Big Creek

WATER BODY NAME	1998 §303(D)[1] BOUNDARIES	ASSESSMENT UNIT	ASSESSMENT UNIT DESCRIPTION
China Creek	Not Listed in 1998	ID17040213SK008_03	3rd Order segment of China Creek
China Creek, Browns Creek	Not Listed in 1998	ID17040213SK008_02	1st and 2nd Order tributaries of China Creek Complex
House Creek	Not Listed in 1998	ID17040213SK005_02	1st and 2nd Order tributaries of House Creek

Figure 4 (and Figure 18) depicts the location of the Salmon Falls Creek Subbasin in relation to other surrounding subbasins and water quality limited water bodies within the Salmon Falls Creek Subbasin. The Assessment Unit descriptions for each water body are located in the above table.

Table 17 shows the pollutants listed for each §303(d) listed AU in the subbasin on the 2002 integrated report. Not all of the water body/pollutant combinations will require a TMDL, as will be discussed later. However, a thorough investigation, using the available data, was performed before this conclusion was made. This investigation, along with a presentation of the evidence of non-compliance with standards for several other tributaries, is contained in the following sections. As a result, TMDLs will be proposed for water body/pollutant combinations for additional AUs and previously unlisted pollutants as well as for many water body/pollutant combinations found on the current §303(d) list

Table 17. 2002 §303(d) Segments in the Salmon Falls Creek Subbasin.

WATER BODY NAME	ASSESSMENT UNIT ID NUMBER	POLLUTANTS
Cedar Creek	ID17040213SK000_04	BAC, NUT, DO, SED
Cedar Creek Reservoir	ID17040213SK004_0L	
Cottonwood Creek	ID17040213SK015_02 ID17040213SK015_03	NUT, DO, SED
Hot Creek	ID17040213SK012_02 ID17040213SK012_03 ID17040213SK012_03A	SED, TEMP, UNK
Salmon Falls Creek	ID17040213SK009_06	NUT, TEMP
Salmon Falls Creek	ID17040213SK001_06	BAC, NUT, DO, SED
Shoshone Creek	ID17040213SK013_04	SED, TEMP

WATER BODY NAME	ASSESSMENT UNIT ID NUMBER	POLLUTANTS
Shoshone Creek	ID17040213SK011_04	SED, TEMP
Big Creek	ID17040213SK014_02	UNK, TEMP
Big Creek	ID17040213SK014_03	UNK
China Creek	ID17040213SK008_03	SED
Shoshone Creek	ID17040213SK016_02	BAC
Shoshone Creek	ID17040213SK016_03	UNK

BAC = bacteria, DO = dissolved oxygen, Nut = nutrients, SED = sediment, TEMP = temperature, and UNK = unknown.

2.2 Applicable Water Quality Standards

Under the state water quality standards, Idaho is divided into six separate hydrologic basins. Within each basin, the major rivers, lakes/reservoirs, and creeks are identified (designated) for specific beneficial uses. Most tributary waters, however, are not yet designated. These undesignated tributary waters are protected for beneficial uses, which include all recreational uses in and on the water and for the protection and propagation of fish, shellfish, and wildlife wherever attainable (IDAPA 58.01.02.101.01.a). Industrial water supplies, wildlife habitats, and aesthetics are minimum designated standards for all waters of the state.

Other water quality standards that apply to the Salmon Falls Creek Subbasin are included in IDAPA 58.01.02.051.01-02, which is the state's antidegradation policy. It reads:

> Maintenance of Existing Uses for All Waters. The existing in-stream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
>
> High Quality Waters. Where the quality of the waters exceeds levels necessary to support propagation of fish, shellfish and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the Department finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the Department's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the Department shall assure water quality adequate to protect existing uses fully.

IDAPA 58.01.02.50.01 states:

> Apportionment of water. The adoption of water quality standards and the enforcement of such standards is not intended to conflict with the

> apportionment of water to the state through any of the interstate compacts or court decrees, or to interfere with the rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations which have been granted to them under the statutory procedure…

IDAPA 58.01.02.50.02.a states:

> Wherever attainable, surface waters of the state shall be protected for beneficial uses which for surface waters includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic life;

IDAPA 58.01.02.50.02.b states:

> In all cases, existing beneficial uses of the waters of the state will be protected.

Table 18 summarizes Idaho's beneficial uses and criteria for its water bodies as defined in IDAPA 58.01.02.100.

Table 18. Beneficial Uses and Applicable Criteria.

BENEFICIAL USES	APPLICABLE CRITERIA
Agricultural Water Supply	Water quality appropriate for the irrigation of crops or as drinking water for livestock. This use applies to all surface waters of the state (IDAPA 58.01.02.100.03.b). Numeric criteria as needed are derived from the EPAs Water quality criteria 1972 (EPA 1973). (IDAPA 58.01.02.252.02).
Domestic Water Supply	Water quality appropriate for drinking water supplies (IDAPA 58.01.02.100.03.a). Numeric criteria for specific constituents and turbidity (IDAPA 58.01.02.252.01.a-b).
Industrial Water Supply	Water quality appropriate for industrial water supplies. This use applies to all waters of the state (IDAPA 58.01.02.100.03.c). Numeric criteria are categorized as general surface water quality criteria (IDAPA 58.01.02.252.03).
Cold Water Aquatic Life	Water quality appropriate for the protection and maintenance of viable aquatic life community for cold water species (IDAPA 58.01.02.100.01.a). Numeric criteria are established for pH, dissolved oxygen, gas saturation, residual chlorine, water temperature, ammonia, turbidity, and toxics (IDAPA 58.01.02.250.02.a-g).

BENEFICIAL USES	APPLICABLE CRITERIA
Seasonal Cold Water Aquatic Life	Water quality appropriate for the protection and maintenance of viable aquatic life community of cool and cold water species (IDAPA 58.01.02.100.01.c). Numeric criteria are established for pH, dissolved oxygen, gas saturation, residual chlorine, water temperature, ammonia, turbidity, and toxics (IDAPA 58.01.02.250.03.a-c).
Warm Water Aquatic Life	Water quality appropriate for the protection and maintenance of viable aquatic life community for warm water species (IDAPA 58.01.02.100.01.d). Numeric criteria are established for pH, dissolved oxygen, gas saturation, residual chlorine, water temperature, ammonia, and toxics (IDAPA 58.01.02.250.04.a-c).
Modified Aquatic Life	Water quality appropriate for an aquatic life community that is limited due to one (1) or more conditions set forth in 40 CFR 131.10(g) which preclude the attainment of reference streams or conditions (IDAPA 58.01.02.100.01.e). Numeric criteria for pH, dissolved oxygen, gas saturation, residual chlorine, water temperature, ammonia, and toxics will be considered on a case by case basis (IDAPA 58.01.02.250.05).
Salmonid Spawning	Waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes (IDAPA 58.01.02.100.01.b). Numeric criteria are established for pH, gas saturation, residual chlorine, dissolved oxygen, intergravel dissolved oxygen, water temperature, ammonia, and toxics (IDAPA 58.01.02.250.02.e).
Primary Contact Recreation	Water quality appropriate for prolonged and intimate contact by humans or for recreational activities when the ingestion of small quantities of water is likely to occur. Such waters include, but are not restricted to; those used for swimming, water skiing, or skin diving. (IDAPA 58.01.02.100.02.a). Numeric criteria are established for Escherichia coli bacteria (IDAPA 58.01.02.251.01.a-b).
Secondary Contact Recreation	Water quality appropriate for recreational uses on or about the water which are 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 (IDAPA 58.01.02.100.02.b). Numeric criteria are established for Escherichia coli bacteria (IDAPA 58.01.02.251.02.a-b).
Wildlife Habitats	Water quality appropriate for wildlife habitats. This

BENEFICIAL USES	APPLICABLE CRITERIA
	use applies to all surface waters of the state (IDAPA 58.01.02.100.04). Numeric criteria are categorized as general surface water quality criteria (IDAPA 58.01.02.253.01).
Aesthetics	This use applies to all surface waters of the state (IDAPA 58.01.02.100.05). Numeric criteria are categorized as general surface water quality criteria (IDAPA 58.01.02.253.02).
Special Resource Water	Those specific segments or water bodies that are recognized as needing intensive protection to preserve outstanding or unique characteristics. Designation as a special resource water recognizes at least one of the following characteristics: (1) the water is of outstanding high quality, exceeding both criteria for primary contact recreation and cold water aquatic life; (2) the water is of unique ecological significance; (3) the water possesses outstanding recreational or aesthetic qualities; (4) intensive protection of the quality of the water is in paramount interest of the people of Idaho; (5) the water is part of the National Wild and Scenic River System, or is within a state or National Park or wildlife refuge and is of prime or major importance to that park or refuge; (6) intensive protection of the quality of the water is necessary to maintain an existing but jeopardized beneficial use (IDAPA 58.01.02.056). Special resource waters receive additional point source discharge restrictions (IDAPA 58.01.02.054.03 and 400.01.b).
	NOTE: All waters are protected through general surface water quality criteria. Narrative criteria prohibit ambient concentrations of certain pollutants that impair designated uses. Narrative criteria established in Idaho water quality standards include hazardous materials; toxic substances; deleterious materials; radioactive materials; floating, suspended, or submerged matter; excess nutrients; oxygen demanding materials; and sediment (See IDAPA 58.01.02.200.01-08).

Beneficial Uses

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described in the following paragraphs. The Water Body Assessment Guidance, second edition (Grafe et al. 2002) gives a more detailed description of beneficial use identification for use assessment purposes. The beneficial uses of Salmon Falls Creek Subbasin are identified in Table 19.

Existing Uses

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

Designated Uses

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

Presumed Uses

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

Table 19. Salmon Falls Creek Subbasin beneficial uses of 2002 §303(d) listed streams.

WATER BODY	ASSESSMENT UNIT	USES[A]	TYPE OF USE
Cedar Creek	ID17040213SK000_04	CW, SCR, AWS	Existing/Presumed
Cedar Creek Reservoir	ID17040213SK004_0L	CW, PCR, AWS	Existing/Presumed
Cottonwood Creek	ID17040213SK015_02 ID17040213SK015_03	CW, SCR, AWS	Existing/Presumed
Hot Creek	ID17040213SK012_02 ID17040213SK012_03 ID17040213SK012_03A	CW, SCR, AWS	Existing/Presumed
Salmon Falls Creek	ID17040213SK009_06	CW, SS, PCR, AWS	Designated
Salmon Falls Creek	ID17040213SK001_06	CW, SS, PCR, AWS	Designated
Shoshone Creek	ID17040213SK013_04	CW, SCR, AWS	Existing/Presumed
Shoshone Creek	ID17040213SK011_04	CW, SCR, AWS	Existing/Presumed
Salmon Falls Creek Reservoir	ID17040213SK007_06	CW, SS, PCR, AWS	Designated
Big Creek	ID17040213SK014_02	CW, SCR, AWS	Existing/Presumed
Big Creek	ID17040213SK014_03	CW, SCR, AWS	Existing/Presumed
China Creek	ID17040213SK008_03	CW, SCR, AWS	Existing/Presumed
China Creek, Browns Creek	ID17040213SK008_02	CW, SCR, AWS	Existing/Presumed

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

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 20).

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 Water Body Assessment Guidance (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

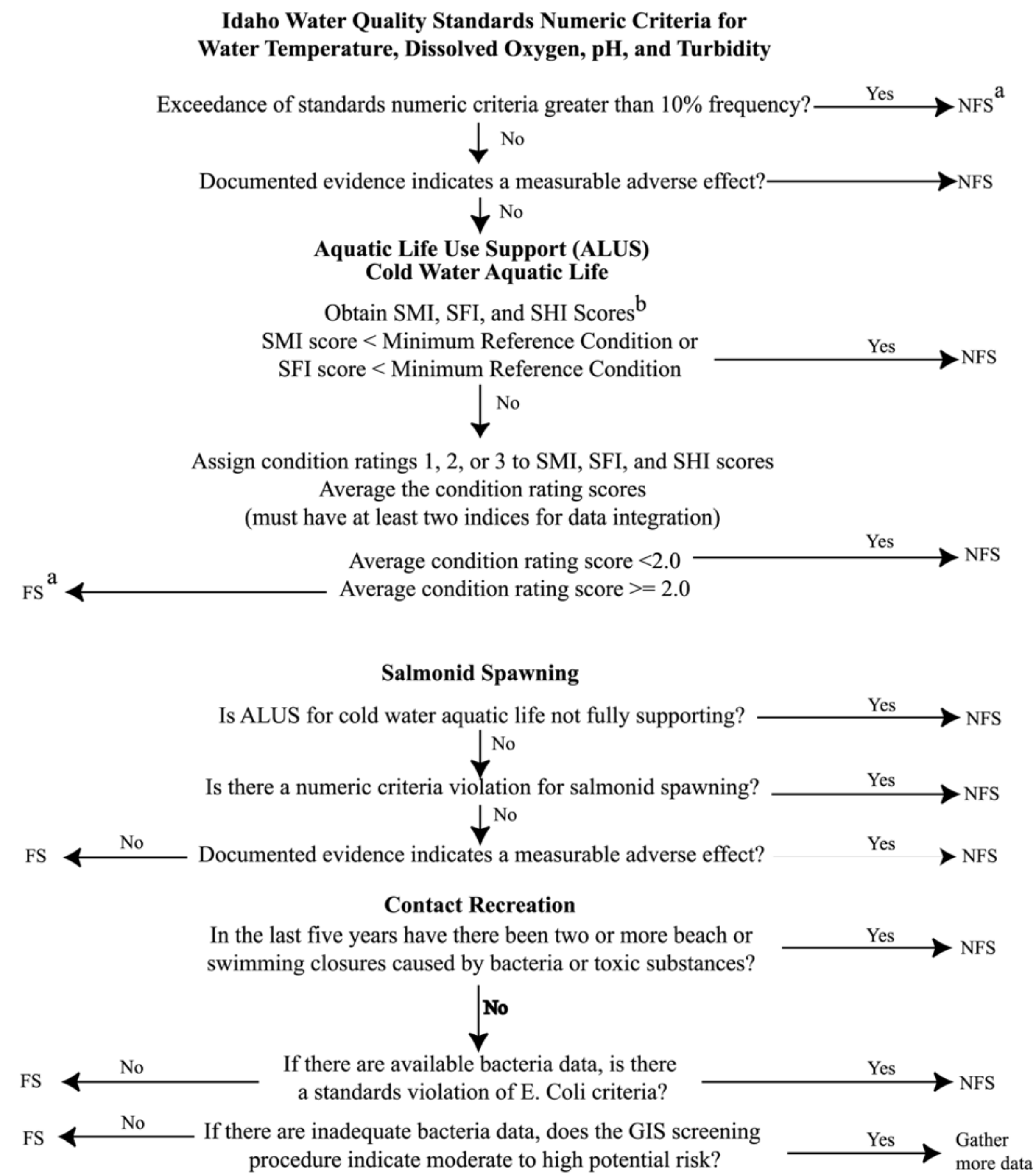
Table 20 includes the most common numeric criteria used in TMDLs.

Figure 19 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 20. 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
Temperature[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
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.	
Mercury			0.3 mg/kg wet weight methylmercury	

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



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

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

Figure 19. Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: *Water Body Assessment Guidance*, Second Addition (Grafe *et al*. 2002)

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses 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 anthropogenic sources cause these to reach unnatural levels, they are considered “pollutants” and can impair the beneficial uses of a stream.

Violations of the following narrative and/or numeric water quality standards, DEQ recommendations, and EPA guidelines have been documented through monitoring events in 2005, 2006, and in data from past studies. Not all listed water bodies have had documented water quality violations. Lists of those water bodies in which violations have been documented follow the criteria that were violated.

Temperature

Temperature is a water quality factor integral to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or coldwater aquatic community is present. Many factors, natural and anthropogenic, affect stream temperatures. Natural factors include altitude, aspect, climate, weather, riparian vegetation (shade), and channel morphology (width and depth). Human influenced factors include heated discharges (such as those from point sources), riparian zone 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 once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. As flows decrease, the amount of aeration typically decreases and the 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 depressed levels of DO in comparison to levels before the alteration. Nutrient enriched waters have a higher biochemical oxygen demand (BOD) due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand results in lower instream DO levels.

Dissolved oxygen is a typical concern in systems with excess nutrients or other sources of organic enrichment. IDAPA 58.01.02.200.07 states that surface waters of the state shall be free from oxygen-demanding materials in concentrations that would result in an anaerobic water condition. Additionally, numeric water quality standards set the lowest level of DO concentrations at not less than 6 mg/L for cold water aquatic life, seasonal cold water aquatic life, and salmonid spawning. The DO level has been set at not less than 5 mg/L for warm water aquatic life. During daylight conditions, these standards are rarely exceeded due to the respiration of aquatic plants, unless large amounts of oxygen demanding materials are present. However, during nighttime periods, systems with large quantities of aquatic plants will exceed the aquatic life standards and in some cases may become anaerobic. As a result, diel studies of the DO concentrations are required. Low DO directly affects the beneficial uses by stressing the organisms and increasing their chances of mortality. In cases of long periods of anaerobic conditions catastrophic fish kills are common. In the macroinvertebrate community the assemblages are more dominated by diptera and other tolerant taxa.

Fish kills have not been noted on any of the listed streams in the subbasin. Additionally, macroinvertebrate analysis indicated that the communities contain taxa intolerant to organic enrichment and the resulting low DO. All streams in the subbasin are listed for DO problems. Daytime DO levels fell below 7 mg/L in one of the creeks. China Creek experienced low DO levels days prior to the creek drying up. This was not unexpected. Discharge at this time was very near zero. Diel DO measurements are not available at this time for any of the creeks.

Sediment

Both suspended (floating in the water column) and bedload (moves 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 (SSC) 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.

Sediment is one of the most common listed pollutants in the state and in the Salmon Falls Creek Subbasin. It is a pollutant on all water bodies in this subbasin listed in 1998. Sediment impacts the aquatic life beneficial uses by smothering fish spawning and rearing grounds, leading to a homogenization of available habitats. Additionally, it reduces the available habitat for the food organisms of the fish, as well as smothering the food organisms themselves (IDHW 1991). In addition, increased sedimentation leads to a loss of juvenile rearing and over-wintering habitat. As water temperatures decline in the winter, juvenile salmonids seek interstitial spaces in the substrate where they become torpid. When sediment fills the interstitial spaces, it leaves the juvenile fish with no cover during this period of inactivity and makes them more vulnerable to predation. Furthermore, the most common nonpoint pollutant in the state of Idaho is sediment (IDHW 1989), and the dominant portion of sediment loads in southern Idaho is suspended sediment (IDHW 1989).

The IDAPA criteria for suspended sediment are narrative. Therefore, other sources were reviewed to determine appropriate limits and targets for suspended sediment. Suggested limits for suspended sediment have been developed by the European Inland Fisheries Advisory Commission and the National Academy of Sciences and adopted by the state of Idaho in previous TMDLs. A limit of 25 mg/L total suspended sediment (TSS) would provide a high level of protection of the aquatic organisms, 80 mg/L TSS moderate protection, 400 mg/L TSS low protection, and over 400 mg/L TSS very low protection (USFS 1990, Thurston et al. 1979). DEQ program managers have proposed a target of suspended solids not to exceed a monthly average of 50 mg/L TSS with a daily maximum of 80 mg/L TSS to allow for natural variability due to storm and seasonal runoff events. All systems within the subbasin will be assessed using the 50 mg/L TSS monthly average and 80 mg/L TSS daily maximum guidelines.

Bedload sediment also impairs the beneficial uses of some streams in the subbasin. In order to restore the beneficial uses, reduction in both the suspended and bedload sediments needs to occur. However, guidelines or recommendations for other components of sediment are lacking. In other cases the ability to correctly monitor bedload or washload is limited by the short time lines under which the Salmon Falls Creek SBA-TMDL must be completed. To over come these shortcomings the DEQ Twin Falls Regional Office (TFRO) has adopted a method to address sediment. The first of these is by using other streams in the subbasin to set the guidelines and recommendations for sediment targets. Streams in which the beneficial uses are supported will be surveyed to determine appropriate sediment targets and establish criteria to compare the §303(d) listed water bodies. The rational is that if the beneficial uses in the other stream are fully supported, then the sediment impaired streams should have goals to meet a similar percent surface fines, and bank stability, as well as the TSS guidelines. This approach will be used to set targets and determine appropriate reductions for any TMDL developed in the Salmon Falls Creek Subbasin.

In the DEQ data set Salmon Falls Creek, Shoshone Creek, Cottonwood Creek, Big Creek, House Creek, and Left Hand Fork House Creek exceeded the daily maximum TSS guideline (80 mg/L). These exceedances typically occurred in spring sampling events. However, the exceedances in both House Creeks were late summer events. Monthly average exceedances (TSS guideline of 50 mg/L) were less frequent. Salmon Falls Creek had elevated sediment in April and May 2002, Shoshone Creek May 2001 and April, May, and June 2002. The House Creeks also had exceedances of the average TSS guideline. These occurred in September for House Creek (1,649 mg/L average) and July and August for Left Hand Fork House Creek. The Cottonwood Creek site did not exceed the monthly average guideline and the two instantaneous events were anomalous with the other sampling events and parameters studied on the creek.

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.

IDAPA 58.01.02.251.01 states that waters designated for primary contact recreation are not to contain Escherichia coli (E. coli) bacteria significant to the public health in concentrations exceeding:

A single sample of 406 organisms per 100 ml; or
A geometric mean of 126 organisms per 100 ml based on a minimum of five samples taken every three to five days over a 30-day period.

For waters designated for secondary contact recreation according to IDAPA 58.01.02.251.02, the criteria state that waters are not to contain *E. coli* bacteria significant to the public health in concentrations exceeding:

A single sample of 576 organisms per 100 ml; or
A geometric mean of 126 organisms per 100 ml based on a minimum of five samples taken every three to five days over a 30-day period.

The state has interpreted these standards to mean that the instantaneous standard is used to determine if further monitoring is required. If at such time the geometric mean standard is exceeded then a water quality violation has occurred.

Although only Salmon Falls, Birch, and Shoshone Creeks were originally listed for bacteria, DEQ collected bacteria samples on all the listed water bodies in the subbasin. North Fork Salmon Falls Creek has not exceeded the bacteria standards for either primary or secondary recreation. Left Hand Fork House Creek and House Creek consistently exceeds the geometric mean standard for both primary and secondary contact recreation. Other creeks in the subbasin exceeded the instantaneous standard for both primary and secondary contact recreation beneficial uses occasionally, yet don’t exceed the geometric mean standard. Therefore these streams do not exceed the water quality standards. Follow up monitoring was typically conducted twice each month if no exceedance was noted.

Nutrients

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

The first step in identifying a water body’s response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass. Either phosphorus or nitrogen may be the limiting factor for algal growth, although 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, typically greater than 90% of the TP present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than TP that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the TP fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

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

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

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in 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.

Salmon Falls Creek and China Creek will be assessed with a 0.05 mg/L TP monthly average the 0.08 mg/L TP daily maximum guideline, 15 μg/L chlorophyll a sestonic indicator, as they discharge directly into a reservoir. The remaining systems will be assessed using the 0.1 mg/L TP monthly average and 0.16 mg/L TP daily maximum guidelines and the 15 μg/L chlorophyll a sestonic indicator as they are free flowing rivers or streams. Lower Salmon Falls Creek Reservoir and Cedar Creek (Roseworth) Reservoir will be assessed using the 0.025 mg/L TP monthly average and 0.04 mg/L TP daily maximum guidelines and the 15 μg/L suspended chlorophyll a indicator.

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 sediments release 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 nitrogen oxides (NOx) 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 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.

IDAPA 58.01.02.200.06 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." Nutrients in excess quantities often cause rapid eutrophication of aquatic systems. The primary production in an aquatic system is often limited by the available concentrations of one of these micronutrients at a time (Brorchardt 1996). In the western United States, phosphorus is typically the nutrient that most limits production of aquatic plants and algae. Nitrogen (N) to phosphorus (P) ratios are often used to determine the limiting factor in aquatic vegetation production and biomass. If all nutrients are in excess quantities; however, the ratios are of little use (Schanz and Juon 1983). Other factors, such as light or available substrates, then may limit production of aquatic macrophytes.

In order to determine if nutrients are in excess, benthic and sestonic chlorophyll *a* samples were analyzed for streams and rivers and water column chlorophyll *a* samples were analyzed for reservoirs. The algae that grows on the stream and river substrates is called periphytic or benthic algae. It typically consists of single celled organisms called diatoms. These diatoms are the primary food source for many pollution intolerant aquatic macroinvertebrates that scrape the diatoms from the substrate. Sestonic forms of algae are free floating algae cells. They may be dislodged diatoms or other types. If nutrients are in excess of the physiological needs of the diatom community, other less palatable forms of algae grow causing a reduction in the intolerant aquatic community. These less palatable forms include filamentous and colonial algae. In addition to being less palatable, these organisms are considered by some to be aesthetically unpleasing and are what typify nuisance aquatic growths.

Because the state does not have a numeric criteria for suspended or benthic chlorophyll *a*, a guideline was developed after referencing the scientific community, other states' targets, and EPA guidelines. It has been suggested by several authors that the threshold nuisance levels of benthic algae is 100 to 200 mg/m^2 for free flowing rivers and streams - Horner et al. 1983, Welch et al. 1988, Welch et al. 1989, Watson and Gestring 1996). At levels above 100 to 200 milligrams per square meters (mg/m^2), aesthetics are impaired. DEQ assumes that at these same levels aquatic life communities are also affected. It is assumed that the presence of filamentous and colonial algal forms at these levels will reduce the abundance of pollution tolerant macroinvertebrates and other forms of aquatic life thereby impairing the beneficial uses of the stream or river.

Appropriate indicators for lakes and reservoirs have been developed by a number of states. Oregon has determined that 15 micrograms per liter ((g/L) of chlorophyll *a* is an appropriate indicator of excess nutrients in lakes that do not thermally stratify (EPA 1999), such as Lower Salmon Falls Creek Reservoir. North Carolina also uses 15 (g/L chlorophyll *a* for cold water systems (EPA 1999). These indicators are linked to the beneficial use impairment either indirectly or directly. For example, indirect beneficial use impairment presents as low dissolved oxygen (DO) and pH at or above these chlorophyll *a* levels. Beneficial use impairment is directly linked to the chlorophyll *a* indicators during nuisance algal blooms. In streams and flowing systems , a large meta-data set was analyzed to determine if trophic boundaries could be determined from benthic and sestonic chlorophyll *a* (Dodds et al. 1998). The suggested boundary between mesotrophic and eutrophic levels was 30 (g/L sestonic chlorophyll *a* (Dodds et al. 1998).

If nutrients were the limiting factor in an aquatic system, a reduction in phosphorus would reduce vegetative growths. This shift and reduction in production and biomass is due to the magnitude of vegetative growths associated with the different micronutrients. When nitrogen is limiting, additions of the nutrient can increase vegetation biomass theoretically by 70 times the molecular weight of the nutrient. In contrast, with phosphorus additions the increase is closer to a 500-fold increase in biomass (Wetzel 1983). Because of this, a reduction in phosphorus can reduce the aquatic vegetation to a greater extent than can reductions in nitrogen.

While no state of Idaho standards exists for the numeric value of excess nutrients (phosphorus in this case), EPA has suggested guidelines to determine when phosphorus is in excess. To prevent the development of a biological nuisance and to control accelerated cultural eutrophication, TP (as P) should not exceed 0.05 milligram per liter (mg/L) in streams that enter a lake or reservoir (EPA 1977, 1986). As a guideline, it has been demonstrated in many TMDLS throughout southern Idaho that when TP (as P) does not exceed 0.1 mg/L in any stream or other flowing waters nuisance aquatic vegetation does not occur. The Salmon Falls Creek Subbasin Assessment and TMDL will use both the chlorophyll *a* indicator guidelines and the TP concentration guidelines developed for southern Idaho to determine if beneficial use impairment has occurred and to set future targets for allocations. Elevated nutrient concentrations will not necessitate a TMDL. However, elevated nutrient concentrations and elevated chlorophyll *a* concentrations or excess biomass will trigger the TMDL development for excess nutrients. The rational for this dual indicator is that elevated nutrient concentrations do not link directly to beneficial use impairment unlike chlorophyll *a*.

Flow Alteration

There are currently no water quality standards, either narrative or numeric, which address flow alteration. Additionally, it is DEQ policy, with concurrence with EPA, that flow and habitat alterations are pollution and therefore not a "TMDLable" pollutant. These forms of pollution will remain on the §303(d) list of the Clean Water Act. Furthermore, the estimation of load capacity and load allocations for flow alteration is not practical. Due to these constraints, a TMDL for flow alteration will not be completed for the segments listed for flow alteration in the Salmon Falls Creek Subbasin.

2.4 Summary and Analysis of Existing Water Quality Data

Water quality data within the Salmon Falls Creek Subbasin are very sparse. Three USGS gauges exist(ed) within the subbasin. These gauges were used to develop hydrographs for the remaining ungauged watersheds. The IDFG has collected some fish information from streams in the subbasin, but these efforts were very limited in most water bodies while in others, such as Salmon Falls Creek Reservoir, they provided extensive information. Additionally, these collections were usually done in conjunction with the BLM or USFS for their management needs.

Some information exists within the EPA's STORET database. Again, this information is very limited or applicable to non-water quality limited streams. For example, Nevada Division of Environmental Protection (NDEP) collected some information on Salmon Falls Creek, which flows into Idaho. The EPA's STORET database was queried for each water quality limited water body within the subbasin, but, for the most part, DEQ TMDL monitoring data and BURP information make up the largest portion of the available data. The subbasin has been further subdivided into 62 sixth field watersheds (Figure 20). These units will be used extensively in allocating nonpoint source loads.

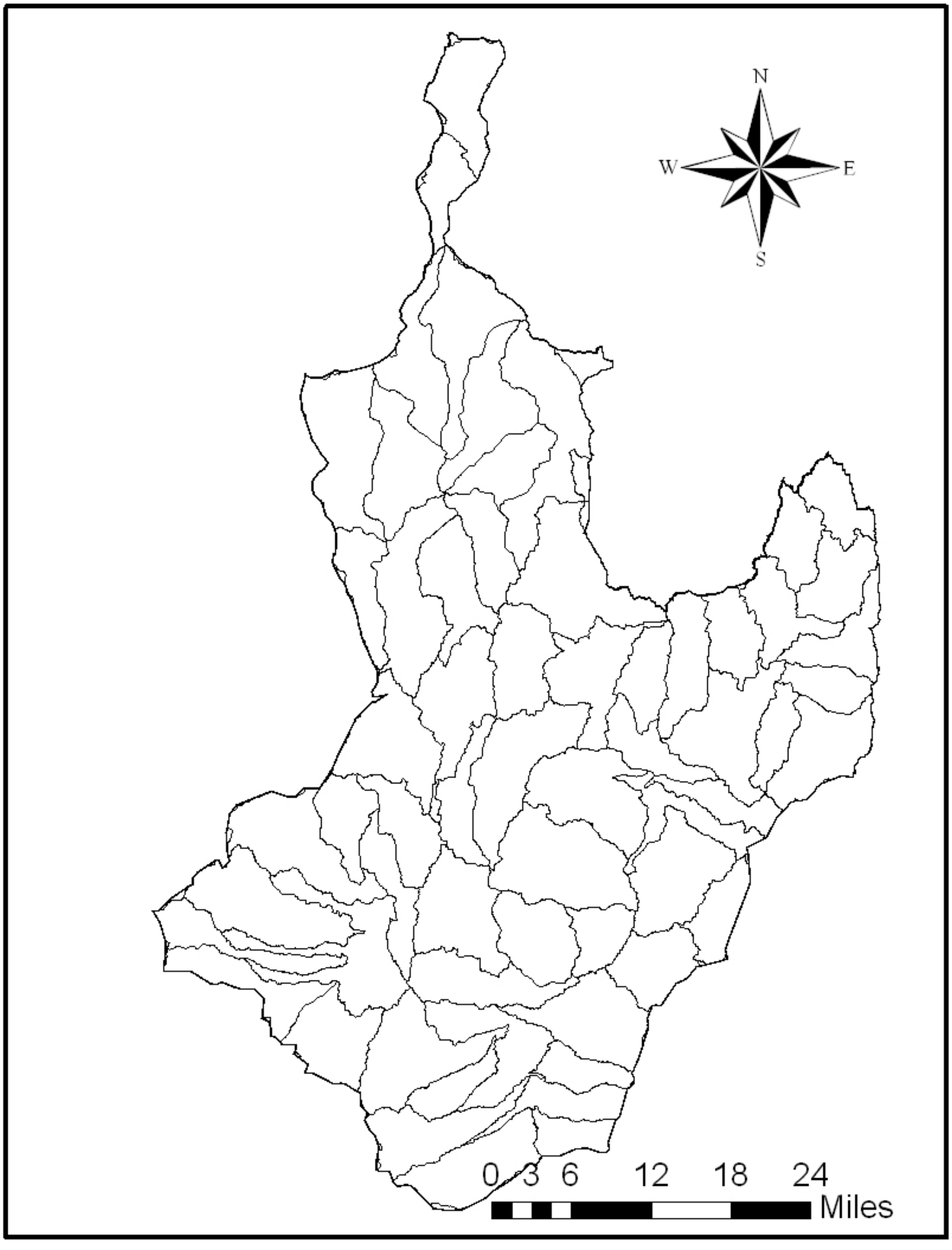


Figure 20. Salmon Falls Sixth Field Watersheds.

Upper Salmon Falls Creek Assessment Unit

Physical Characteristics

The Upper Salmon Falls Creek Assessment Units ID17040213SK009_06 includes the sixth order segment of Salmon Falls Creek that begins at the Idaho/Nevada border and terminates at the confluence of the Salmon Falls Creek Reservoir. The assessment unit contains the perennial stream of Upper Salmon Falls Creek, as well as up to eleven ephemeral channels. However, none of these contribute any meaningful flow to the system on an annual basis.

Salmon Falls Creek receives a large amount of spring runoff discharge from the upper watershed, but for much of the year the stream is relatively small (see Figure 21). The contributing watershed area for the upper reach of Salmon Falls Creek is 1,485 $miles^2$ and includes the Shoshone Basin. Salmon Falls Creek originates in Nevada at the confluence of the North Fork and South Forks of Salmon Falls Creeks; it flows for approximately 47 miles before it enters Idaho. The total length of the stream from the Nevada/Idaho Border to the confluence of Salmon Falls Creek Reservoir is 9.7 miles.

Flow Characteristics

Throughout Upper Salmon Falls Creek's length, it flows through the Northern Basin and Range ecoregion. Along this course, many ephemeral tributaries enter the system and may minimally add flow to the system during rain events. The USGS has operated a gauge located in Nevada just south of Jackpot called the San Jacinto Gauge (#13105000). The period of record for this gauge runs from June 6, 1910 to date. The hydrology of the system will be based upon discharge measurements collected by the USGS. Figure 21 presents the monthly average stream discharge.

Due to the wide range of variability in Salmon Falls Creek flows, knowing the percentage of days in a year when given flows occur is essential to understanding the system. Generally, the percentage of time during which specified flows are equaled or exceeded may be compiled in the form of a flow duration curve, a cumulative frequency curve of daily mean flows without regard to chronology of occurrence (Leopold, 1994). The flow duration curve includes all flows observed at the gauge for the applicable period of record; flow rates are sorted from the highest value to the lowest. For each flow value, the curve displays the corresponding percent of time that flow value is met or exceeded–the flow duration interval (FDI). A FDI can also be referred to as a flow recurrence interval. Extremely high flows are rarely exceeded and have low FDI values; very low flows are often exceeded and have high FDI values.

Figure 22 presents a flow duration curve using data from Salmon Falls Creek near Jackpot, NV. The figure illustrates that the highest observed flow value at this gage for the period of record is 3,620 cubic feet per second (cfs) and the lowest observed flow is 3.2 cfs. The median flow (the 50 percent FDI) is approximately 62 cfs.

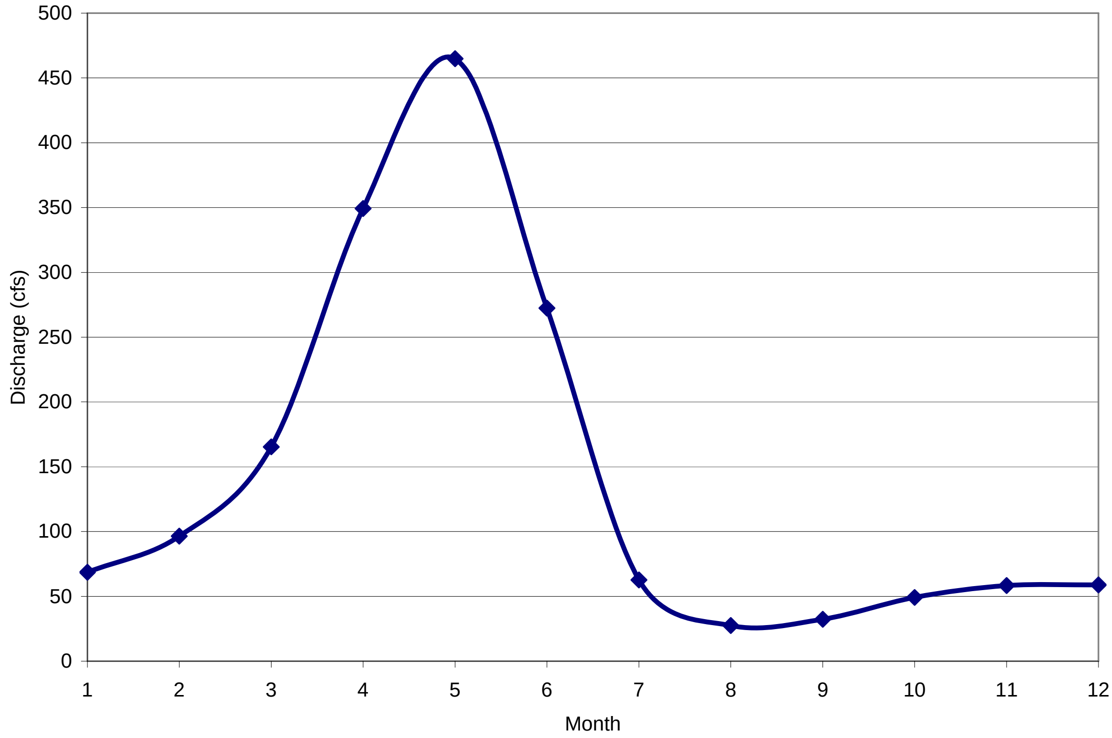


Figure 21. Salmon Falls Creek Monthly Average Discharge Measured at the San Jacinto Gauge in Nevada.

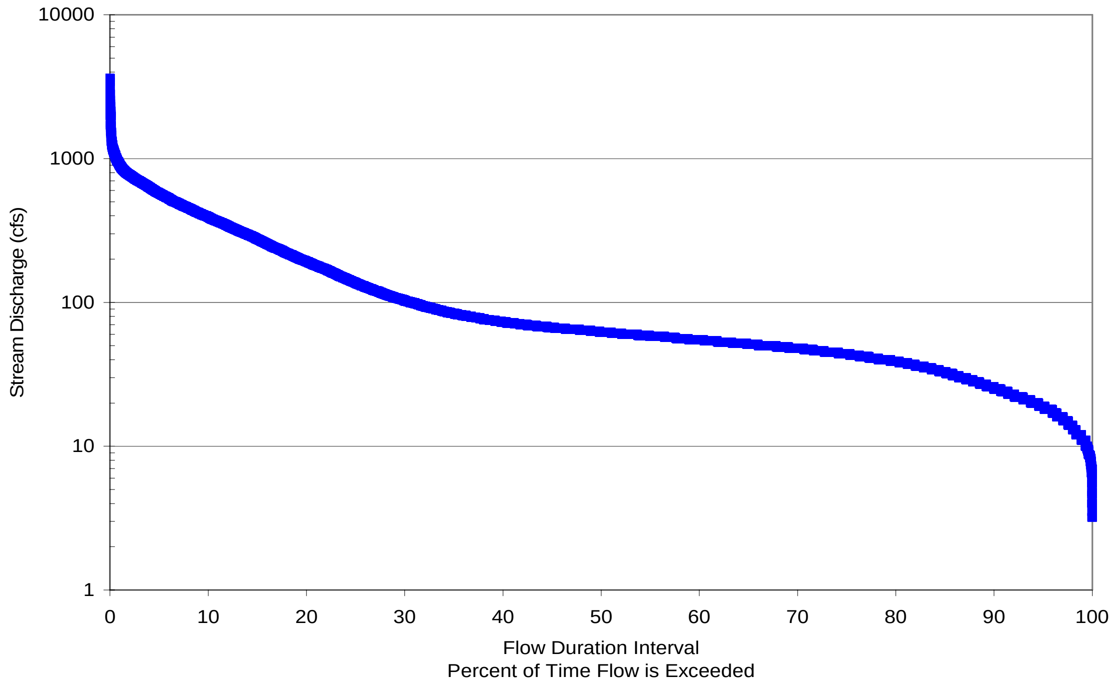


Figure 22. Salmon Falls Creek Flow Duration Curve.

A load duration or load capacity curve can then be created from a flow duration curve by multiplying the flow values by the applicable water quality criterion or target and a conversion factor. The independent x-axis remains as a duration interval but is a load duration interval (LDI), and the dependent y-axis depicts the load at that point in the watershed (rather than the flow). The load capacity curve therefore represents the allowable load (or the load capacity) at each flow condition. A load duration curve for Salmon Falls Creek is shown in Figure 23, using a target of 0.05 mg/L total phosphorus. Figure 23 also displays the observed loads, which are calculated by multiplying the sampled total phosphorus concentration by the daily mean flow associated with the sample. Points plotting above the curve represent exceedances of the target and are therefore unallowable loads. Those plotting below the curve represent compliance with the target and allowable daily loads.

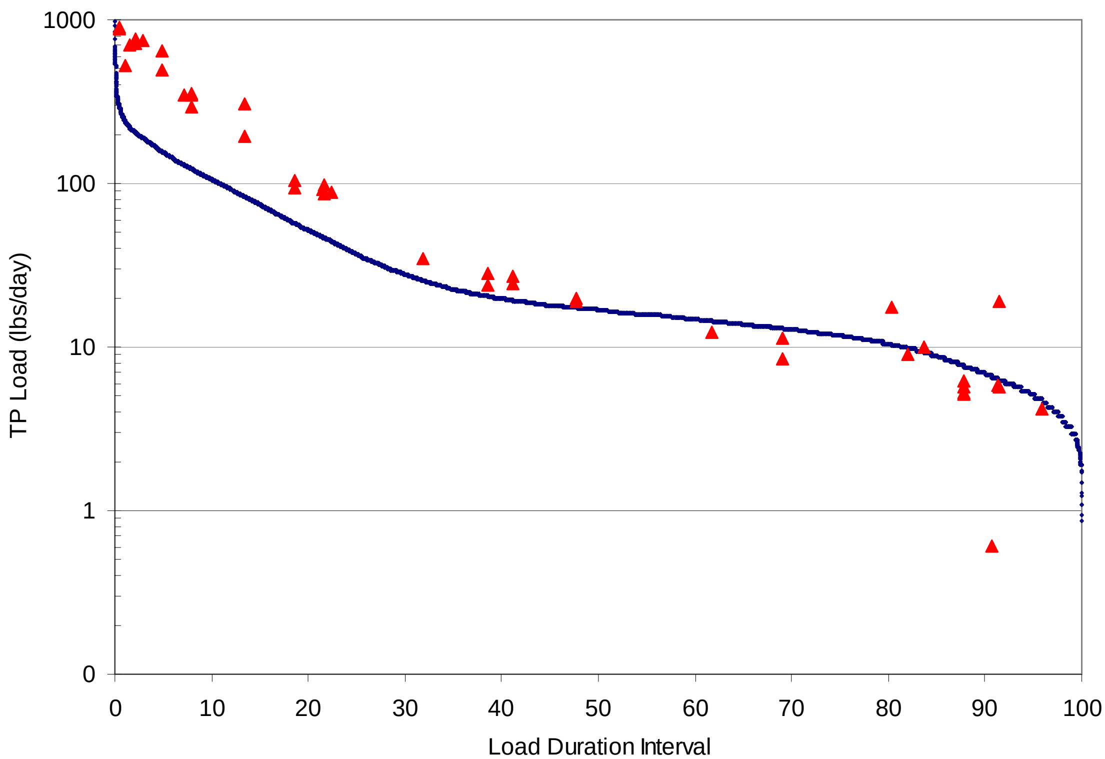


Figure 23. Salmon Falls Creek Total Phosphorus Load Duration Curve and Observed Data.

Important information can be interpreted from a load duration curve. First, the extent of the impairment can be visually assessed based on the number of loads that are above or below the load capacity curve. The load duration curve indicates that some of the observed loads in Salmon Falls Creek are above the allowable limit. Secondly, the nature of the impairment can be inferred based on when the loads occur (Cleland, 2003). Loads that plot above the curve during flow duration intervals of 60 to 90 (dry conditions) are likely indicative of constant discharge sources such as wastewater treatment plants, irrigation return flows, or dry weather flows. Those plotting above the curve between flow duration intervals of 10 to 40 reflect wet weather contributions associated with bank full events, sheet and rill erosion, wash-off processes, and, potentially, stream bank erosion. Some combination of the two source categories lies in the transition zone of 40 to 60 percent. Those loads plotting above the curve at flow duration intervals greater than 90 or less than 10 percent reflect extreme hydrologic conditions of drought or flood, respectively. Figure 23 illustrates that allowable total phosphorus loads in Salmon Falls Creek are exceeded most commonly during wet weather and extreme high flow ranges, indicating that bank and overland erosion sources contribute to the impairment.

Water Column Data

Water quality samples containing a full suite of constituents collected within the listed segments of Upper Salmon Falls Creek are rare. Historical samples include those collected by Idaho Department of Environmental Quality in the early 1970s near the state line and Nevada Department of Conservation and Natural Resources samples collected near Jackpot. Nevada from 1966 to 1998. Idaho DEQ also collected samples in at the state line location and at a location just up stream from the confluence with the reservoir in 2005-2006. However, due to the limited number of sampling periods in the data sets, DEQ's confidence in monthly average concentrations is low. The lack of a robust data set was due to limited budgets and in part by a limited time frame for collecting data. In most cases one sample was the most collected in any given month. Infrequently, multiple samples were collected for any given month. This sampling design was intended to determine annual load. The annual load estimated by this type of design would over estimate the annual load by 25 to 50 percent (Robertson and Richards 2000). To assist in the determination of seasonal components and appropriate critical conditions, the data will be presented as monthly averages in the following tables while period of record averages are presented in the text, tables, and used for any future load calculations. For those cases when a parameter was below detection limits, half the detection limit was used to calculate the monthly average and as part of the period of record average.

The primary DEQ sampling location was near the confluence with the reservoir with sampling beginning in May 2005 (Figure 24). The site was used to determine concentrations and loads for the stream. An additional site near the state line was sampled to determine loading from Nevada portions of the watershed as well as net change in loads in the Idaho portion of the system.

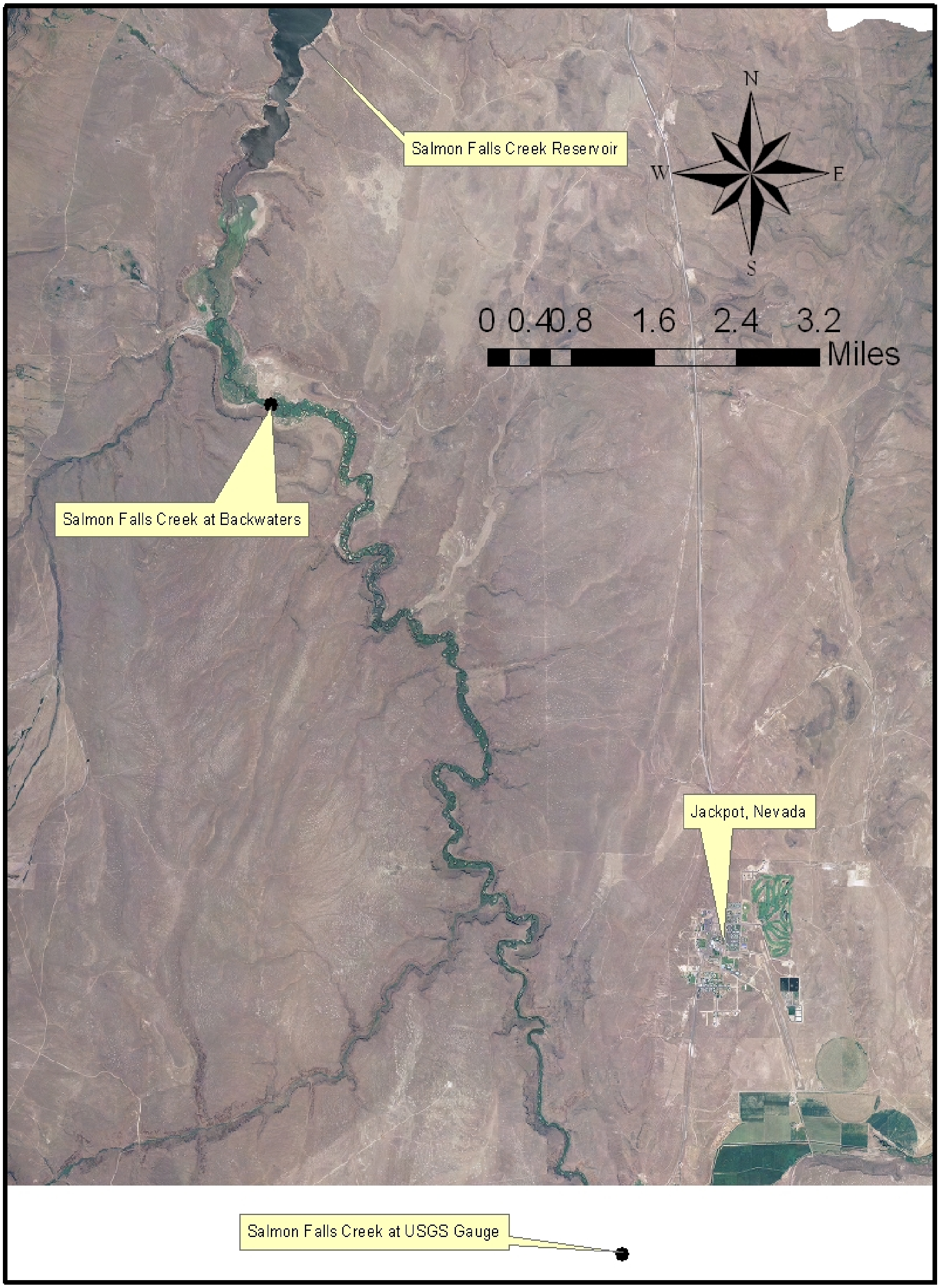


Figure 24. Upper Salmon Falls Creek Monitoring Locations, Showing Position Relative to Jackpot, Nevada and Salmon Fall Creek Reservoir.

Near the backwaters sampling location, the effects of land uses can be seen in the slightly elevated levels of some of the measured constituents in comparison to those levels measured at the state line location. These increases in most all cases are of a small magnitude, indicating similar use and degradation, only a few were significantly different ($p>0.05$). Average SSC near the backwaters was 49.86 mg/L, while at the state line SSC average was 42.39 mg/L. Total phosphorus increased as well, although less dramatically than did suspended sediments. Near the backwaters of Salmon Falls Creek Reservoir the average TP concentration was 0.100 mg/L, while at the state line site the average TP concentration was 0.088 mg/L average. The chemical constituents at both sites seemed to be similar throughout the sampling period. In order to determine if this was the case, a two-sample t-test was conducted to test the null hypothesis.

H_o: Salmon Falls Creek Backwaters Mean = Salmon Falls Creek Nevada Mean.
H_a: Salmon Falls Creek Backwaters Mean ≠ Salmon Falls Creek Nevada Mean.

Each constituent sampled at the two locations was tested using Systat 7.0. For most constituents the null hypothesis was not rejected ($p>0.05$). The only mean which exhibited any significant difference between the state line sample location and the backwaters area was E coli ($p = 0.04$). Therefore, the null hypothesis was rejected in this case. However the direction of the change appeared to be a decrease in *E. coli* numbers from the state line to the backwaters area, which is consistent with the land use patterns observed in the area. Access to the river system is readily available in the upper portions of the watershed while in the Idaho portion the stream is generally confined to a narrow deep canyon with limited accessibility to cattle and other organisms that may contribute *E. coli* to the system. Although there was a significant change in E coli numbers from the upstream location to the downstream location, it should be noted that neither sample location exhibited E coli numbers in excess of state water quality standards.

Instantaneous temperature measures were also collected in Upper Salmon Falls Creek. In the current DEQ data set, instantaneous temperature samples never exceeded water quality standards of 22 °C. The temperature of the stream also showed a slight cooling from the state line sample point to the confluence with Salmon Falls Creek Reservoir. Average temperatures at the state line were near 14.82 °C while at the confluence temperature had dropped to 13.43 °C. The DO at neither site was below levels indicative of water quality impairment. Dissolved oxygen is often used in conjunction with pH to determine if excess nutrients have caused nuisance aquatic growths. DEQ had determined that excess aquatic growths have not occurred in Upper Salmon Falls Creek during the sampling periods. The DO and pH data support this contention. Therefore, DEQ finds that Upper Salmon Falls Creek is not polluted with oxygen demanding materials.

Monthly concentrations of TP also were not indicative of excess nutrients that may cause impairment (nuisance aquatic vegetation) to the river system itself. However, Concentrations of TP seen in Salmon Falls Creek may in fact be a source of impairment to the reservoir system. Guidelines that DEQ has used in the past for river and stream systems that discharge into lakes and reservoirs are no more than 0.08 mg/L TP in any single sample, 0.05 mg/L TP in any average monthly sample, and 0.05 mg/L TP as a period of record average (Lay 2000, Lay 2001). These guidelines were commonly exceeded, at both sample locations, during high flow events and into the mid flow range of the flow duration curve, FDI <50 (Figure 23). In order to be protective of the reservoir's beneficial uses DEQ concludes that a TMDL for nutrients is warranted for Upper Salmon Falls Creek.

As mentioned above, bacteria samples were also collected with the water chemistry samples. No single sample, of the 37 total, collected at either location on upper Salmon Falls Creek indicated significant bacteria contamination (Figure 25). In the upper reach bacteria concentrations averaged 92 cfu/100ml, while at the backwaters location bacteria averaged 52 cfu/100ml. Therefore, DEQ concludes that bacteria do not impair the beneficial uses of the upper segment of Upper Salmon Falls Creek.

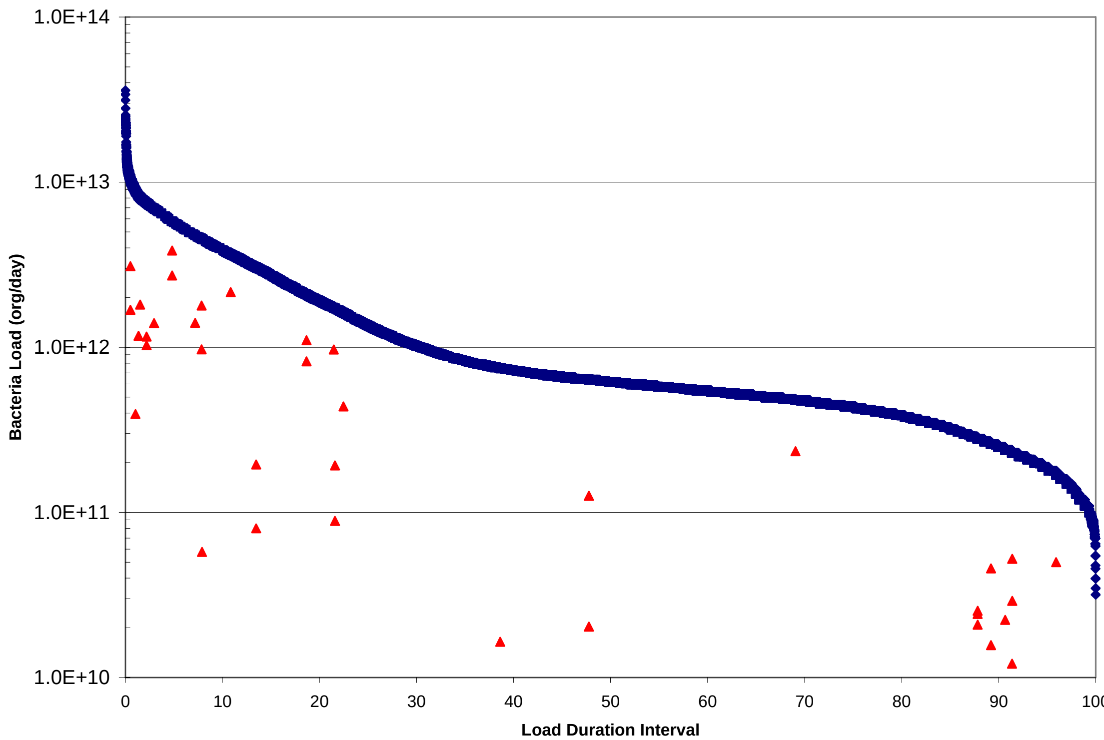


Figure 25. Salmon Falls Creek Bacteria Load Duration Curve and Observed Data from Both the Upper and Lower Monitoring Locations.

From both DEQ data sets, total suspended sediment also appears to be effecting beneficial uses. However, given the apparent release from continued drought cycles and the hydrological regime of the system, much of the sediment stored in the system may have been transported through the reach as a suspended load during DEQ's sampling. Alternatively, overland flow, wash-off processes, and bank instability may be the source of the suspended sediment loads seen during the sample regime. The load duration curve supports the later contention in that most SSC load exceedances occur during the high to extremely high flow events, FDI <20, at both the backwaters area sampling site and at the state line samples site (Figure 26).

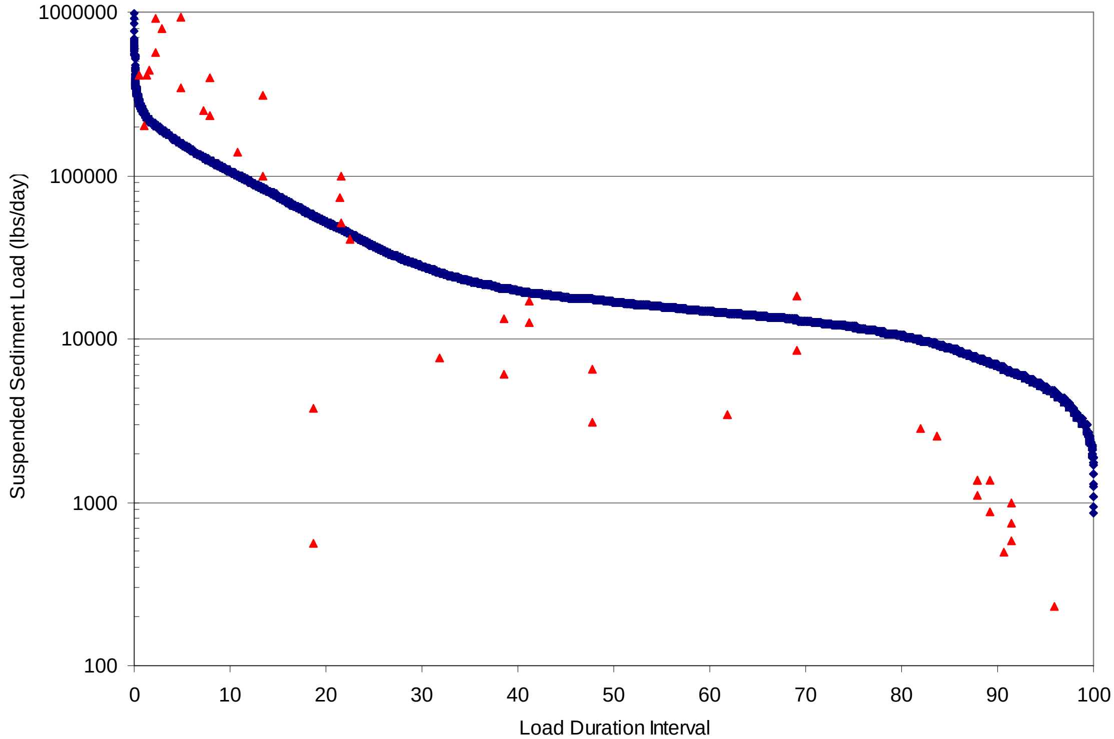


Figure 26. Salmon Falls Creek Upper Sediment Load Duration.

From suspended sediment sampling, it was determined that the suspended fraction of the sediment load was not impairing beneficial uses during mid-range and low-flow conditions. Because this sampling for suspended sediments in the Upper Salmon Falls Creek system was limited, DEQ took additional measures to determine if other forms of sediment were impairing beneficial uses. A series of McNeil cores for depth-fines were collected in the upper section of the river to determine if bedload sediment might be impairing beneficial uses. See the McNeil sediment core sample protocols used as outlined in the Cottonwood Creek Assessment Unit.

The Upper Salmon Falls Creek backwaters area percent depth fines ranged from 45 to 99 percent of the total volume. The overall average depth fines in Upper Salmon Falls Creek was 72 percent, which is well above the 28 percent depth fines target established to be protective of salmonid spawning in other Idaho TMDLS.

Mercury

Total mercury samples were collected monthly in The Backwaters area of Salmon Falls Creek from August of 2005 until November of 2006. Sample design included weekly sample collection during the spring runoff period. During base flow mercury concentrations were very low, while during high flow events concentrations increased dramatically. This can be described using a load duration curve, where the y axis is mercury load and the x axis is percent of time. In this graph (Fig. 27) a 12 ng/L concentration in water is used for calculating a reference Hg load duration curve as a basis for comparing observed Hg loads[1]. Any TMDL developed from this data will be calculated using Idaho's methylmercury criterion of 0.3 mg/Kg fish tissue, not 12 ng/L total mercury concentration in water.

As can be seen in Figure 27, mercury load in Salmon Falls Creek approaches the reference load duration curve only under high flow conditions and is well below the curve in wet, midrange, dry, and extreme low flow conditions. The nature of the mercury load in Salmon Falls Creek can also be inferred from the load duration curve. Data points plotting near or above the load duration curve in the 0 to 40 percent duration interval describe wet weather and high flow contributions associated with sheet and rill erosion, wash-off processes, and potentially stream bank erosion. Additionally, the very low position of the data on the load duration curve is consistent with the fish tissue information collected from game fish within the upper Salmon Falls Creek system and the low bioaccumulation seen in them (see the following discussion of fish tissue).

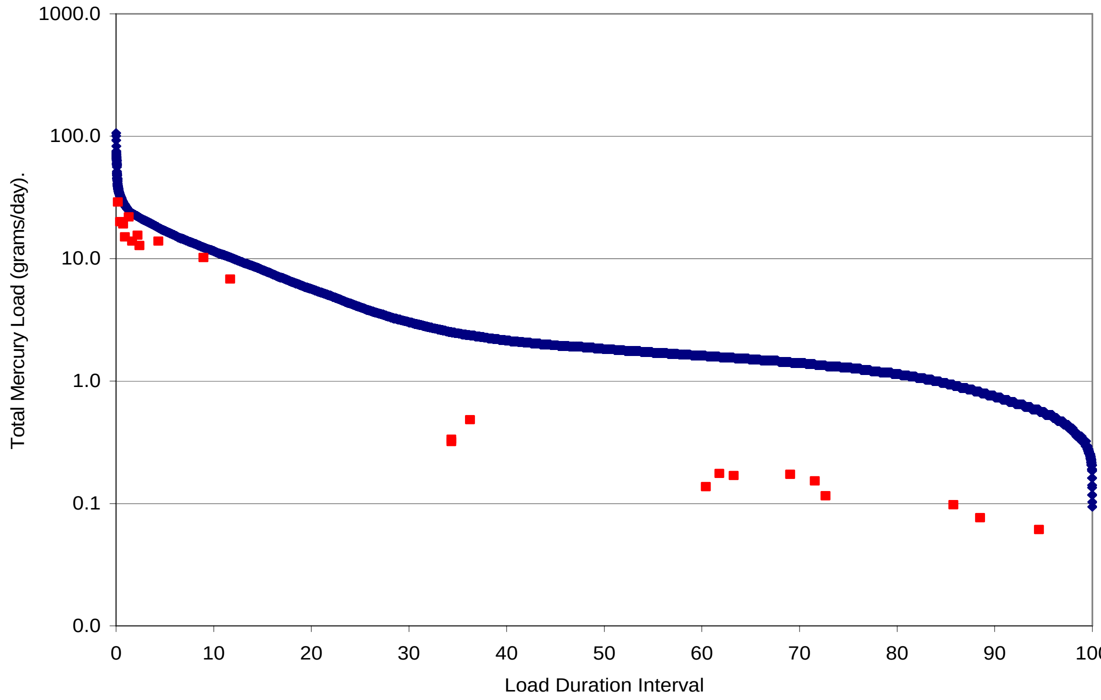


Figure 27. Total Mercury Load Duration Curve and Observed Loads from the Backwaters Monitoring Location.

[1] Twelve ng/l total Hg is a concentration somewhat above background in many waters. It corresponds to the CCC recommended by EPA prior to 1995 and at one time in Idaho's WQS.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that brown trout, rainbow trout, largemouth bass, and October spawning kokanee salmon have been stocked in Upper Salmon Falls Creek at various times since the early 1970s and continuing to date. The IDFG surveyed the fishery in Upper Salmon Falls Creek in 1983 and again in 1993 to determine if walleye had entered into the upper sections of the stream system. In 1983 the IDFG found few game fish (1 brown trout and 6 rainbow trout), however; they were looking primarily for the presence of *walleye* and fished a relatively short (300+ m) reach. In 1993, with similar goals, the upper section of the river was electrofished looking for spawning walleye, of which none were found. At that time, IDFG biologists noted the presence of 31 mountain whitefish, 5 hatchery rainbow trout, and 1 wild rainbow trout.

DEQ has electrofished Upper Salmon Falls Creek three times, once each in 1994, 1996, and 2005. In those events, DEQ collected redside shiner, speckled dace, suckers, pike minnows, and sculpin. Few, if any, trout were captured, and decreasing numbers of whitefish and increasing numbers of pike minnow were also noted. The DEQ electrofishing locations were upstream from the confluence with the reservoir.

Fish tissue analysis for total mercury concentration was conducted on the fishes collected by DEQ in 2005. The concentration of mercury in the lone whitefish was 0.181 mg/kg, well below the Idaho criteria of 0.3 mg/kg. The mercury concentration in the rainbow trout were 0.0813, 0.0893, and 0.126 mg/kg, again well below the fish tissue criteria. Pike minnow fish tissue was also collected at the time, as an indicator of fish tissue concentration in piscivorous fishes. Pike minnow mercury concentration ranged from 0.0813 to 0.504 mg/kg and averaged 0.264 mg/kg with a standard deviation of 0.077 mg/kg.

The Salmon Falls Creek consumption based average mercury concentration, which would exclude the pike minnow from the sample set and place more weight on the rainbow trout, was 0.132 mg/kg total mercury. Weighting factors were derived from EPA mercury TMDL guidance consumption estimates of 17.5 grams of fish per day where 32.6 percent of a typical fish meal consists of trophic level 3 fishes, or rainbow trout in this case, and 21.7 percent of a typical meal is from trophic level 2 fishes, or Mountain whitefish in Salmon Falls Creek. In general, the mercury concentrations in the fluvial population of fishes in Salmon Falls Creek appear to be below levels indicative of mercury contamination. However, the same cannot be said for the fishes of the reservoir where bioaccumulation of mercury is much more pronounced.

Salmonid spawning, Mountain whitefish and rainbow trout, appears to have been an existing beneficial use in Upper Salmon Falls Creek. More fish were found until the mid to early 1990s and since that time only a few whitefish or wild rainbow trout can be found within the system. The cause of the beneficial use impairment is likely fine sediment impacts to spawning substrates, as evidenced by the McNeil core information presented above, in conjunction with predation/competition from the increasing numbers of pike minnow. These factors may act synergistically to negatively impact the beneficial use at this time.

Macroinvertebrates

DEQ has collected macroinvertebrates in Upper Salmon Falls Creek twice. Macroinvertebrates were collected once in 1994 near the backwaters area, and once again in 2002 near the state line. The macroinvertebrate community represented in these temporally and spatially different scales indicate that the cold water aquatic life is generally fully supported. The macroinvertebrate scores from these two events were very similar in index scores and relatively high in comparison with benchmark values. As a result, the macroinvertebrates were well above threshold values of support. In addition, one obligate cold water taxon was collected in Upper Salmon Falls Creek, further bolstering the conclusion that Upper Salmon Falls Creek is fully supporting cold water aquatic life.

Aquatic Vegetation

Limited aquatic vegetation has been noted in many reaches of Upper Salmon Falls Creek. However, estimations of the coverage of aquatic vegetation were limited due to poor access of the creek. Although, at those locations where the creek could be accessed, aquatic plant communities were almost entirely absent, possibly due to elevated bedload and extremes in flow events scouring the system on a regular basis over the past several years. A few sestonic chlorophyll *a* samples were collected during the peak of the summer growing period to determine if nuisance conditions existed. The samples collected averaged 9.6 μg/L of chlorophyll *a* at the backwaters area and 11.13μg/L both of which are well below the 15 μg/L value suggested to indicate nuisance aquatic vegetation growths. These sample values confirm nutrient assessment that indicated TP was not in excess. However, in order to be protective of the downstream reservoirs beneficial uses a nutrient TMDL is still warranted.

Bank Stability

Bank stability measures were collected at two locations within the Upper Salmon Falls Creek system. The first of these was near the state line and the second was upstream of the confluence with the reservoir. In the upper 4.6 miles of the system, measured bank stability averaged 74.28 percent. In comparison, bank stability measures collected following BURP protocols in 2002 ranged from 95 to 97 percent stable. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 162.94 tons of sediment per year is delivered to the downstream reach. While the proposed sediment delivery rate for this reach is 56.32 tons per year.

Bank stability measures collected in the lower 5 miles also indicate that excessive bank sediment is being delivered to the reservoir system through the Upper Salmon Falls Creek channel. Bank stability in this region averages 25.57 percent. For comparison, BURP data collected in this reach in 1994 indicated poor bank stability with only 42 percent of the banks being stable. The differences between the BURP data and the more recent bank stability work conducted by DEQ may be a bank response to some of the extreme flow events recorded in the watershed over the past few years.

Based upon the bank stability measures and recession rate information collected it is estimated that nearly 1,080 tons of sediment per year are being mobilized through the backwaters reach of the Salmon Falls Creek channel. The target or proposed sediment delivery for this reach is of 108.86 tons per year. Overall Upper Salmon Falls Creek would require a 86.71 percent reduction in sediment to meet existing criteria and targets. This reduction would need to occur in the Idaho portions of the system.

Temperature

Four creeks were placed on the 1998 303d list of impaired waters by EPA for reasons associated with temperature criteria violations (Tables 21 and 22).

Effective shade targets were established for the four creeks and a number of their tributaries based on the concept of maximum shading under potential natural vegetation equals natural background temperature levels. Shade targets were actually derived from effective shade curves developed for similar vegetation types in the Northwest. Existing shade was determined from aerial photo interpretation field verified with solar pathfinder data.

All streams examined had excess heat loads due to a lack of shade. Shoshone Creek and Salmon Falls Creek had the largest excess loads due to their size, although percent reductions to achieve loading capacities were only 40% and 20%, respectively. In order to prioritize water bodies, those streams with high excess loading and percent reductions greater than 20% should be examined for possible shade recovery. Such candidates would include most tributaries examined in this analysis.

Loading analyses for each water body include tables that show where existing shade is less than target shade and thus where excess solar loading is occurring. These tables are important tools for prioritizing and directing implementation activities to those areas where shade is needed the most.

Table 21. Streams and Pollutants for Which Temperature TMDLs Were Developed.

Stream	Pollutant(s)
Salmon Falls Creek, NV/ID border to Salmon Falls	Temperature

Stream	Pollutant(s)
Shoshone Creek, NV/ID border to Magic Hot Springs	Temperature
Shoshone Creek, Cottonwood Creek to Big Creek	Temperature
Hot Creek, headwaters to mouth	Temperature

Table 22. Summary of Temperature Assessment Outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Salmon Falls Creek ID17040213SK001_06 ID17040213SK003_06 ID17040213SK009_06	Temperature	Yes	n.a.	Existing Shade
Shoshone Creek ID17040213SK011_04 ID17040213SK013_04 ID17040213SK016_04	Temperature	Yes	n.a.	Existing Shade
Hot Creek ID17040213SK012_03A ID17040213SK012_04	Temperature	Yes	n.a.	Existing Shade

Pathfinder Methodology

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

At each sampling location, the solar pathfinder should be placed in the middle of the stream about the bankfull water level. Follow the manufacturer's instructions (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. Start at a unique location such as 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 100 m, every 100 paces, every degree change on a GPS, every 0.1 mile change on an odometer, etcetera). One can also randomly locate points of measurement by generating random numbers to be used as interval distances.

It is a good idea to measure bankfull widths and take notes while taking solar pathfinder traces, and to photograph the stream at several unique locations. Pay special attention 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, one can take densiometer readings at the same location as solar pathfinder traces. This provides the potential to develop relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

Canopy coverage estimates or expectations of shade based on plant type and density are provided for natural breaks in vegetation density, marked out on a 1:100K or 1:250K hydrography. Each interval is assigned a single value representing the bottom of a 10%-canopy coverage or shade class as described below (*adapted from the cummulative watershed effects (CWE) process, IDL, 2000)*. For example, if we estimate that canopy cover 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. The typical vegetation type (below) shows the kind of landscape a particular cover class usually falls into for a stream 5m wide or less. For example, if a section of a 5m wide stream is identified as 20% cover class, it is usually because it is in agricultural land, meadows, open areas, or clearcuts. However, that does not mean that the 20% cover class cannot occur in shrublands and forests, because it does on wider streams.

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

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

Stream Morphology

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

The only factor not developed from the aerial photo work presented above is channel width (i.e., NSDZ or Bankfull Width). Accordingly, this parameter must be estimated from available information. We use regional curves for the major basins in Idaho, data compiled by Diane Hopster of Idaho Department of Lands (Figure 28).

These regional curves use bankfull dimensions that have been collected and field calibrated at the various gage stations throughout the basin to plot the relationship between bankfull width and the size of the drainage area above the station. Plots of bankfull channel dimensions prove useful for estimating similar channel dimensions for ungaged areas (Rosgen, 1996).

For each stream evaluated in the loading analysis, bankfull width is estimated based on drainage area of the Upper Snake curve from Figure 28. Additionally, existing width is evaluated from available data. If the stream's existing width is wider than that predicted by the Upper Snake curve in Figure 28, then the Figure estimate of bankfull width is used in the loading analysis. If existing width is smaller, then existing width is used in the loading analysis. The results of this bankfull width analysis are presented in Table 23. In most cases, the existing widths are smaller than those estimated from the regional curve. Thus, existing bankfull widths are used in the analysis for natural widths in these areas.

Figure 28. Bankfull Width as a Function of Drainage Area

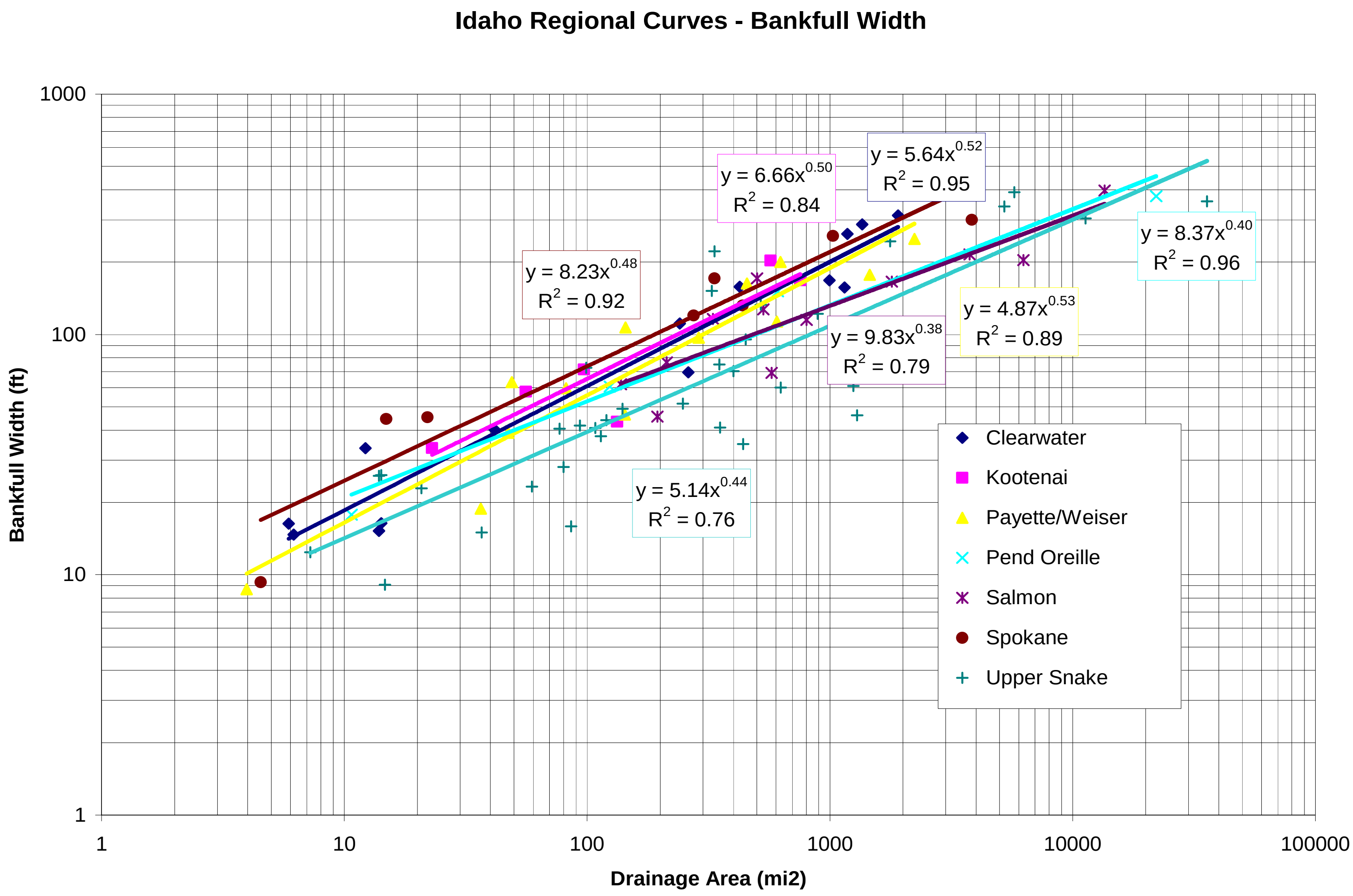


Table 23. Bankfull Width (BFW) Estimates and Measurements for Streams in the Salmon Falls Subbasin.

Location	Drainage Area (mi^2)	Estimated BFW (m)	Existing BFW (m)	Elevation Range (ft)
Salmon Falls Creek @ NV/ID border	1460	39	20	10200 - 6350
Salmon Falls Creek ab SF Reservoir	1480	39		10200 - 5010
Salmon Falls Creek ab Cedar Creek	1820	43		10200 - 3800
Salmon Falls Creek ab Devil Creek	1974	44	12	10200 - 3300
Salmon Falls Creek @ mouth	2200	46	16	10200 - 2900
Player Creek @ mouth	4.91	3	2.3	7500 - 6280
China Creek @ mouth	25.7	7	3.5	7540 - 5050
Browns Creek @ mouth	7	4	1.2	7420 - 5060
Whiskey Slough @ mouth	9.72	4		7070 - 5020
Antelope Canyon	14.1	5		6630 - 4620
Cedar Creek @ mouth	164	15		7730 - 3820
Cedar Creek ab Cedar Reservoir	31.9	7	2.4	7730 - 5230
Black Canyon @ mouth	10.4	4		7320 - 5240
House Creek @ mouth	49.2	9	4.6	7730 - 5250
House Creek ab Little House Creek	24.9	6	11	7730 - 5690
Little House Creek @ mouth	9.06	4	2.8	7280 - 5690
Devil Creek @ mouth	158	15		7380 - 3530
Devil Creek ab Cedar Draw	80.8	11		7380 - 4550
Devil Creek ab diversion to House Cr.	9.6	4		7380 - 5770
Cedar Draw @ mouth	37	8		5920 - 4560
NF Salmon Falls @ border	17.2	5	4	7540 - 6410
SF Shoshone Creek @ mouth	11.1	5	4	7480 - 5920
Shoshone Creek ab Pole Camp	17.1	5	6.6	7480 - 5850
Pole Camp Creek @ mouth	4.9	3	5	6570 - 5860
Shoshone Creek bl Pole Camp	22	6	8	7480 - 5850
Langford Flat Creek @ mouth	7.9	4		6730 - 5700
Cottonwood Creek ab Langford Flat	19.3	6	5.1	7530 - 5700
Cottonwood Creek @ mouth	27.3	7		7530 - 5700
Shoshone Creek ab Cottonwood	44.7	8		7480 - 5700
Shoshone Creek bl Cottonwood	72	10	8	7530 - 5700
Hannahs Fork @ mouth	5.75	3		7520 - 5740
Big Creek ab Hannahs Fork	15.1	5	3.7	7460 - 5740
Big Creek bl Hannahs Fork	20.9	6		7520 - 5740
Big Creek @ mouth	25.6	7	2.6	7520 - 5650
Shoshone Creek ab Big Creek	97.1	12	8	7530 - 5650
Shoshone Creek bl Big Creek	124	13		7530 - 5650
Horse Creek @ mouth	17.3	5		7490 - 5630
Hot Creek @ mouth	56.5	9	3.7	8140 - 5630
Shoshone Creek bl Hot Creek	200	16	8	8140 - 5620
Shoshone Creek @ NV/ID border	243	18	9	8140 - 5380

Drainage area and elevation range estimated with USGS Streamstats for Idaho.
Estimated BFW based on IDL Upper Snake Regional Curve. Existing BFW based on available BURP data for nearest location.

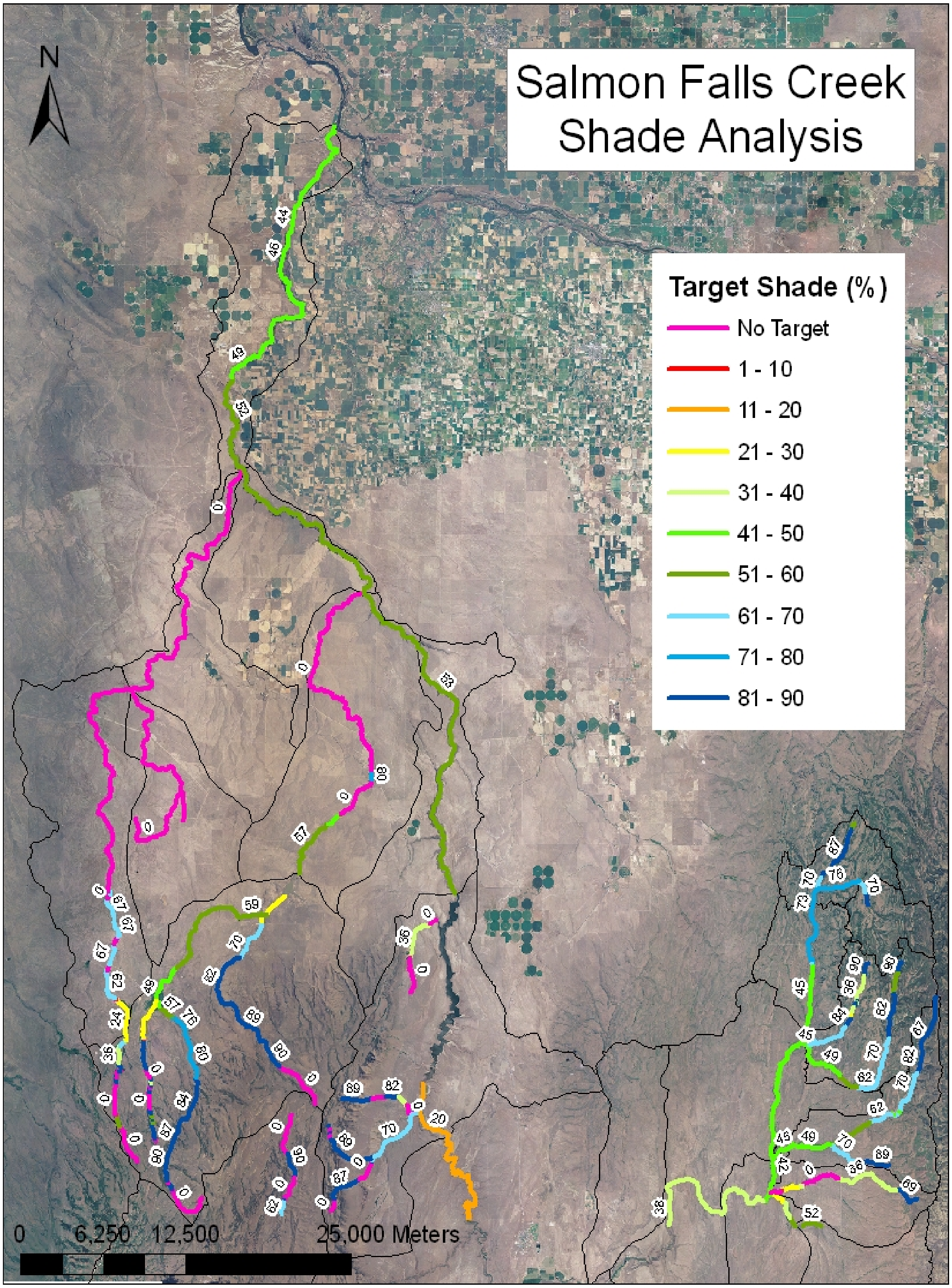


Figure 29. Target Shade for Salmon Falls Creek Subbasin.

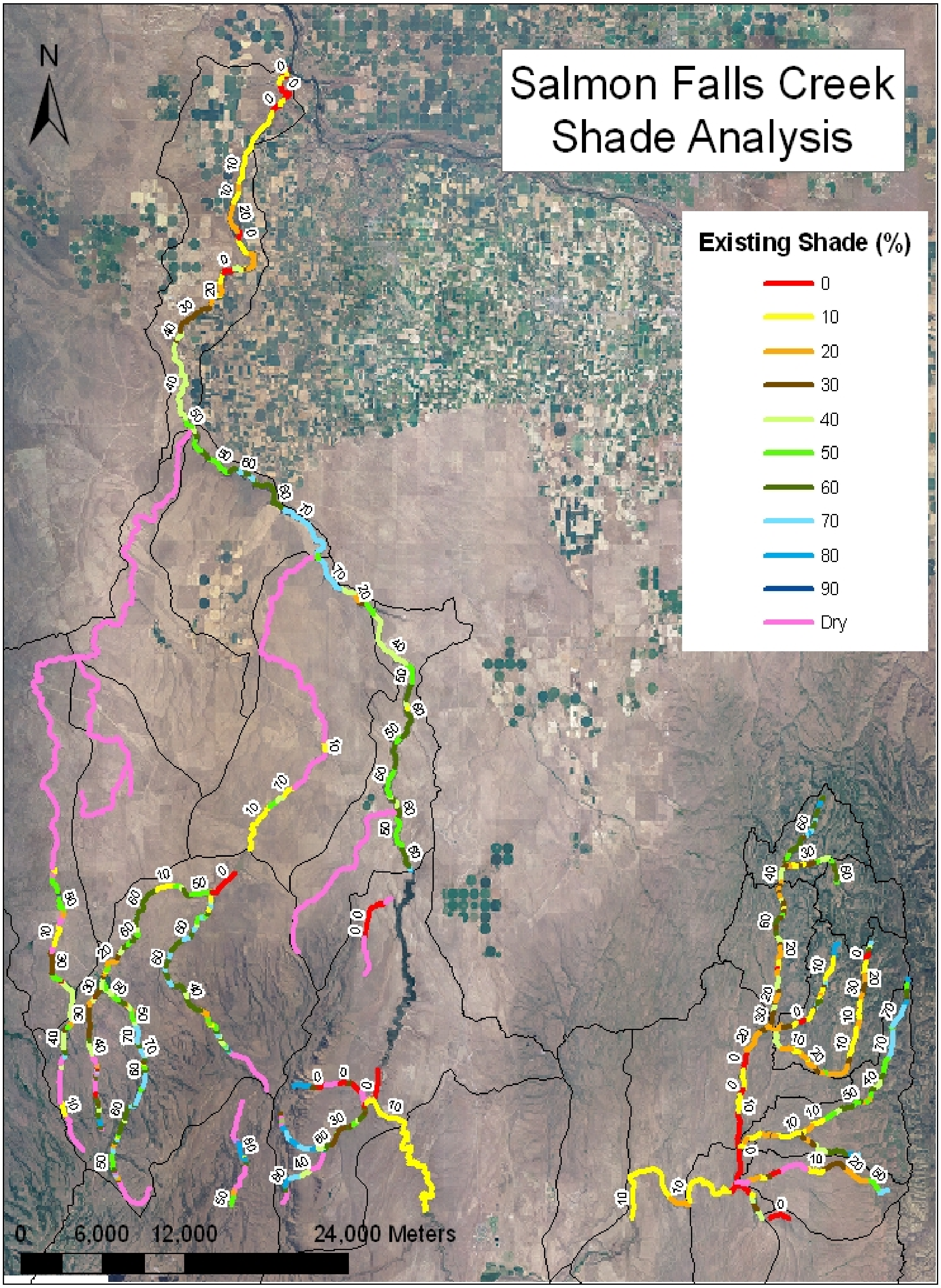


Figure 30. Existing Cover Estimated for the Salmon Falls Creek Subbasin by Aerial Photo Interpretation.

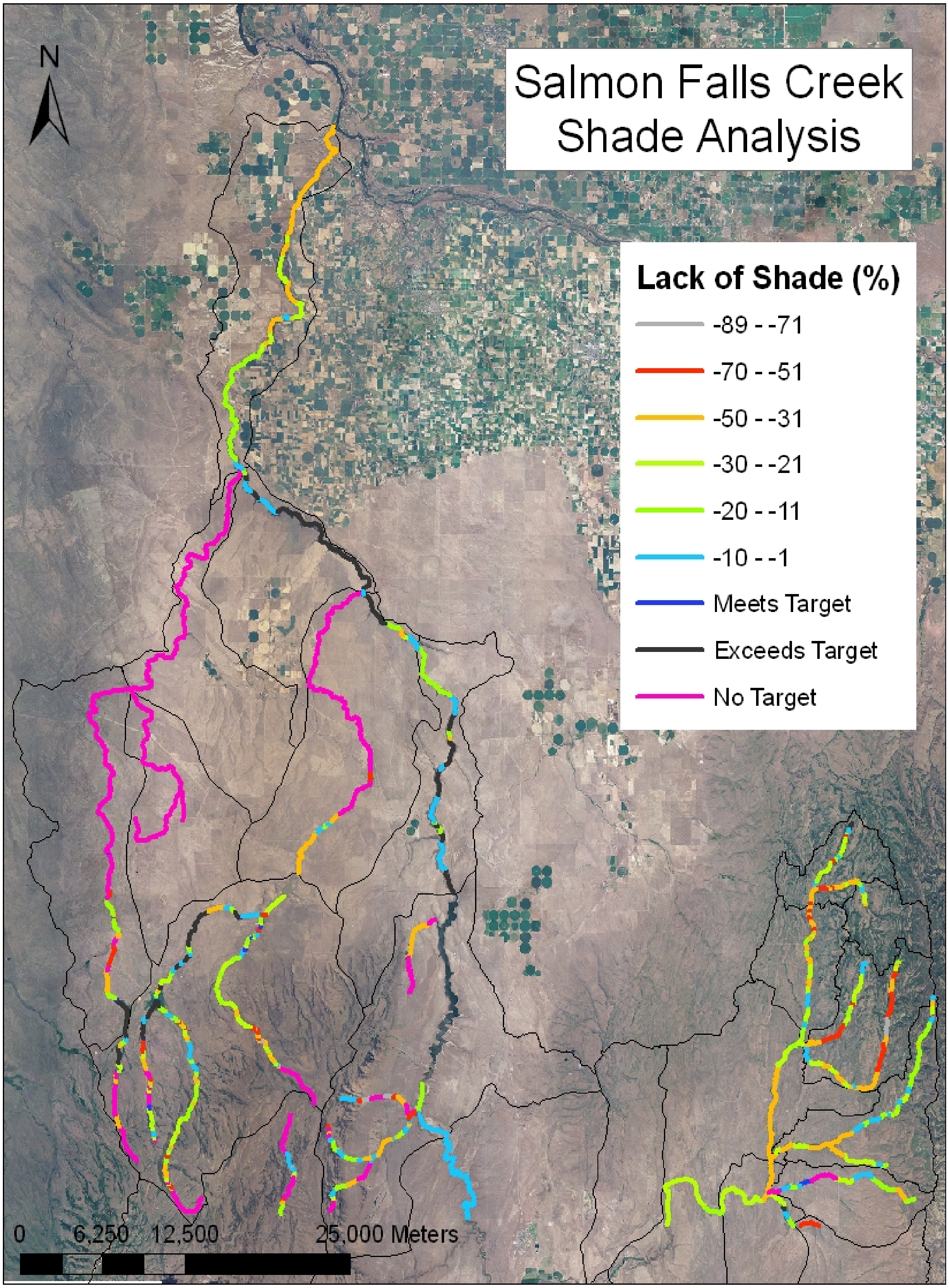


Figure 31. Lack of Shade (Difference Between Target and Existing) for Salmon Falls Creek Subbasin.

Status of Beneficial Uses

The above data suggest that the designated beneficial uses of Upper Salmon Falls Creek, cold water aquatic life and primary contact recreation, are impacted. It can also be clearly demonstrated that salmonid spawning is not fully supported and is impacted a great deal by sediment. Additionally, it appears that the source of the sediment is poor bank stability and that the sediment is generated during high flow events. Furthermore, nutrients, although not impacting the Salmon Falls reach itself, are likely impacting the receiving water and therefore should be addressed in a TMDL. Similarly mercury has been show to have limited impact to the fishery within the upper Salmon Falls Creek reach, yet has a profound effect in the receiving water's biota. As a result a mercury TMDL should be undertaken (see the assessment of Salmon Falls Creek Reservoir in following sections for more information).

Conclusions

Based upon the above assessment, a sediment TMDL should be developed for the Upper Salmon Falls Creek Reach. Additionally, to be protective of the downstream receiving water body, nutrient and mercury TMDLs should also be completed. Similarly, it is recommended that these constituents should also be addressed in the Nevada portion of the system, because the impact form the Nevada portion of the stream directly influences the Idaho portion.

Cedar Creek Assessment Units

Physical Characteristics

The Cedar Creek Assessment Unit ID17040213SK000_04 includes the fourth order segment of Cedar Creek that originates at Cedar Creek Reservoir and terminates at the confluence of Salmon Fall Creek approximately 19.5 miles downstream (Figure 32). However, most of this assessment unit has been dewatered since the reservoir was constructed around 1910. Only the upper 3.7 miles of stream sees any significant flow, and this is generally only during the irrigation season when water is being diverted from Cedar Creek Reservoir to the Cedar Mesa Canal. For the remainder of the time the stream is completely dewatered while Cedar Creek Reservoir fills.

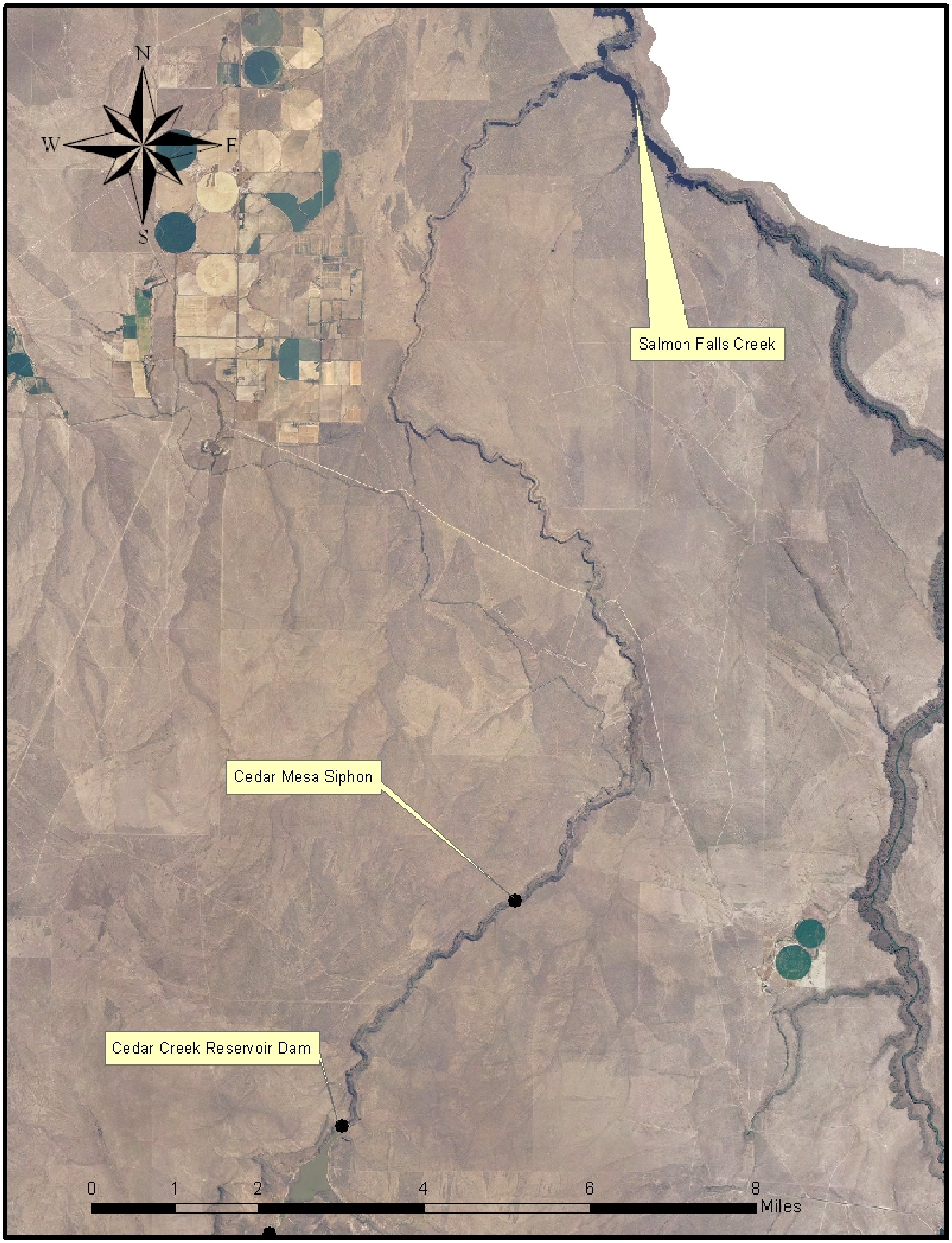


Figure 32. Cedar Creek Below Cedar Creek Reservoir, Showing Cedar Mesa Siphon and Salmon Falls Creek.

Flow Characteristics

Throughout Cedar Creek's length, it flows through the Northern Basin and Range ecoregion. Along this course, several ephemeral and intermittent tributaries enter the system. Although, they do not contribute any meaningful discharge to the system. What little is delivered to the system does not change Cedar Creek to a perennial system   The USGS has not had a gauge located in the lower segment of Cedar Creek below Cedar Creek Reservoir. However, a USGS gauge, operated between 1985 and 1987, at Cedar Creek Reservoir indicates that on average approximately 44 cfs is discharged into the upper 3.7 miles of the creek during the irrigation season. Stream discharge was calculated from the difference between reservoir storage on successive measurement dates. The underlying assumption was that the only change in storage between dates was due to direct discharge to Cedar Creek. Evaporative losses during the summer and infiltration and leakage losses were not taken from the storage differential. Irrigation withdrawals generally ran between the first week in May and the end of September during the period of record. Figure 33 presents Cedar Creek Reservoir storage and Figure 34 presents calculated stream discharge.

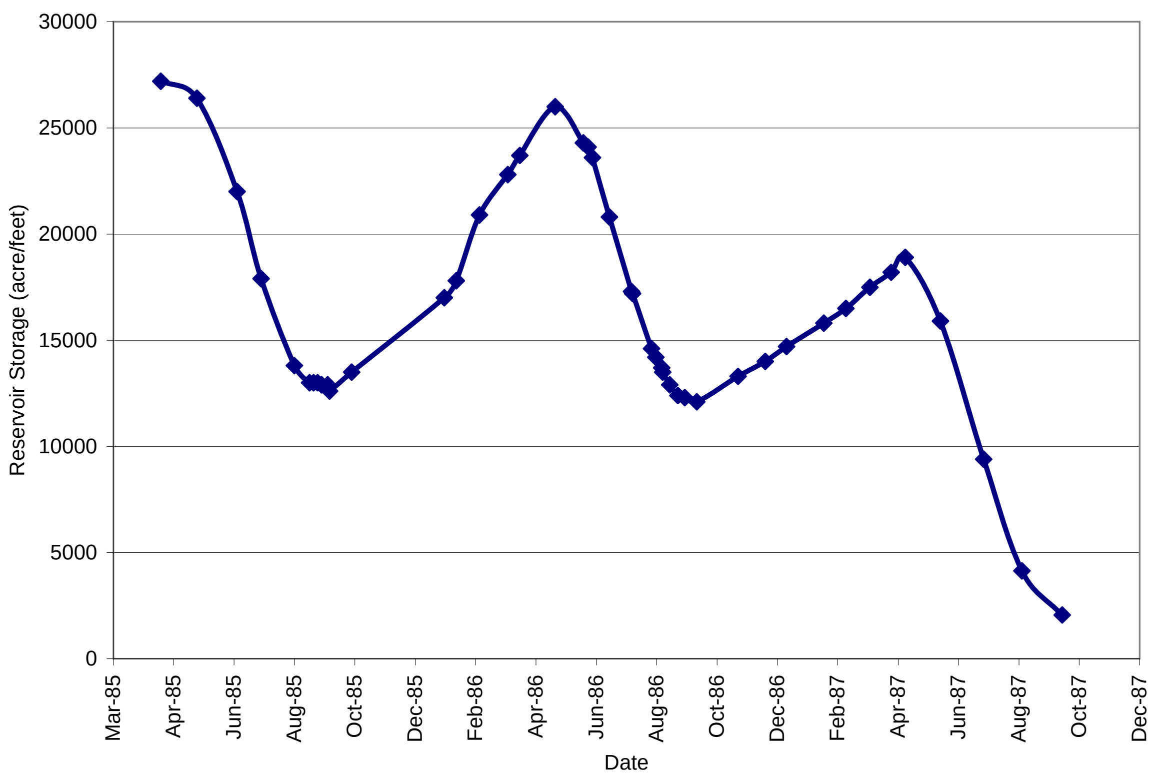


Figure 33. Cedar Creek Reservoir Storages from USGS Data.

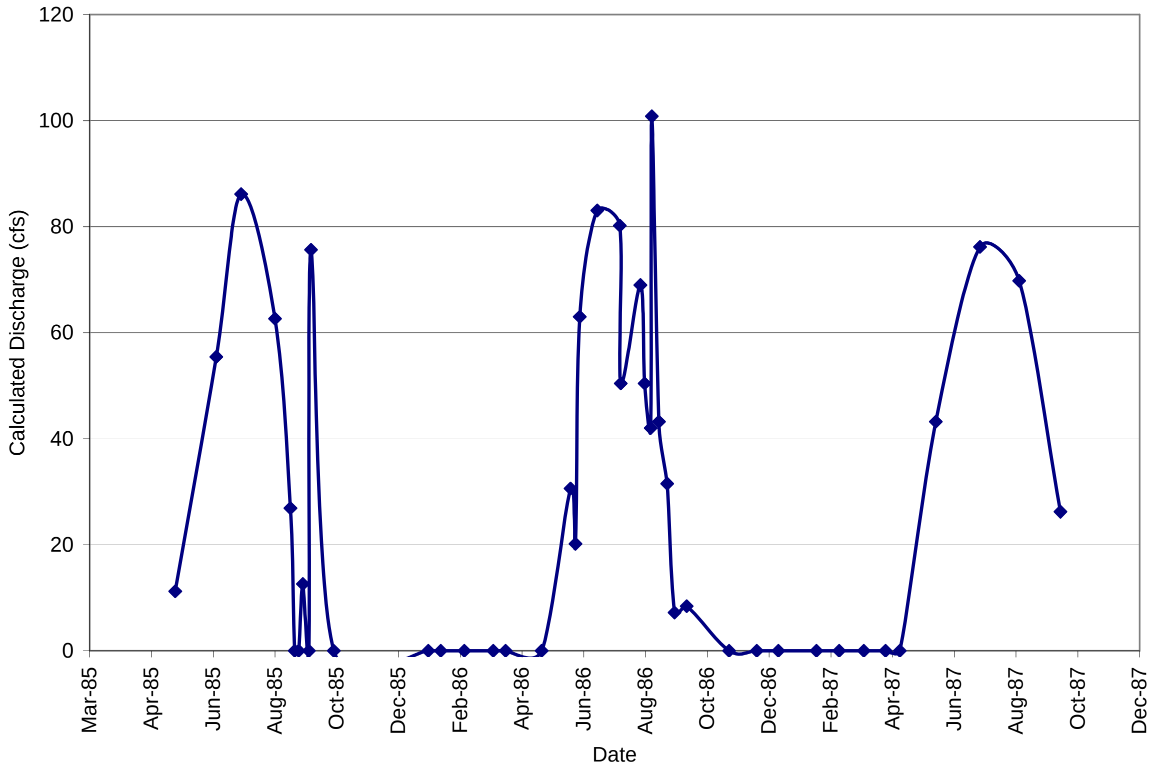


Figure 34. Cedar Creek Reservoir Discharge Calculated from Storage Data.

Based upon the historical reservoir stage data an interpretation of hydrological events in Cedar Creek include extended periods of little or no flow throughout the length of Cedar Creek. This period ranges from the middle of September to the beginning of May, or 7.5 months for the upper 3.7 miles, while the length of time the remainder of the stream sees little or no flow extends to the full year. These conditions have existed for approximately 97 years and will likely continue to exist for the life of the reservoir. As a result the extreme conditions, brought about by the flow alteration of the system, preclude the existence of most beneficial uses and predates the Clean Water Act.

Water Column Data

No water column data exist for Cedar Creek. IDEQ personnel visited Cedar Creek below the Cedar Mesa Canal diversion at various points and throughout 2005-2006 to determine if and when discharge events occurred. During this period, the system was dry.

Biological and Other Data

Fisheries

Stocking records indicate that Cedar Creek has never been planted with hatchery fishes. Additionally, Cedar Creek has never been electrofished by IDFG agency personnel nor IDEQ personnel.

Macroinvertebrates

IDEQ has never collected macroinvertebrates in Cedar Creek. Given the hydrological alterations of the system. DEQ-TFRO feels that biological information such as macroinvertebrates and fishes should not be used to assess the beneficial uses of Cedar Creek as Cedar Creek.

Aquatic Vegetation

The presence of terrestrial vegetation was noted in throughout the lower segment of Cedar Creek. The vegetation consisted of mainly annual grasses and various sagebrush species. The presence of sagebrush within the creek channel indicates that the creek channel is not inundated for a significant length of time. Chlorophyll *a* samples were not collected in Cedar Creek due to the lack of water within the creek channel.

Bank Stability

Bank stability measures were collected at two locations within the Cedar Creek system. The first of these was upstream of the Cedar Mesa Canal Siphon and the second was down stream from the siphon approximately 3.1 miles. In the upper 4 miles of the system, the wetted portion, measured bank stability averaged 63 percent. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. However, all of this sediment is captured in the completed removal of Cedar Creek into the Cedar Mesa Canal. Based upon the bank stability measures and recession rate information collected it is estimated that nearly 73 tons of sediment per year is delivered to the Cedar Mesa Reservoir.

Bank stability measures collected in the lower 15.5 miles also indicate that bank sediment may be delivered to the Salmon Falls Creek system via the old Cedar Creek channel. In the dry portions of the system a historic channel exists through which ephemeral events travel. During these events sediment is scoured from the Cedar Creek system and moved downstream, eventually to enter the lower portion of Salmon Falls Creek. Bank Stability in this region averages 77 percent with a slightly high bank recession rate due to the bank cover vegetation holding the historic banks together consisting of annuals and other poorly rooting plants. Based upon the bank stability measures and recession rate information collected it is estimated that nearly 217 tons of sediment per year could be mobilized through the Cedar Creek channel.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

The beneficial uses of Cedar Creek have not been existing uses since 1910 following construction of the Cedar Creek Reservoir. The biggest factor impacting the presumed uses within the system is flow alteration. A significant portion of the system never sees any sustained flow while a very short segment sees irrigation demand flow only during the short irrigation season. Furthermore, sediment delivery through the wetted portion of the system is elevated and is likely impacting the beneficial uses of the stream with fine sediment while water is present within the system. However, this may be a relatively minor consideration given the current hydrological constraints upon the system.

Conclusions

Cedar Creek should be retained on the integrated report under flow alteration.

Cedar Creek Reservoir

Cedar Creek Reservoir lies within the south central Snake River Plain of Idaho in an area south of the town of Castleford. The major sources of water for the reservoir are Cedar Creek and House Creek. At full pool, the reservoir covers approximately 393 hectares. The USGS operated a gauge at the reservoir from 1985 to 1987. The Cedar Creek Reservoir watershed is an area of approximately 129 $miles^2$. Usable storage in the reservoir is approximately 27,000 acre-feet. The construction of the dam began around 1910. The reservoir has never spilled since its initial construction. Historically Cedar Creek Reservoir has under filled in most years. The water from Cedar Creek Reservoir currently services approximately 5,000 acres of farmland.

Physical Characteristics

The reservoir has an overall length of 2.8 mile, and an effective length of 2.6 miles through the Cedar Creek arm. The maximum width is 1.7 miles, while the average width is 0.5 miles. Shoreline development ratio (or shoreline area) is moderate at 2.49. (Shoreline development ratio is defined as the length of the shoreline to the circumference of a circle whose area is equal to that of the water body; a perfectly round lake would have a shoreline development ratio of 1.0, while a highly dendritic lake would have much higher shoreline development). For comparison, Lake Mead has a shoreline development ratio of 9.72, and the third lake of the Independence Lakes has a shoreline development of 1.03. The maximum depth measured in 2005 was 14 m. Average depth of the reservoir (volume/ area) is 8.5 meters. These morphological characteristics indicate that Cedar Creek reservoir is a relatively shallow, open bowl shaped reservoir highly unlikely to stratify and should mix throughout the summer given any sort of wind event. These morphological characteristics will also impede the production of salmonid fisheries due to high temperatures and low dissolved oxygen throughout the water column at moderate to low levels of eutrophication.

Flow Characteristics

The amount of water that enters Cedar Creek Reservoir can best be described by a summation of House Creek and Cedar Creek, while the major losses from the reservoir would include the canal diversion, evaporation and infiltration.

To estimate the reservoir water budget DEQ estimated the House Creek and Cedar Creek discharge data from discharge measurements and relationships with surrounding USGS gauges; estimated evaporative losses from reservoir area using nearby evaporation rates; and assumed infiltration losses were negligible. Annual average input from the Cedar Creek, based on historic USGS gauge date, averaged approximately 5,428 acre-feetacre-feet per year. House Creek contributes approximately 20,996 acre-feet per year, based upon a relationship between measured discharge in House Creek and the USGS gauge at San Jacinto on Salmon Falls Creek. Flow duration curves (Figures 35 and 36) for both Cedar Creek and House Creek were developed from the historic USGS Gauge information and a regression with the San Jacinto Gauge.

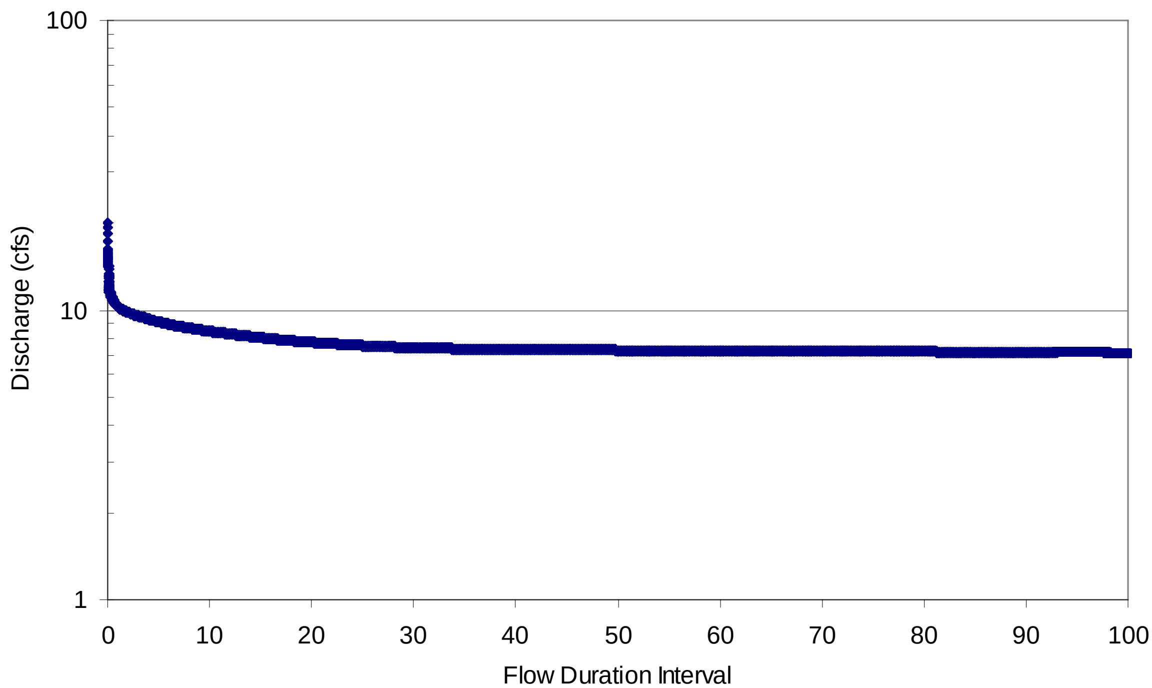


Figure 35. Cedar Creek Flow Duration Curve.

Losses from the system include approximately 3,489 acre-feet per year from evaporation. Evaporation losses may be less that this, as the full pool area of the reservoir was used to make this estimate. As the reservoir is drawn down, the surface area would decrease thus decreasing evaporation potential.

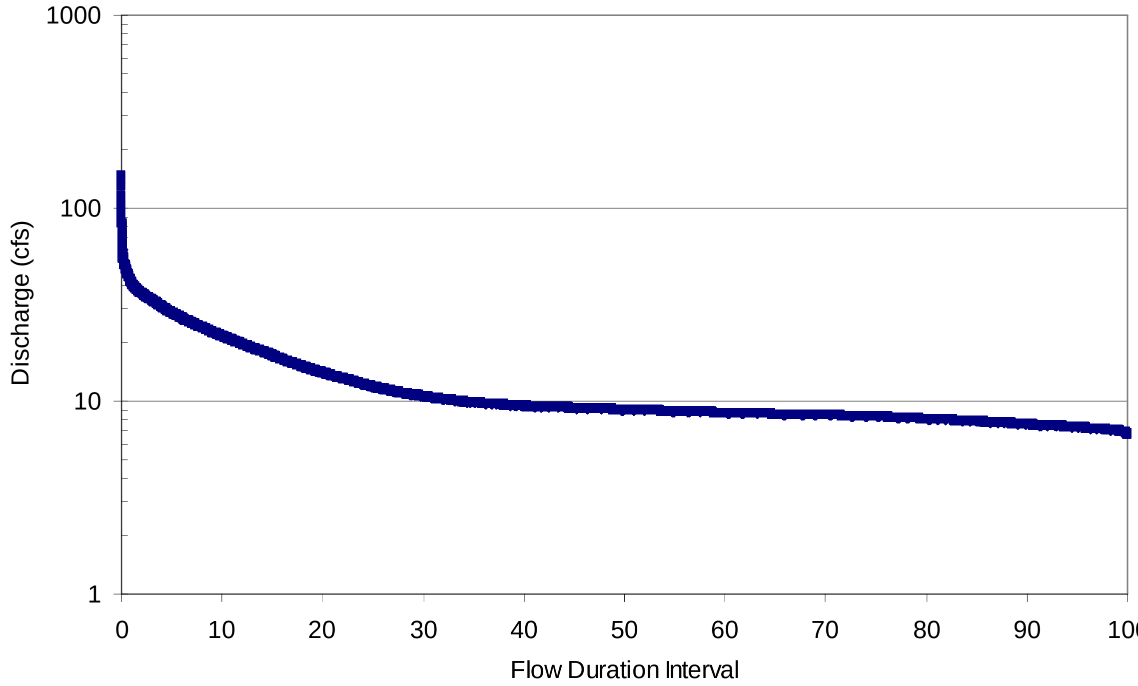


Figure 36. House Creek Flow Duration Curve.

Irrigation losses were based upon a very limited reservoir storage gauge record, which indicates an average reservoir net volume change of approximately 87 acre-feet per day during the irrigation season. Using this data set, the irrigation withdrawals would be near 150 acre-feet per day or 75.69 cfs during the irrigation season. Considering that the irrigation season typically runs from mid April until the end of September, losses from the system for irrigation would be near 25,200 acre-feet per year. However, irrigation withdrawals are variable according to reservoir volume and downstream demand, thus this value may be higher in wet years with good hold over of water and much less during drought years.

A summation of these gains and losses indicate that on average the system is operating at a net loss of nearly 2,000 acre-feet in an average year. This net loss would be made up from the budget by reduced irrigation withdrawals and decreased evaporation rates due to the smaller reservoir surface area. From a water quality and beneficial use assessment standpoint, the water budget indicates that the beneficial uses of the system are highly likely to be impacted by flow alteration in all but wet water years. In average or drought years the losses from the system would out pace the gains making carryover water unlikely and unsuitable for long-term aquatic life and recreational beneficial uses.

Water Column Data

The EPA’s STORET database contains no samples collected from the reservoir. Data queries from other agencies have yielded no water chemistry data. Therefore, DEQ data are the only readily available data for Cedar Creek Reservoir.

DEQ sampled in the reservoir over the course of the summer of 2005, and additional samples will be collected throughout the various phases as budgets and time frames allow. In order to determine internal loading of nutrients a mass balance sample design will be implemented in the summer of 2007. That data will be included in the implementation phase of the TMDL. However, due to the limited number of sampling periods in the original data set, DEQ's confidence in average concentrations is low. The lack of a robust data set was due to limited budgets and in part by a limited time frame for collecting data. In most cases one sample was the most collected in any given month. Infrequently, multiple samples were collected for any given month. For those cases when a parameter was below detection limits, half the detection limit was used to calculate the parameter average and as part of the period of record average.

Two sample locations were set up in Cedar Creek Reservoir, with sampling occurring in June, July and August of 2005 (Figure 37). The first sampling site was near the dam in the area of the deepest part of the reservoir or Zmax. The Zmax site was used to determine average concentrations for the water body. At this location, the reservoir waters have had a chance to equilibrate and begin to function as a lake rather than like a river. The additional sampling location was established in the inlet arm of the reservoir. This location was used to understand the relative contribution from the two major inputs. The stream inputs from House Creek and Cedar Creek were assessed in the Cedar Creek Arm of the reservoir. The relative difference in chemical constituents between each site seemed to be very small throughout the sampling period. In order to determine if this was the case, a paired t-test analysis was conducted to test the null hypothesis.

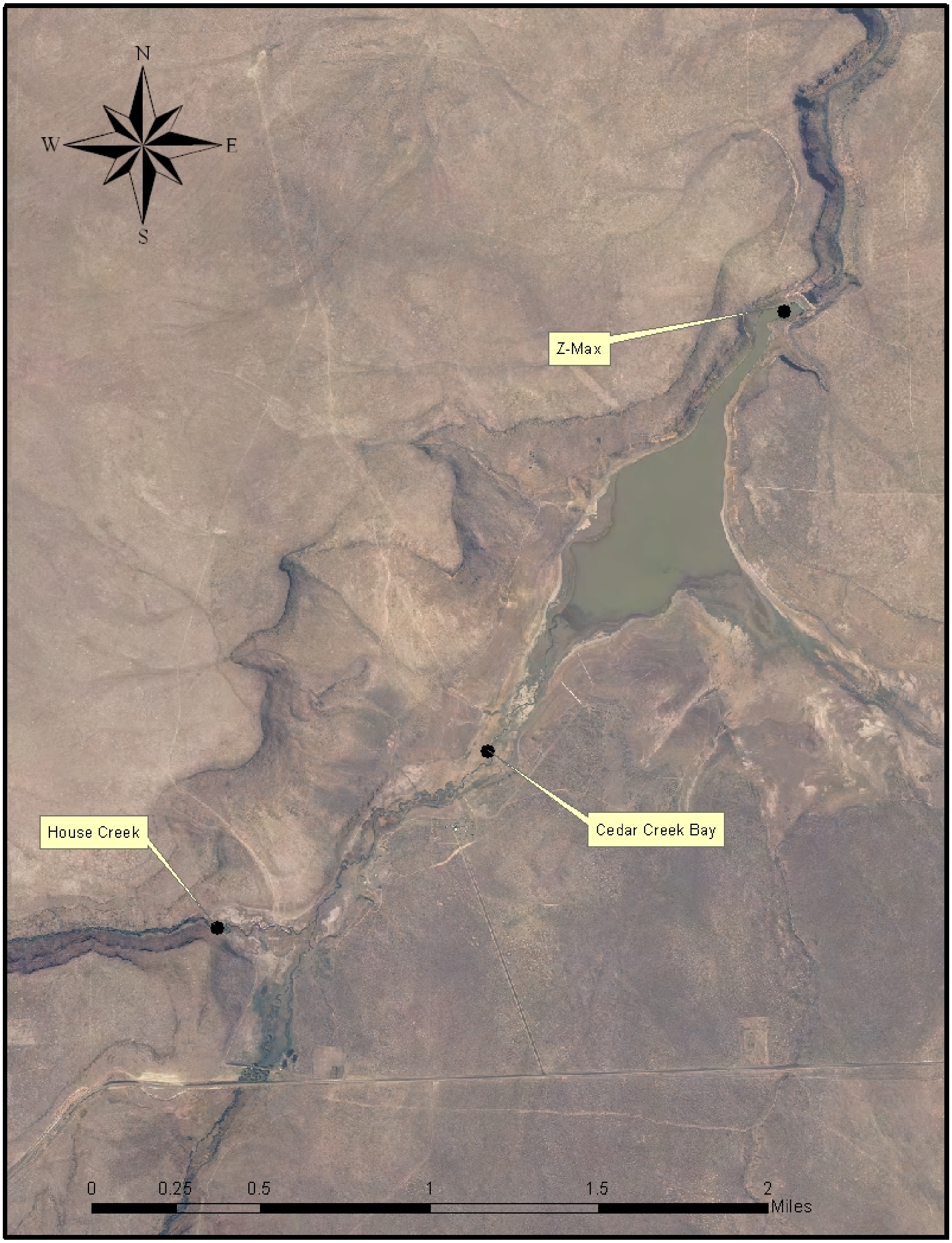


Figure 37. Cedar Creek Reservoir Monitoring Locations.

H_o: Cedar Creek arm = Zmax
H_a: Cedar Creek arm ≠ Zmax

The t-test for each constituent sampled was completed using Systat 12.0. For all constituents (TP, ammonia (NH_3), temperature, DO, and TSS) the null hypothesis was not rejected ($p>0.05$). For clarity then, the constituents from both locations can be pooled for discussion.

The levels of the measured constituents in Cedar Creek Reservoir are moderate to high. These levels in most all cases indicate lower assimilative capacity of the reservoir, compared to near-by reservoirs, as well as high use and higher degradation of water quality. The reservoir average TP concentration in Cedar Creek Reservoir was 0.102 mg/L for comparison, at Goose Creek Reservoir, a reservoir within the region with similar or higher land use within its watershed, TP concentrations averaged 0.035 mg/L at Zmax.

Carlson's Trophic State Index (TSI) can also be used to determine if nutrients are in excess. A TSI for TP score above 50 has been used in other states as a threshold for excess nutrients because a TSI of 50 corresponds with 0.024 mg/L of TP, 2 m Secchi, and 7.24 μg/L chlorophyll *a*. Based upon these numbers, Cedar Creek Reservoir exceeded the threshold value for TP at every sample date:

- Both sample locations exceeded the Secchi depth threshold throughout the summer. Average Secchi depth for the reservoir during the monitoring period was 1.14 m.

- Chlorophyll *a* was sampled only at Zmax. At that location, the TSI of 50 was almost always exceeded for that parameter.

Likely causes of the decreased transparency in the tributary bays are increased sediment load from the streams, with increased chlorophyll *a* due to the higher nutrient concentrations, or a combination of the two. Because chlorophyll *a* was not available from the bays, caution should be exercised in determining the root of the decreased transparency.

Overall, the reservoir average TSI scores were above the 50 threshold. Average TSI for the sample period was 60.28.

The TSI scores in a reservoir can be very complicated under severe drawdown events, which occur annually at Cedar Creek Reservoir. Phosphorus can be mobilized from the sediments in the deeper portions of the lake due to natural processes. When a lake is drawn down, this layer of water becomes mixed with the epilimnetic (and low TP) waters, enriching the system later in the year when it is typically poor in nutrients (Wetzel 1983). In addition, sediments rich in adsorbed TP can be remobilized as the waters recede (Wetzel 1983). Both of these situations likely occur in Cedar Creek Reservoir annually.

Further investigations are required to determine if there is a significant trend in TSI scores. However, it appears from, TSI scores for TN and TP, that the reservoir contains excess nutrients as the TSI scores were typically in the mid 60s to 70s, while Secchi scores were near 50. Thus, it is highly likely that nutrients are impairing the beneficial uses of the reservoir. The sources of nutrients within the reservoir are from the tributaries and internal load. Insufficient information is available at this time to calculate an areal, internal, load for the reservoir. Tributary loads for House Creek can be seen in Figure 38. DEQ assumes that the load for Cedar Creek is similar to that of House Creek.

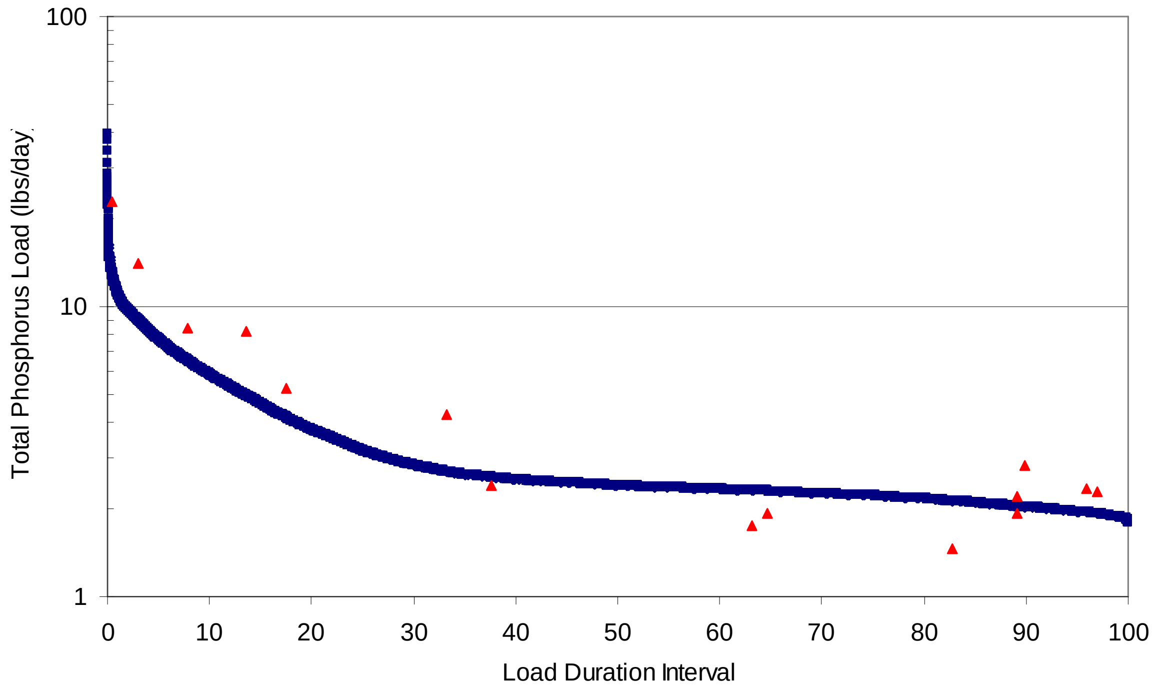


Figure 38. House Creek Total Phosphorus Load Duration Curve, Showing Observed Loads Entering Cedar Creek Reservoir.

Bacteria samples were collected near the more heavily used House Creek arm. This area is in close proximity to the boat ramp and one of the few access points to the water. Colonies of *E. coli* were seldom present in the samples, and, when they were, it was in very low numbers (2 col/100 ml).

Bacteria samples were also collected from House Creek to determine the bacterial concentration within this Assessment Unit (ID17040213SK005_02), which is listed for bacteria. No observed loads exceeded the bacteria load capacity of the system (Figure 39). Therefore, DEQ finds that House Creek, in addition to Cedar Creek Reservoir is not impaired by bacteria contamination.

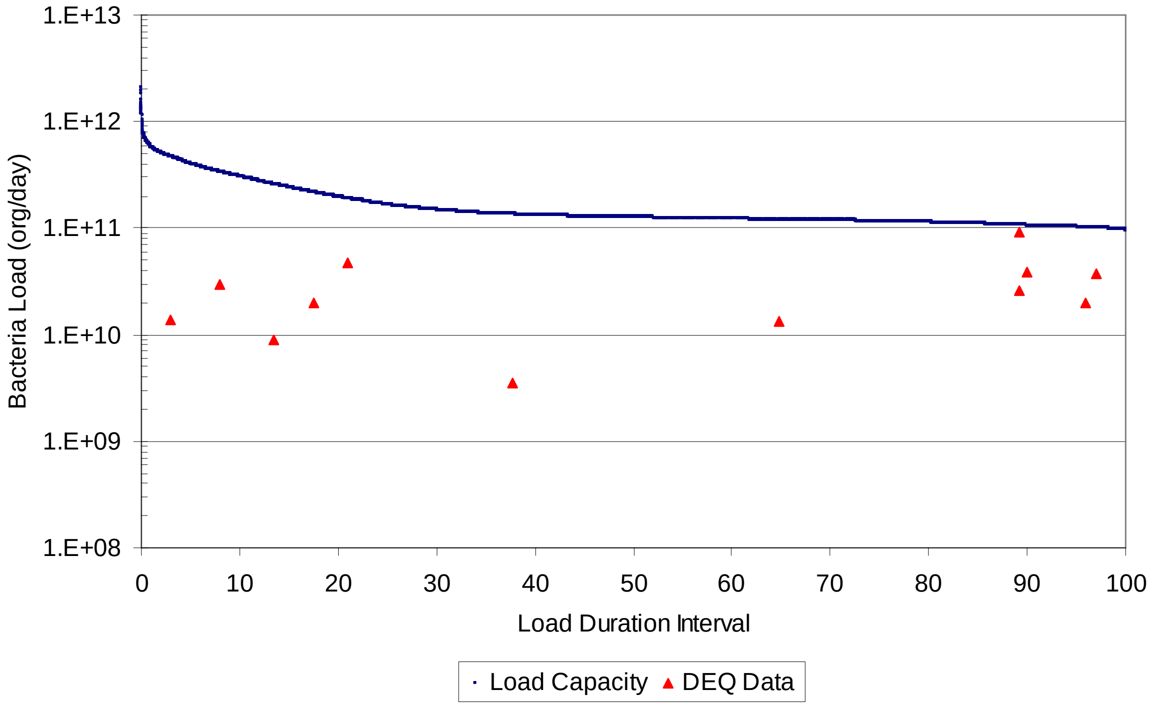


Figure 39. Observed Bacteria Load in House Creek, and Bacteria Load Capacity.

Temperature profiles were collected in 2005 (Zmax data presented in Figures 40 and 41) at the two reservoir locations. The reservoir appears to develop a weak stratification in early July, but this quickly breaks down, and the reservoir becomes isothermal throughout the summer. Due to the morphology of the reservoir and the extremes in drawdown seen annually, it is unlikely that the reservoir would remain stratified in most years.

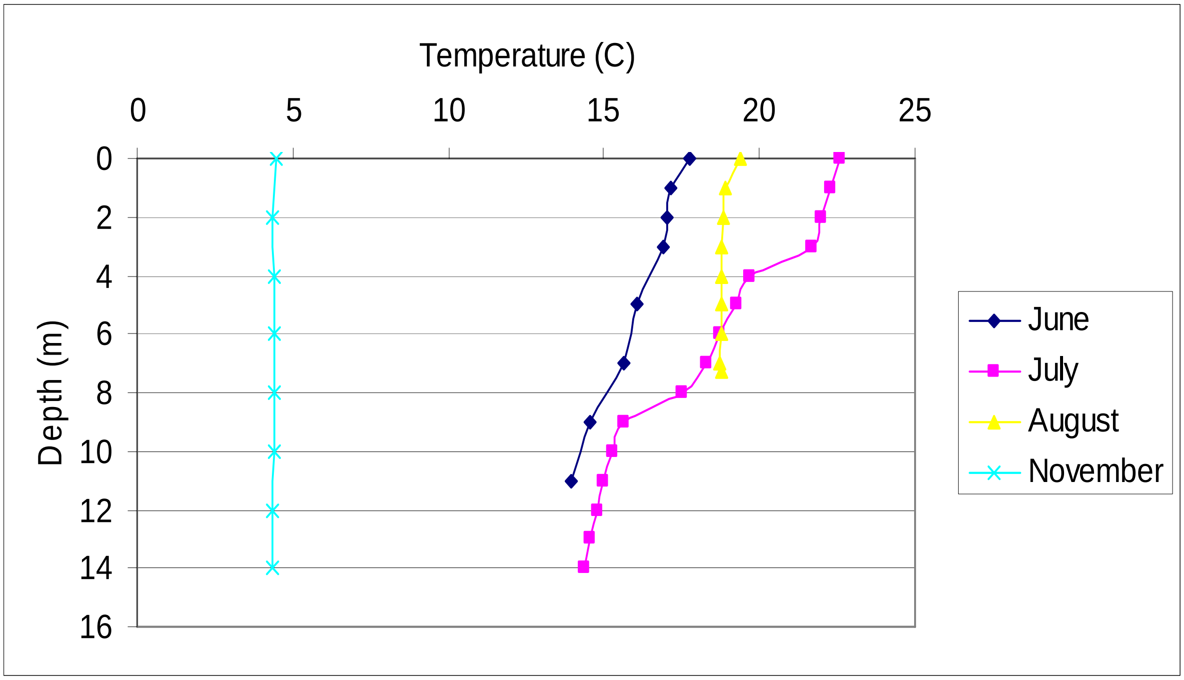


Figure 40. Temperature Profiles of Cedar Creek Reservoir.

Dissolved oxygen profiles were also collected along with the temperature profiles, and similar situations are observed. Although, during the early summer stratification period, DO levels were very low throughout the water column, oxygen depletion was noted throughout the water column, and almost complete oxygen depletion was seen near the sediment interface. The oxygen depletion became less evident as the year progressed, likely due to the reservoir becoming isothermal and increased oxygen production as the water column filled with the blue green algae.

Based upon the chlorophyll *a* concentrations and the early season oxygen depletion, DEQ has determined that excess aquatic growths are a regular occurrence in Cedar Creek Reservoir. Therefore, DEQ finds that Cedar Creek Reservoir is polluted with excess nutrients that lead to an increase in oxygen demanding materials.

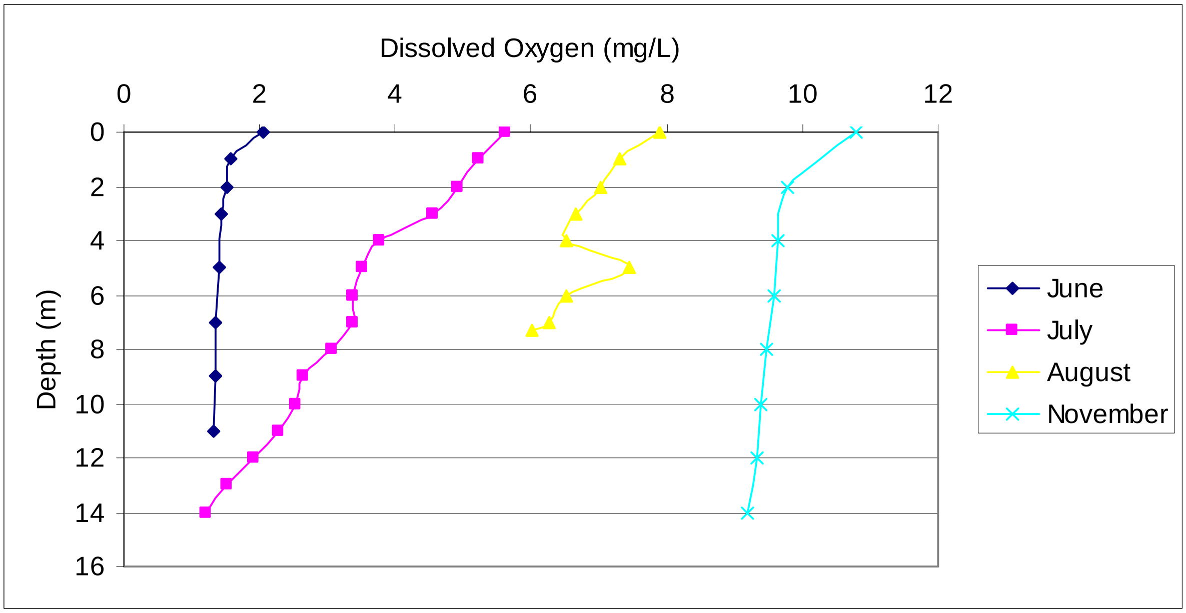


Figure 41. Dissolved Oxygen Profiles of Cedar Creek Reservoir.

Individually, TSI scores can give additional information when interpreting single constituents, but the determination of the overall trophic state should not be based upon a single component of the index. To better understand what is occurring within Cedar Creek Reservoir, the individual components of the TSI score will be presented here. (It should be recognized that the overall score is the basis for the water quality assessment.)

- Individually, the components of the overall TSI score indicate that Cedar Creek is a eutrophic reservoir. Much of the weight behind this determination is placed on the exceptionally high TP values: the TSI score based upon TP averaged 71.04.

- The average Secchi TSI score (58.71), however, is more indicative of a mesotrophic state. Likewise, the TSI based upon chlorophyll *a* is also much lower (52.47) in the main area of the lake than would be indicated solely by TP. Thus, it appears that TP may not influence the aquatic vegetation in Cedar Creek Reservoir as strongly as the TSI TP scores would seem to indicate.

- Furthermore, TN also appears to be near the eutrophic threshold of 50 (TN TSI averages 53.55). Thus, it can be seen the weight TSI-TP has in the overall average. Overall, TSI indicates that Cedar Creek Reservoir is a eutrophic reservoir. The TSI values also may provided an explanation of the near complete dominance of blue-green algae in the reservoir. While TP is elevated, nitrogen is very low in the system, allowing for the nitrogen fixing algae, such as the blue greens, to proliferate and dominate the system.

A certain tradeoff exists between fish production and water quality. Mesotrophic reservoirs are often seen as well balanced in terms of fish production and water quality. Therefore, mesotrophic lakes are viewed by many as the ideal target; hence, the many states and entities use a TSI target of 50 as their management goals. In more oligotrophic lakes, fish production is lower while water quality is higher.

The same tradeoff exists for eutrophic waters with higher fish production and lower water quality. However, often the fish production seen in eutrophic waters in the west is towards less desirable species of fishes, as the water quality is such that salmonids, the desirable species, are stressed by the higher temperatures or lower DO levels seen in eutrophic waters.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that rainbow trout have been stocked into Cedar Creek Reservoir since 1967. On rare occasions, other species, such as Coho, steelhead, or cutthroat trout have also been placed into the water body. Typically, one strain or another of rainbow trout are stocked each year (up to several times per year), ranging from fingerlings to catchable sizes. Therefore, DEQ assumes that any salmonids captured in Cedar Creek Reservoir are from stocked populations. However, no information was available concerning the population of game fishes. Idaho Department of Fish and Game management strategies for the reservoir over the past 10 years have been to maintain a general fishery when water was available. Therefore, no special regulations, such as slot limits, are in place.

Macroinvertebrates

DEQ collected macroinvertebrates in Cedar Creek Reservoir one time in 1997. Macroinvertebrates were collected in three general locations and pooled for analysis. The first location was near the boat launching area near the Cedar Creek and House Creek inlets, the second in the main bay of the reservoir, and the third was near the dam. Few macroinvertebrates were collected in the pooled samples.

Overall, the community consisted of chironomids and oligochaet worms, but an assessment of the water quality based on the macroinvertebrate community will not be completed. Statewide, there is a limited number of limnetic benthic samples, a lack of a reference communities for comparison, and a general shift towards lower trophic level analysis using Carlson’s trophic state index (TSI).

However, the macroinvertebrate community in Cedar Creek Reservoir appears similar in density and community composition to other eutrophic lakes and reservoirs. The predominance of very tolerant species of chironomids speaks to the overall nature of Cedar Creek reservoir with its large percent drawdown annually and overall morphology that assists in warming the water column and robbing the system of needed dissolved oxygen.

Aquatic Vegetation

Emergent aquatic vegetation, such as water smartweed (*Polygonum amphibium)* and pondweed (*Potomogeton amplifolius),* is noticeably lacking within the reservoir. It appears that the most significant primary production comes from algal cells within the reservoir. DEQ collected phytoplankton in 1997 to determine the composition of the algae in the reservoir, and at that time, the phytoplankton community consisted of two groups: cryptophyts, and blue-green algae.

Typically, blue-green algae dominate highly eutrophic systems. In Cedar Creek Reservoir, the blue-greens made up 98.25 percent of the biovolume, while cryptophyts made up the remainder of the biovolume.

As another indicator of trophic state, chlorophyll *a* samples were collected throughout the year to determine if nuisance conditions existed. For lakes, Carlson's TSI can be used to determine if a lake is undergoing cultural eutrophication. Utah Department of Environmental Quality has used a TSI score of 50 as a threshold value to indicate impaired water quality in many of the TMDLs completed for excess nutrients in lakes (UDEQ 2000). In order to reach a TSI of 50 for chlorophyll *a,* the concentration of chlorophyll *a* has to be higher that 7.25 μg/L. The samples collected from Cedar Creek Reservoir throughout the summer were all above this value, indicating nuisance aquatic vegetation growths (mean chl a = 8.75 μg/L). As such, it is likely that excessive nutrients are the factor affecting the beneficial uses of Cedar Creek Reservoir, in conjunction with flow alteration.

Bank Stability

See bank stability measures for upper Cedar Creek and House Creek Assessment Units.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

Cold Water Aquatic Life, and Primary Contact Recreation in Cedar Creek Reservoir have likely been moving towards *not full support* since 1910, following construction of the Cedar Creek Reservoir. This trend is likely the result of the reservoir acting as a nutrient sink from the upper watersheds. As a nutrient sink, the internal nutrient load eventually overcomes the relatively good water quality of the source streams, leading to the situation seen today.
In addition, the second biggest factor impacting the presumed uses within the system is flow alteration. The reservoir sees a significant portion of the reservoir volume removed to meet the irrigation demand flow during the irrigation season. Furthermore, sediment delivery from the upstream portions of the system is elevated and is likely impacting the beneficial uses of the reservoir with fine sediment while water is present within the system. However, this may

be a relatively minor consideration given the current hydrological constraints upon the system.

Conclusions

It appears, from the TSI data, that nutrients are outside the bounds of water quality determined to be supportive of the designated beneficial uses. Consequently, DEQ will complete a nutrient TMDL on the reservoir to address the nuisance aquatic vegetation and oxygen demanding materials that cause the very low DO found within the reservoir. Bank Stability sediment TMDLS will be completed in the source watersheds to address the sediment delivery issues while shade TMDLs in the sources watersheds will be completed to address the temperature-related issues within the reservoir.

Cottonwood Creek Assessment Units

Physical Characteristics

The Cottonwood Creek Assessment Units ID17040213SK015_02, and _03 includes the first, second, and third order tributaries and segments of Cottonwood Creek that originate in the eastern edge of the Shoshone basin and terminate at the confluence of Shoshone Creek. The assessment unit contains the perennial stream of Cottonwood Creek, as well as the intermittent streams of Langford Flat Creek, Sheep Spring Creek, Eagle Spring Creek, and Jack Diamond Creek. Only Cottonwood Creek sees any significant flow, and this is generally only during the early spring season when water is being delivered from the snowpack. For much of the year the stream is relatively small consisting of only a few cfs.

Flow Characteristics

Throughout Cottonwood Creek’s length, it flows through the Northern Basin and Range ecoregion. Along this course, several ephemeral and intermittent tributaries enter the system. Langford Flat and Eagle Spring Creek contribute a large amount of the discharge to the system during the spring time, while the other tributaries contribute discharge only marginally. The USGS has not operated a gauge located in the Cottonwood Creek Assessment Unit watershed. As a result, the hydrology of the system will be based upon discharge measurements collected by DEQ and other agencies and a relationship between these discharge measurements and the Salmon Falls Creek Gauge located near the town of Jackpot Nevada. The underlying assumption being that precipitation events across the subbasin would be similar within the smaller watershed of Cottonwood Creek and the much larger watershed of Salmon Falls Creek. See Figure 42 for calculated average monthly stream discharge.

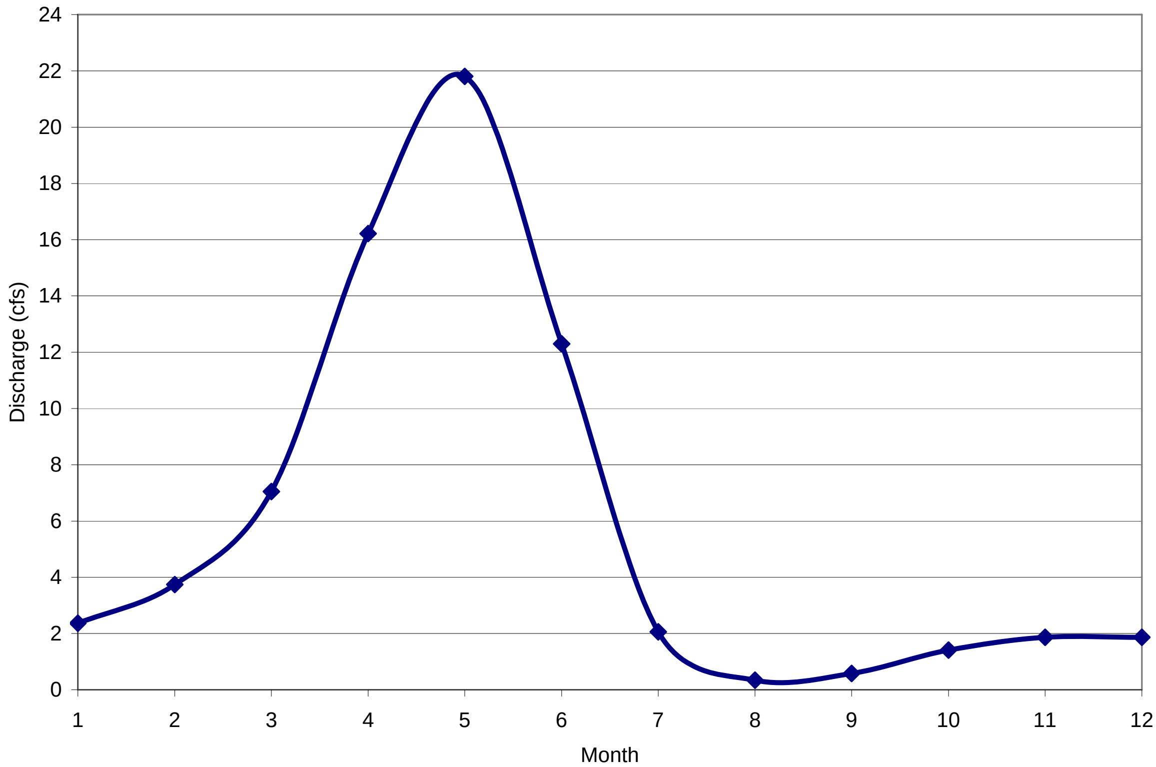


Figure 42. Predicted Monthly Average Discharge for Cottonwood Creek.

Based upon the gauge data relationship, an interpretation of hydrological events in Cottonwood Creek include extended periods of little or no flow throughout the length of Cottonwood Creek. This period ranges from August to the beginning of October, or 3 months. It is assumed that these conditions have existed throughout the period of record for the San Jacinto gauge data (1910 to date) and will likely continue to exist for the foreseeable future as land use within the Cottonwood watershed and the larger Salmon Falls Subbasin have not change dramatically. As a result of the extremes in flow conditions, brought about by the natural flow regime of the system, the existence of most beneficial uses is limited and will be assessed as an intermittent stream system. The extremes in flow are best depicted by a flow duration curve based upon the watershed ratio regression and the USGS daily flow data collected at the San Jacinto Gauge (Figure 43).

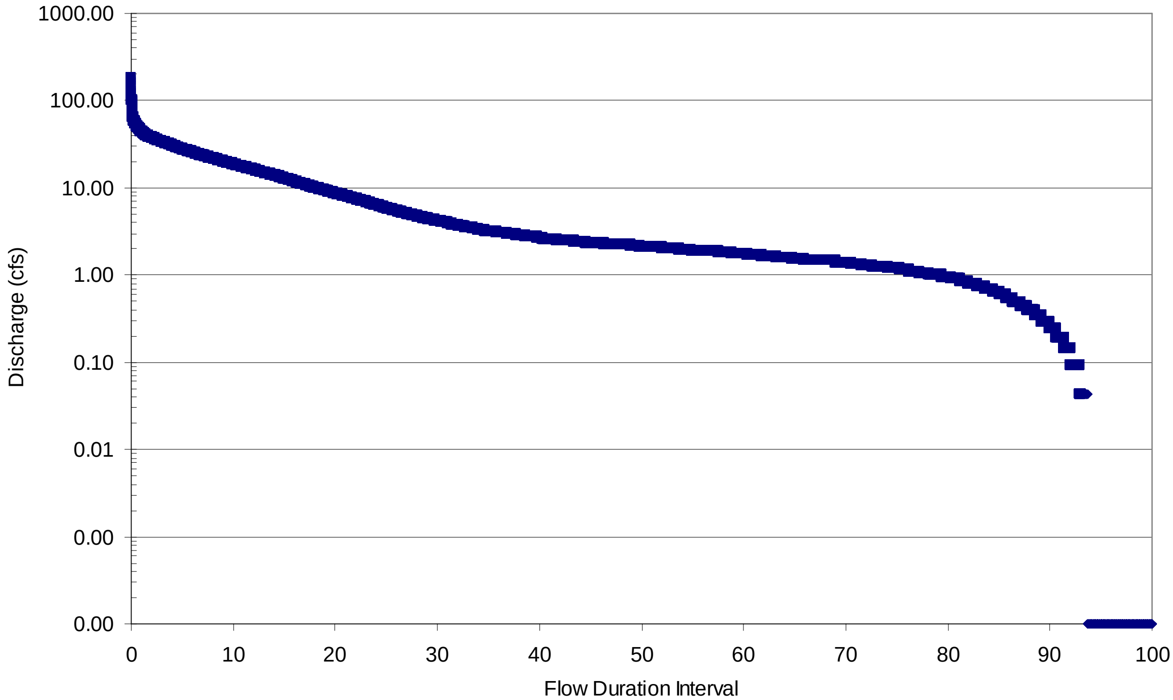


Figure 43. Cottonwood Creek Flow Duration Curve.

From the flow duration curve Cottonwood Creek is greater than 1 cfs 78.18 percent of the time. Median flow in Cottonwood Creek is 2.11 cfs.

Water Column Data

Water quality samples containing a full suite of constituents collected within the listed segments of Cottonwood Creek are rare. No samples were recorded in the EPA's STORET database. The Idaho Association of Soil Conservation Districts has sampled in the creek at various times in the years of 2000, 2001, and 2005. DEQ collected samples in an upper location in 2005-2006. The sample locations for the Idaho Association of Soil Conservation Districts (IASCD) and DEQ are shown in Figure 44.

However, due to the limited number of sampling periods in the data sets, DEQ's confidence in monthly average concentrations is low. The lack of a robust data set was due to limited budgets and, in part, by a limited time frame for collecting data. In most cases, one sample was the most collected in any given month. Infrequently, multiple samples were collected for any given month. This sampling design was intended to determine annual load.

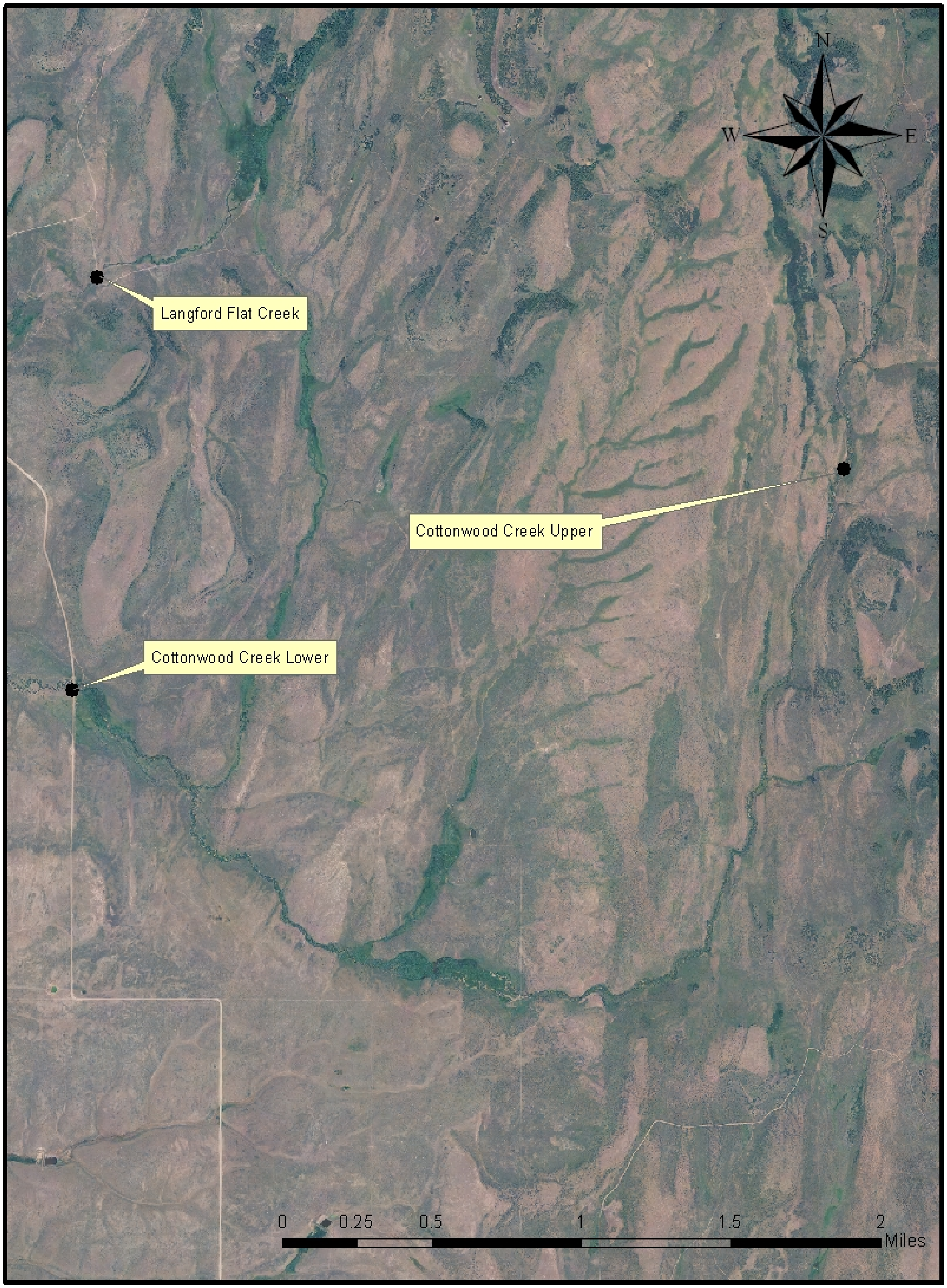


Figure 44. Cottonwood Creek Monitoring Locations.

The annual load estimated by this type of design would overestimate the annual load by 25 to 50 percent (Robertson and Richards 2000). To assist in the determination of seasonal components and appropriate critical conditions, the data will be presented as load duration curves in the following figures, while period of record averages are presented in the text and used for any future load calculations. For those cases when a parameter was below detection limits, half the detection limit was used to calculate the monthly average and as part of the period of record average.

The DEQ sampling at the upper Cottonwood Creek location began in May 2005. The site was used to determine concentrations and loads for the stream from the upstream forested portion of the watershed. An additional site in the downstream, private/rangeland, segments of the river was sampled by the IASCD to determine net change. The lower site was used to determine the concentrations and loads due to activities along the listed reach.

At the lower sampling location, the effects of land uses can be seen in the slightly elevated levels of the measured constituents in comparison to those levels measured at the upper location. These increases, in most cases, are of a small magnitude, indicating similar or slightly higher use and degradation, and few were significantly different ($p>0.05$). For example, SSC in upper Cottonwood Creek averages 6.2 mg/L, while at the lower site the SSC average was 11.6 mg/L.

Total phosphorus increased as well, although less dramatically than did suspended sediments. At the upper Cottonwood Creek site the average TP concentration was 0.044 mg/L, while at the lower site the average TP concentration was 0.064 mg/L average. However at most times TSS and TP concentrations were below target levels (50 mg/L and 0.1 mg/L, respectively) set in other TMDLs (Lay 2000, Lay 2001). The chemical constituents at both sites seemed to be similar throughout the sampling period. In order to determine if this was the case, a two-sample t-test was conducted to test the null hypothesis.

H_o: Cottonwood Creek Lower Mean = Cottonwood Creek Upper Mean.
H_a: Cottonwood Creek Lower Mean ≠ Cottonwood Creek Upper Mean.

Each constituent sampled at the two locations was tested using Systat 7.0. For most constituents the null hypothesis was not rejected ($p>0.05$). However, dissolved oxygen percent saturation and specific conductivity were significantly different from upstream to downstream ($p< 0.05$). Therefore, the null hypothesis was rejected in these cases.

The downstream sample location was directly downstream from a large culvert with an approximate drop to the water surface of four feet, while the upper location was located in a more typical riffle-run habitat. The difference between the two sites may simply be a matter of oxygen entrainment into the water column from the plunge into the pool below the culvert. However, the DO at neither site fell below levels indicative of water quality impairment.

Dissolved oxygen is often used in conjunction with pH to determine if excess nutrients have caused nuisance aquatic growths. DEQ had determined that excess aquatic growths have not occurred in Cottonwood Creek during the sampling periods. The DO and pH data support this contention. Therefore, DEQ finds that Cottonwood Creek is not polluted with oxygen demanding materials.

Concentrations of TP were indicative of excess nutrients that may cause impairment (nuisance aquatic vegetation). The guideline value that DEQ used to develop the load duration capacity was 0.100 mg/L TP. The guideline was often exceeded at the lower sample location, as shown in Figure 45. However, a general lack of aquatic vegetation has been noted within the system. Therefore, DEQ concludes that a TMDL for nutrients may be warranted for Cottonwood Creek.

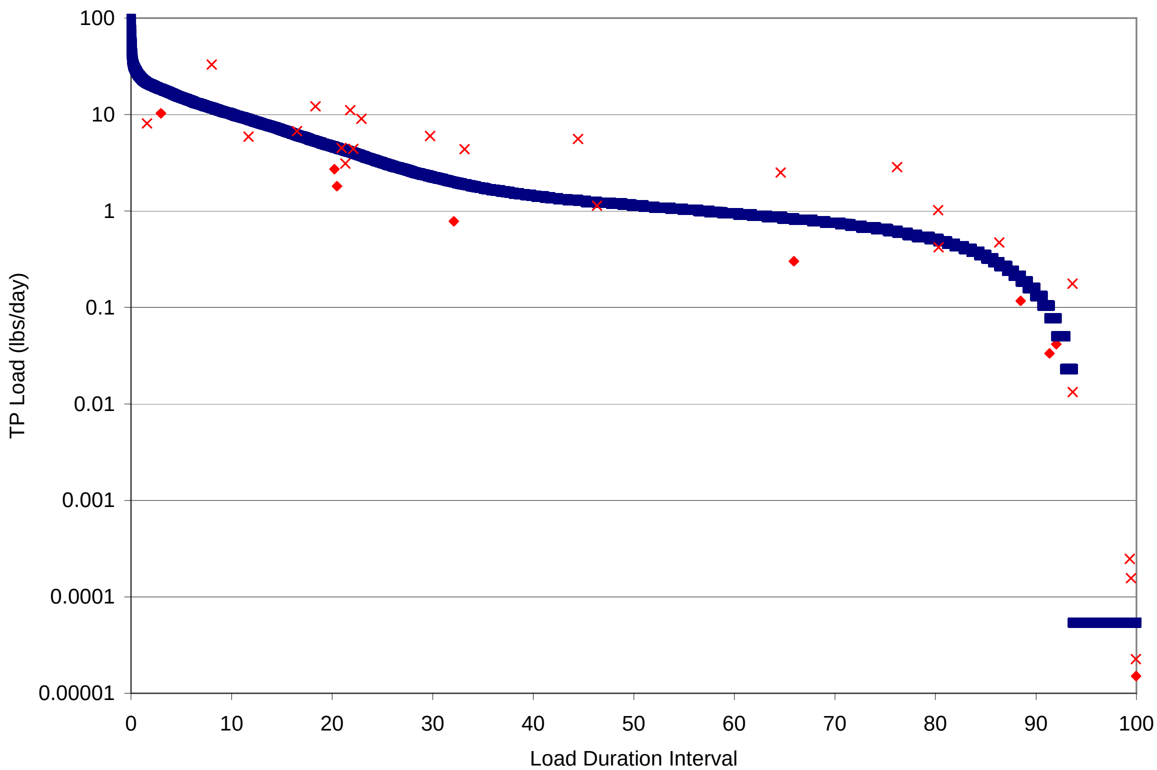


Figure 45. Cottonwood Creek Total Phosphorus Load Duration Curve, Showing Upper (■) and Lower (x) Sample Location Differences.

Instantaneous temperature measures were also collected in Cottonwood Creek. In the IASCD data set, 25 percent of instantaneous temperature samples exceeded water quality standards. These exceedances began as early as May, but were more typical in July as the stream began to go dry. However, in the upper reaches of the stream no exceedances of temperature criteria were noted. Temperature is likely an issue in Cottonwood Creek due to decreased flow and poor shade components shielding the stream from solar radiation.

Bacteria samples were also collected with the water chemistry samples. Multiple samples collected at lower Cottonwood Creek indicated significant bacteria contamination (>700 col/100 ml). Bacteria concentrations were slightly elevated in the mid range flow conditions and increased dramatically as the summer progressed and flow conditions entered the dry and low flow periods (Figure 46). Therefore, DEQ concludes that bacteria do impair the beneficial uses of the lower segment of Cottonwood Creek, as seen by the IASCD data set. Similar events occurred in the upper portion of the watershed as well, with bacteria elevated above standards in the summer, although not above the single sample maximum of 576 col/100ml.

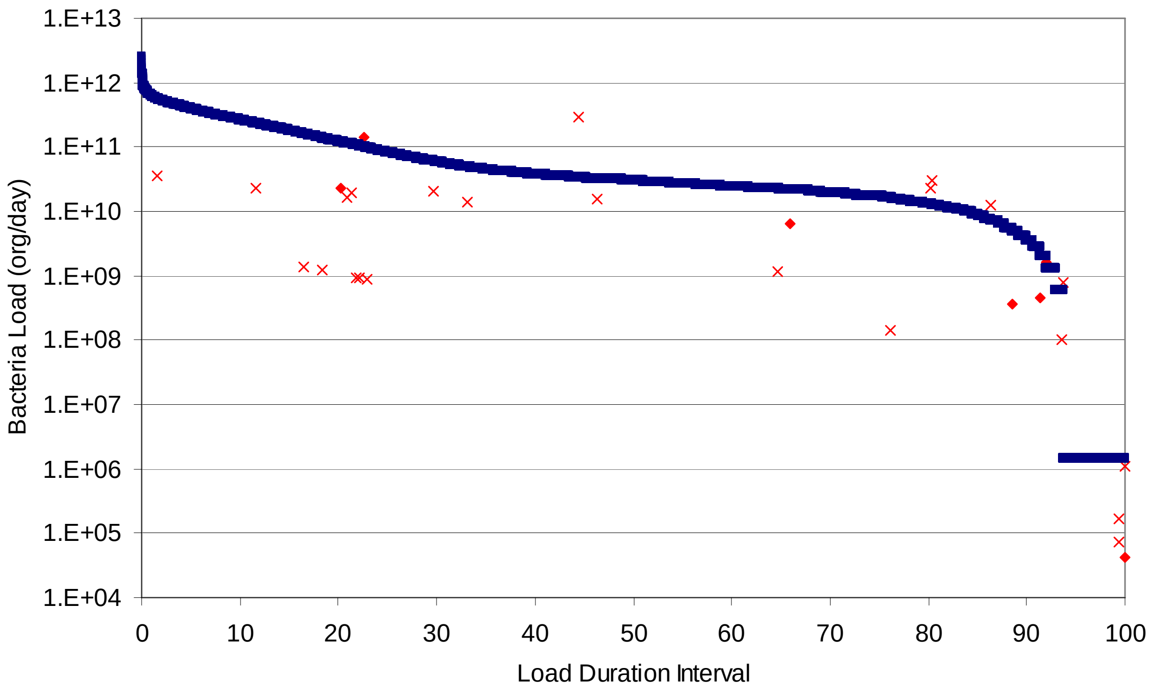


Figure 46. Cottonwood Creek Bacteria Load Duration Curve, Showing Upper (■) and Lower (x) Sample Location Differences.

From both the IASCD and DEQ data sets, total suspended sediment appears to be a non-factor effecting beneficial uses (Figure 47). However, given the continued drought cycles in which water levels were diminished throughout the region, much of the sediment stored in the system was never transported out of the reach as a suspended load. In a higher water year, the data from the suspended fraction may support the contention that a sediment TMDL is required. However, DEQ is constrained to complete a TMDL for Cottonwood Creek with the data at hand.

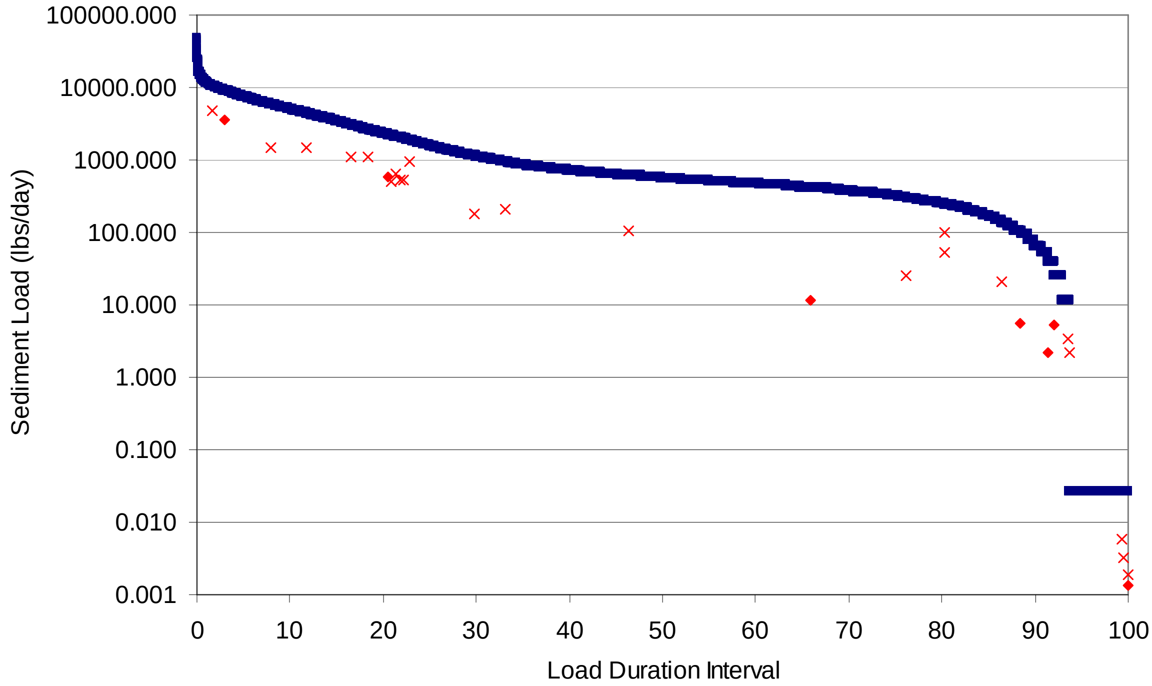


Figure 47. Cottonwood Creek Sediment Load Duration Curve, Showing Upper (x) and Lower (■) Sampling Location Differences.

Due to DEQ's limited sampling for suspended sediments in the Cottonwood Creek system, additional measures were taken to determine if other forms of sediment were impairing the beneficial uses. From DEQ's sampling regime, it was determined that the suspended fraction of the sediment load was not impairing the beneficial uses. Therefore, a series of McNeil cores for depth-fines were collected in the upper section of the river to determine if bedload sediment was impairing beneficial uses.

The McNeil sediment core samples were collected to describe size composition of bottom materials in potential salmonid spawning beds of the Cottonwood Creek watershed. The McNeil sampling method was developed to determine the amount of fine sediment in spawning gravels for fish habitat studies in wadeable streams (Bunte and Abt 2001). In order to determine support of salmonid spawning beneficial use, DEQ defines the term "fine" as particles less than 0.25 inches (6.3 mm) in diameter. These particles would pass through a 0.25-inch mesh sieve. In common usage, these particles would be termed as silt, sand, or very small gravels.

Sites were selected in appropriate potential spawning habitat determined according to gravel size, depth, and velocity as identified by an experienced fisheries biologist. The sites were located below pools, just downstream of a pool tailout area.

A 12-inch diameter cylinder was worked into the substrate of the stream. The bottom material are dug by hand to a depth of four to six inches into the substrate without breaking the seal of the cylinder with the stream's substrate. The sample was then placed wet into a stack of sieves, and washed and shaken to divide the sample into particle size classes. Nine sieves were stacked in descending size classes from 63 mm to 53 µm. Silt passing the finest sieve was discarded, since this size of material would be removed through the physical action of building a redd for spawning. The volume of solids retained by each sieve was measured using a water displacement method. The solids retained by each sieve is poured into a water-filled heavy bucket with a spigot near the top. A graduated cylinder was placed under the spigot where displaced water pours out of the bucket. The volume of water displaced was recorded to determine the volume of solids retained in that particular sieve size.

The percent fines are computed for size distributions after subtracting the large particle sizes for 63 mm (2.5 inches) and greater. This is so that the percent fines are not affected by the presence of a few larger particles (Bunte and Abt 2001). If a large cobble were added to a sample, it could be 20% of the sample mass, and the percent fines would be smaller than if the large cobble were removed. Three sediment core samples were collected and the particle sizes are analyzed in two groups: 6.3 mm and greater; and 4.75 mm to 0.53 mm. The result for a site equals the volume of particles in the 4.75 to 0.53 mm group expressed as a percentage of the total sample. Each of the three samples are averaged for an overall percentage of fine sediment for the site.

The Cottonwood Creek percent depth fines ranged from 25.4 to 48.9 percent of the total volume. The overall average depth fines in Cottonwood Creek was 36.4 percent, which is well above the 28 percent depth fines target established to be protective of salmonid spawning in other Idaho TMDLS.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that trout have not been stocked in Cottonwood Creek since 1967. Nor has IDFG surveyed the fishery in Cottonwood Creek. Therefore, DEQ assumes that any salmonids captured in Cottonwood Creek are from wild or naturalized populations. The naturalized populations may be from fish stockings that have occurred historically in Shoshone Creek.

DEQ electrofished Cottonwood Creek once in the past (July 1995). At that time, DEQ collected redside shiner, speckled dace and sculpin. No salmonids were captured. The BURP site where the fish data was collected was located in the upper reaches of Cottonwood Creek.

Macroinvertebrates

DEQ has collected macroinvertebrates in Cottonwood Creek five times. Macroinvertebrates were collected once in 1995, 1996, and three times in 2002. The macroinvertebrate community represented in these temporally different scales indicate that the cold water aquatic life is of mixed support status. The lowest site sampled was near Sheep Springs which was sampled in 1996 and again in 2002. The macroinvertebrate scores from these two events are widely different in both index scores and flow regime at the sampling event.

Under high flow conditions in 1996 the macroinvertebrates were below threshold values of support, while at near zero flow the index scores were well above fully support levels with a condition rating score of three. In almost all cases the intermittent nature of Cottonwood Creek best explains the extreme variation in macroinvertebrate abundance and species composition as well as, ultimately, the index scores.

Aquatic Vegetation

The lack of aquatic vegetation was noted in many reaches of Cottonwood Creek. However, estimations of the coverage of aquatic vegetation were limited due to poor access of the creek. At those locations where the creek could be accessed, aquatic plant communities were never excessively abundant. In some cases, the community consisted of periphyton film on the cobbles in the streambed. A few chlorophyll *a* samples were collected during the peak of the summer growing period to determine if nuisance conditions existed. The samples collected was well below 15 μg/L value suggested to indicate nuisance aquatic vegetation growths. This is likely the result of much of the aquatic vegetation consisting of epilithic periphyton and mainly diatoms rather than filamentous growths seen in degraded reaches. The sample values confirms the beneficial use assessments based upon the previous sections discussion of nutrients, fisheries, and macroinvertebrate communities.

Bank Stability

Bank stability measures were collected at two locations within the Cottonwood Creek system. The first of these was upstream near Sheep Springs and the second was down stream from the Shoshone Basin Road. In the upper 8.7 miles of the system measured bank stability averaged 84 percent. Stream erosion and recession rate estimates indicate that this portion of the stream is not contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected, it is estimated that only 26.24 tons of sediment per year is delivered to the downstream reach—slightly under the proposed sediment delivery rate of 31.92 tons per year.

Bank stability measures collected in the lower 1.9 miles also indicate that bank sediment is being delivered to the Shoshone Creek system through the Cottonwood Creek channel. Bank stability in this region averages 37 percent with a higher bank recession rate due to a lack of appropriate bank cover vegetation holding the banks together. Based upon the bank stability measures and recession rate information collected it is estimated that nearly 800 tons of sediment per year are being mobilized through the Cottonwood Creek channel—well over the target sediment delivery of 113 tons per year.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

The above data suggest that existing beneficial uses of Cottonwood Creek, coldwater aquatic life, and secondary contact recreation, are impacted to varying degrees by several different pollutants. The biggest factor impacting the presumed uses within the system is the intermittent flow regime of the system. This flow regime may be the root cause or it may simply exacerbate the issues by impacting the riparian zone along the system.

Along with a poorly developed riparian zone, are bank destabilization and increased nutrient and sediment delivery as seen in the lower reach of the system. Again, this may be the result of the intermittent hydrology of the system or it may be a result of heavier rangeland activities occurring along the lower reach as evidenced by the increased bacterial contamination seen at the IASCD monitoring location.

Conclusions

TMDLs for nutrients, sediment, bacteria, and temperature will be developed for Cottonwood Creek.

Hot Creek Assessment Units

Physical Characteristics

The Hot Creek Assessment Units ID17040213SK012_02, and _03 includes the first, second, and third order tributaries and segments of Hot Creek that originate in the eastern edge of the Shoshone basin and terminate at the confluence of Shoshone Creek. The assessment unit contains the perennial stream of Hot Creek, as well as the intermittent stream Horse Creek. Only Hot Creek sees any significant flow. For much of the year the stream is relatively small consisting of only a few cfs. Generally, the stream does not receive early spring season flow increase when water is typically being delivered from the snowpack due to its small low elevation watershed. The contributing watershed area for Hot Creek is 57 $miles^2$, while the total length of the stream from the Hot Creek Spring in Nevada to the confluence of Shoshone Creek, Idaho is 6.4 miles. Hot Creek originates in Nevada flows for approximately 1.8 miles before it enters Idaho, it then flows for 0.9 miles in Idaho before entering Nevada again for a short distance (0.4 mile). Finally, Hot Creek flows for the remainder of the time in Idaho, 1.7 km, where it reaches its confluence with Shoshone Creek.

Flow Characteristics

Throughout Hot Creek's length, it flows through the Northern Basin and Range ecoregion. Along this course, the Horse Creek intermittent tributary enters the system and minimally adds flow to the system. Although most of the flow from Horse Creek is captured in a small reservoir upstream of the Hot Creek Confluence The USGS has not operated a gauge located in the Hot Creek Assessment Unit watershed. As a result, the hydrology of the system will be based upon discharge measurements collected by DEQ and other agencies and a relationship between these discharge measurements and the Salmon Falls Creek Gauge located near the town of Jackpot Nevada. The underlying assumption being that precipitation events across the subbasin would be similar within the smaller watershed of Hot Creek and the much larger watershed of Salmon Falls Creek. See Figure 48 for the predicted monthly average stream discharge.

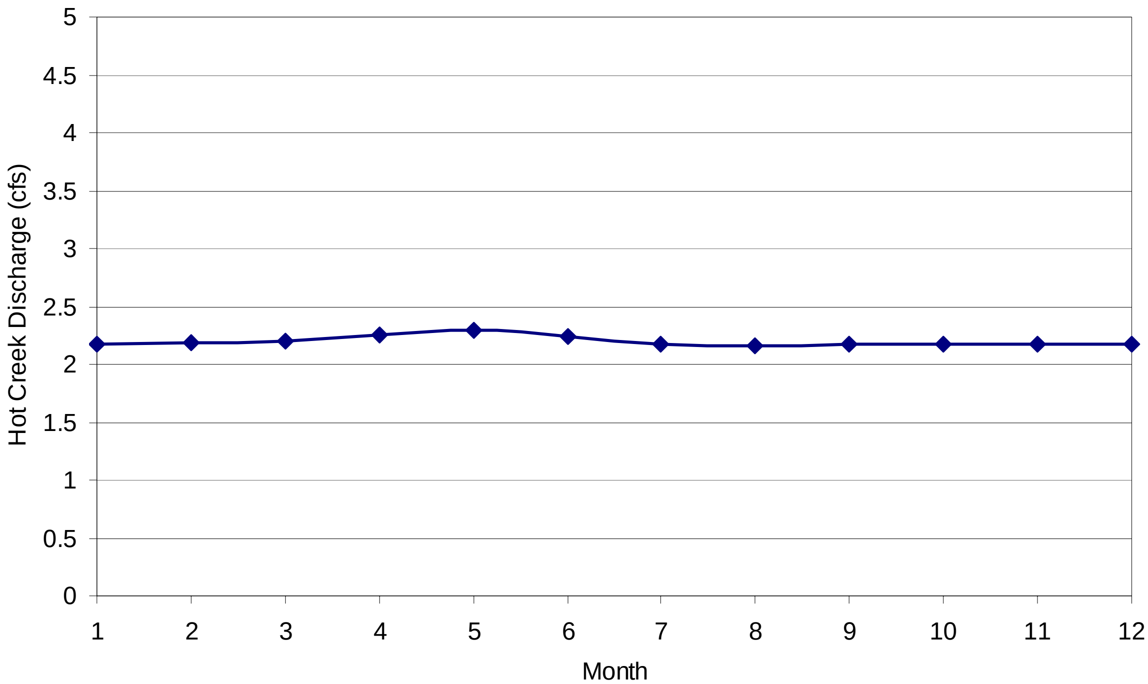


Figure 48. Hot Creek Predicted Monthly Average Discharge.

Based upon the gauge data relationship an interpretation of hydrological events in Hot Creek include a nearly constant discharge of 2 cfs throughout the length of Hot Creek with little or no spring runoff associated with snowpack or rainfall events. It is assumed that the conditions that the relationship is derived from have existed throughout the period of record for the San Jacinto gauge data (1910 to date) and will likely continue to exist for the foreseeable future as land use within the Hot Creek watershed and the larger Salmon Falls Subbasin have not change dramatically.

Water Column Data

Water quality samples containing a full suite of constituents collected within the listed segments of Hot Creek are rare. No samples were recorded in the EPA's STORET database.

IASCD has sampled in the creek at various times in the years of 2000, 2001, and 2005, and DEQ collected samples in an upper location in 2005-2006. However, due to the limited number of sampling periods in the data sets, DEQ's confidence in monthly average concentrations is low. The lack of a robust data set was due to limited budgets and in part by a limited time frame for collecting data. In most cases one sample was the most collected in any given month. Infrequently, multiple samples were collected for any given month. This sampling design was intended to determine annual load. The annual load estimated by this type of design would over estimate the annual load by 25 to 50 percent (Robertson and Richards 2000). To assist in the determination of seasonal components and appropriate critical conditions, the data will be presented as load duration in the following figures while period of record averages are presented in the text, and used for any future load calculations. For those cases when a parameter was below detection limits, half the detection limit was used to calculate the monthly average and as part of the period of record average.

The DEQ sample location was set up on Hot Creek sampling began in May 2005 (Figure 49). The site was used to determine concentrations and loads for the stream from a upstream location nearest the springhead. An additional site in the downstream, private/rangeland, segments of the river was sampled by the IASCD to determine net change. The lower site was used to determine the concentrations and loads due to activities along the listed reach.

At the lower sampling location, the effects of land uses can be seen in the slightly elevated levels of the measured constituents in comparison to those levels measured at the upper location. These increases in most all cases are of a small magnitude, indicating similar or slightly higher use and degradation, and few were significantly different ($p>0.05$). For example, SSC in upper Hot Creek averages 4.66 mg/L, while at the lower site the SSC average was 14.05 mg/L. Total phosphorus increased as well, although less dramatically than did suspended sediments. At the upper Hot Creek site the average TP concentration was 0.012 mg/L, while at the lower site the average TP concentration was 0.07 mg/L average. However at most times TSS and TP concentrations were below target levels (50 mg/L and 0.1mg/L, respectively) set in other TMDLs (Lay 2000, Lay 2001). The chemical constituents at both sites seemed to be similar throughout the sampling period. In order to determine if this was the case, a two-sample t-test was conducted to test the null hypothesis.

H_o: Hot Creek Lower Mean = Hot Creek Upper Mean.
H_a: Hot Creek Lower Mean ≠ Hot Creek Upper Mean.

Each constituent sampled at the two locations was tested using Systat 7.0. For most constituents the null hypothesis was not rejected ($p>0.05$). However, as mentioned above SSC and TP were significantly different from upstream to downstream ($p< 0.05$). Therefore, the null hypothesis was rejected in these cases. In addition, temperature and DO were also significantly different upstream from downstream ($p< 0.05$).

The temperature of the stream showed a pronounced cooling from the thermal spring to the confluence with Shoshone Creek. Average temperatures at the spring were near 23.46 °C while at the confluence temperature had dropped to 16.48 °C. Dissolved oxygen also increased from upstream to downstream, although percent saturation was not significantly different. Thus, the likely reason for the increased DO was cooling of the water, allowing high concentrations to be carried.

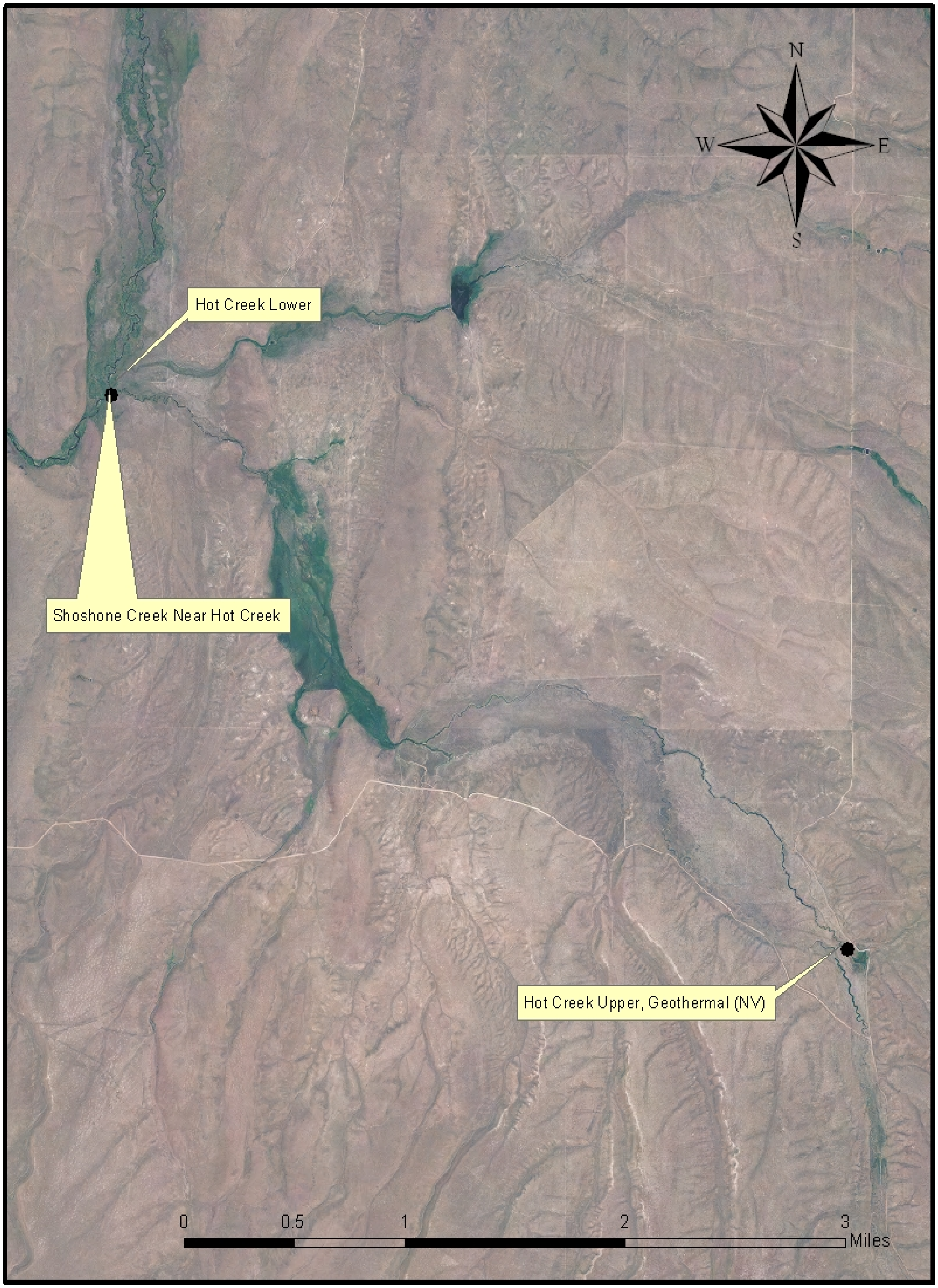


Figure 49. Hot Creek Monitoring Locations.

The DO at neither site was below levels indicative of water quality impairment (Figure 50). On a load duration curve, those data points that plot below the curve are considered exceedance of the water quality criteria. In this case, 6.0 mg/L DO water quality standard. As can be seen very few data are less than 6 mg/L. Dissolved oxygen is often used in conjunction with pH to determine if excess nutrients have caused nuisance aquatic growths. DEQ had determined that excess aquatic growths have not occurred in Hot Creek during the sampling periods. The DO and pH data support this contention. Therefore, DEQ finds that Hot Creek is not polluted with oxygen-demanding materials.

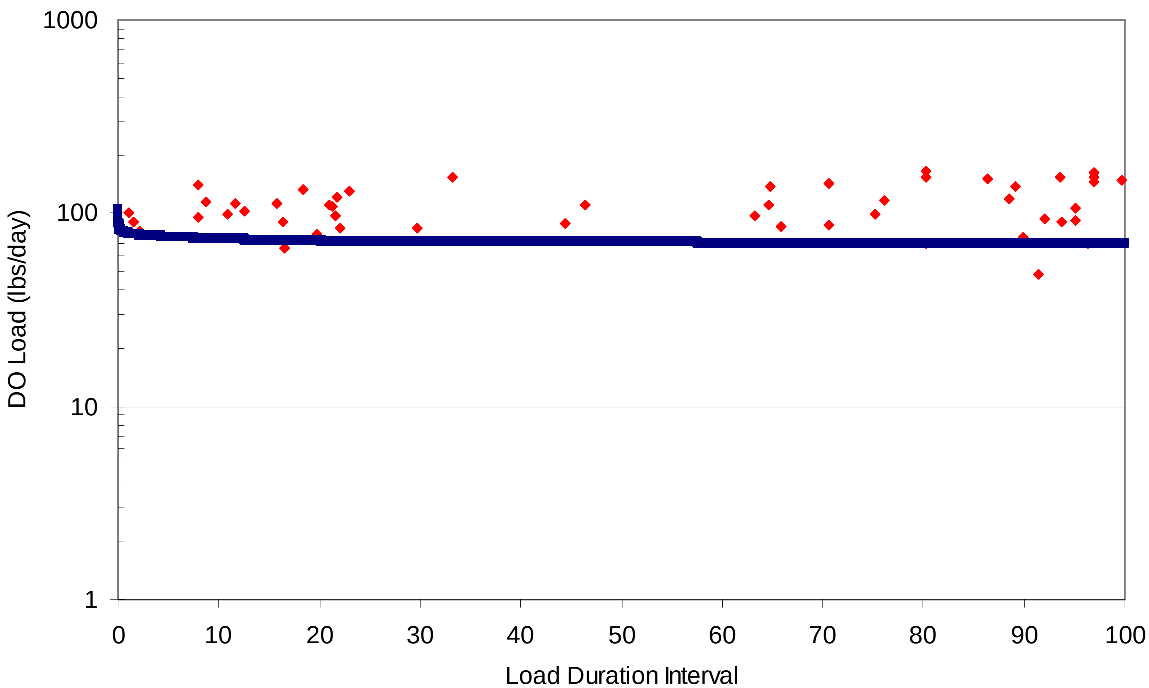


Figure 50. Hot Creek Dissolved Oxygen Load Duration Curve.

Monthly concentrations of TP also were not indicative of excess nutrients that may cause impairment (nuisance aquatic vegetation). The guideline value that DEQ used to determine the load duration curve was 0.100 mg/L TP. The daily and monthly guidelines were exceeded at the lower sample location in May of 2005 under high flow conditions for the system. (Figure 51). However, a general lack of aquatic vegetation has been noted within the system and the overall period of record average for Hot Creek was 0.041 mg/L. Therefore, DEQ concludes that a TMDL for nutrients is not warranted for Hot Creek.

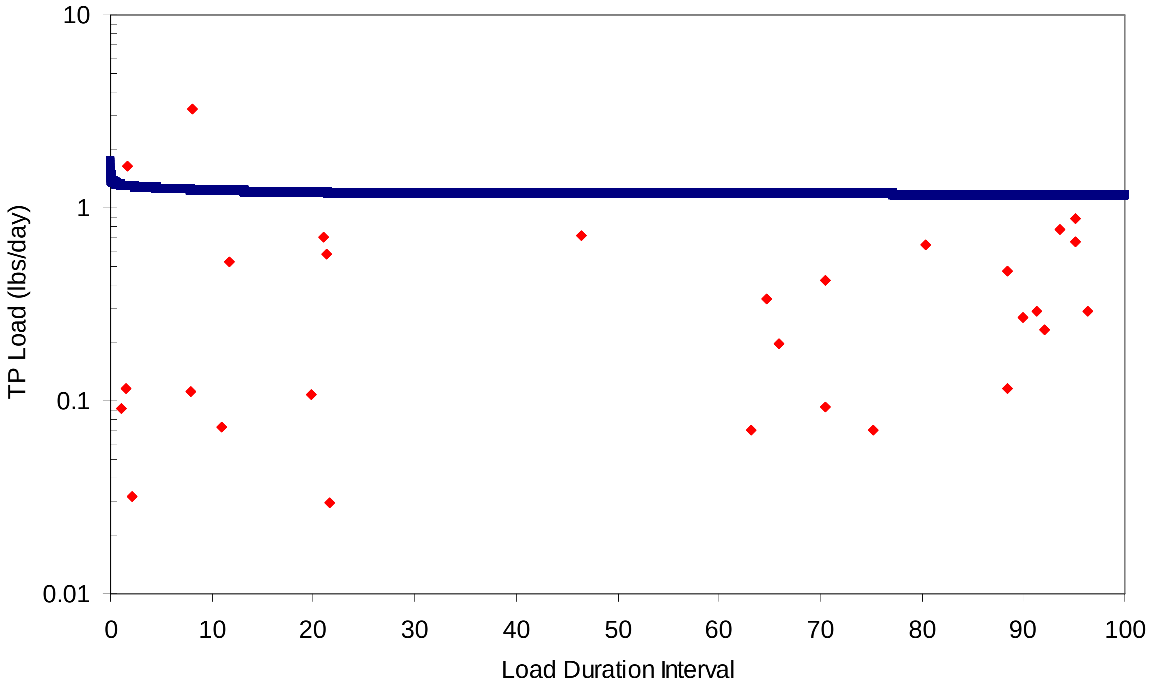


Figure 51. Hot Creek Total Phosphorus Load Duration Curve.

Instantaneous temperature measures were also collected in Hot Creek. In the IASCD data set, 6 percent of instantaneous temperature samples exceeded water quality standards of 22 °C, while at the upper location almost 85 percent of the data exceeded this value as the water came from the ground. However, as this is a geothermal spring system, coldwater aquatic life temperature standards should not be applied. The warm water temperature criterion of 33 °C was never exceeded in the upper reaches.

Bacteria samples were also collected with the water chemistry samples. One sample collected at lower Hot Creek indicated significant bacteria contamination (580 col/100 ml). In the upper reach, bacteria concentrations were very elevated in the mid to late summer and decreased dramatically as the summer progressed (Figure 52). Therefore, DEQ concludes that bacteria impair the beneficial uses of the upper segment of Hot Creek in Nevada, but are not widespread as seen by the IASCD data set. The bacteria contamination is likely due to numerous cattle congregating around the spring during the months of July and August. Simple BMP application near the spring should alleviate this issue.

From both the IASCD and DEQ data sets, total suspended sediment also appears to be a non-factor effecting beneficial uses (Figure 53). However, given the continued drought cycles and the hydrological regime of the system much of the sediment stored in the system was never transported out of the reach as a suspended load. In a higher water year, the data from the suspended fraction may support the contention that a sediment TMDL is required. However, sediment storage within small watershed spring systems is a normal and natural process.

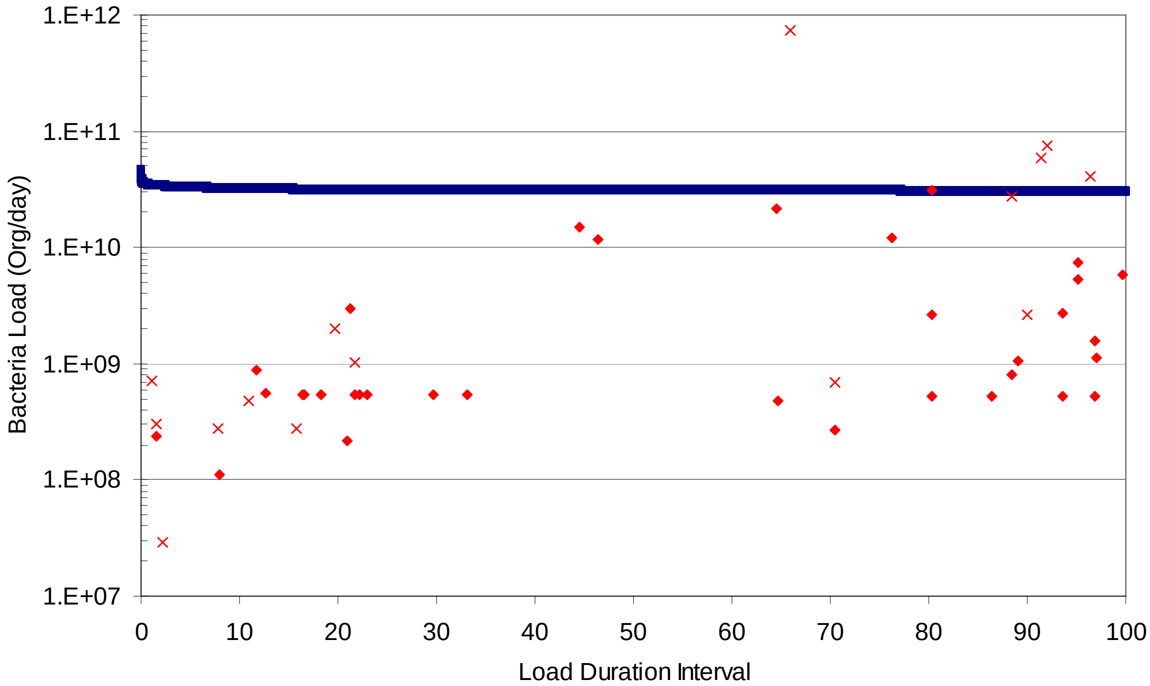


Figure 52. Hot Creek Bacteria Load Duration Curve, Showing the Nevada Location Data (x) and the Lower Idaho Location Data (■).

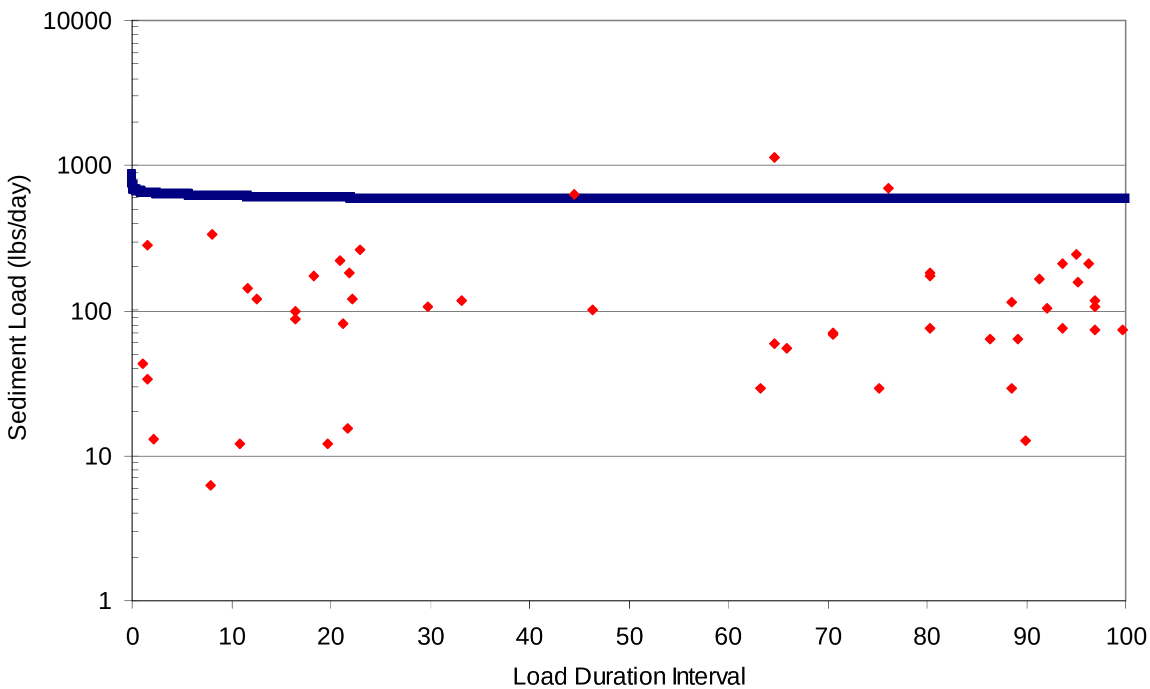


Figure 53. Hot Creek Sediment Load Duration Curve.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that brown trout have been stocked in Hot Creek beginning in 1973 and continuing until 1989. The IDFG surveyed the fishery in Hot Creek in 1988 to determine the survival of stocked brown trout. Five hatchery brown trout were collected in a 200 m reach near the confluence with Shoshone Creek. brown trout stockings were curtailed due to low survival rates in both Shoshone Creek and Hot Creek.

DEQ has electrofished Hot Creek twice, once in 1996 and again in 2002. In those events, DEQ collected redside shiner, speckled dace, suckers, pike minnows and sculpin. No salmonids were captured. The electrofishing locations were near the confluence with Shoshone Creek and in the upper reach near the spring source.

Salmonid spawning does not appear to be an existing beneficial use in Hot Creek since 1973 or earlier.

Macroinvertebrates

DEQ has collected macroinvertebrates in Hot Creek four times. Macroinvertebrates were collected twice in 1996, and once each in 1998 and 2002. The macroinvertebrate community represented by these temporally different collection events indicate that the cold water aquatic life is of mixed support status. Most of the sampling was completed near the confluence of Shoshone Creek, which was sampled in 1996, 1998, and again in 2002. The macroinvertebrate scores from these three events were very similar in both index scores and flow regime at the sampling event. The macroinvertebrates were well below threshold values of support. In almost all cases, the warm water and spring fed nature of Hot Creek best explains the extreme low values in macroinvertebrate indices. In addition, no obligate cold water taxa were collected in Hot Creek, further bolstering the conclusion that Hot Creek is a warm water system and should be assessed as so.

Aquatic Vegetation

An abundance of aquatic vegetation has been noted in many reaches of Hot Creek, even though estimations of the coverage of aquatic vegetation were limited due to poor access of the creek. At those locations where the creek could be accessed, aquatic plant communities were never excessively abundant. In some cases, the community consisted of filamentous algae typically associated with spring fed low gradient systems. A few sestonic chlorophyll *a* samples were collected during the peak of the summer growing period to determine if nuisance conditions existed. The samples collected averaged 5.26 µg/L of chlorophyll *a*, which is well below the 15 µg/L value suggested to indicate nuisance aquatic vegetation growths. The sample values confirm the beneficial use assessments and warm water nature of the system based upon the previous sections discussion of nutrients, fisheries, and macroinvertebrate communities.

Bank Stability

Bank stability measures were collected at two locations within the Hot Creek system. The first of these was near the Shoshone Creek confluence and the second was upstream in the reach where Hot Creek is again in Idaho. In the upper 3.2 miles of the system, measured bank stability averaged 69.63 percent. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 38.01 tons of sediment per year is delivered to the downstream reach—slightly over the proposed sediment delivery rate of 25.03 tons per year.

Bank stability measures collected in the lower 3.2 miles also indicate that excessive bank sediment is not being delivered to the Shoshone Creek system through the Hot Creek channel. Bank stability in this region averages 87.86 percent. Based upon the bank stability measures and recession rate information collected it is estimated that nearly 16.16 tons of sediment per year are being mobilized through the Hot Creek channel in this reach. The target or proposed sediment delivery for this reach is of 26.62 tons per year. Overall Hot Creek would require a 4.66 percent reduction in sediment to meet existing criteria and targets. This reduction would need to occur in the upper Idaho and Nevada portions of the system.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

The above data suggest that existing beneficial uses of Hot Creek, warm water aquatic life, and secondary contact recreation, are impacted to varying degrees by several different pollutants. A factor impacting the presumed uses within the system is the relatively constant flow regime of the system with limited seasonal flushes to mobilize accumulated sediments and scour out the filamentous algae communities. Additionally localized bacterial contamination is seen in the upper, Nevada, reaches of the system, which may impact secondary contact recreation ther, but this is not the general case for much of the system and maybe readily resolved.

Conclusions

Sediment and bacteria issues in the Nevada portion of the system should be addressed, but water quality criteria and beneficial uses in the lower Idaho portion of the system are being met or are fully supporting warm water aquatic life and secondary contact recreation.

Lower Salmon Falls Creek Assessment Units

Physical Characteristics

The Lower Salmon Falls Creek Assessment Unit ID17040213SK001_06 includes the sixth order segment of Salmon Falls Creek that begins at the confluence with Devil Creek and terminates at the confluence of the Snake River. Throughout Lower Salmon Falls Creek's length, it flows through the Snake River Plain ecoregion.

The assessment unit contains the five perennial streams identified from the NHD ArcGis coverage, as well as up to 32 additional ephemeral channels, seeps, and irrigation returns. Most of these seeps and irrigation return channels (29) are located on the eastern side of the Salmon Falls Creek canyon. The remaining seven are found on the western side.

The east-west bias is most easily explained as a function of irrigation source water. Salmon Falls Creek forms the western terminus of the Twin Falls Canal Company which uses irrigation water withdrawn from the Snake River at Milner Dam while the lands on the western side of the canyon are irrigated with water pumped up from Salmon Falls Creek. The numbers of drains and irrigation returns are simply an expression of the volume of water from each source. These drains, seeps, returns, and springs may constitute a significant source of discharge to the system on an annual basis, and may be a significant source of pollutants such as nutrients and sediment as well.

Salmon Falls Creek receives little if any spring runoff discharge from the upper watershed as a result of the construction of Salmon Falls Creek Reservoir.

To date the reservoir has spilled once, in 1984, since its completion in the early 1900s. Leakage from the dam and spring systems are the only available waters left to recharge the system. Discharge measurements collected below the dam average 7 to 10 cfs. Discharge directly below the dam is somewhat dependant upon reservoir storage. As a result of the mixed sources of water entering into Salmon Falls Creek and the presence of the dam, it is impractical to calculate a contributing watershed area as it has little to do with the current hydrology of the system.

The total length of the stream from the confluence with the Snake River to Devil Creek is 20.8 miles. Salmon Falls Creek continues another 27.7 miles to the dam that forms Salmon Falls Creek Reservoir.

Flow Characteristics

The USGS has operated a gauge on Salmon Falls Creek located near Hagerman Idaho close to the confluence with the Snake River. As a result, the hydrology of the system will be based upon discharge measurements collected the USGS. See Figure 54 for monthly average stream discharge. See Figure 55 for flow duration curve based upon the period of record daily discharge measured at the USGS gauge.

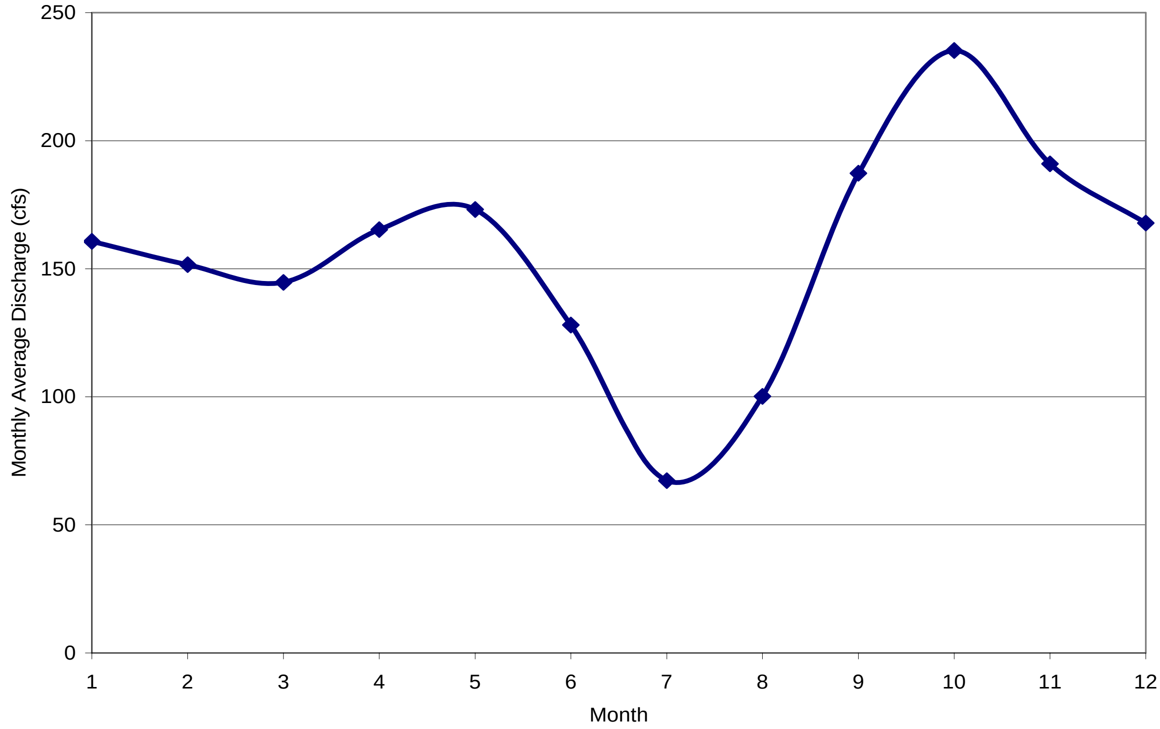


Figure 54. Lower Salmon Falls Creek Monthly Average Discharge.

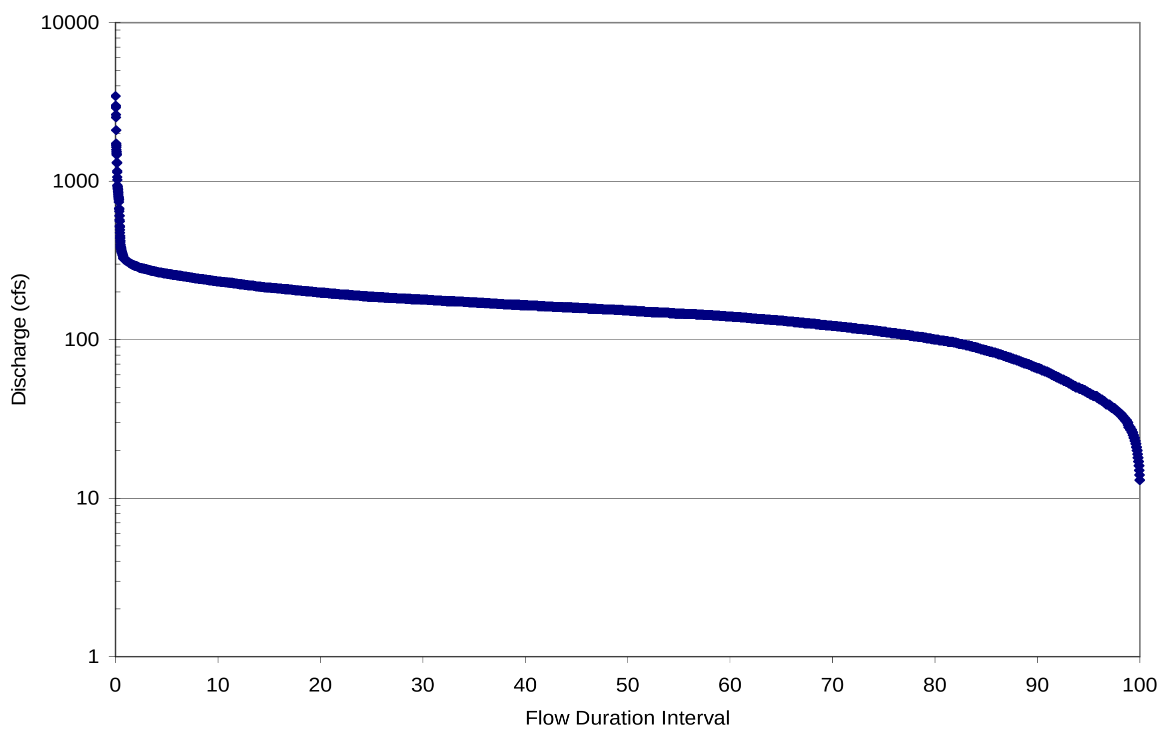


Figure 55. Lower Salmon Falls Creek Flow Duration Curve.

An interpretation of hydrological events in Lower Salmon Falls Creek, based upon the gauge data, include a median base flow discharge of 150 cfs. Most of the base flow is derived from near-by spring sources. Very high flood events are uncommon in this system, as it has been cut off from the upper watershed by the reservoir. Seasonally, the hydrograph shows the effects land use and irrigation practices on the surrounding farm lands, most of which are outside of the subbasin.

The base flow of 150 cfs continues through the winter months with slight increases during spring runoff from what is left of the connected watershed, but this is nowhere near as dramatic as in the unregulated upper watershed (i.e. Salmon Falls Upper annual average hydrograph). Beginning in May, irrigation water is pumped from the river to irrigate some of the surrounding farmlands, causing a dramatic decrease in stream flows, which reach minimum average flows of 67 cfs in July. As growing season comes to a close and irrigation needs are decreasing, excess water from the Twin Falls irrigation system spills into the river increasing the flow in Salmon Falls Creek. These increases tend to peak in October, just before the Twin Falls system shuts down for the season. In the following months, the stream then returns to base flow conditions near 150 cfs again.

As can be seen from the flow duration curve, events over 280 cfs occur in less than three percent of the daily flow data while events greater than 500 cfs occur in less than half a percent. Very low flow events are also uncommon in this portion of Salmon Falls Creek. Flows greater than 67 cfs are seen approximately 90 percent of the time while flows greater than 46 cfs are seen 95 percent of the time.

Water Column Data

The Lower Salmon Falls Creek system is replete with water quality samples. The USGS has collected samples from near the gauge for a number of years as has the DEQ. Additionally, IASCD has collected samples from the Balanced Rock and Lily Grade areas for TMDL support, shown in Figure 56. To assist in the determination of seasonal components and appropriate critical conditions, the data will be presented as load duration curves. For those cases when a parameter was below detection limits, half the detection limit was used in any calculation.

The primary DEQ and USGS sampling location was near the confluence with the Snake River at the USGS gauge 13108150 with DEQ sampling occurring between July 1992 and September 1997 and USGS sampling coving from 1965 to 1993. However, not all parameters are continuous throughout both data sets. Additionally, the site was used to determine concentrations and loads for the Salmon Falls Creek contribution to the Snake River in the Upper Snake Rock TMDL.

Load allocations for Sediment and TP were determined to be 5,966.6 tons/year for sediment and 80.5 lbs/day for TP. However, as a TMDL for the Salmon Falls Creek watershed was scheduled for completion after the Upper Snake Rock TMDL, therefore the load allocations in that document were set at the existing load of the Salmon Falls Creek system. Further reductions for the Salmon Falls Creek system may be warranted based upon the water quality and support status of the beneficial uses of Salmon Falls Creek.

Instantaneous temperature recorded by the USGS and DEQ provide a clear picture of the temperature regime of the system. Of the 423 temperature measures recorded, 22 °C was exceeded four times or approximately one percent of the time. These exceedances typically occurred in the mid to late summer but only in a few years (1975, 1986, 1988, and 1992). Mean summer (June-August) temperatures from the USGS and DEQ data sets were 18.29 and 18.16 °C respectively. Mean winter temperatures recorded from the two data sets were 6.22 and 7.21 °C which indicate a predominance of groundwater in the makeup of the stream discharge.

Dissolved oxygen at the sampling location also provides a very clear water quality picture when both data sets are considered. A load duration curve was developed to better understand the seasonality of the data and to more clearly see how the older USGS data compares with the DEQ data set. Development of the load duration curve consisted of using the flow duration FDI as the independent x-axis and DO load (in lbs per day) on the dependant y-axis. The dissolved oxygen load capacity was calculated from the 6 mg/L cold water aquatic life standard, the daily average flow recorded at the USGS gauge, and a conversion factor of 5.39. Instantaneous DO measures were also converted to load using the same process.

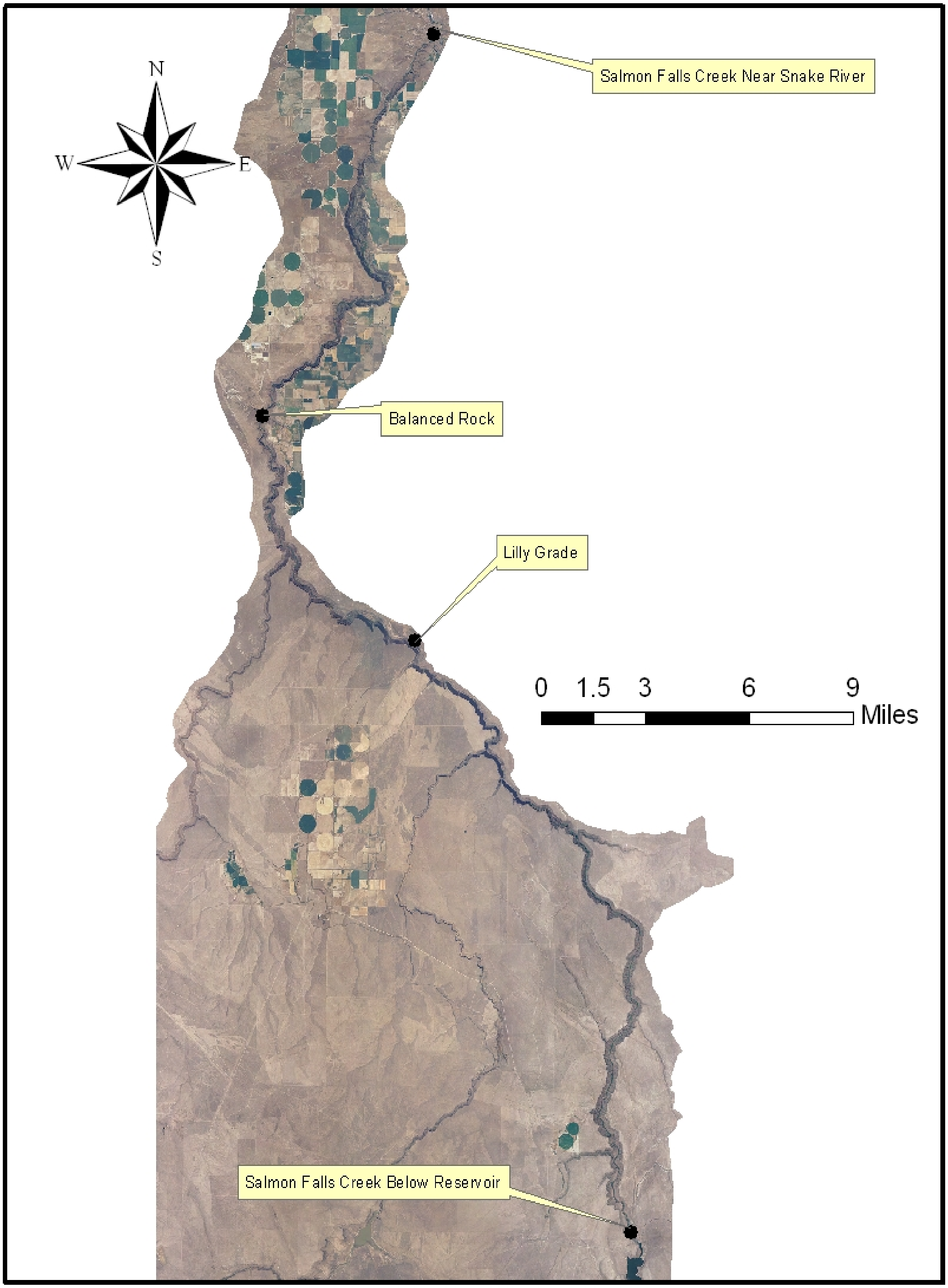


Figure 56. Salmon Falls Creek Lower Monitoring Locations.

In setting up the load duration curve in this manner, data points that fall below the load duration curve are considered exceedances of the water quality standard while those that plot above the line do not. As can be seen from the load duration curve for oxygen (Figure 57) all of the DEQ data plot well above the criterion as do the much older USGS data.

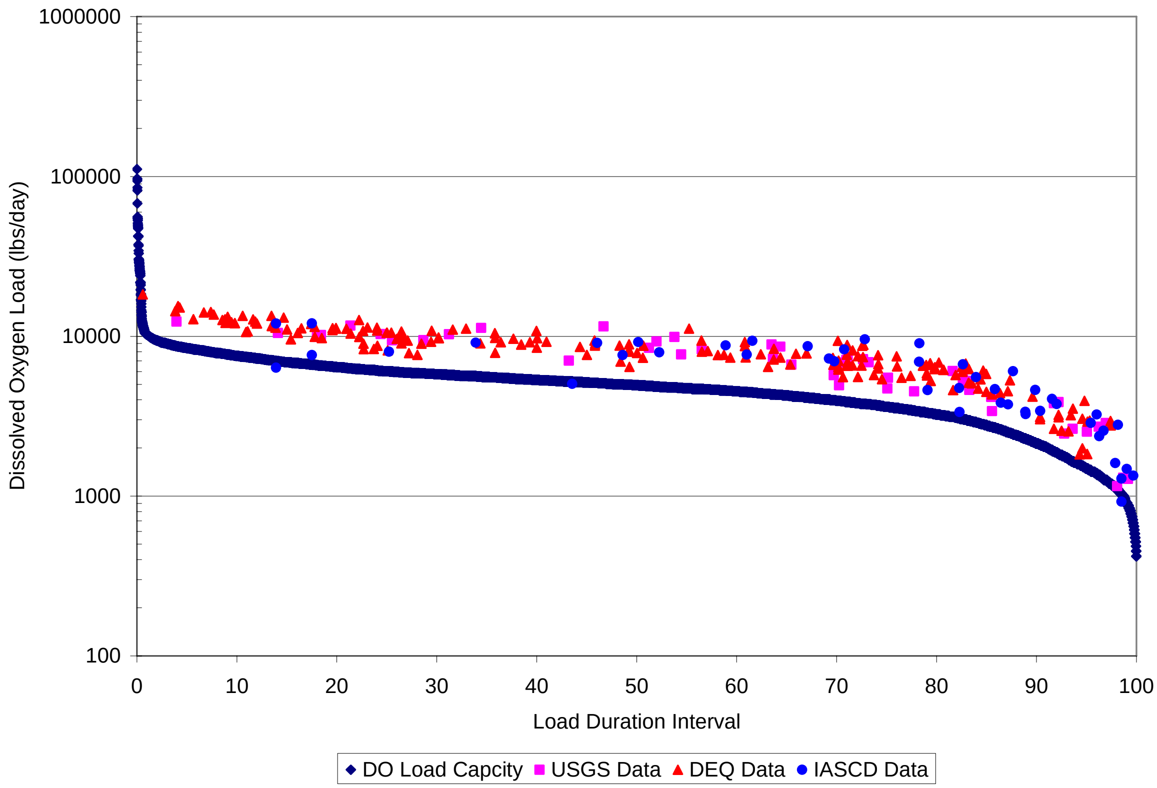


Figure 57. Lower Salmon Falls Creek Dissolved Oxygen Load Duration Curve.

Although temperature and DO seem to indicate that the beneficial uses should be fully supported within the lower Salmon Falls system, nutrient concentrations and loads paint a drastically different picture. Salmon Falls Creek flows through or forms the western edge of the Twin Falls groundwater nitrate priority area. This area has been identified as an aquifer that is contaminated with elevated levels of nitrate pollution. As discussed above, Salmon Falls Creek receives a very high proportion of its discharge from spring sources located along the listed stream course. Many of these springs are conduits from the nitrate priority area aquifer. As would be expected, the TN found within Salmon Falls Creek is elevated in comparison with upstream surface water driven systems. For example, average TN in the upper watershed is 0.389 mg/L while in the lower watershed average TN is 2.964 mg/L.

The total nitrogen load duration curves illustrate the magnitude and potential sources of the problem readily. The TN load duration curve was developed in a similar fashion as the DO load duration curve. The assessment criterion used in this case was 1.5 mg/L TN. This criterion has been used in many nutrient TMDLs as an indicator of excess nutrients that would lead to nuisance aquatic growth. As can be seen from the load duration curve (Figure 58) almost all data points plot well above the load capacity curve. The lone exception is a single USGS data point that is abnormally low. Data collected prior to and following this sampling event seem to indicate that this data is actually a transcription error.

In addition to all the data plotting well above the load capacity curve the seasonality and relative constant nature of the existing loads regardless of the magnitude of the flow in the system seems to indicate a rather constant and large percentage of the TN is coming from the source water of the system. In this case the majority of the source water is discharge from springs. The other two sources of water into the system include the limited spring runoff from what is left of the connected watershed and agriculture return flows (see annual average hydrograph Figure 54). Neither of these two sources would be considered consistent nor constant. Which indicates that the nitrate source is likely the groundwater entering the system which appears to be very consistent and constant.

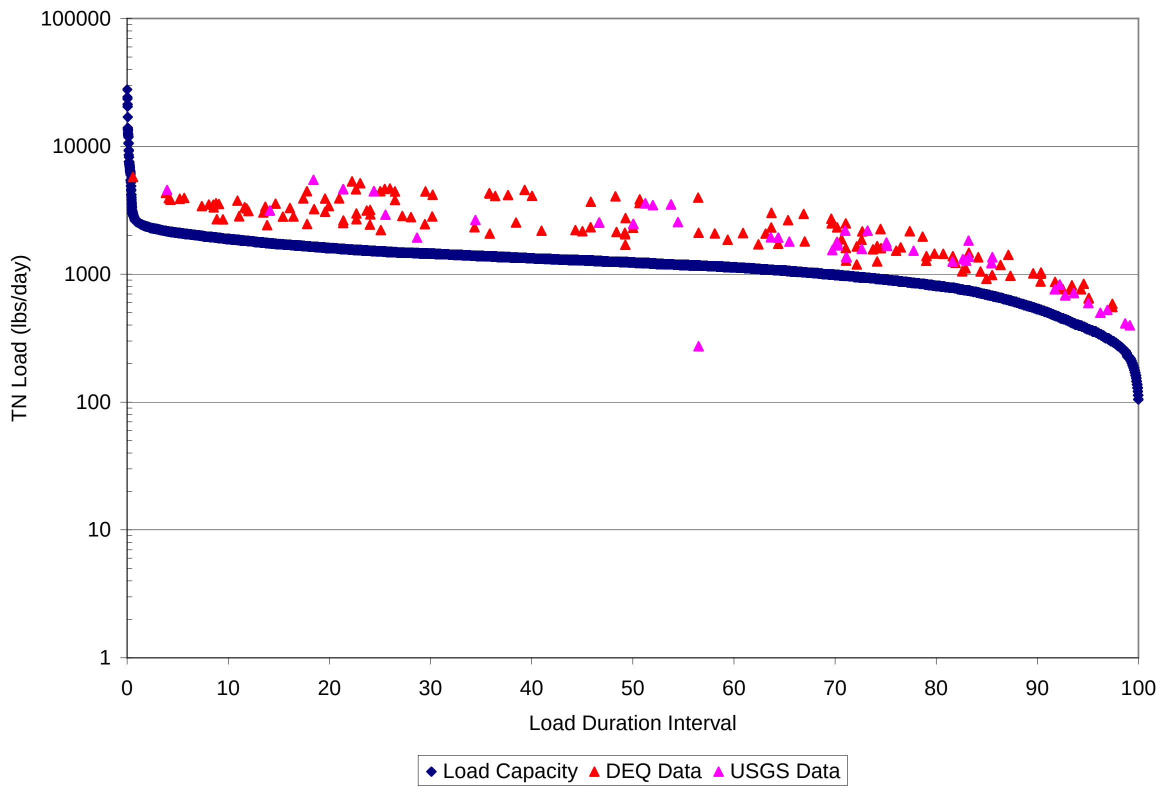


Figure 58. Lower Salmon Falls Creek Total Nitrogen Load Duration Curve.

To compare the contribution and seasonality of TP in the system a load duration curve was developed using the same methods as the other duration curves with an assessment criterion of 0.1 mg/L TP. The TP criterion was originally derived from modeling runs for the Middle Snake River TP TMDL and have been used extensively throughout South Central Idaho.

While TN numbers seemed to be very consistent seasonally and under different flow regimes, TP measures seem to fluctuate widely along the load duration curve (Figure 59). Most notably, a preponderance of the data plot above the load capacity curve in the flow duration intervals between 0 to 70. Salmon Falls Creek in this area is somewhat unique in that outside of 1984, when Salmon Falls Creek Reservoir spilled, the seasonal peak discharge is in October. This hydrology must be kept in mind when a load duration curve is being interpreted and the data plot in different locations above and below the curve (unlike TN and DO).

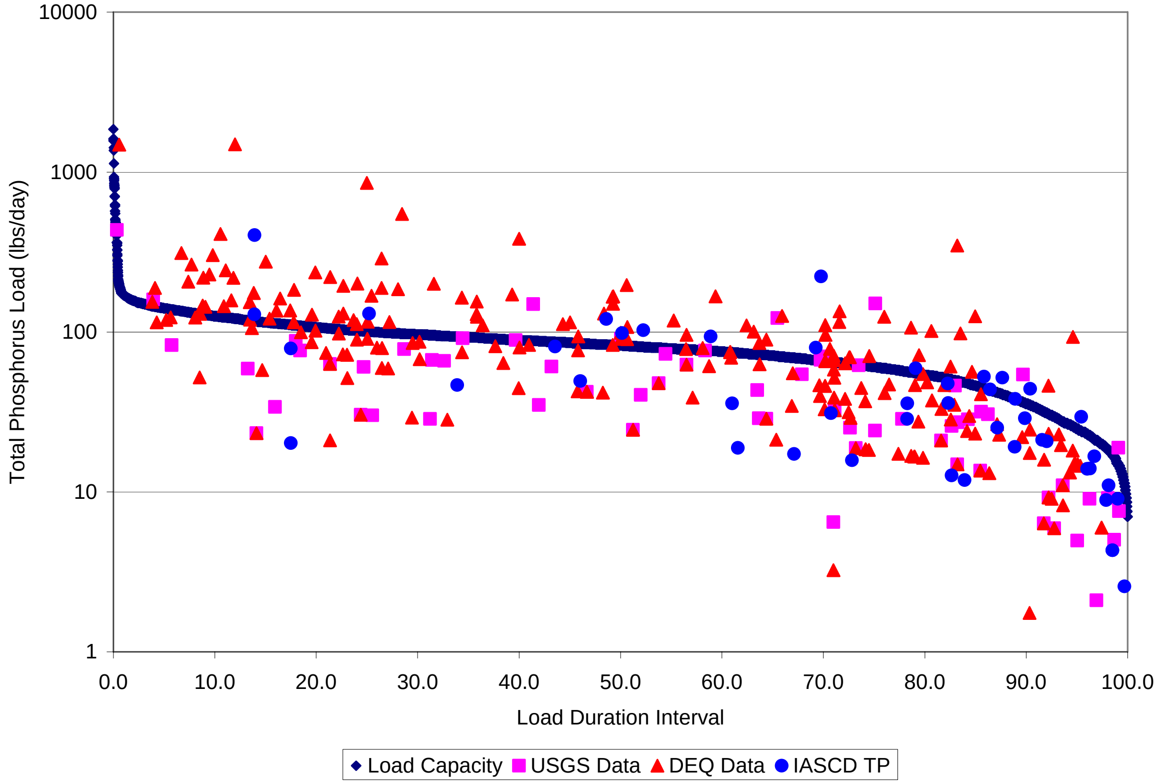


Figure 59. Lower Salmon Falls Creek Total Phosphorus Load Duration Curve.

To assist the interpretation of the load duration the monthly average FDI was calculated and is presented in Figure 60. The monthly average FDI curve is in effect the inverse of the monthly average annual hydrograph (see Figure 54). However, important information can be gleaned from this presentation of the data. For example, low FDI are typically associated with wet weather, but in Salmon Falls Creek low FDIs (high flows) are associated with the end of the irrigation season and increasing irrigation return flows. Further more, high FDIs (low flows) are associated with the spring and summer months which coincide with increasing irrigation withdrawals from the system and occur earlier in the year than would be normal.

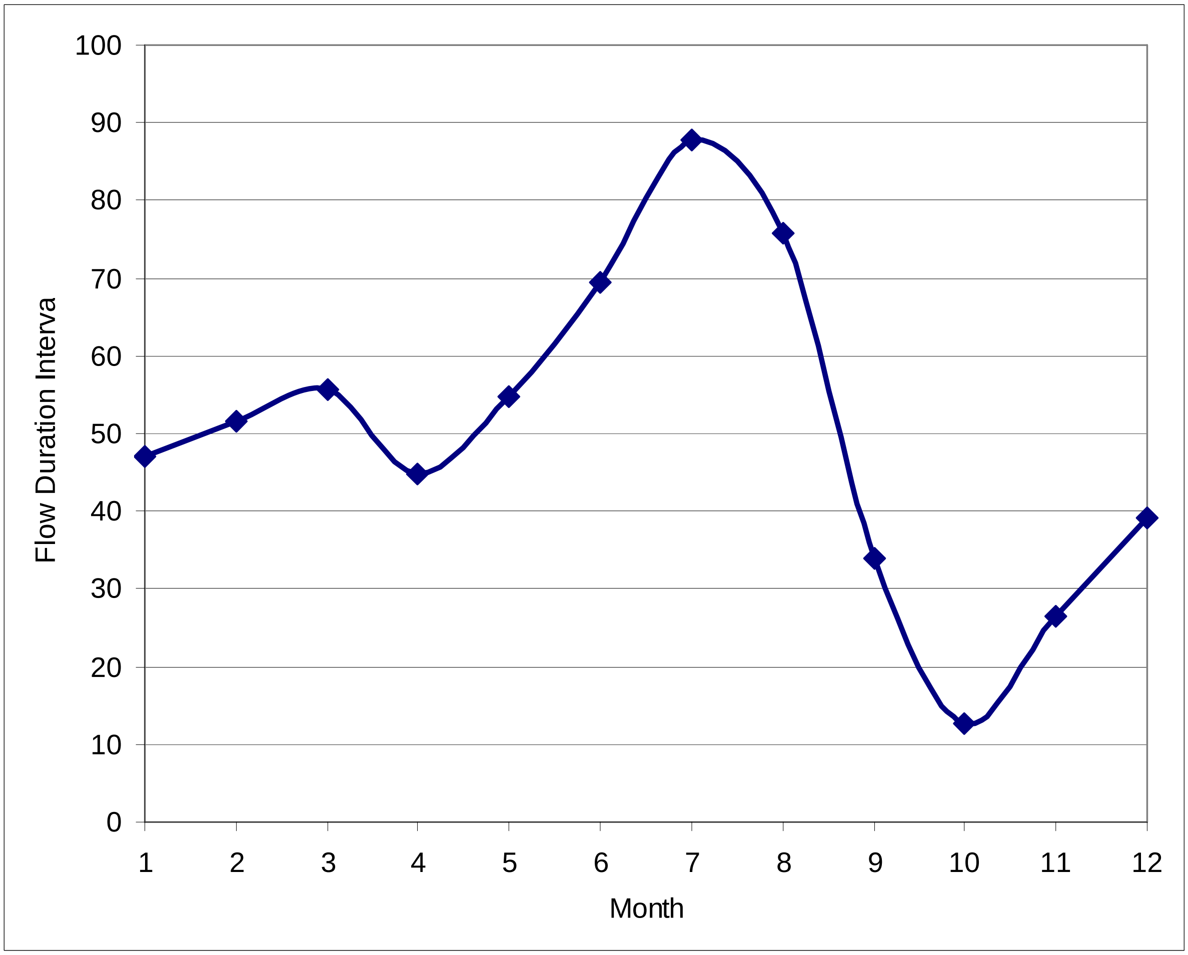


Figure 60. Lower Salmon Falls Creek Monthly Average Flow Duration Interval, Showing Different Seasonality of Flow Regime.

Generally, it appears that TP is in excess for much of the year with the majority of data plotting above the load capacity curve. This is especially true during period when irrigation water is returning to the system and during winter base flow conditions. During the periods when irrigation water is being withdrawn from the system and during extreme low flow periods, TP plots below the load capacity curve.

As both TN and TP are in excess, according to the assessment criteria, the question of which is a limiting nutrient arises. The 16:1 TN:TP Redfield Ratio serves as a starting point in any discussion of nutrient limitation. The Redfield Ratio provides the inflection point to determine which nutrient may be the limiting nutrient, with higher ratios indicating TP limitation and lower indicating TN limitation.

Further work in freshwater reservoir systems has been done to develop an effective tool for assessing potential nutrient limitation. Dzialowski et al 2005 identified the following inflection points, or TN:TP ratios, N limitation at <18; co-limitation between 20 and 46; and P limitation at greater than 65. For assessment of nutrient limitation, DEQ used the following inflection points shown in Table 24 along with the percent of time the Salmon Falls Creek data fell within the category.

Table 24. Salmon Falls Creek TN:TP Ratios.

WATER COLUMN TN:TP RATIO	LIMITING NUTIRENT	SALMON FALLS CREEK DATA (PERCENT)
< 18	N limitation	13.02
18 to 46	Co-limitation by N and P	44.65
> 46	P limitation	42.33

To compare the contribution and seasonality of TSS in the system, a load duration curve was developed using the same methods as the other duration curves, with an assessment criterion of 50 mg/L TSS. The TSS criterion was originally derived for the Middle Snake River TSS TMDL and has been used extensively throughout south central Idaho in other TMDLS.

With Salmon Falls Creek's unique hydrology in mind, as discussed above, the seasonality on source contributions can be readily seen (Figure 60). During periods of extreme drought conditions and early season irrigation withdrawals, when the flows in the system are decreased below the base flow provided by the spring system, TSS loads plot well below the load duration curve (Figure 61). Only 5.88 percent of the data plot above the load duration curve in this region.

During base flow conditions, FDI 30-75, TSS load is also generally low. Although a greater number of exceedances are noted, roughly 17.65 percent of the data points plot above the duration curve in this region. Most of those points plotting above the load duration curve in this region occurred in April and are potential runoff driven events. In the high flow region of the load duration curve, with FDIs less than 30, nearly 30 percent of the data plot above the load duration curve. It is in this region of the curve where post irrigation return flows peak as well as when spring runoff in April and May likely reside. Again, the majority of the elevated TSS samples seem to be collected in the months of April and May some what dissimilar to TP exceedances which was more likely to occur in September and October.

The water quality interpretation based upon the load duration curve indicates that TSS is elevated in significant portions of the flow regime and are centered in the high flow periods in the spring and are somewhat inclusive of the September October post irrigation flush as well. Likely sources of this sediment are bank stability and in-channel stored sediments from previous years.

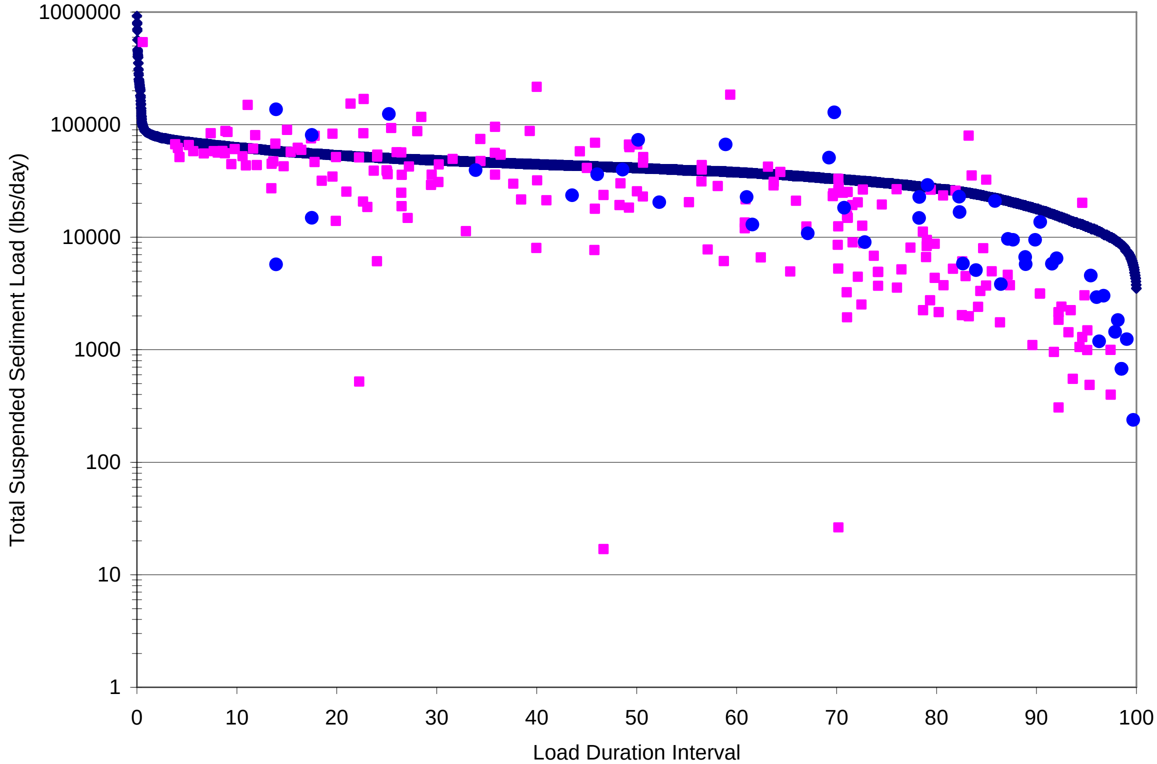


Figure 61. Lower Salmon Falls Creek Sediment Load Duration Curve.

Bacteria data was also collected by both DEQ and the USGS. However, the data collected was fecal coliform cfu/100ml. As a result, it was necessary to determine an appropriate fecal coliform to *E. coli* ratio to be able to assess the data with the current water quality standards for the primary contact recreation (PCR) beneficial use.

The ratio DEQ used was from a large study of *E. coli* Fecal coliform ratios from publicly owned treatment works (POTW) in the Midwest (Doran et al 2004). The choice of ratio was based upon the assumption that E coli are a subset of fecal coliform. Several POTWs in the study exhibited ratios very different than this assumption. However the majority conformed to the notion that *E. coli* are a subset of fecal coliform. The average ratio from the POTWs was 0.61:1. Applying this ration to the fecal numbers collected by DEQ and the USGS allows the fecal coliform numbers to be assessed against the PCR water quality standards for *E. coli*.

A load duration curve was developed to better understand the seasonality of the bacteria data and to more clearly see how the older USGS data compares with the DEQ data set (Figure 62). The development of the load duration curve was consistent with the other load duration curves of Salmon Falls Creek with the FDI as the independent x-axis and Bacteria (in organisms per day) on the dependant y-axis.

The bacteria load capacity was calculated from the 406 cfu/100ml PCR standard, the daily average flow recorded at the USGS gauge, and a conversion factor of 24,468,480. Instantaneous bacteria measures were also converted to load using the same process after adjusting the fecal coliform to an *E. coli* equivalent using the 0.61:1 *E. coli* to fecal coliform ratio.

As seen in Figure 62, bacteria load data collected by the USGS is always below the load capacity curve while a few significant excursions above the load duration capacity curve can be seen in the newer DEQ data. This positioning of the data may suggest that more sources of bacteria are present in the watershed or that degradation potential has increased since 1993. Overall, the data plots closer to the LDC during the summer months and in lower flow period where the FDI is greater than 75. Additionally there appears to be a generally consistent amount of bacteria found within the system, which again would be more indicative of natural background sources or point sources. However, no point source dischargers of bacteria exist within the lower Salmon Falls system. Although the bacteria exceedance do occur, the frequency of those exceedances are very small. In fact, the bacteria criteria trigger was exceeded in only 3.53 percent of the data over the period of record, making it highly unlikely that the geometric mean standard of 126 cfu/100ml would have been exceeded.

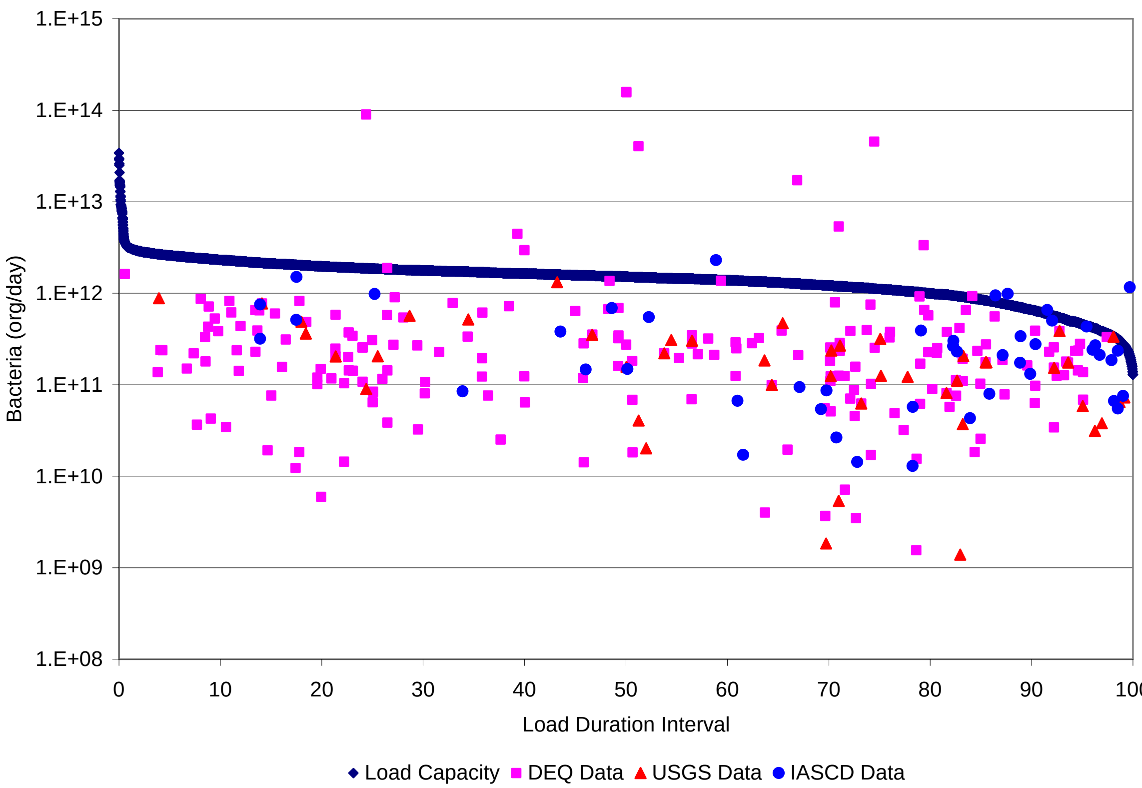


Figure 62. Lower Salmon Falls Creek Bacteria Load Duration Curve.

To further understand the effects of land use changes occurring along the length of the system, the IASCD collected water quality data at the USGS gauge, Lily Grade , and Balanced Rock. This data will be use to understand what, if any, longitudinal changes occur between the upper locations and the lower DEQ and USGS sampling location.

At the different sampling location, the effects of land use, irrigation practices, and ground water influences can be seen in the longitudinal changes in the levels of some of the measured constituents as you proceed downstream. Average SSC at the Balanced Rock area was 5.03 mg/L, at the Lily Grade location the SSC average was 2.45 mg/L, while at the USGS gauge location SSC averaged 19.90 mg/L. Total phosphorus changed as well. Near the Balanced Rock area the average TP concentration was 0.033 mg/L, downstream at the Lily Grade location TP averaged 0.039 mg/L and at the USGS gauge location average TP concentration went to 0.085 mg/L. Most of the chemical constituents at all three sites seemed to fluctuate in a similar fashion throughout the sampling period and most seemed to exhibit the same increasing trend longitudinally. In order to determine if this was the case, an ANOVA test was conducted to test the null hypotheses.

Ho: Balanced Rock Location Mean = Lily Grade Location Mean = USGS Gauge Location Mean.

Ha: Balanced Rock Location Mean ≠ Lily Grade Location Mean ≠ USGS Gauge Location Mean.

A Tukey’s post hoc pairwise comparison test was conducted in those cases where the mean was determined to be significantly different. The alpha used to determine significance was 0.1, or 90 percent confidence. Each constituent sampled at the three locations were tested using Systat 12.0. For most constituents the null hypothesis was rejected ($p<0.1$). Table 25 presents the mean of each parameter as well as the results from the ANOVA and post hoc tests. Those stations and parameters that were not significantly different are represented with the same letter in the table column.

Table 25. Post Hoc Hypothesis Test Results.

PARAMETER	ANOVA P	STATION LOCATION					
		BALANCED ROCK	MEAN	LILY GRADE	MEAN	USGS GAUGE	MEAN
Flow	0.000	B	34.11	B	12.06	A	104.40
DO	0.224	NS	9.55	NS	9.37	NS	10.25
Temperature	0.726	NS	15.38	NS	17.10	NS	15.14
% DO Saturation	0.061	AB	95.28	B	89.56	A	101.78
Specific Conductivity	0.000	A	909.32	B	364.73	A	988.13

PARAMETER	ANOVA P	STATION LOCATION					
		BALANCED ROCK	MEAN	LILY GRADE	MEAN	USGS GAUGE	MEAN
Total Dissolved Solids	0.000	A	445.09	B	175.48	A	484.13
Log pH	0.000	B	0.89	B	0.90	A	0.91
pH	0.000	B	7.83	B	7.87	A	8.17
Total Suspended Solids	0.000	A	5.49	B	2.63	C	14.06
Total Suspended Sediment	0.000	B	5.03	B	2.45	A	15.84
Total Phosphorus	0.000	B	0.033	B	0.039	A	0.085
Ortho Phosphorus	0.000	B	0.027	B	0.029	A	0.045
E. coli	0.000	AB	78.59	B	33.27	A	199.59

For the most part, the means from the upper locations were significantly different from the USGS sampling location. In addition, the direction of the change appeared to be an increase in concentrations with the down sample locations being progressively more elevated, which is consistent with the land use patterns observed in the area. Access to the river system is readily available in the lower portions of the watershed while in the upstream portions the stream is generally confined to a narrow deep canyon with limited accessibility to cattle and other organisms that may contribute pollutants to the system. Furthermore the number of irrigation returns that enter the system in the upper portion of the stream are far fewer than in the lower section.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records do not differentiate between stocking events in the upper portion of the creek and the lower. Therefore it is unknown what the types and numbers of fishes were planted in the lower portion of the creek. However, as presented in the upper Salmon Falls Creek Assessment unit the IDFG has indicate that brown trout, rainbow trout, largemouth bass, and October spawning kokanee salmon have been stocked in Salmon Falls Creek at various times since the early 1970s and continuing to date. It is highly probably that the kokanee were not planted in the lower system as these fish would likely require the reservoir for a portion of their life histories. Also it is quite probable that the largemouth bass were also limited to the upper river system for similar reasons.

The IDFG surveyed the fishery in Lower Salmon Falls Creek in 1983, 1993, and again in 1994. The 1983 sampling occurred below the dam and was conducted to determine if walleye had escaped into the lower sections of the stream system. In this sampling event, the IDFG found few game fish (1 wild rainbow trout and 4 hatchery fish). In addition, they noted that they missed five other trout, but they were looking primarily for the presence of walleye and fished a relatively short (300+ m) reach.

In 1993, the river was electrofished with a goal of describing the fish composition near a water diversion impoundment that was to be replaced. At that time, one wild rainbow trout was captured. The salmonid habitat was described as very poor with significant amounts of fine sediments that were probably the result of limited flushing flows, irrigation return flows with high sediment, warm water and migration barriers affecting trout populations and survival.

A more comprehensive study was undertaken in 1994 to describe the fish species composition. Sampling events centered around the Balanced Rock and Lily Grade areas. In this study, enough trout were collected to determine fish density in the upper reaches of the listed stream. Wild rainbow trout densities ranged from 0.8 to 14.2 fish/100 m^2. In addition, Brook trout were also present in this data set with densities calculated at two sites. Brook trout densities were 0.8 and 35.0 fish/100 m^2. At several locations, length-at-age data was collected from scale annuli. This data indicated that three-year-old wild rainbow trout were present in the system. Additionally there were numerous (23) 1+ year old fish captured. This serves as an indication that the beneficial use of Salmonid Spawning is an existing as well as designated beneficial use.

DEQ has not electrofished the lower section of Salmon Falls Creek.

Salmonid spawning, Brook trout and rainbow trout, appears to have been be an existing beneficial use in Lower Salmon Falls Creek since at least 1993. Trout were likely more abundant prior to the Salmon Falls Dam construction and subsequent reduction of the flushing flows and increases in stored sediment. Since that time, only a few wild rainbow trout have been documented within the system. The probable cause of the beneficial use impairment is fine sediment impacts to spawning substrates. The various land use practices and flow regime modifications may act synergistically to negatively impact the beneficial use at this time.

Macroinvertebrates

DEQ collected macroinvertebrates in Lower Salmon Falls Creek three times in 1995. Conveniently, the BURP sites were located at or near the same locations of the IASCD water quality stations of Balanced Rock, Lily Grade, and the USGS gauge. The macroinvertebrate community represented in these spatially different scales indicate that the cold water aquatic life is generally impaired.

The macroinvertebrate scores from these three events exhibited similar trends in decreasing metric values longitudinally as did the water quality samples collected by the IACSD. For example, macroinvertebrate abundance decreased from Balanced Rock (981) to Lily Grade (659) and further decreased at the USGS gauge location (443). However, it appears that the invertebrate habitats are of higher quality in the middle portion of the system near Lily Grade. The index scores were higher here than either the upstream and downstream locations. In addition, one obligate cold water taxon was collected in the Lily Grade sample location, indicating the cold water aquatic life beneficial use was existing. However, even at the Lilly Grade location the index score was low in comparison with benchmark values. At both the Balanced Rock location and the USGS gauge location, index scores were well below the minimum threshold values of support.

At the USGS gauge location gastropods made up over 94 percent of the total abundance of invertebrates while oligochaet worms and midges consisted of the remainder, 3.6 and 2.5 percent respectively. This is likely a function of the degraded habitats found in the vicinity. In the Balanced Rock area the New Zealand mud snail (*Potamopyrgus antipodarum*) has made significant inroads in this spring dominated area. At the BURP location, this snail made up over 25 percent of the total invertebrate abundance and probably accounted for the dramatic decrease in the SMI score. At the Lily Grade location, which has less spring features and coarser sediments the mud snail was absent.

Aquatic Vegetation

Dense amounts of aquatic vegetation has been noted in many of the lower reaches of Salmon Falls Creek. However, estimations of the coverage of aquatic vegetation were limited due to poor access of the creek. Although, at those locations where the creek could be accessed, aquatic plant communities were very abundant. Possibly due to stored sediments, limited scouring events in the system, and the elevated TN and TP seen in the water quality samples collected since the 1970s.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

The above data suggest that the designated beneficial uses of Lower Salmon Falls Creek, cold water aquatic life and salmonid spawning are impacted. Additionally, it appears that the source of the sediment is in-channel storage and irrigation return flows which are carrying an elevated sediment load. Poor bank stability and the sediment that is generated during high flow events may also be a source within the system but is not evidenced in the longitudinal analysis. Furthermore, nuisance aquatic vegetation appears to be impacting the beneficial uses of the system a great deal. The principle factor influencing vegetation in the system is likely elevated nutrients coupled with the limited flushing flows seen in the river system since the construction of the Salmon Falls Creek Reservoir.

It has been further demonstrated that the bacteria concentrations measured to date indicate that primary contact recreation is fully supported.

Conclusions

Based upon the above assessment, TMDLs for TSS, TP, and TN will be developed for the lower reaches of Salmon Falls Creek.

Salmon Falls Creek Reservoir

Salmon Falls Creek Reservoir lies within the south central mountains of Idaho in an area south and east of Twin Falls, near the town of Rogerson Idaho. The reservoir is not currently listed as impaired on the most recent (2002) integrated report. However, due to concerns about a fish consumption advisory for mercury, DEQ opted to investigate the water quality and the beneficial uses status of the reservoir concurrently with the Salmon Falls Creek Subbasin Assessment and TMDL process.

The principle use of the reservoir is for irrigation water storage. There are as many as 35,000 acres of croplands irrigated from Salmon Falls Creek Reservoir waters. Secondarily, the reservoir provides for many recreational opportunities for the local community such as boating, fishing, hunting, and other water sports. Salmon Fall Creek Reservoir is also one of a few *walleye* fisheries in the state, and the current (and all of the past) state record *walleye* was recently caught in the reservoir. Annually a large *walleye* fishing tournament takes place on Salmon Falls Creek Reservoir, drawing visitors from around the west. Socially and economically, Salmon Falls Creek reservoir is very important to the surrounding communities.

Physical Characteristics

The major source of water entering the reservoir is Salmon Falls Creek. Minor contributions are also made from the few, small, perennial streams such as China Creek as well as many intermittent streams like Brown’s Creek, and Cottonwood Creek in Nevada. The major outlet from the reservoir is through the Salmon River Canal Company’s outlet works at the dam. Minor seepage and leakage occurs through and around the columnar basalts in which the dam is situated. Typically water is stored in the reservoir during winter and early spring months and discharged into the outlet canal late spring through early fall. The reservoir has spilled only twice in its history; consequently, the river system below the dam is hydrologically isolated from the reservoir and the upper watershed.

Salmon Falls Creek Reservoir has an overall length of 12.7 miles (measured along the centerline of the reservoir). Due to the sinuous nature of the reservoir, the effective length is only 4.4 miles through the Grey’s Landing to Whiskey Slough area. The maximum width is 1 mile, while the average width is 0.3 mile. The shoreline development ratio (or shoreline area) is high at 4.89. (A perfectly round lake would have a shoreline development ratio of 1.0, while a highly dendritic lake would have much higher shoreline development ratio.)

For comparison, Lake Mead has a shoreline development ratio of 9.72 and the third lake of the Independence Lakes has a shoreline development of 1.03. The maximum depth of the reservoir is approximately 61 m with a mean depth of 27.76 m (Volume/surface area A_o).

At full pool, the reservoir covers approximately 1,024.72 hectares. The Salmon River Canal Company operates a nonrecording gauge at the reservoir. That data is then shared with the USGS and is available in the annual water resource reports and online. The Salmon Falls Creek Reservoir watershed is an area of approximately 1,626 $miles^2$. Usable storage in the reservoir is 182,650 acre-feet. In addition, there is 48,000 acre-feet of unusable or dead water.

The bottom of the outlet works is at 80 feet below the crest of the dam. The dam was completed in 1911, with storage beginning in 1910. As stated above, the reservoir has spilled only twice since its initial construction. The first of these events was during May 11 to June 29, 1984. The second time was April 22-30, 1985. Historically, Salmon Falls Creek Reservoir has always underfilled. This factor led to the immediate reduction of water project lands by 35,000 acres in 1912, shortly after the reservoir was completed. Additional reductions occurred in the following years.

Salmon Falls Creek Reservoir is a very deep, narrow, sinuous reservoir. These morphological characteristics make it highly likely to stratify early in the summer periods. Additionally the sinuous nature of the system minimizes the fetch of the reservoir (i.e. the relative length) which would also promote stratification as any sort of wind event would act on only locally small aspects of the reservoir. These morphological characteristics may also impede the production of salmonid fisheries due to high epilimnetic temperatures and low dissolved oxygen content in the hypolimnion. Furthermore, these factors coupled with the seasonal water level fluctuation of the reservoir may also increase the rate of methylation of mercury (Sorensen et al 2005; Evers et al 2007).

Flow Characteristics

The amount of water that enters Salmon Falls Creek Reservoir can best be described by a summation of Salmon Falls Creek and other minor tributaries, while the major losses from the reservoir would include the canal diversion, evaporation, infiltration, and seepage losses.

To estimate the reservoir water budget, DEQ gathered Salmon Falls Creek discharge data from discharge measurements; estimated evaporative losses from reservoir area using nearby evaporation rates; and assumed infiltration losses were negligible. Seepage losses were based on several discharge measurements taken directly below the reservoir. Annual average input from the Salmon Falls Creek Watershed, based on historic USGS gauge date, averaged approximately 103,176 acre-feet per year. China Creek contributes approximately 965 acre-feet per year, based upon a relationship between measured discharge in China Creek and the USGS gauge at San Jacinto on Salmon Falls Creek. Cottonwood Creek in Nevada is assumed to contribute a similar volume of water.

Losses from the system include approximately 8,446 acre-feet per year from evaporation. Evaporation losses may be less that this, as the full pool area of the reservoir was used to make this estimate. As the reservoir is drawn down, the surface area would decrease, thus decreasing evaporation potential.

Seepage losses through the basalt below the dam was estimated based on several discharge measures collected below the dam in 2006. The range of discharge below the dam was 7 to 10 cfs. The discharge below the dam may have a closer relationship with pool volume rather than a constant rate and therefore the 7 to 10 cfs values are likely an overestimate of the seepage losses as the discharge measures were collected while the reservoir was near the peak volume of 2006. Nevertheless, seepage losses were estimated to be between 5,068 and 7,240 acre-feet per year.

Irrigation losses were based upon the USGS gauge record between 1937 and 2006, which indicates an average discharge from the reservoir of approximately 200 cfs per day during the irrigation season. Using this data set, the irrigation withdrawals would be near 113,220 acre-feet per year. However, irrigation withdrawals are variable according to reservoir volume and downstream demand, thus this value may be higher in wet years with good hold over of water and much less during drought years.

A summation of these gains and losses indicate that on average the system is operating at a net loss of nearly 22,000 acre-feet in an average year. This net loss would be made up from the budget by reduced irrigation withdrawals, decreased evaporation rates due to the smaller reservoir surface area, and potentially less seepage through the basalts near the dam. However, due to the nature of the outlet works the reservoir has approximately 48,000 acre-feet of dead storage that cannot be tapped for irrigation demands. From a water quality and beneficial use assessment standpoint, the water budget indicates that without this dead storage the beneficial uses of the system would be impacted by flow alteration in average or drought years.

Water Column Data

The EPA's STORET database contains no samples collected from the reservoir. Data queries from other agencies have yielded no water chemistry data. Therefore, DEQ data are the only readily available data for Salmon Falls Creek Reservoir.

DEQ sampled in the reservoir over the course of the summer of 2005 and spring of 2006; additional samples will be collected throughout the various phases of TMDL development and implementation, as budgets and time frames allow. In order to determine internal loading of nutrients, a mass balance sample design will be implemented in the summer of 2007. That data will be included in the implementation phase of the TMDL.

However, due to the limited number of sampling periods in the original data set, DEQ's confidence in average concentrations is low. The lack of a robust data set was due to limited budgets and a limited time frame for collecting data. In most cases, one sample was the most collected in any given month. Infrequently, multiple samples were collected for any given month. For those cases when a parameter was below detection limits, half the detection limit was used to calculate the parameter average and as part of the period of record average.

Three sample locations were set up in Salmon Falls Creek Reservoir, shown in Figure 63. The first sampling site was near the dam in the area of the deepest part of the reservoir or Zmax. The Zmax site was used to determine average concentrations for the water body and will be considered the point of compliance. At this location, the reservoir waters have had a chance to equilibrate and begin to function as a lake rather than like a river. The additional sampling locations were established in the inlet arm of the reservoir in the backwaters and near Grey's Landing in the middle portion of the reservoir. The backwaters location was used to understand the relative contribution from the major input. The stream inputs from Salmon Falls Creek and China Creek were assessed in the Backwaters Bay of the reservoir.

The middle sample location near Grey's Landing was established to determine the difference between the riverine section of the reservoir and the more lake like quiescent area of the reservoir near the dam. The relative difference in chemical constituents between each site seemed to be very small throughout the sampling period. In order to determine if this was the case, an ANOVA analysis was conducted to test the null hypothesis.

H_o: Backwaters Bay = Grey's Landing = Zmax
H_a: Backwaters Bay ≠ Grey's Landing ≠ Zmax

The ANOVA for each constituent sampled was completed using Systat 12.0. For the following constituents ammonia (NH_3), TKN, and NOx the null hypothesis was not rejected ($p>0.1$), while the null hypotheses was rejected for TP and total mercury. A Tukey's post hoc pairwise comparison test was conducted in those cases where the mean was determined to be a significantly different. The alpha used to determine significance was 0.1, or 90 percent confidence. The pairwise comparison test for TP indicated that the Zmax location was significantly different than both the Grey's Landing and Backwaters locations, while the Grey's Landing and Backwaters locations were very similar with each other. Thus it appears that TP is dropping out of suspension in the area downstream from the Grey's Landing area. Mercury was also significantly lower in the Zmax area in comparison with the Grey's Landing location ($p = 0.015$).

The levels of the measured constituents in Salmon Falls Creek Reservoir are high to very high. These levels in most all cases indicate a higher loading and degradation of water quality compared to near-by reservoirs. The average TP concentrations from the backwaters to Grey's Landing to the Zmax location were 0.144, 0.130, and 0.079 mg/L respectively. Overall the average TP concentration in the reservoir was 0.114 mg/L. In comparison, Cedar Creek Reservoir, a eutrophic reservoir, averaged 0.102 mg/L while at a near by mesotrophic reservoir, Goose Creek, TP concentrations averaged 0.035 mg/L at Zmax. N to P ratios are also telling in Salmon Falls Creek Reservoir. In the backwaters area the N:P ration was less than 5, indicating excess TP, 100 percent of the time. In the Grey's Landing area the ratio was less than 5 nearly 75 percent of the time while at the Zmax location N:P was less than 5 only 37.5 percent of the time. Biologically this indicates that blue green algae and other unpalatable forms of nitrogen fixing algae will dominate in the backwaters through Grey's

Landing areas. Furthermore, these types of algae are often associated with algae blooms that the general public view as nuisance. In all cases the N:P ratio was less than approximately 10. Indicating that even under the best conditions TP was still in excess.

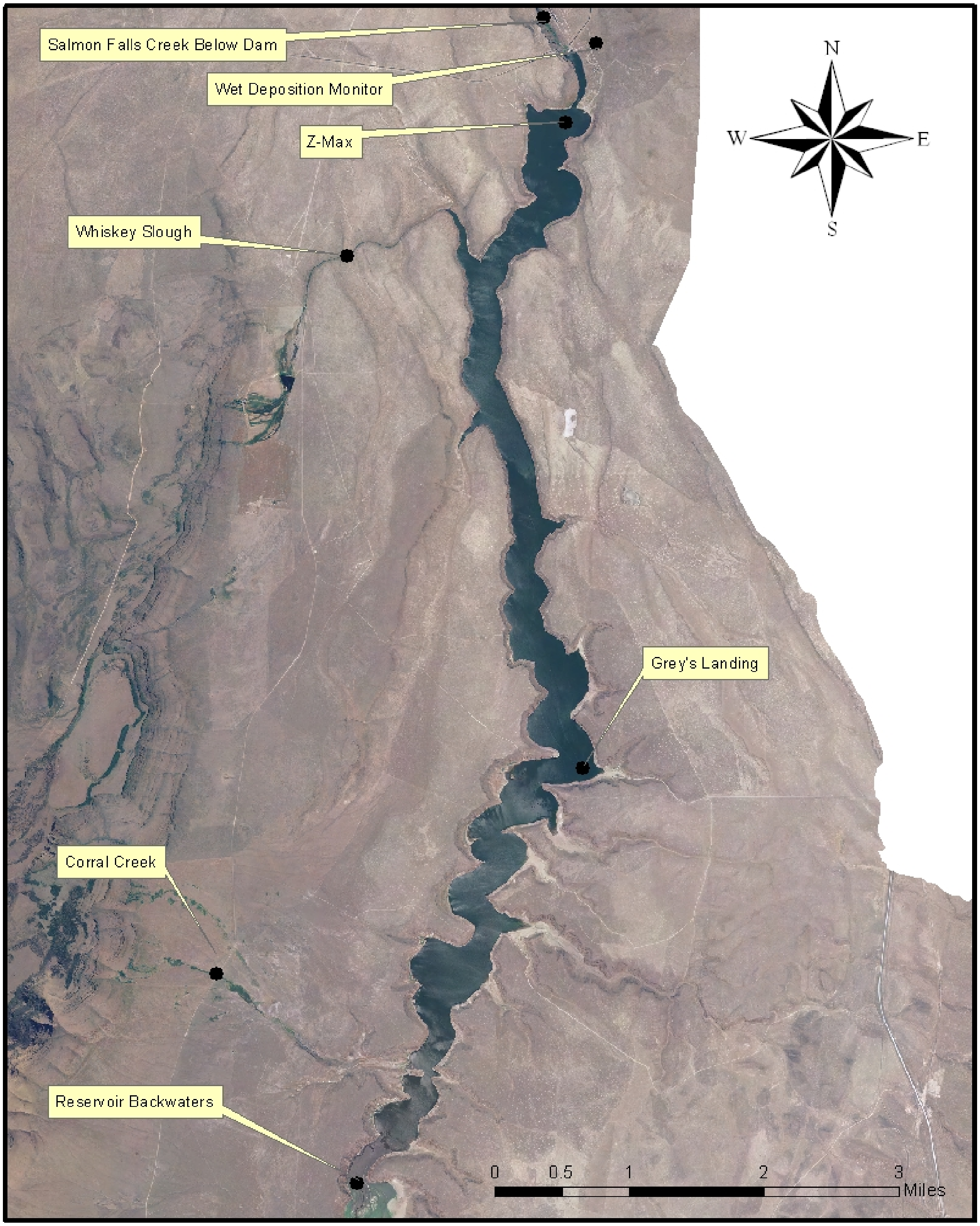


Figure 63. Salmon Falls Reservoir Monitoring Locations, Showing Wet

Deposition Monitor Location and Other Nearby Systems.

Total mercury in the Grey's Landing area of the reservoir averaged 2.29 ng/L with a range of 0.76 to 4.25 ng/L. Some seasonality was noted in the Grey's Landing area. During spring runoff mercury concentrations exhibited an upward trend, but the data was highly variable as seen in Figure 64. Some of this variability can be explained by the intrusion of stream flow from Salmon Falls Creek carrying elevated mercury during the spring runoff and mixing with bottom sediments due to low water levels and higher wind events in the spring as the reservoir refills.

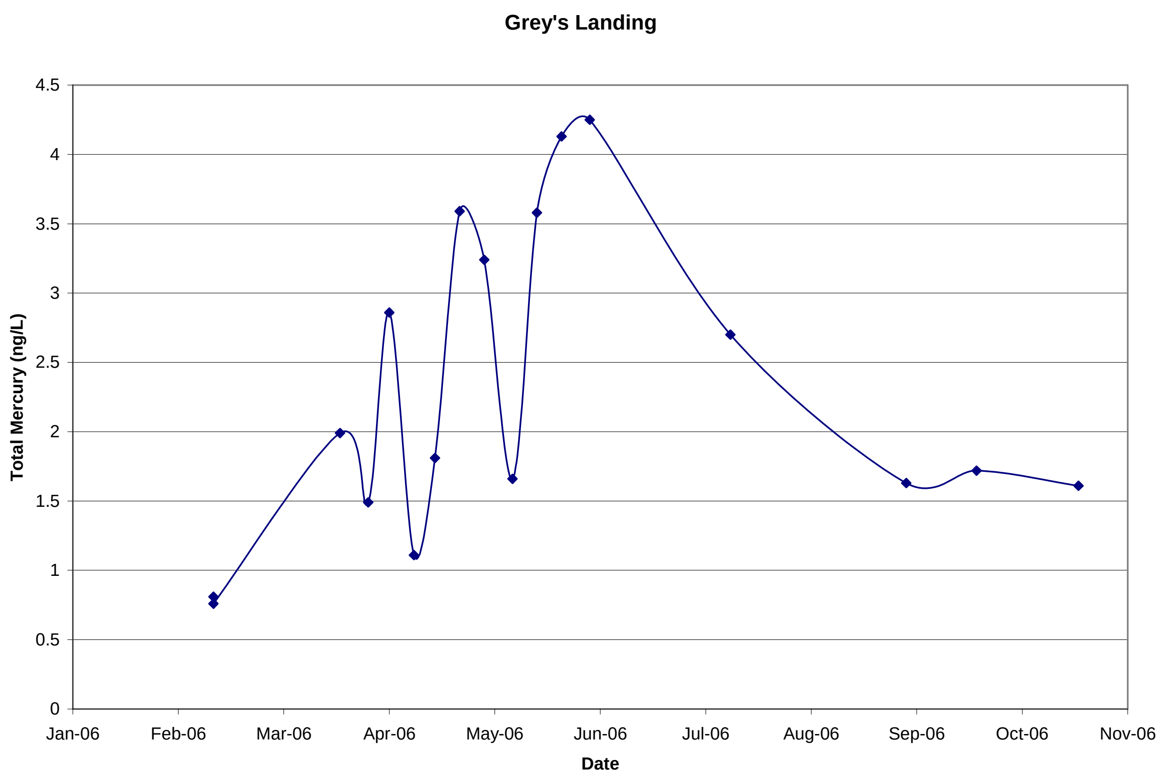


Figure 64. Total mercury water column concentration at Grey's Landing.

At the Z-max location total mercury averaged 1.41 ng/L with a range of 0.81 to 3.19 ng/L. Again mercury concentration increased following spring runoff and fell as the summer progressed (see Figure 65). The between sample date variability was much lower than that seen at Grey's Landing, probably due to the distance from the stream intrusion.

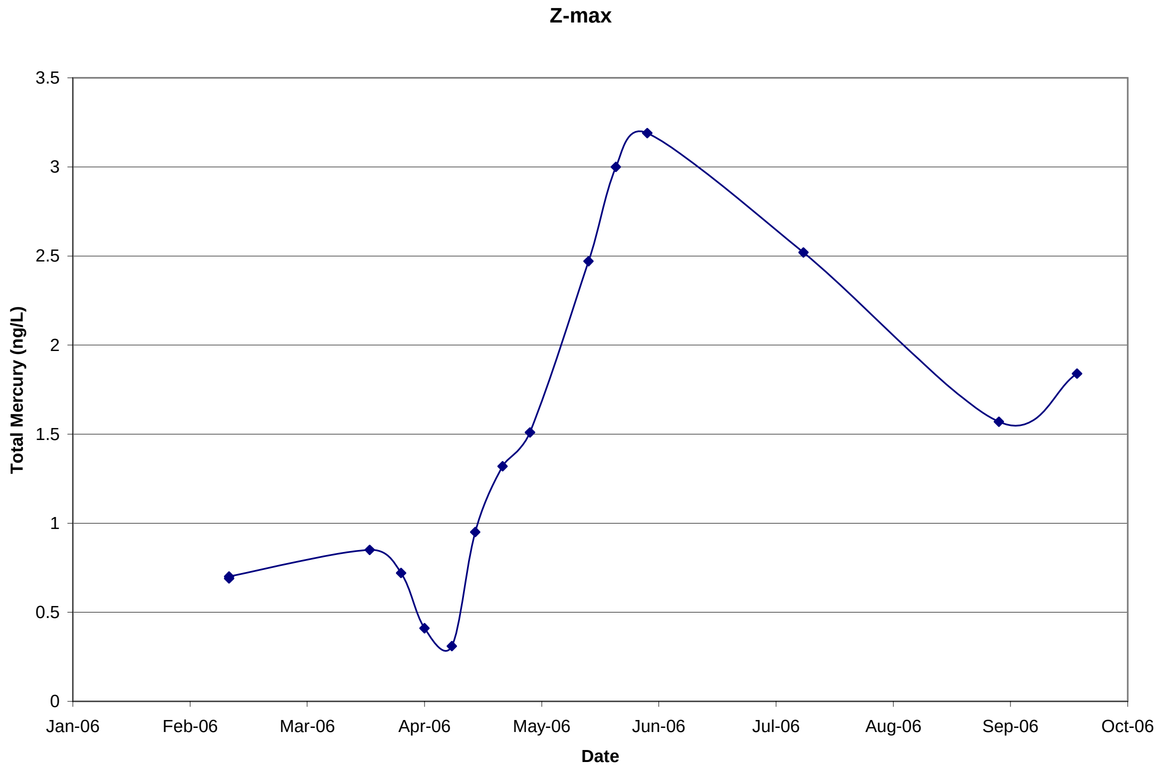


Figure 65. Total mercury water column concentration at Z-max.

For lakes, Carlson's TSI can be used to determine if a lake is undergoing cultural eutrophication (Carlson 1977). The Utah Department of Environmental Quality has used a TSI score of 50 as a threshold value to indicate impaired water quality in many of the TMDLs completed for excess nutrients in lakes (UDEQ 2000).

However, a certain trade off exists between fish production and water quality. Mesotrophic reservoirs are often seen as well balanced in terms of fish production and water quality. Therefore, mesotrophic lakes are viewed by many as the ideal target; hence, the many states and entities that use a TSI target of 50 as their management goals. In more oligotrophic lakes, fish production is less while water quality is higher. The same trade off exists for eutrophic waters with higher fish production and lower water quality. However, often the fish production seen in eutrophic waters in the west is towards less desirable species of fishes, as the water quality is such that salmonids, the desirable species, are stressed by the higher temperatures or lower DO levels seen in eutrophic waters.

Average TSI values for the three locations sampled in Salmon Falls Creek Reservoir were 60.21 at the backwaters, 58.0 near Grey's Landing and 52.39 near the dam at the Zmax location. All three locations exceed the mesotrophic break point of 50, indicating the reservoir is eutrophic. Additionally the conditions in the backwaters are highly eutrophic or hypereutrophic. In general this indicates that a nutrient reduction is needed throughout the reservoir. However, in order to determine the mechanism of impairment the Carlson's TSI can be broken into its individual components. This coupled with a mass balance model of TP in the reservoir would provided the necessary information to determine load reductions.

Individual components of Carlson's TSI can also be used to determine if nutrients are in excess. A TSI for TP above 50 has been used in other states as a threshold for excess nutrients. A TSI of 50 corresponds with 0.024 mg/L of TP, 2 m Secchi, 7.23 µg/L chlorophyll *a*, and 0.734 mg/L of TN. Based upon these numbers Salmon Falls Creek Reservoir exceeded the threshold value for TP at every sample date while never exceeding the TN threshold value. Both upper sample locations exceeded the Secchi depth threshold throughout the monitoring period. The average TP TSI in the Backwaters, Grey's Landing and Zmax locations were 75.55, 73.02, and 67.01 respectively.

Average Secchi depth for the reservoir during the monitoring period followed a similar trend with much lower clarity near the backwaters and increasing clarity to the dam. Water clarity or Secchi depth was 0.77 m in the backwaters (TSI 63.77), 1.46 m in the Grey's Landing area (TSI 54.55), and 2.44 m at Zmax (TSI 47.15).

An inverse pattern was seen in Chlorophyll *a* concentrations collected in the epilimnetic waters during the summer time. Depth profiles of Chlorophyll *a* were collected at all three sample locations along with temperature profiles to determine if the location had thermally stratified. Summer-time, epilimnetic, chlorophyll *a* averaged 12.39 µg/L, or TSI of 55.125, at the Zmax location near the dam. At Grey's Landing the summer-time, epilimnetic Chlorophyll *a* averaged 10.70 µg/L (TSI 53.69). While in the Backwaters, where there was no stratification, chlorophyll *a* concentrations averaged 10.96 µg/L (TSI 53.15).

The apparent conflict between the Chlorophyll *a* and Secchi data at the backwaters location and the Grey's Landing location was likely due to suspended sediment decreasing water clarity rather than a decrease in water clarity due to increased algal biomass.

The TSI scores in a reservoir can be further complicated under severe drawdown events as well as during spring filling events as seen above. The complications from drawdown events, which occur annually at Salmon Falls Creek Reservoir, can arise when phosphorus is mobilized from the sediments in the deeper portions of the lake due to natural processes under anaerobic conditions.

When a lake is drawn down, the hypolimnetic layer of water, with the elevated TP concentrations can become mixed with the epilimnetic (and low TP) waters, enriching the system later in the year when it is typically poor in nutrients (Wetzel 1983). In addition, sediments rich in adsorbed TP can be remobilized as the waters recede (Wetzel 1983). Both of these situations likely occur in Salmon Falls Creek Reservoir annually.

Further investigations are required to determine if there is a significant trend in TSI scores. However it appears from TSI values for Chlorophyll and TP, that the reservoir contains excess nutrients as the TSI scores were typically in the mid 60s to 70s, while Secchi scores were near 50. Thus, it is highly likely that nutrients are impairing the beneficial uses of the reservoir.

Sources of the excess nutrients typically seen in mass balance approaches include inlet loading, atmospheric (e.g. dust), and internal loading. Mass balance losses include outlet load and sedimentation. The Department of Environmental Quality used a steady state phosphorus mass balance model described by Vollenweider (1976) to finalize the assessment of excess nutrients in the reservoir (Table 26).

Inlet load was calculated on an annual basis from monitoring locations at Salmon Falls Creek and China Creek. Atmospheric load was assumed to be negligible for this analysis. Outlet load was calculated from flow data collected by the canal company and given to the USGS. TP concentration in the outlet and seepage was assumed to be equal to the concentration measured at Z max. Outlet seepage was measured several times in 2006. During this time discharge below the reservoir was very consistent and ranged from 7 to 10 cfs. Therefore, seepage losses were assumed to be a constant 10 cfs. Internal load was derived from the following equation rearranged to solve for W or the areal load of the reservoir under existing conditions.

$$P = \frac{W}{\bar{Z}\& + V_s}$$

P = in-lake TP concentration (mg/L)

W = areal loading rate (g/m^2/year)

$\bar{Z}$ = mean lake depth (m)

Q/V = & where Q = lake outflow (m^3/year)
V = Lake volume (m^3)

$k_s = \&^{0.5}$

$V_s = k_s\bar{Z}$

Salmon Falls Creek Reservoir TP Areal Loading Equation.

Table 26. Salmon Falls Creek Reservoir Existing TP Load.

SOURCE/LOSS	EXISTING TP LOAD (lbs/Year)	TP LOAD CAPACITY (LBS/YEAR)
Salmon Falls Creek	27,000	
China Creek and other tributaries	1,419	
Canal	-16,017	
Seepage	-1,564	
Internal Load	96,244	
Total Areal Load	107,082	22,543

The reservoir net annual TP load is approximately 11,000 lbs. Over the life of the reservoir this equates to a storage of over 1,000,000 lbs of TP within the reservoir. Consequently the internal load makes up nearly 90 percent of the available load on an annual basis, therefore limiting the effectiveness of upstream nutrient reductions and extending the practical timeline to reach a implementation goal of 0.025 mg/L to somewhere between 26 and 264 years.

Bacteria samples were also collected from Salmon Falls Creek Reservoir. Several samples were collected during the early summer of 2005. Samples were collected from the backwaters, near the more heavily recreationally used Grey's Landing and near the boat ramp near the dam. Organisms of *E. coli* were seldom present in the samples, and when they were, it was in very low numbers (7 col/100 ml max).

Temperature profiles were collected in 2005 and 2006 at the three reservoir locations. Following ice-off, the reservoir was isothermal until a weak stratification began to develop in May. By early June, the reservoir is strongly stratified, with an epilimnion depth of 12 meters. Epilimnion depth at Grey's Landing at this time was between 5 and 8 meters, while the backwaters area was isothermal in June, July, and August. The Zmax portion of the reservoir remain stratified throughout the summer with maximum epilimnetic temperatures reaching 20+ ° C in late July. The average epilimnetic temperature at this time was 19.72 °C, slightly above the coldwater aquatic life criteria. During this time the epilimnion remained between 10 and 12 meters deep. In late August through October the reservoir began to cool and the thermocline began to erode until the reservoir was again isothermal. Due to the morphology of the reservoir it is highly likely that the reservoir would stratify in most years. However, it appears that during the critical summer months the epilimnion reaches 22 °C rarely, and average epilimnion temperatures remain below 19 °C.

Dissolved oxygen profiles were also collected along with the temperature profiles. Similar situations are observed. Although, during the early summer stratification period, DO levels were very low throughout the water column. The oxygen depletion became more evident as the year progressed, likely due to the reservoir becoming strongly stratified and increased bacterial respiration in the hypolimnion removed dissolved oxygen. Oxygen depletion was noted throughout the water column and almost complete oxygen depletion below 30 meters in July. The anoxic zone extended from the bottom to 15 meters in August. Based upon the chlorophyll a concentrations and the early season oxygen depletion DEQ has determined that excess aquatic growths are a regular occurrence in Salmon Falls Creek Reservoir.

Mercury

The biogeochemical cycling of mercury is complex, and the potential for global atmospheric transport of mercury on fine particulates or in the vapor state further complicates matters. The industrialized nations of the world have found many uses for mercury and its compounds. These uses include colorants, antibacterial preparations, fungicides, batteries, catalytic reactors, dental amalgam, and electrical switches.

Mercury exists naturally and can be found in many precious metal ore bodies. Other naturally occurring sources of mercury include coal, which may contain relatively high quantities of mercury that are released to the atmosphere when the coal is combusted (to generate electricity or to heat water for industrial uses).

While most anthropogenic sources of mercury have become highly regulated in the United States, releases in the global environment from power generating stations, mineral extraction, and industrialization continue to be a problem. Although highly regulated within the United States, localized impacts still occur. Additionally, in the western United States our legacy of mining may have resulted in our current localized mercury contaminations.

The Salmon Falls Creek Reservoir fish consumption advisory for mercury was developed in 2001. Since then, additional consumption advisories have been issued for other lakes and reservoirs in Idaho. These fish advisories are scattered across the state. The implication being that the global atmospheric load is contributing to mercury contamination throughout Idaho. However, the sources of mercury contamination in the Salmon Falls Creek Reservoir have not been identified. Nor have the sources for the newer advisories.

It has been hypothesized that several sources exist that may contribute significantly to the mercury load in Salmon Falls Creek Reservoir. Three main sources are considered: 1) the global atmospheric load; 2) geological sources within the subbasin; and 3) anthropogenic sources within or near the subbasin. The latter may include the large mining district located south of the reservoir in Nevada, coal-fired boilers in the Twin Falls and Minidoka Counties, phosphate mining and milling operations in Eastern Idaho, or cement manufacturing in Eastern Oregon as well as Eastern Idaho. Many of these sources are considered minor due either to a small load (less that 10 lbs per year) or are located in regions distant (or down wind) from the normal air shed of the reservoir.

The Idaho Department of Environmental Quality has undertaken a mass balance approach to determine the loading of total mercury into the Salmon Falls Creek Reservoir as follows.

$$\frac{dmHg}{dt} = \text{Inlet Stream Load} - \text{Outlet Load} + \text{Atmospheric Load} - \text{Volatilization} - \text{Sedimentation}$$

The various compartments of above model are shown in Figure 66.

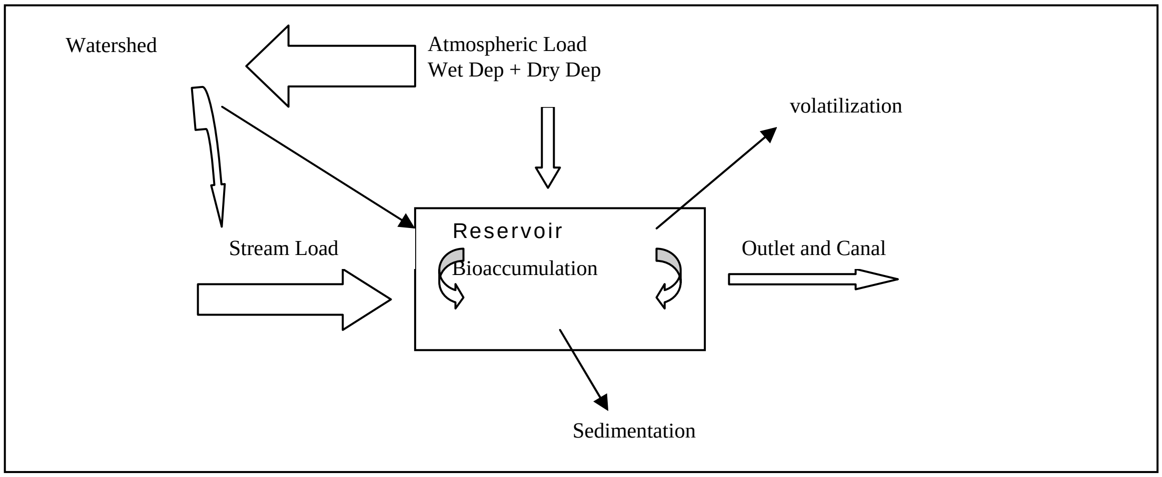


Figure 66. Mercury Mass Balance Diagram.

Mercury toxicity

Once methylmercury enters the human body it is very difficult to remove. If the input continues over time, the concentration of mercury in tissue can rise to potentially dangerous levels. The toxic effects of methylmercury can impact very basic cellular functions, causing a wide range of symptoms; researchers are still working to understand the complex nature of mercury toxicity.

Much of the damage done to a victim of mercury intoxication is permanent, persisting even after the body burden has returned to background levels. Moreover, if the tissues of a pregnant or breastfeeding woman are contaminated with mercury, a disproportionate amount of that mercury is passed to the baby, where it attacks the developing nervous system. A child exposed to mercury in this way may be irreparably harmed.

Methylmercury is readily adsorbed through the gastrointestinal tract following ingestion. Almost complete absorption (95 percent) has been shown in several studies (as cited in US EPA 2001: Aberg et al 1969, Miettinen 1973). While other studies indicate that dermal absorption is significantly lower in comparison (approximately 3 to 5 percent) (EPA 2001). Once absorbed into the body, methylmercury is distributed throughout the body via the cardiopulmonary circulation system.

Methylmercury has also been show to easily cross the placental barrier (Hansen 1988, Hansen et al 1989). Accumulation in neonates was higher than in adult rats in one study (Thomas et al. 1988). It was determined that 94 percent of a dose was still detected in fetal rats 10 days after administration compared to 60 percent in the adults (EPA 2001). Methylmercury is only slightly lipophilic (Log_{kow} = 0.0763) although it readily penetrates nerve cells. There it binds to cysteines on acetylcholine receptors leading to neurological dysfunction. The ability to pass lipid membranes leads to necrosis and degeneration of neurons. Brain size and development of young are also impaired (Crosby 1998).

Mercury hazards to wildlife

Humans are not the only population at risk. Wildlife exposed to mercury via their diet may be subject to reproductive failure, immune system impairment, behavioral aberrations, motor dysfunctions, or even direct toxicity. Most at risk are those animals at upper trophic levels that feed on fish, or on other animals that feed on fish.

However, there are no known instances of mercury intoxication of wildlife in Idaho. Assessment of the impact of mercury on wildlife is difficult, since some of the symptoms associated with chronic mercury poisoning may not be immediately apparent, resulting in reduced functionality, inappropriate breeding behavior, or early mortality by some other mechanism. Although there have been no recorded instances of mercury toxicity in wildlife, DEQ does not know if there is a problem as no one has looked into it. Therefore this aspect of mercury in the Salmon Falls watershed should be considered a data gap. Additional work that could be done includes: (1) some inventory of wildlife that feed on fish in important wildlife/aquatic habitats in the State (e.g., loon, cormorant, osprey, mink), (2) a review of published work in this area (e.g., Lane and Evers recent work on Saltmarsh Sharp-tailed Sparrow), (3) incorporation into the State's mercury program plans for some reconnaissance sampling of critical species in sensitive wildlife areas.

Fish tissue mercury concentrations

Despite the extremely low concentrations of mercury in the reservoirs tributary waters (1.04 to 10.6 ng/L), levels in the tissues of most fish species in the reservoir, *walleye* (*Sander vitreus vitreus*), yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieu*), rainbow trout (*Oncorhynchus mykiss*), and largescale sucker (*Catostomus macrocheilus*) exceeded the Idaho water quality standard of 0.3 mg/kg.

It is the tendency of mercury to biomagnify as it is passed up the food chain that generates concern. Fish are about ten times as tolerant of mercury than are humans (http://mercuryinschools.uwex.edu/curriculum/hg_in_env.htm) because they may have evolved an efficient strategy for sequestering mercury away from vital organs.

Virtually all of the mercury found in the edible portion of a fish and other aquatic life has combined with a simple organic molecule, methane, to form methylmercury (meHg). The process of methylation has been shown to be bacterially mediated (Figure 67). In Salmon Falls Creek Reservoir methylmercury comprised five percent to 31 percent of the total mercury present in the water column (mean 14.47 percent).

Typical fractions of meHg to total Hg are variable but average 10 percent (Mason 2003). Of greatest concern is that lakes and reservoirs will accumulate large amounts of mercury without efficient means to eliminate it from the aquatic system. Lentic water bodies are mercury sinks. Salmon Falls Creek Reservoir is typical in that it is an Hg sink until it become anoxic. Then it becomes a major source of MeHg in the food chain. Some preliminary fish data was collected in the late 1990s to establish a fish consumption advisory. More recent fish data are presented in the following Table (27).

Table 27. Existing Mercury Concentrations and Average Fish Lengths in Salmon Falls Creek Reservoir Fish Tissue Samples.

	2005 (N = 13)		2006 (10 FISH COMPOSITE, FROM EACH SPECIES)	
SPECIES	TOTAL MERCURY mg/kg	STANDARD DEVIATION	TOTAL MERCURY mg/kg	STANDARD DEVIATION
walleye	0.753	0.256	1.25	NA
Length (mm)	457	159	442	123
smallmouth bass			1.020	NA
Length (mm)			339	122
yellow perch			0.587	NA
Length (mm)			264	117
rainbow trout			0.357	NA
Length (mm)			355	120
largescale sucker			0.489	NA
Length (mm)			495	120

Idaho's water quality standard is a consumption based, trophic-level-weighted average for a particular water body. This average should reflect species that are normally consumed, and be weighted by trophic level. Idaho uses EPA's current national default consumption rate of 17.5 g/day, broken down to 3.8 g/day from trophic level 2, 5.7 g/day from trophic level 3, and 8 g/day from trophic level 4. Without site-specific data on fish consumption, this provides the basis for consumption rate and trophic level weighting. A water quality exceedance only occurs if the weighted average methylmercury concentration of fish consumed is above 0.3 mg/kg.

Trophic level two fishes are those species that are considered herbivores, trophic level three fishes are those species which consume zooplankton or other small herbivorous fishes, and trophic level four fishes are those species which are normally piscivorous and consume both trophic level two and trophic level three fishes.

Idaho Fish and Game fisheries biologist provided information concerning the trophic level status of the fish species collected in 2006. walleye and smallmouth bass are considered trophic level 4 fishes, rainbow trout and yellow perch are considered trophic level 3 fishes, and the largescale suckers are considered trophic level 2 fish. As a result, the trophic level consumption based methylmercury concentration average for Salmon Falls Creek Reservoir can be seen in Table 28.

Concern about the contamination of sport fish led the State of Idaho to conduct a survey of the potential sources of mercury within the Salmon Falls Creek Subbasin and Salmon Falls Creek Reservoir. In 2005 and 2006. staff of the Surface Water Quality Section of the Twin

Falls Regional Office of DEQ conducted a screening for mercury covering several tributaries of Salmon Falls Creek Reservoir, some of the geothermal springs found within the subbasin and fish tissues samples collected from the reservoir and tributary systems.

Analyses were conducted by Brooks Rand LLC in Seattle, Washington. Brooks Rand was able to provide a minimum detection limit of 0.1 ng/L (0.1 parts per trillion). Using ultra-clean sample handling protocols developed by EPA, nine stations were sampled within the Salmon Falls Creek Watershed. In addition to the surface water component, the State Office personnel of the DEQ and personnel from the Idaho National Laboratory began an airshed monitoring program. Combined, these studies are the most comprehensive evaluation of mercury levels in Idaho's waters conducted to date.

Table 28. Trophic Level Weighted Average Mercury Concentrations in Salmon Falls Creek Reservoir Fish Tissue.

Trophic Level Average		Consumption	Product of Weighting Factor and Concentration	Weighted Average Concentration (mg/kg)
	Concentration (mg/kg)	weighting factor (g/day)		
Trophic level 2	0.489	3.8	1.8582	
Trophic level 3	0.472	5.7	2.6904	
Trophic level 4	1.135	8.0	9.0800	
		17.5	13.6286	0.779

Sources of mercury

Mercury can enter into Salmon Falls Creek Reservoir from three sources. The first of these is Salmon Falls Creek, second is from the smaller intermittent and ephemeral tributary streams and immediate watershed of the reservoir, and third is from direct deposition on the reservoir surface. It is unknown if springs discharge directly into the reservoir. The probability of this appears minimal, as the reservoir has undergone severe drawdown due to drought over the past seven years, exposing much of the reservoir bottom. During this time, spring sources along the exposed bottom of the reservoir were not evident (personal observation).

When released to the air, mercury can disperse along several pathways, depending on the speciation of the element. Speciation also affects dispersion distances as well. Typically, Hg^0, elemental mercury, is the species that is volatilized from the soils and vegetation, and it is this species that is emitted from the stacks and furnaces of many sources. The log H’ for mercury is -2.9576, which indicates it will undergo volatilization at a rate similar to DDT (Crosby 1998)

Once Hg^0 is released into the atmosphere, it can disperse very long distances. While in the atmosphere, Hg^0 can undergo oxidization reactions and be converted to Hg^{2+}, divalent mercury. Atmospheric Hg^{2+} readily dissolves and thus has a relatively short dispersal distance as it is easily washed out in rain and snow. Particulate Hg^{2+} can also be transported from a source via winds although the dispersal mechanism is still short range.

Once scrubbed from the atmosphere Hg^{2+} adsorbs to soil particles through covalent bonding with clay particles. The water carbon partition coefficient for mercury is very low (Log_{koc} = 0.6074), which would indicate little affinity to the organic carbon found within soils. Both Hg^0 and Hg^{2+} can also be directly deposited within a stream or reservoir water body.

Once in the soils, mercury can be re-volatilized back into the atmosphere (Hg^{2+} after undergoing reduction to Hg^0) or transported to the aquatic system via a runoff event as either species. It is in aquatic systems that mercury best exerts its toxic nature. Here, Hg^{2+} is converted to methylmercury (meHg), a much more toxic form. Methylmercury is typically produced in aquatic sediments from microbial processes, usually by sulfur reducing bacteria, but these types of reaction and conversions can occur in any anaerobic condition.

Salmon Falls Creek Reservoir typically has a very large anoxic zone during most of the summer. The reservoir is eutrophic or hyper eutrophic in nature partially as a result of the large contributing watershed and partially from current and historical land use practices that have occurred within the watershed. In addition, Salmon Falls Creek Reservoir is a very deep and narrow water body. These morphological conditions do not allow for a significant amount of wind induced mixing following spring turnover. Consequently, the reservoir quickly stratifies at the onset of warmer weather. Furthermore, these morphological characteristics allow stratification to remain firmly established throughout the summer months. The high productivity combined with the morphology of the reservoir produces a very large anoxic zone within the reservoir each summer—an effective mercury methylation chamber.

Once methylated, meHg is readily incorporated into the lowest trophic level. It is often seen in many lakes that the biomagnification of meHg is a factor of 100,000 in the algae and a factor of 10 in each following trophic level (Environment Canada www.ec.gc.ca/ceqg-rcqe). The following figure depicts the various pathways of mercury in the environment.

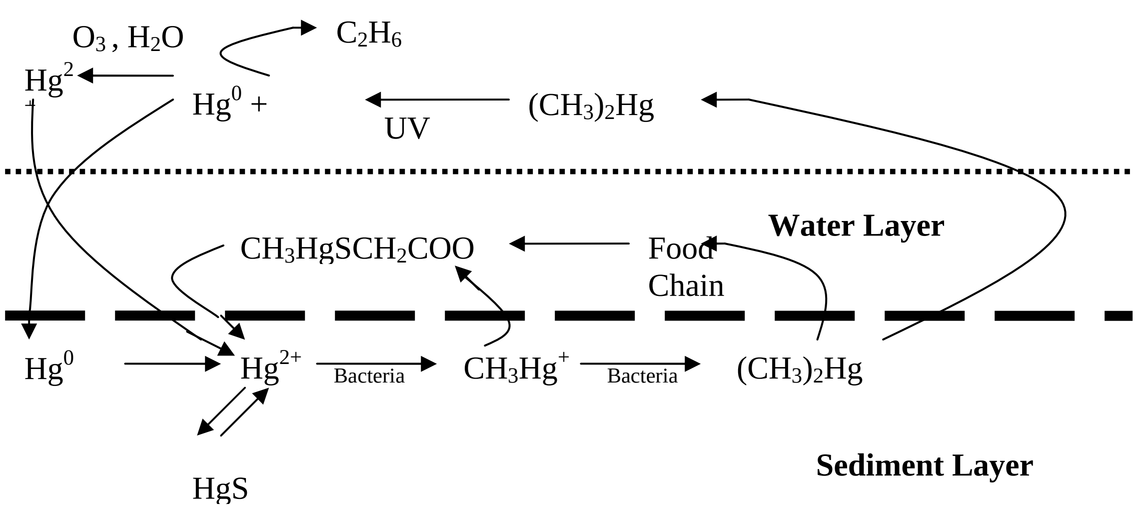


Figure 67. Environmental Pathways of Mercury in the environment.

(adapted from www.agen.ufl.edu/.../ lect/lect_22/FG14_028.GIF).

Geological Sources

Natural sources of mercury include emission from enriched soils, erosion and weathering from naturally occurring deposits and enriched soils, global atmospheric load from the oceans, wildfires, and geological processes such as geothermal springs and volcanoes.

The Salmon Falls Creek subbasin is relatively rich in geothermal activities. These geothermal springs result from the pressurized geothermal layer that underlies much of the subbasin. Throughout southern Idaho, when the Idavada layer of volcanics exists geothermal activity also exists (Young and Whitehead 1974). The Idavada volcanics are found in the northern portion of the Salmon Falls Creek Subbasin (Alt and Hyndman 1989).

Ground water concentrations collected in several springs indicate that geothermal springs are a source that could exert an impact on the local receiving water body. Average total mercury concentrations from two geothermal springs located within the subbasin was 14.26 ng/L (range 10.6 to 16.2 ng/L). However, it should also be noted that samples collected in the receiving water body, Shoshone Creek, was near background concentrations.

As mentioned previously the mercury concentration in Shoshone Creek was 2.14 ng/L, and the range in measured concentrations was 0.54 to 5.89 ng/L. Several factors could explain the attenuation in the stream system:

First, the mercury from the geothermal springs may be settling out close to the sources, in which case fishes closer to spring sources should have higher concentrations of methylmercury within their tissues. This however, is not what we observe, as can be seen in the fisheries data for Salmon Falls Creek upper and Shoshone Creek.

Second, the mercury load (mass per unit time) from the springs is actually very small as the flow from geothermal springs sampled were very small, in the range of 0.5 to 2 cfs, while Shoshone Creek averages 37 cfs. Within the region covered by the 1:250,000 scale maps of Twin Falls ID and Wells NV there are 15 geothermal springs in the Twin Falls, Idaho area, and 23 within the Wells, Nevada area (because of the broad scale of the map we can not tell if all of these geothermal springs are actually within the subbasin). If one assumes each spring contributes 1 to 5 cfs and has similar mercury concentrations as the springs we sampled, then subbasin mercury load from the geothermal springs is approximately 0.48 to 2.4 kg/y.

A second important source of mercury is from naturally occurring geological sources of in the Salmon Falls Creek Subbasin, which includes the naturally enriched soils and the outgassing of mercury from soils as well as mercury from runoff and erosion events. The magnitude of these sources is very difficult to determine. Based on the long history of precious metal mining within the southern portion of the subbasin, it might be assumed that mercury within the soils of the subbasin would be quite high naturally. As a result, the outgassing and erosion based mercury sources could also be quite high.

One study of the soils and outgassing of mercury from a locally rich area indicated that as much as 78 kg/year were emitted to the atmosphere from a 227 $miles^2$ area (Engle et al 2001), or 15.30 ng/m^2/hour. In other studies of mercury rich soils, the natural emission factor is much less (1.5 ng/m^2/hour). (It should be noted that not all of the subbasin would contain such highly enriched soils as the Ivanhoe district.)

However, the load of mercury outgassed to the atmosphere for the entire subbasin, based on these two emission rates, would be between 71 and 723 kg/y. The fraction of this mercury finding its way into Salmon Falls Creek Reservoir is even more difficult to determine, and may already be captured in the dry deposition and wet deposition information presented below.

The amount of mercury entering the Salmon Falls Reservoir from erosion of soils is unknown at this time and no estimate of the load from this source is available. Several inferences can be made concerning the erosional processes as discussed in previous sections of this document (see the Salmon Falls Creek upper mercury load duration curves).

Atmospheric Sources

In general, the greatest source of mercury to most watersheds is atmospheric deposition. Mercury concentration in the atmosphere is typically very low, usually measured in nanograms or picograms per cubic meter of air. However, atmospheric deposition is typically an ongoing chronic source contamination rather than an acute event. In addition, atmospheric concentrations in the Salmon Falls Creek Subbasin may be much higher than average US or global background levels due to localized mineral deposits, mining operations, and large numbers of wildfires annually within the airshed. Other areas in the United States have seen higher atmospheric concentrations due to localized industrial facilities, such as coal fired electrical generation or municipal waste incineration. In general, the global atmospheric "background" load has increased as a result of industrialization, and may continue to do so as more second and third world countries become industrialized despite the reductions seen in Europe and North America.

The Salmon Falls Subbasin provides a large area for the deposition of atmospheric mercury. The subbasin is approximately 2,103 $miles^2$. Additionally the watershed to reservoir ratio is very high (approximately 526:1) which may increase the amount of mercury that is available to wash into the reservoir simply based on the size of the watershed alone.

Atmospheric deposition of mercury occurs via two processes. During wet deposition, Hg compounds are scrubbed from the atmosphere during rain and snow events. Typically most mercury is deposited within the first 15 minutes of a precipitation event (Frontier geosciences 2005). The second process is dry deposition; this fraction is not well understood and may or may be more significant in comparison with the wet deposition. Many published studies indicate dry deposition is greater than wet deposition in arid western locations. Some of these include studies in New Mexico, Nevada, and in the Salmon Falls Creek area (in press) in addition to modeling studies (e.g., Lin et al., Atmos Env. 41, 6544), which found that dry deposition accounted for 2/3 of the total deposition.

Air monitoring data within the Salmon Falls Creek subbasin is very limited, although the data set is one of the more robust data sets compared to other published studies in the U.S. and the western states. Data from an initial survey indicate seasonal averages of 3.2, 8.2, 13.7, and 2.3 pg/m^3 of reactive gaseous mercury (RGM) in the air mass measured near the Salmon Falls Creek Reservoir in the winter spring, summer, and fall respectively (Abbott and Einerson 2006). This form of mercury is thought to have a relatively short life span (six to ten days) in the atmosphere (Schroeder and Munthe 1998) and as a result may be more indicative of regional sources.

Gaseous elemental mercury (GEM) was also measured at the same time as the RGM measures were taken. The seasonal average GEM concentrations reported were 1.32, 1.39, 1.91, and 1.65 ng/m^3 in the winter, spring, summer, and fall respectively (Abbott and Einerson 2006). The lifespan of GEM is very long in comparison to RGM, on the order of months or years. Additionally, GEM is the form of mercury naturally emitted or reemitted from soils and vegetation which further complicates the dry deposition picture. Furthermore, most industrial sources purport to emit mostly GEM rather than RGM or particulate mercury (PHg). Background levels of GEM, RGM and PHG, measured in central Oregon area average 1.54 ng/m^3 of GEM, 43 pg/m^3 of RGM , and 5.2 pg/m^3 PHg (Swartzendruber et al 2006).

To obtain an estimate of dry deposition loading or flux, measured concentrations are typically multiplied by seasonally adjusted deposition velocities for the various forms of mercury. Abbott and Einerson (2006) calculated seasonal dry deposition for the Salmon Falls area. These seasonal deposition rates were converted to a load for the watershed, giving 9.72 kg/year of RGM and 52.80 kg/year of GEM. Although, a brief seven day experiment seemed to indicate that the GEM fraction may be insignificant due to an upward gradient in concentrations which would result in more emission of GEM rather than deposition (Abbott and Einerson 2006).

Weekly monitoring was conducted by DEQ in the Salmon Falls watershed from February 2006 until February 2007 to determine the amount of wet deposition mercury falling on the watershed and reservoir. Data collected at the wet deposition site near the Salmon Falls Creek Reservoir Dam included precipitation, total mercury, wind speed, and wind direction. The data set includes data for 53 weeks. Measurable precipitation was recorded in 37 of those 53 weeks, for a total of 10.19. Average annual precipitation from three nearby meteorological stations are presented for comparison. Average annual precipitation in the nearby Hollister area is 11.02 inches, in the Jackpot, Nevada area average annual precipitation is 10.33 inches, and in the Castleford area average annual precipitation is 10.50 inches. Mercury concentration measured in the 37 weeks of precipitation “events” range from 2.28 ng/L to 130 ng/L. Average mercury concentration for the data set is 26.76 ng/L. Converting these concentrations to an areal load gives mercury deposition of from 8.18 ng/m^2 to 466 ng/m^2, an average wet deposition per week of 103 ng/m^2. Summing for the year (all weeks with measurable precipitation events) yields 4.122 μg/m^2 of total mercury deposition via wet deposition. Extrapolation to the watershed surface yields approximately 19.33 kg of total mercury deposited via wet deposition in one year. Given that the recorded annual precipitation appears similar to the average annual precipitation at the three nearby meteorological stations DEQ assumes that the 19.33 kg/year measured in 2006 is representative of average wet deposition of Hg in the watershed.

In addition to the wet deposition events, mercury (Hg^{2+}) that has been deposited within the basin (dry or wet) is readily carried by runoff into the stream systems due to weak covalent bonding and adsorption on fine clay particles of soil. Other forms of mercury are less mobile and are generally carried mechanically by other precipitation events. Clay particles are easily held in suspension and eventually settle out of suspension in the calm lacustrine environments of the reservoir. These particles then deposit onto the poorly oxygenated bottom of the reservoir. In the anoxic sediments and hypolimnetic waters above them, sulfate reducing bacteria transform the inorganic mercury into methylmercury which then bioaccumulates. Methylmercury is progressively concentrated as it passes up the food chain, reaching unhealthful levels over time in larger and higher trophic level fishes.

Gold Mining

The northwestern Nevada gold mining district near Contact Nevada has a long mining history. Substantial deposits in the area were discovered in the late 1850s and have become known as the Comstock lode. By the 1860s many mills were in operation throughout the region. The mills at that time used a variety of refinement and milling techniques to extract the gold and silver from the ore. A mercury amalgamation process was the primary technique used. Following the amalgamation process, the amalgam would then be heated in a retort to remove the precious metals, while mercury was either lost to the environment or recovered for subsequent reuse in the process.

Technological improvements have reduced the number of operators using the mercury amalgamation process in the Comstock/Contact Nevada region. Currently there are approximately five companies operating seven milling and roasting facilities in the Comstock/Contact Nevada region. The most common feature of these operations is the sodium cyanide leaching process to remove gold, silver, and mercury from the ore slurry. During this process, the raw ore is roasted at temperatures near 1,100 degrees Fahrenheit. At theses temperatures some mercury is volatilized and released into the gas flue. Various stack scrubbers have been employed to reduce the emissions of volatized mercury (Johnson 2000).

Ore from the roasters is then quenched and cooled to form a slurry. To this slurry, sodium cyanide is added to form a precipitate with gold, silver, and mercury. The precipitates then travel to a mercury retort to remove mercury and the precious metals.

In addition to the mercury emissions from the retort process, the mining area also contributes mercury to the environment from the mechanical processing of large amounts of rock and soils high in mercury content. These sources are classified as fugitive Hg emissions on the EPA toxic release inventory. Two components make up the fugitive emissions: volatilization and wind borne dust. The volatilization of the mercury is enhanced by high temperatures common during the summers in that Salmon Falls Creek Subbasin. These mercury emissions can travel very long distances (Johnson 2000), and the sources include ore, tailings, and waste rock. Windborne dusts include both Hg^0 and pHg emissions. These emissions are facilitated by high winds, which are also very common in the Salmon Falls Creek Subbasin year round. The sources include ore, waste rock, tailings, and disturbed areas. Unlike the volatilized fraction, these sources have very short dispersion distances.

A summary of the current mining and roasting facilities located in or near the subbasin include the following operations, associated processes and potential Hg sources (Johnson 2000). These sources and the emission loads can be found at the EPA toxic release inventory database and are summarized in Table 29.

The Jerritt Canyon Joint Venture uses ore roasting and cyanide leaching processes to refine gold, silver, and mercury. Hg is volatilized at high temp and released through the flue. A series of scrubbers removed the volatilized Hg from the gas stream. A dilute solution of sodium cyanide is added to the roasted ore slurry. Precipitates are then passed through a mercury retort to remove Hg from the precious metals.

The Getchell Mine uses a retort with carbon columns to capture Hg, in addition an autoclave pretreatment converts Hg into Jarosite a stable mineral. As a result, very little mercury is lost to the environment. The largest Hg source for this operation is from fugitive dust emissions. Other operations in the area that use a similar process include Barrick Goldstrike which uses roasting and retort; Coeur Rochester which uses a reverberatory furnace and mercury retort that is 95-100 % efficient in mercury removal; and Newmont Mining which currently has 3 operations in the area.

Besides the operational aspects of the milling and refining processes other sources of mercury emissions exist. As stated previously the fugitive mercury emissions from ore and waste rock can be quite high. In addition, the crushing and mining procedures expose large areas of mercury-enriched material. These exposed areas are the main contribution to volatilized Hg; there are strict controls on tailing and ore from entering into stream systems.

The principle source of Hg from the mining operations is Hg^0 from the roasting and retort processes. A second source is particulate Hg from crushing, mining, and transportation processes. The third source is volatilized Hg^0 from tailings, waste rock, and ore. This is the same form as the Hg volatilized from the roasting and retort process.

Table 29. Mercury Releases to Air by Nevada Mining Sources, EPA TRI.

FACILITY NAME AND LOCATION	TOTAL AIR EMISSIONS (lb/year)							
	1998	1999	2000	2001	2002	2003	2004	2005
Getchell Gold Corp Golconda	9	7	7	0	0	0	23.1	0.2
Jerritt Canyon Joint Venture Elko	9,400	9,400	6,700	7,990	4,740	790	461	381
Newmont Gold Company Carlin South Area	82	90	106	501	534	565	262	690
Newmont Gold	2	3	8	71	50	65	59	63

FACILITY NAME AND LOCATION	TOTAL AIR EMISSIONS (lb/year)							
	1998	1999	2000	2001	2002	2003	2004	2005
Company Lone Tree Mine								
Newmont Gold Company Twin Creeks	2,560	1,248	648	603	560	588	327	592
Barrick Goldstrike Mine Elko	1,515	1,411	1,514	1,324	1,299	1,452	2,205	1,701
Coeur Rochester Inc Lovelock	8	8	55.45	15.9	5.3	5.3	7.5	7.5
Total	13,576	12,167	9,038.45	10,504.9	7,188.3	3,465.3	3,344.6	3,434.7

Coal Fired Boilers and Other Sources

Three coal-fired boilers are located within the vicinity of Salmon Falls Creek Reservoir. All are owned and operated by the Amalgamated Sugar Company. The closest is a sugar processing plant in Twin Falls Idaho. The second is the sugar processing plant in Paul Idaho. The third is the sugar processing plant in Nampa, Idaho. According to the EPA toxic release inventory, these facilities are minor sources and contribute less than 9 kg Hg per year each. These emissions consist largely of volatilized Hg^0 with some particulate Hg. However, only with northeasterly winds would the mercury from these local sources reach Salmon Falls Creek Reservoir. Northeasterly winds are uncommon in southern and western Idaho.

Other downwind and distant sources of mercury include the Ash Grove cement manufacturing facility in Eastern Oregon which emits 259 kg/year of mercury, Nucor steel in Northern Utah, 50 kg Hg/year, US Magnesium, Kennecott Copper, Clean Harbors Aragonite from north central Utah which emit a combined 136 kg Hg/year, and the Intermountain Power coal fired electrical generation facility near Delta, Utah which emits approximately 101 kg Hg/year.

Phosphate Mining

Two large phosphate facilities are in operation in the eastern portion of Idaho. These facilities are probably the largest anthropogenic sources of mercury located within southern Idaho. Together they combine to release nearly 606 kg/y of mercury. The methods of disposal are through land filling of waste tailings and deposits from mineral extraction processes. The emissions can be characterized as fugitive dust emissions and volatilization. As with the coal-fired boilers, the phosphate mining operations are in a location where the prevailing winds would likely not transport mercury to the Salmon Falls watershed. As a result, these sources probably impact the reservoir only minimally.

River and Tributary System Sources

Much of the river and tributary analysis was presented in the Salmon Falls Creek upper Shoshone Creek, and China Creek assessment units. This analysis consisted of using load duration curves to assess the seasonality and magnitude of mercury delivery in those systems. In summary, it was determined that Salmon Falls Creek exhibited a pronounced seasonality in the delivery of mercury from the upper watershed, while China Creek was much more consistent throughout the year that data was collected. Shoshone Creek also exhibited a seasonal pattern similar to that seen in Salmon Falls Creek. However, this is not surprising as Shoshone Creek makes up a large percentage of the Salmon Falls Creek discharge. Furthermore, based on precipitation events recorded at the Salmon Falls Creek Dam and water yield records for the reservoir it was determined that the data was collected during what is considered an average runoff year. Therefore, DEQ is confident that the data represent average mercury loading to the reservoir.

To determine reservoir mercury loading DEQ will apply the seasonal averages determined from the current data set for Salmon Falls Creek and the overall average mercury concentration determined from the data set for China Creek. Daily average discharge information from the period of record will be used to determine the appropriate design flow conditions and to determine the average daily, monthly, and annual mercury load entering the reservoir from China Creek and Salmon Falls Creek. Additionally, several streams enter the reservoir for which neither flow data nor mercury concentration data are available. For these systems, the areal loading calculated from the China Creek system will be used, thus loading for the smaller streams will be a multiplier of the China Creek load. These streams include Cottonwood Creek in Nevada, Browns Creek, Corral Creek, and Whiskey Slough in Idaho. Of these only Cottonwood Creek is perennial, the other streams flow for a portion of the year (see various discussions for these systems in the China Creek Assessment unit section). From this data DEQ, calculates that the total load for these small tributary systems is 2.5 times that of China Creek load.

Based on the above, Salmon Falls Creek contributes on average 2.26 g/day of total mercury to the reservoir. Monthly and annually, this equates to 68.86 g/month, and 825.54 g/year. China Creek and the other small tributaries combine to contribute on average 0.02 g/day. Monthly average combined contribution for the tributaries is approximately 0.52 g/month, and average annual contribution from the tributaries is approximately 6.30 g/year. Graphically this is shown in Figure 68.

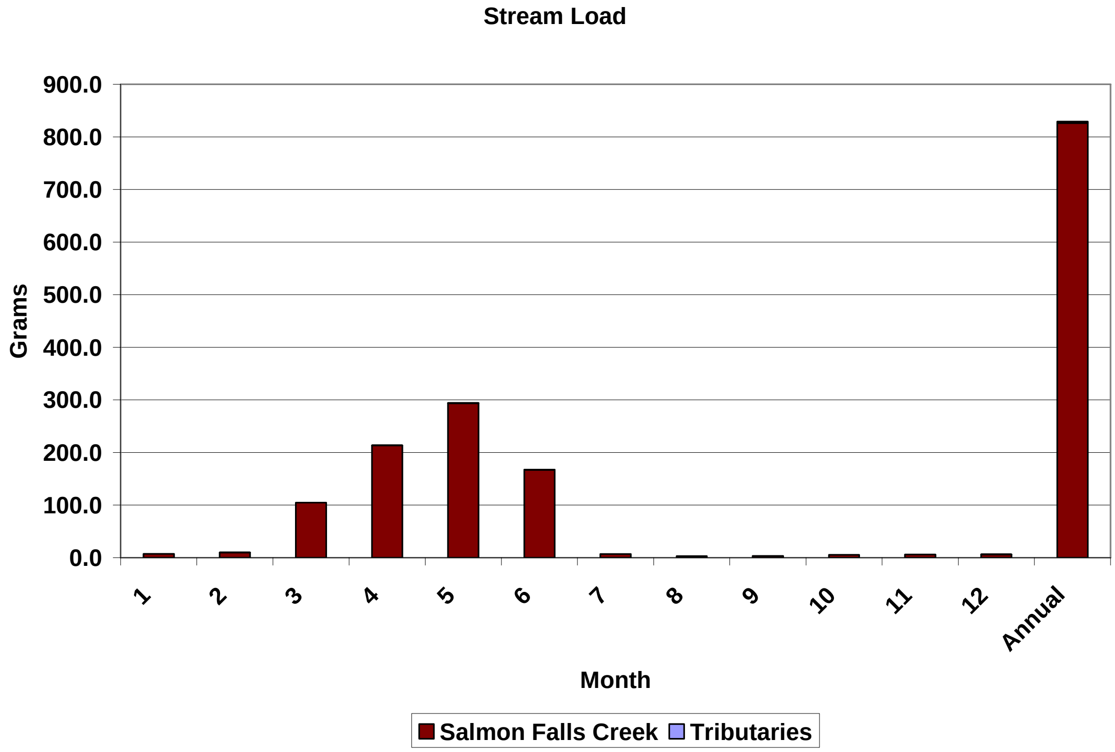


Figure 68. Total Mercury Load from Salmon Falls Creek and Tributaries (grams).

The loads seen in the river and tributary systems would be the accumulation of the wet and dry deposition that fell on the watershed, the geological contribution from the soils and parent material found within the subbasin, and the contribution from the geothermal springs located in and along the river and tributaries.

A non-quantified, and presumably small, amount of additional loading to the reservoir from these same sources arises from the near lake environment. As stated previously, no geothermal springs have been documented near the reservoir or in the lakebed. Erosion of soils from the near lake environment not associated with a river or tributary may contribute a small portion of the mercury load, but it is undoubtedly even less than the calculated load from all the minor tributaries, themselves insignificant in comparison with the load from Salmon Falls Creek. Wet and dry deposition directly to the reservoir can be estimated from the work of Abbott and Einerson (2006). Given the deposition rates calculated from the air mass concentrations and the seasonal depositional velocities of the various forms of mercury, the atmospheric load that falls on the reservoir surface consists of 36.72 g Hg/year of wet deposition, 18.13 g Hg/year of RGM deposition, and 99.37 g Hg/year of GEM. The direct atmospheric loads are shown in Figure 69, and compared to stream loads in Figure 70.

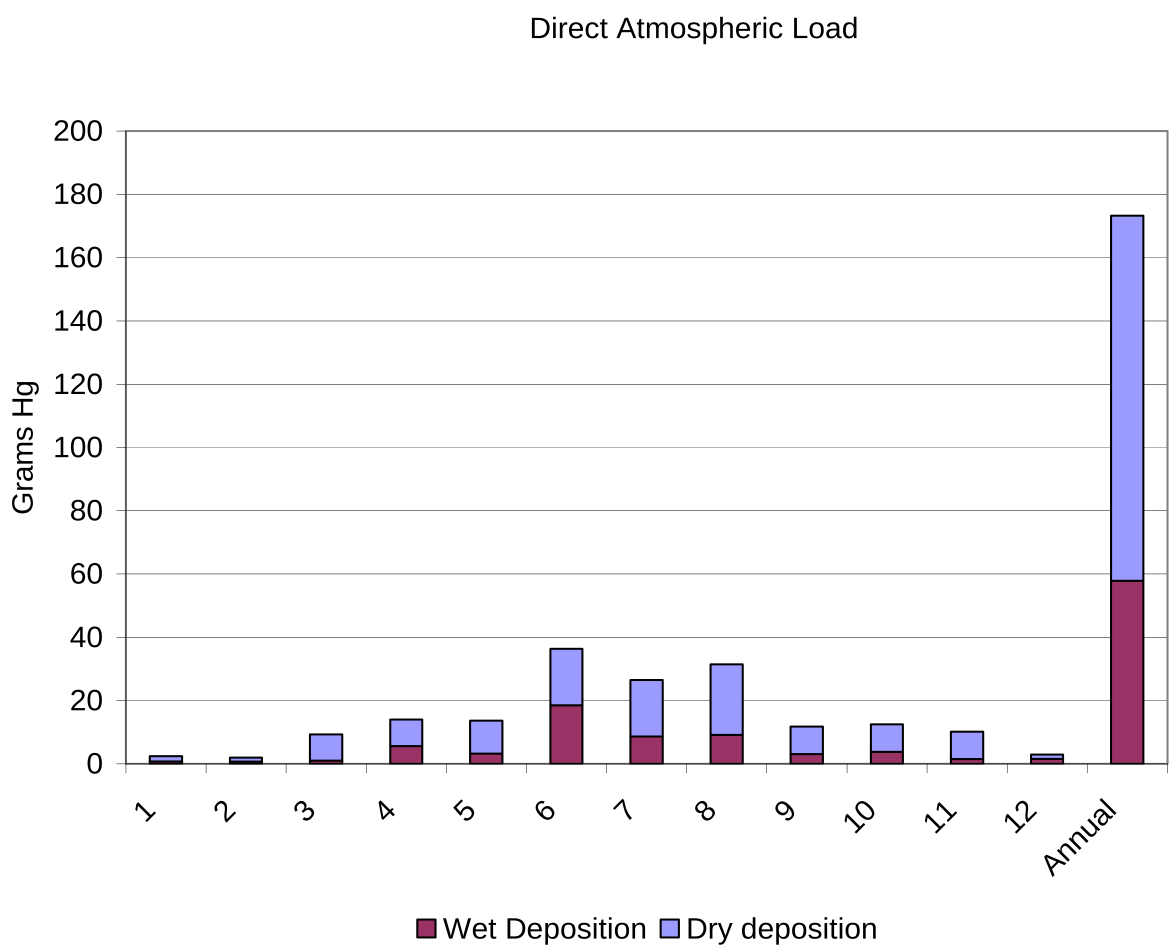


Figure 69. Direct Atmospheric Mercury Load to Salmon Falls Creek Reservoir.

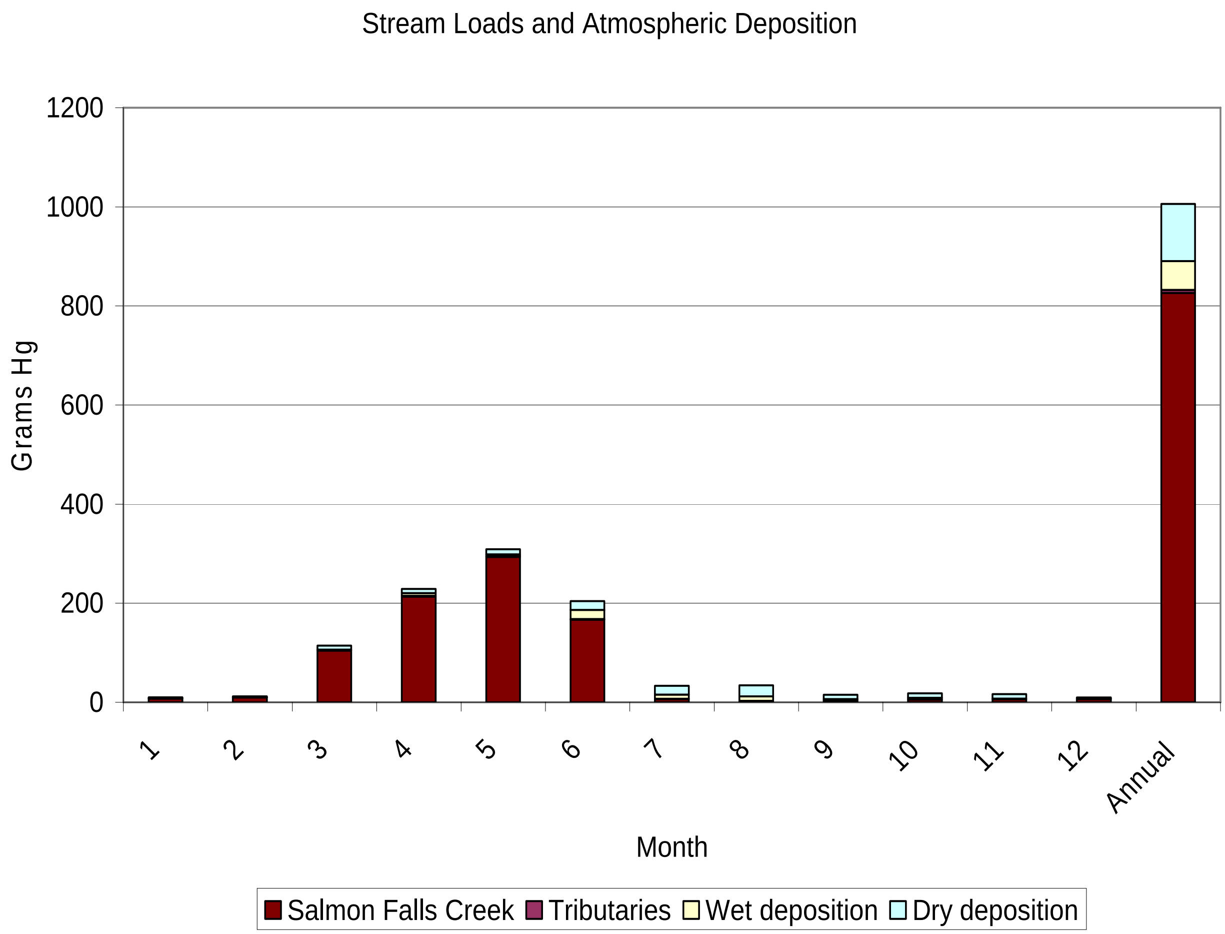


Figure 70. Stream Loads and Atmospheric Loads to Salmon Falls Creek Reservoir.

Mercury Losses

Mercury losses from the reservoir include direct export of mercury through the canal and outlet seepage, volatilization of mercury from the water surface, and sequestering of mercury within sediments. Some of these compartments are easily quantified, such as the export of mercury via the canal and outlet seepage. The other compartments are estimated based upon studies conducted elsewhere in the United States extrapolated to Salmon Falls Creek.

Canal and Outlet Losses

Samples were collected monthly from the canal during the irrigation season of 2006 and analyzed for their mercury concentration. Additional samples were collected from below the dam in the seepage waters on a monthly basis. Together these samples describe the outlet loss compartment of the mass balance model. Concentrations over the course of the study averaged 1.83 ng/L in the canal system with a standard deviation of 0.45 ng/L. Mercury concentrations in the outlet seepage were similar to the canal and averaged 1.79 ng/L with a standard deviation of 0.69 ng/L.

Discharge records for the canal are available from 1922 to date. However, very few discharge measures are available for the seepage below the dam. Seepage below the dam is a function of pool volume of the reservoir. As pool volume increases the seepage rate increases. Based on the few recorded measures collected from below the dam this rate varies between 7 and 10 cfs. Loads for the outlet losses were calculated based on the daily average discharge measures collected for the period of record for the canal and a constant 10 cfs from below the dam. Outlet loads are presented in Figure 71, and clearly show the large loss of Hg via the canal discharge during the irrigation season.

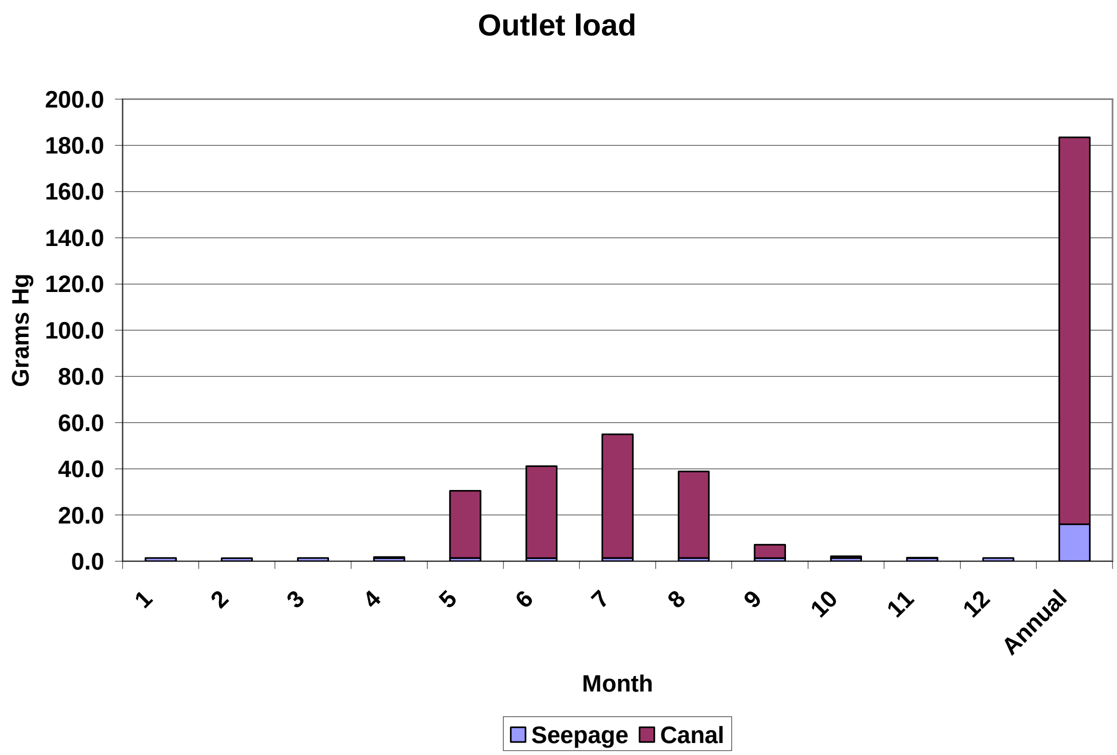


Figure 71. Outlet Mercury Load from Salmon Falls Creek Reservoir.

Based on this mass balance model it is demonstrated that the reservoir acts as a mercury sink for most of the year. The overall annual net storage of mercury within Salmon Falls Creek Reservoir is approximately 800 grams per year (Figure 72). Assuming the mercury inputs and losses were consistent through the life of the reservoir (1907-to date) this would mean that 80,000 grams of mercury have accumulated in the reservoir as an internal load. Also depicted in Figure 72 is a small seasonal net loss of mercury in July and August due to increased water withdrawal to meet irrigation demands.

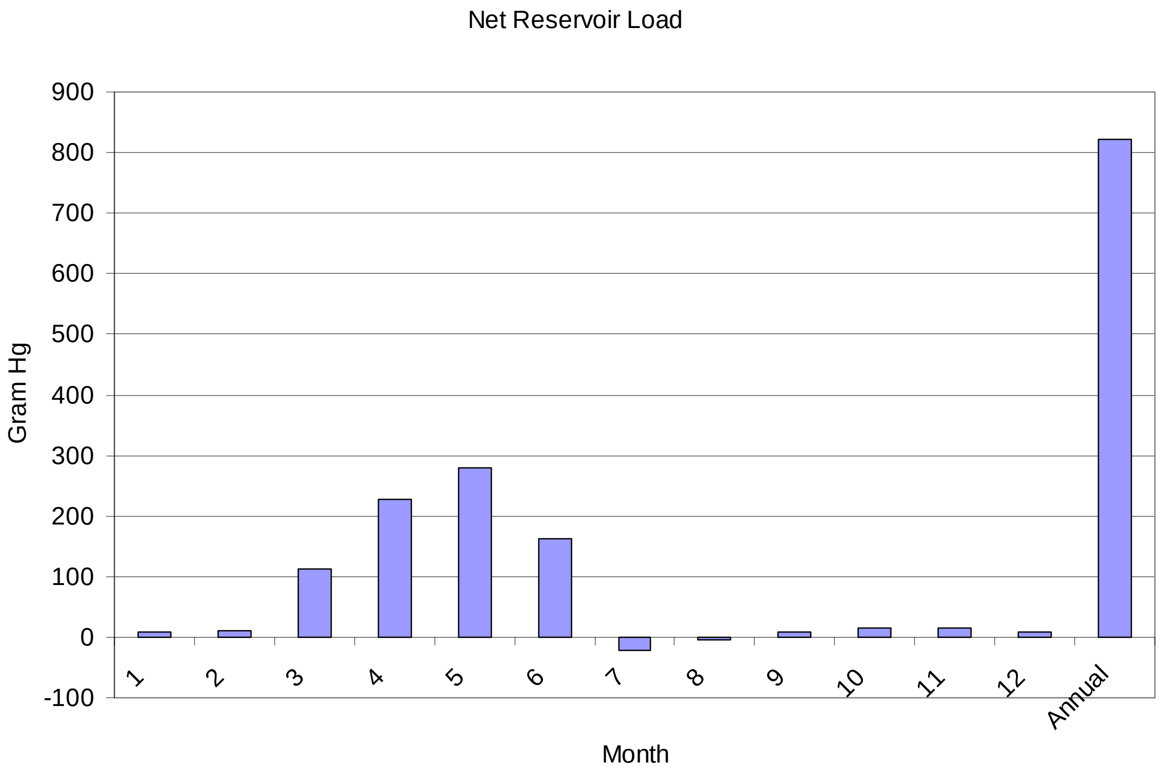


Figure 72. Net Mercury Load to Salmon Falls Creek Reservoir.

Sedimentation

Losses to sedimentation can be estimated from sediment coring, mercury analysis, and radiometric dating. In 2005, the USGS collected two sediment cores from the Grey's Landing area of the reservoir. From these cores it was determined that the average annual mercury flux to the sediment was 340 $\mu g/m^2$. In comparison, the average mercury flux, between 1994 to 2005, seen in several cores collected in Lake Champlain ranged from 19.4 to 54.4$\mu g/m^2$.

Peak mercury flux in these cores ranged from 95.7 to 221.7 $\mu g/m^2$ (Gao et al 2006). To determine total Hg lost to sedimentation it is necessary to factor in the bottom area of the reservoir. Typically, bottom area can be derived from a hypsographic curve which is developed from bathymetry, lake surface elevation, and lake volume information. Currently this data is not available for Salmon Falls Creek Reservoir. More simply, loss of Hg to the sediment can be estimated assuming the bottom area of the reservoir is equal to the surface area, yielding a sedimentation loss of approximately 3,484 g/year. While an underestimate due to the bottom area assumption, clearly this value exceeds the sum of all identified inputs to the system by a factor of three and cannot be correct. However, given the extreme average value seen in the preliminary core data DEQ's confidence in calculating sedimentation losses is minimal at best.

Several factors may reduce this estimate of Hg loss to sedimentation. First, Salmon Falls Creek Reservoir undergoes significant drawdown each year. As the reservoir surface recedes, the sediments in the near shore area are mixed and the mercury found there may be re-entrained into the water column or mixed into the upper layer of sediment where it could be considered available. Drawdown also reduces the area of bottom for sedimentation.

The second factor is that the sedimentation rate estimated from the core (0.2 to 0.4 inch per year) and the age of the reservoir may mean that most of the mercury found within the sediments is available. Although peak methylation rates likely occur in the top 1.6 to 3.1 inches of the sediment, methylation and sulfate reduction continues to occur at depths of 7.1 to 7.9 inches (Choi and Bartha 1994). At 0.2 to 0.4 inch per year of sediment accumulation mercury deposited within the system between 20 and 40 years ago is still available. During this time, the reservoir has seen many significant drops in water level exposing much of the sediment to remixing. Therefore, for purposes of the present mass balance, sedimentation losses will be considered insignificant. This will be revisited at such time more sediment cores are collected around the reservoir to better characterize the lake-wide Hg flux to sediment and when a hypsographic curve for the reservoir can be developed.

Volatilization

Volatilization rates of mercury from lake waters is a complex process and can be affected by many environmental conditions such as air and/or surface water temperature; the intensity and spectral region of solar radiation; wind speed and air turbulence; type of surface; and the chemical composition of the water (e.g. organic carbon content). Mass balance models for several other lakes that have included volatilization as a component. Goa et el (2006) Calculated the volatilization losses for Lake Champlain to be approximately 56.6 percent of the total losses from that large water body. Gbor et al (2004) used many of the same methodologies to model mercury emission rates for Northeastern North America. In this study the maximum volatilization from both soils and water was less than 10 ng Hg/m^2/hour (Gbor et al 2004). Using this volatilization rate the volatilization component for Salmon Falls Creek Reservoir can be estimated. Assuming that winter time volatilization is minimal due to either ice cover or very low ambient temperatures maximum volatilization is approximately 600 g/year.
Further refinement of the volatilization estimate can be made following the methodologies outlined in Gao et al (2006) and Gbor et al (2004). For the mass balance model the following equation was used.

$$F_w = K_w C_w$$

Where F_w is the emission flux of Hg_o from water in ng/m^2/sec, K_w is the mass transfer coefficient, and C_w is the concentration of dissolved gaseous mercury (DGM). As cited in the Chamberlain Lake mass balance study, Driscoll et al (1994) determined that 10 to 30 percent of total dissolved mercury is dissolved gaseous mercury. Others have assumed that all the total mercury in a lake is in the dissolved state (Gbor et all 2006). K_w was calculated from the following equation.

$$K_w(Hg) = K_w(O2)[D_w(Hg)/D_w(O_2)]^{0.67}$$

Where $D_w(Hg)$ and $D_w(O_2)$ are the diffusion coefficients of mercury and O_2 in water, and $K_w(O_2)$ is the velocity of dissolved oxygen.

$K_w(O_2)$ is a function of wind speed and can be determined with the follow equation.

$$K_w(O_2) = 4.0 \text{ x } 10^{-4} + 4.0 \text{ x } 10^{-5}(\text{wind speed m/s})^2$$

Wind speeds were measured at 15-minute intervals at the wet deposition monitor location near the dam and were used to determine the daily average wind speed near the reservoir. $K_w(Hg)$ was then calculated for each day that the wet deposition monitor was operational.

Concentrations of total mercury were collected at a minimum of monthly samples in the large bay (Z-max) near the dam throughout 2006, and are presented below in table 30. During ice covered periods or missing months mercury concentrations from the proceeding and following months were averaged to estimate the mercury concentrations for missing months. Monthly average concentration values were applied to each day of each specific month. For comparison, DEQ varied the assumed fraction of DGM and present the results based on 10 percent and 30 percent fractions.

Table 30. Monthly average total mercury concentration.

MONTH	AVERAGE TOTAL MERCURY CONCENTRATION (ng/L)
January	0.83
February	0.70
March	0.85
April	0.60
May	1.77
June	3.10
July	2.52
August	1.97 *
September	1.70
October	1.75
November	1.72 *
December	1.13 *

* Estimated monthly concentration based on proceeding and following samples.

Based on this refined volatilization equation and assumed fractions of DGM, DEQ estimates that volatilization losses range between 58 and 174 grams/year. A Volatilization rate of 174 grams per year would account for approximately 48 percent of the total losses from the reservoir.

Graphically, the monthly and annual losses from the mass balance model are shown below in Figure 73 using a 30 percent fraction of DGM.

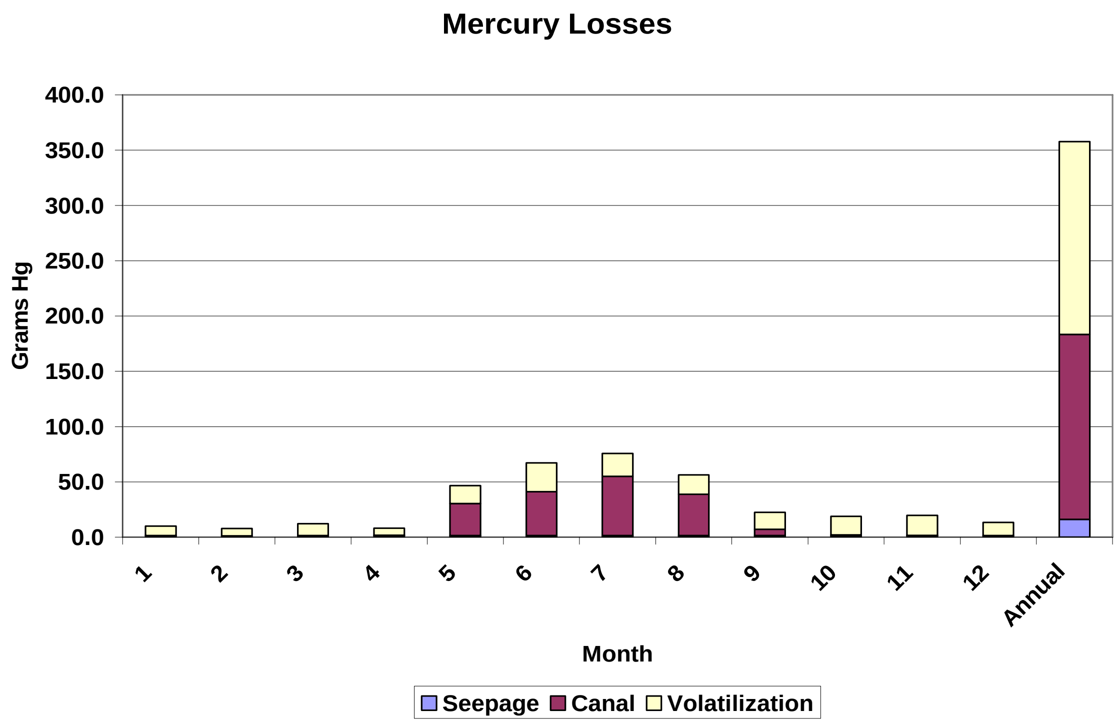


Figure 73. Monthly Mercury Losses from the Salmon Falls Creek Reservoir.

Finally, the mass balance model is presented in Figure 74.

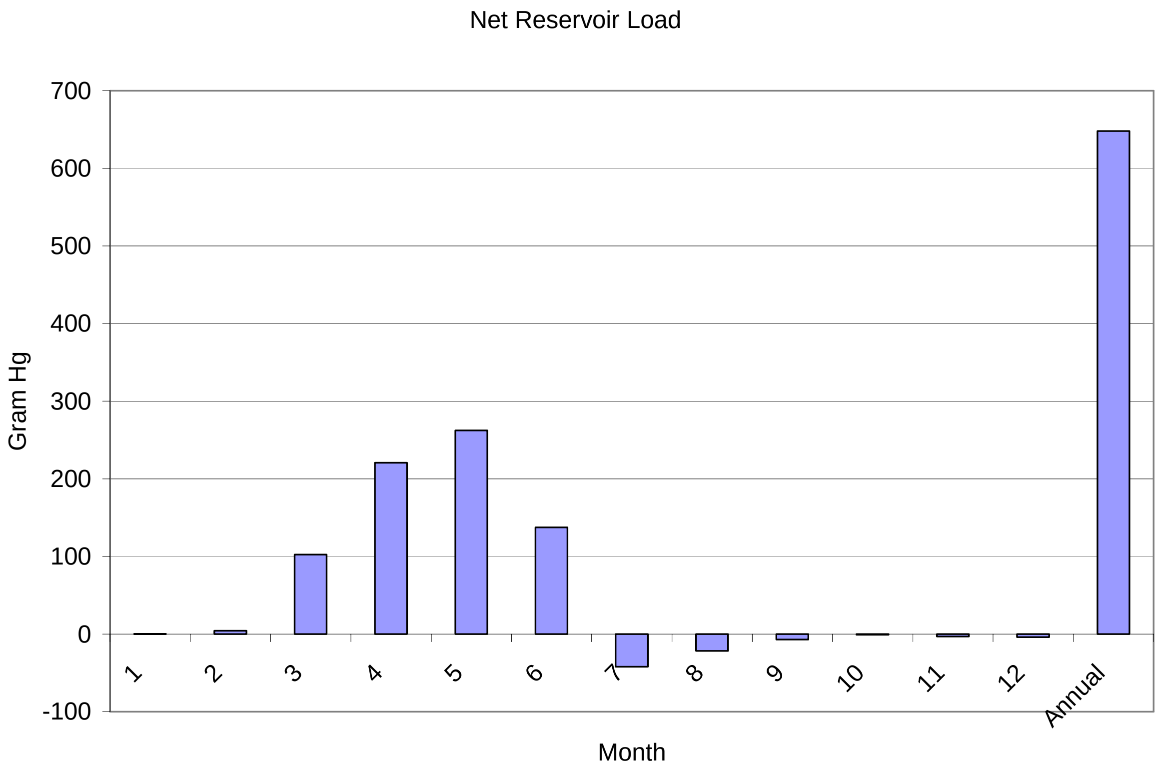


Figure 74. Monthly Mass Balance of Total Mercury in Salmon Falls Creek Reservoir.

Mercury and reservoir management

Salmon Falls Creek Reservoir is used primarily as a irrigation water storage facility. Water is taken out of the reservoir via the Salmon River Canal Company Aqueduct. Limited leakage of water also occurs through the columnar basalts of the Salmon Falls Creek Canyon.

Salmon Falls Creek Reservoir is an extremely deep and narrow water body. Due to its morphology there is a large anoxic area that develops after the reservoir begins to stratify during the summer. Stratification occurs because the deeper areas of a reservoir tend to stay cooler, and therefore denser, than the water above. These deep waters then become isolated during periods of warm weather. Oxygen in these deep regions is rapidly depleted through bacterial decomposition of organic material and respiration of other organisms. This anoxic zone then becomes available to the anaerobic bacteria that produce methylmercury.

Withdrawals from the hypolimnetic zone may provide one mechanism to reduce the amount of mercury found within the reservoir. However, this is fraught with its own perils as the released methylmercury would then be spread onto agricultural fields through the irrigation system. Although the rapid oxidization of methylmercury back to inorganic forms would likely minimize any impact from this spreading of mercury laden water, this is probably not a tenable option.

Because methylation of mercury is primarily a biological process, conditions that favor bacterial activity can be more important than the concentration of total mercury present in the development of elevated fish tissue mercury levels. Anything that promotes the depletion of oxygen will increase the production of bacteria associated with methylmercury conversion. Therefore, reservoir management may be the only factor within our control once mercury has reached the water.

Typically, the microorganisms involved in the methylation process use sulfate rather than oxygen as an electron receptor. However they still require carbon as an energy source. Consequently, nutrient reduction strategies may be the most effective means to reduce fish tissue mercury levels in Salmon Falls Creek Reservoir, as well as other water bodies. Nutrient reduction may eliminate the anoxic zone or reduce the length of time the hypolimnion is anoxic.

It has been demonstrated that fish tissue mercury concentrations rise significantly in the impoundments that form behind new dams, and then gradually decline to an equilibrium level as the carbon provided by flooded vegetation is depleted. It follows that if the water level in a reservoir drops, allowing the growth of vegetation on the exposed littoral areas, that vegetation becomes a fresh source of carbon when it is flooded. With a fresh source of nutrients every time the water rises, bacterial activity, and methylmercury production, increases.

Source Attenuation Strategies

In a comparison study of lake sediments in Minnesota and Alaska, researchers have documented significant reductions of mercury concentrations attributable to regional sources in the Minnesota lakes during the last ten years. This decrease in atmospherically deposited mercury is attributed to the State of Minnesota's aggressive efforts to control all sources and releases of mercury. Given the persistent, bioaccumulative, and toxic nature of mercury in the environment, Idaho and its neighboring states would be wise to undertake a similar comprehensive mercury reduction plan. To this end Nevada has begun to take some of the needed steps. In a joint plan with the mining industry the state of Nevada has developed a mercury control plan (November 17, 2005 press release). These source attenuation strategies may prove to be the best at reducing long term mercury loadings to the Salmon Falls Creek watershed.

Watershed Attenuation Strategies

The State of Idaho is developing this Total Maximum Daily Load for sediment and nutrients in the Salmon Falls Creek Subbasin. The TMDL process will address source loads and determine appropriate load reductions needed to meet water quality standards. The BMPs that are effective in reducing these sediment and nutrients will likely reduce the amount of overland runoff entering streams as well. This will reduce the amount of mercury entering into the reservoir simply by holding it on the watershed were in may be reemitted or sequestered. Similar to the source attenuation strategies, riparian and watershed based BMPs that slow erosion and sediment delivery and minimize nutrient loss may provide the best short term treatment for mercury bioaccumualation available to us at this time.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that numerous species of fish have been stocked into Salmon Falls Creek Reservoir since 1967. Predominantly rainbow trout are placed into the water body several times per year from 1968 to date. Typically, one strain or another of rainbow trout are stocked each year (up to several times per year) and range from fingerlings to catchable sizes. Therefore, DEQ assumes that any salmonids captured in Salmon Falls Creek Reservoir are from stocked populations. However, many of the most recent stocking of rainbow have been sterile triploids.

Fish and Game records indicate that Coho salmon were stocked in the early 70s, Fall Chinook salmon were stocked in the mid 1980s, and kokanee salmon were stock intermittently in the late 60’ and early 70s. From 1988 to now, the IDFG began stocking kokanee on a regular basis, up to several times per year of the different strains of the early and late spawning fish. brown trout were stocked from 1970 to 1986. Bullhead catfish and smallmouth bass were stocked only once in 1994 and 1975 respectively. Incidentally, the 1975 stocking may be the source of smallmouth bass in Shoshone Creek and Salmon Falls Creek

walleye were stocked into Salmon Falls Creek Reservoir beginning as early as 1974 and continuing to date. As many as 12.76 million walleye fry have been placed in the reservoir since 1974. In addition, IDFG has planted spottail shiner (*Notropis hudsonius*) twice, once each in 1987 and 1988, as a forage fish for the walleye population. yellow perch are also found within the reservoir but the stocking records do not indicate if this fish was intentionally introduced to the fishery. Information concerning the population of game fishes of the reservoir is abundant.

In most years IDFG personnel survey the fishery, the most recent report available to DEQ at this time (R-25 00-01) indicates that the fishes present in the water body include bridgelip sucker (*Catostomus columbianus)*, largescale sucker (*Catostomus macrochelius)*, northern pikeminnow (*Ptychocheilus oregonensis)*, rainbow trout, smallmouth bass, spottail shiner, walleye, yellow perch, and black crappie (*Pomoxis nigromaculatus)*. Also collected with the various sampling methods were many crawfish (*Pacifastacus sp)*. Largescale sucker made up 61% of the total biomass of fish sampled while smallmouth bass, walleye, rainbow trout, and yellow perch made up 8.6, 13.2, 10.6, 0.9 percent of the biomass respectively. Game fishes make up nearly 36 percent of the biomass in Salmon Falls Creek Reservoir. Based on the numbers of the fishes collected in 2000, the IDFG indicated that the walleye and smallmouth bass may be food limited in the system.

Idaho Department of Fish and Game management strategies for the reservoir over the past 10 years have fallen in the general fishery category. Therefore, no special regulations, such as slot limits, are in place.

The salmonid species present within the reservoir, rainbow trout and kokanee salmon, are not expected to spawn within the lacustrine environment, rather they are considered adfluvial fishes. The current stocking of triploid rainbow trout by the IDFG also indicates that the management of this fisheries is intended to limit the spawning potential of this fish species. Although the evidence suggests that salmonid spawning is not an existing beneficial use of the reservoir due to management direction, it does not indicate that the water quality is such that the designated use is precluded.

Macroinvertebrates

DEQ has collected macroinvertebrates in Salmon Falls Creek Reservoir one time in 2000. Macroinvertebrates were collected in three general locations and pooled for analysis. Few macroinvertebrates were collected in the pooled samples. Overall, the community consisted of chironomids, oligochaets, amphipods and ostracods. An assessment of the water quality based on the macroinvertebrate community will not be completed. Statewide, there is a limited number of limnetic benthic samples, a lack of a reference community for comparison, and a general shift towards lower trophic level analysis using Carlson's trophic state index (TSI).

Aquatic Vegetation

Emergent aquatic vegetation such as water smartweed (*Polygonum amphibium)* and pondweed (*Potomogeton amplifolius)* is noticeably lacking within the reservoir. It appears that the most significant primary production comes from algal cells within the reservoir. DEQ has not collected phytoplankton in the reservoir to determine the composition of the algae and should be considered a data gap for the reservoir.

As another indicator of trophic state, chlorophyll *a* samples were collected throughout the year to determine if nuisance conditions existed. For lakes, Carlson's TSI can be used to determine if a lake is undergoing cultural eutrophication (Carlson 1977). Utah Department of Environmental Quality has used a TSI score of 50 as a threshold value to indicate impaired water quality in many of the TMDLs completed for excess nutrients in lakes (UDEQ 2000). In order to reach a TSI of 50 for chlorophyll *a* the concentration of chlorophyll *a* has to be higher that 7.22 μg/L. As discussed previously, the samples collected from Salmon Falls Creek Reservoir throughout the summer were well above the value suggested indicating nuisance aquatic vegetation growths. As such, it is likely that excessive nutrients are the factor affecting beneficial uses of Salmon Falls Creek Reservoir.

Status of Beneficial Uses

The above data suggest that the designated beneficial uses of Salmon Falls Creek Reservoir, specifically cold water aquatic life is impaired. Additionally, it appears that the source of the impairment is from several pollutants. Suspended sediment is likely being carried into the system from in-channel storage and bank stability in the upper watersheds of Salmon Falls Creek, Shoshone Creek, and the smaller tributaries of the China Creek Assessment Unit.

Poor bank stability that generates sediment during high flow events has been documented from sources within this system.

TMDLs are proposed to address sediment for Salmon Falls Creek Reservoir and will incorporate the analysis from the other watersheds. Similarly, TP TMDLS are being developed in the upper Salmon Falls Creek and China Creek Assessment Units. The targets and resulting load capacity will be set at levels protective of the water quality in the reservoir, which is more restrictive than if the targets were designed simply for the river and stream systems.

Nuisance aquatic vegetation appears to be impacting the beneficial uses of the system due to low DO levels in the majority of the hypolimnion and metalimnion during the summer months. The principle factor influencing vegetation in the system is elevated nutrients that lead to eutrophication of the reservoir. The development of a nutrient TMDL for the tributary systems should alleviate this condition once the internal load of nutrient is sufficiently reduced.

The remaining pollutant shown to impact the beneficial uses of the reservoir is mercury contamination. Through the mercury mass balance model, DEQ has clearly shown that the largest contributor of mercury load to the reservoir is the seasonal load from Salmon Falls Creek, followed by dry deposition to the reservoir surface, and finally wet deposition to the reservoir surface. However, sources of the mercury transported via the stream systems include wet and dry deposition to the watershed. With the extremely high watershed to lake surface ration (500:1) the atmospheric deposition component may play a larger role than localized geological or geothermal inputs.

It has been further demonstrated that the bacteria concentrations measured to date indicate that primary contact recreation is not currently impaired by pathogens.

Conclusions

Based upon the above assessment, TMDLs for sediment and TP will be developed for the tributary systems of Salmon Falls Creek Reservoir, and that a mercury TMDL will be completed for the Reservoir. In addition to the mercury load from the river and tributary systems the TMDL will also account for atmospheric deposition from anthropogenic sources in nearby states such as Nevada and Utah.

Shoshone Creek Assessment Units

Shoshone Creek includes the Assessment Unit ID17040213SK016_03 which is the third order segment from the source to Cottonwood Creek. It also contains the Section 303d listed Assessment Units ID17040213SK013_04 which is the fourth order segment from Cottonwood Creek to Horse Creek; ID17040213SK012_04 which is the 180 meter segment of Shoshone Creek between Horse Creek and Hot Creek; and ID17040213SK011_04 which is the fourth order segment of Shoshone Creek between Hot Creek and the Idaho/Nevada State line.

Physical Characteristics

Major listed tributary systems that contribute to the loads found within this system include Cottonwood Creek and Big Creek. These systems may in fact be the sources of much of the impairment to the Shoshone Creek Assessment Units. Shoshone Creek flows through the dry, Northern Basin and Range ecoregion. Mean annual precipitation in the area is low. As a result, few perennial systems, outside of Cottonwood Creek and Big Creek, join Shoshone Creek. These other streams typically have very small contributing watersheds, and unless there is a significant spring system, such as with Big Creek, it is highly likely that the streams are intermittent or ephemeral in nature. Therefore, the main discussion will center on Shoshone Creek itself with the understanding that the load and load reductions prescribed for Big Creek and Cottonwood Creek may be the biggest driver of water quality in the reach. Figure (75) below is a graphical representation (not to scale) of the Shoshone Creek Assessment Units and the approximate locations within the system of the monitoring locations.

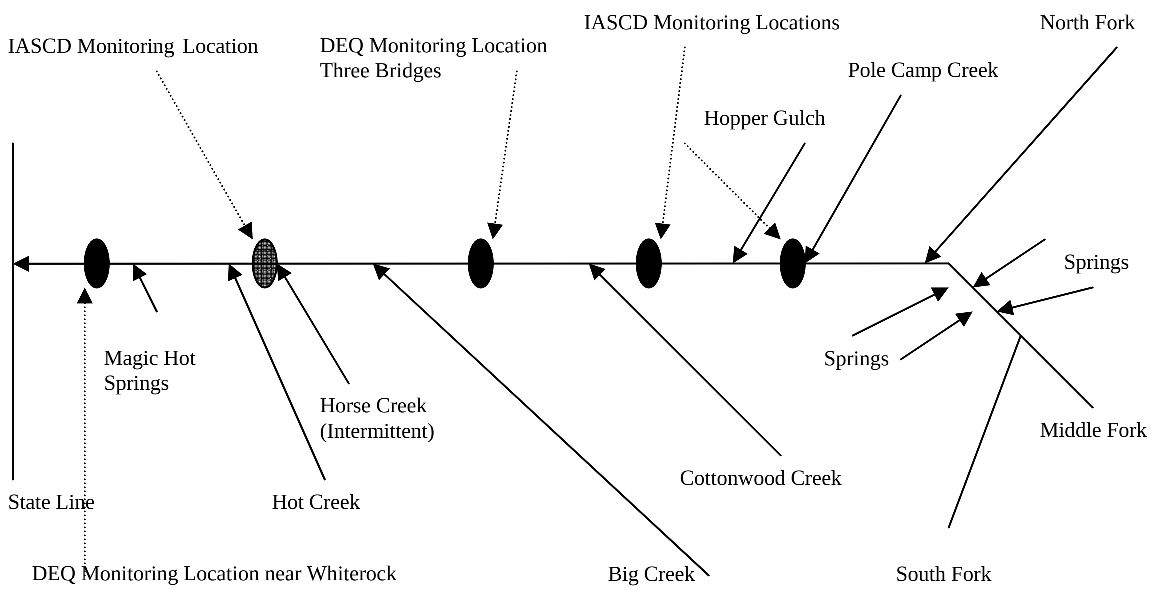


Figure 75. Graphical Representation of Shoshone Creek, Monitoring Locations, and Major Tributaries.

Shoshone Creek begins on the western side of the Cassia Mountains near Black Mountain in Idaho and terminates at the confluence of Salmon Falls Creek in Nevada. This assessment covers that portion of the system between the South Fork and Middle Forks to the Idaho/Nevada State Line. In this area, Shoshone Creek is predominantly a runoff and groundwater base flow fed system but receives a large amount of discharge from the spring fed watersheds of the South Fork, Middle Fork, Cottonwood Creek, and Big Creek. The contributing watershed area for the Idaho portion of Shoshone Creek is 245 $miles^2$. The upper and middle portion of the system includes an area of 144 $miles^2$ which also includes the 28 $miles^2$ watershed of Cottonwood Creek and the 26 $miles^2$ watershed of Big Creek. The upper portion of the system, outside of the listed assessment units includes a contributing watershed of 45 $miles^2$ or 18.39 percent of the Idaho portion of the Shoshone Creek watershed. Characteristics of the above-mentioned watersheds were found at the USGS StreamStats Web site and are presented in the following Table (31).

Table 31. Shoshone Creek Watershed Characteristics.

Parameter	Big Creek	Cottonwood Creek	Shoshone Creek Idaho	Middle Shoshone Creek	Upper Shoshone Creek
Area mi^2	25.6	27.3	243	143	44.7
Area km^2	66.30	70.71	629.37	370.37	115.77
Relief ft	1,870	1,830	2,760	1,910	1,780
Average elevation ft	6,340	6,310	6,100	6,140	6,170
Maximum elevation ft	7,520	7,530	8,140	7,530	7,480
Minimum elevation ft	5,650	5,700	5,380	5,620	5,700
Average area slope in percent	14.2	14.4	10.9	11.4	13.3
Percent of area with slope greater than 30%	11.9	9.23	6.11	6.66	8.06
Percent of area with slope greater than 30% and facing North	2.44	1.67	1.48	1.32	1.6
Percent of area covered by forest	2.08	7.81	2.31	3.68	5.77
Mean annual precipitation in	11.7	13.8	12.4	11.6	11.7

Flow Characteristics

Shoshone Creek has not been gauged in the past, and the closest USGS operated gauge is located in Nevada just south of Jackpot called the San Jacinto Gauge (#13101000). Due to the limited hydrological information concerning the assessment unit, the hydrology will be based upon discharge measurements collected at the USGS and a statistical relationship with the limited measured discharge recorded within the system. See Figure 76 for monthly average stream discharge at the five monitoring locations. Predicted flow patterns seen in Figure 76 provide a graphic representation of the contributions from the various watersheds an illustrate the effects of Big Creek and Cottonwood Creek. The Cottonwood Creek effect can be seen in the dramatic difference in the magnitude of the curve between the data collected above Cottonwood Creek and the Three Bridges data. A similar increase in the magnitude of the curve can be seen in the difference between the Three Bridges location and the Hot Creek sample location, which illustrates the effect of the Big Creek Watershed on the Shoshone Creek system. Also illustrated in this figure is the apparent loss to the groundwater system between the Hot Creek location and the lower sampling location near the state line, and the similarity of the system between the headwaters, below Pole Camp location, and the above Cottonwood Creek location.

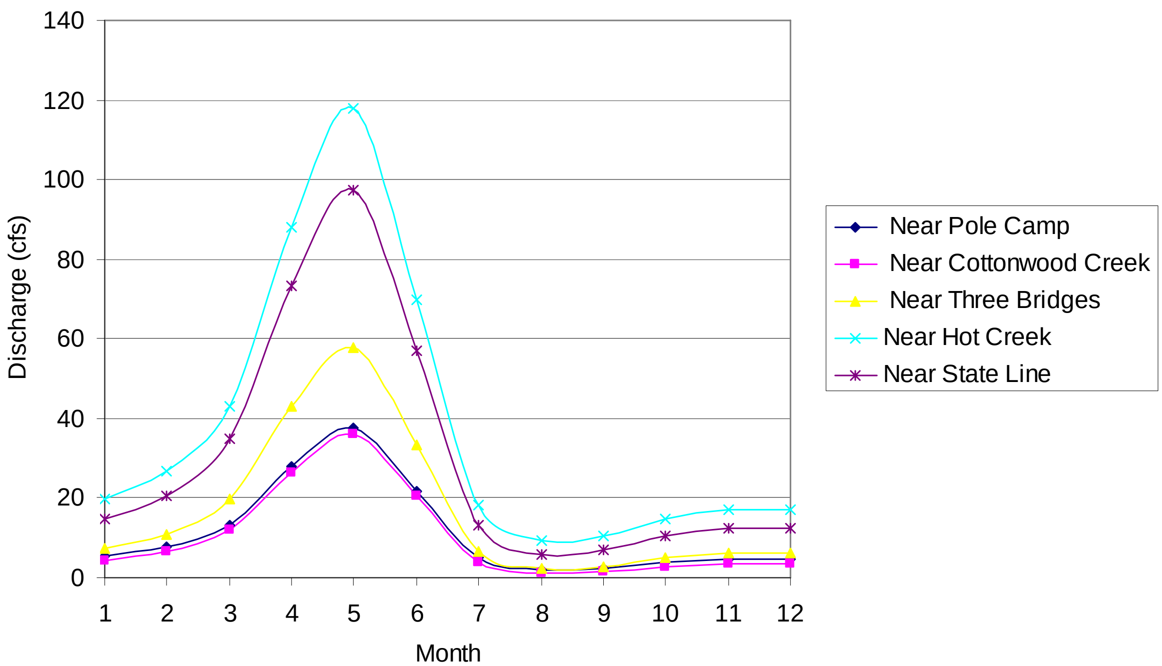


Figure 76. Various Shoshone Creek Locations Monthly Average Flow.

The flow duration curves are most telling of the hydrological regimes seen within a system. Due to the wide range of variability that occur in the Shoshone Creek Assessment Unit systems, knowing the percentage of days in a year when given flows occur is essential to understanding a system. The flow duration curves also provide a visual indication of the potential for a stream to be perennial.

Figure 77 presents a flow duration curves using data from Salmon Falls Creek near Jackpot, NV and linear regressions of flow data collected from the various monitoring locations. The figures illustrate the effects of the small watersheds and low precipitation in the upper Shoshone Creek watershed through to Cottonwood Creek. While in the Lower Shoshone Creek system, the effects of the numerous spring systems can be seen in the stabilization of flow in the high flow duration interval zones below Cottonwood Creek and Big Creek. The average flow duration intervals seen when the systems are predicted to have 1 cfs or greater illustrate these flow regimes well. Near Pole Camp Creek, the 1 cfs FDI was 97.87, above Cottonwood Creek the 1 cfs FDI was 90.86, and at Three Bridges the 1 CFS FDI was 98.81. The FDI at the upper location near Pole Camp indicate that the system contains some small spring sources, enough to keep the system above 1 cfs nearly all the time. The system dries out and becomes smaller and more like a intermittent stream through to Cottonwood Creek where the lower FDI, approximately 90 indicates that the streams sees very low flow in almost 10 percent of the data. The influence of Cottonwood Creek is clearly seen as the 1 cfs FDI rebounds to nearly 99.

Below Big Creek, the largest tributary system feeding the assessment unit, Shoshone Creek never recedes below 4.95 cfs as evidenced by the FDI of 100. However, at the lower sampling location the FDI of 100 was only 2.22 cfs, which may indicate that the portion of the system below Hot Creek is a losing reach. Median flows for the various sampling points within the assessment units were as follows: Shoshone Creek at Pole Camp 4.86 cfs, Shoshone Creek above Cottonwood Creek 3.90 cfs, Shoshone Creek at Three Bridges 9.55 cfs, Shoshone Creek below Hot Creek 17.90 cfs, and Shoshone Creek Near the Idaho/Nevada 13.19 cfs. Coupled with the annual average hydrographs and the flow duration curves it is apparent that the portion of the system below Big Creek and Cottonwood Creek are typically perennial streams. The lower portion of Shoshone Creek never has less than 0.1 cfs while the upper portion, above Cottonwood Creek, is less than 0.1 cfs 2.58 percent of the time.

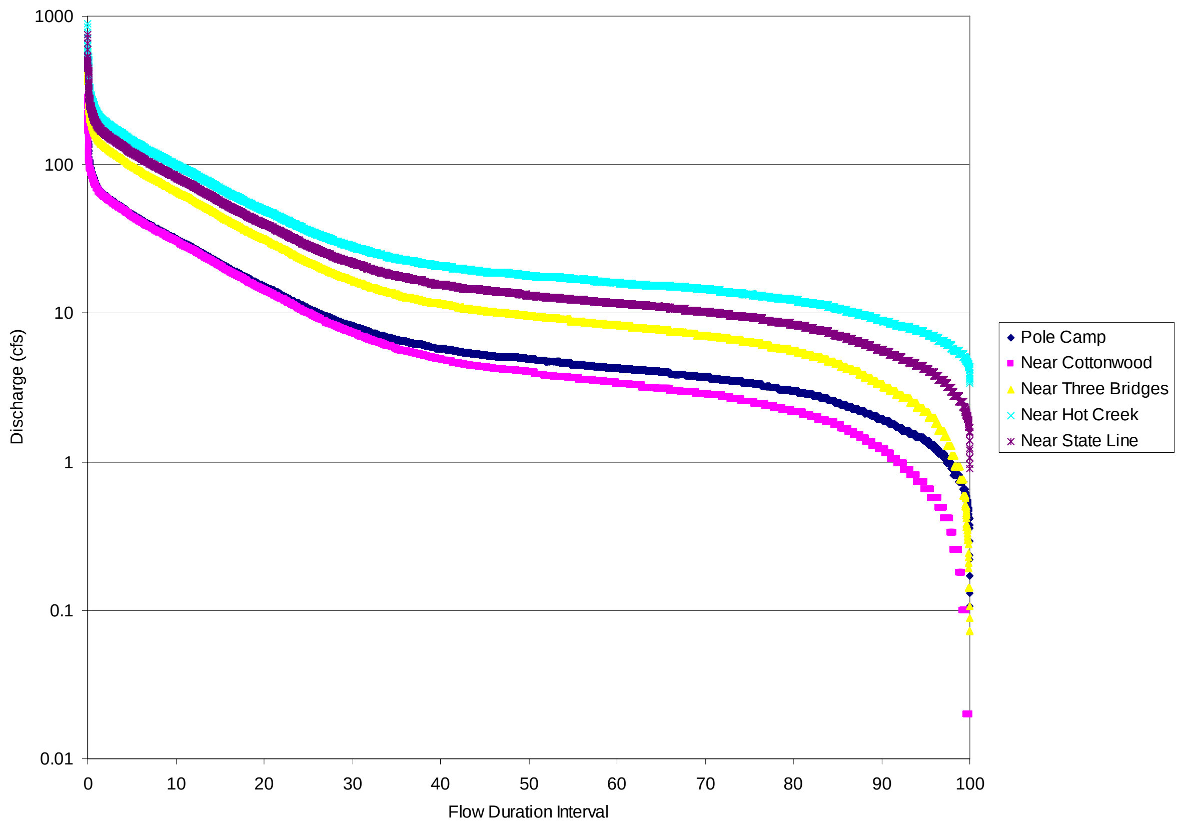


Figure 77. Shoshone Creek Flow Duration Curves for Five Monitoring Locations.

Load duration or load capacity curves for the sampling points within the system were also created from the different flow duration curves and any applicable water quality criterion or target and a conversion factor. Load duration curves for the system are shown below using targets of 0.1 mg/L TP, 1.5 mg/L TN, 50 mg/L SSC, 576 cfu/100ml *E. coli*, and 6 mg/L DO. These figures also display the observed loads, which are calculated by multiplying the sampled constituents by the predicted daily mean flow associated with the sample. Points plotting above the curve represent exceedances of the target and are therefore unallowable loads. Those plotting below the curve represent compliance with the target and allowable daily loads (except in the case of DO were compliance is considered in the points plot above the curve).

Water Column Data

Water quality samples collected within the Shoshone Creek assessment unit systems are rare. These samples are limited to the current DEQ data set collected in 2005 and 2006 and the IASCD data set collected over roughly the same time period and intermittently in 2000 and 2001. To assist in the determination of seasonal components and appropriate critical conditions, the data will be interpreted from the load duration curves. For those cases when a parameter was below detection limits, half the detection limit was used in the loading analysis.

The primary DEQ sampling locations for Shoshone Creek was near the Three Bridges area and near the Idaho/Nevada Border with sampling beginning in May 2005 (Figure 78). Additional sites sampled by the IASCD included a site below the confluence with Pole Camp Creek, a site above the confluence with Cottonwood Creek, and a site near the confluence with Hot Creek.

In general it appears that current land uses and BMPs currently in place are sufficient to be protective of water quality in most of the Shoshone Creek Assessment Unit. This can be seen in the comparison of existing loads with criteria or guideline loads. In almost all cases, the existing loads were below the criteria or guidelines used in this assessment. When an exceedance occurred they were of a small magnitude and infrequent in nature suggesting some type of natural variability or some infrequent land management practice. Furthermore, the Shoshone Creek system's loads generally were expressed in a similar fashion at all locations. This expression is that loads are slightly elevated in the wet and moist ranges of the LDI and even less so during the mid-range and dry LDIs. Again, an indication that land use practices across the general area are similar.

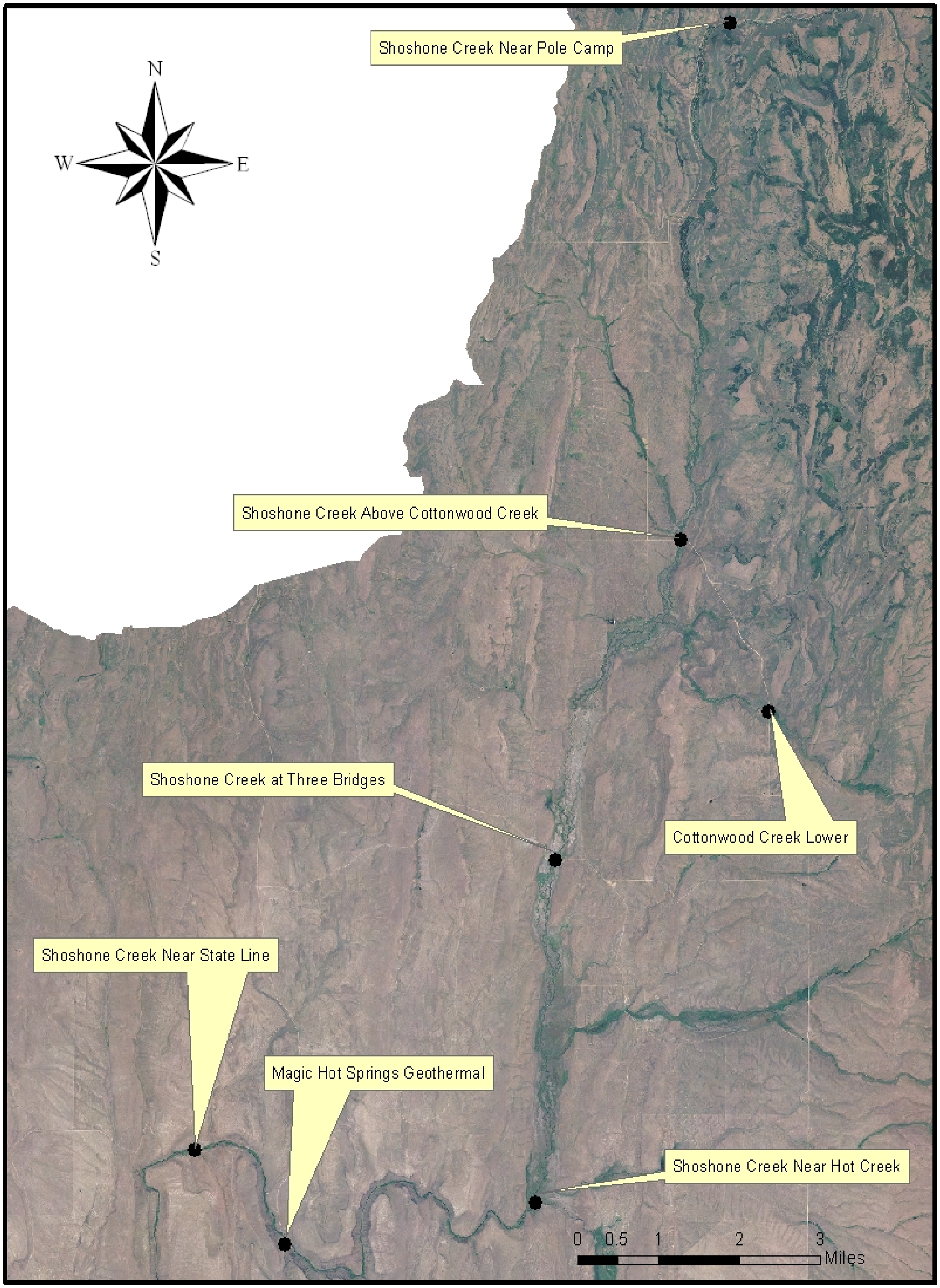


Figure 78. Shoshone Creek Monitoring Locations.

Total suspended sediment appears to be a non-factor effecting beneficial uses throughout the Shoshone Creek Assessment Units. In the Pole Camp area suspended sediments overall were very low, even under wet and moist conditions (Figure 79). At the Cottonwood location, sediment data plotted closer to the load capacity curve during this same period (Figure 80). This may indicate that bank and overland erosional processes may be starting to become issues in this region of Shoshone Creek. Sediment data from further downstream, at the Three Bridges location, plots much closer to the load capacity cure in all cases regardless of LDI zone (Figure 81). This indicates a more consistent delivery of sediment under all flow conditions. Flows capable of transporting sediment are also more common in this reach of Shoshone Creek than in the upper reaches. At the Hot Creek monitoring location, the first exceedances of the sediment load capacity curve are seen (Figure 82). These two data points occur at divergent portions of the LDI, one under high flow conditions and the other under midrange conditions. The typical pattern in sediment is again similar to the upper locations in that under high flow and moist conditions sediment plots much closer to the load capacity curve than during midrange to dry conditions. Additionally, at the lower sampling location, sediment delivery behaves in a similar fashion (Figure 83). Although there are instances of elevated sediment within the system, these are rare and very infrequent with no discernible pattern. Overall it appears that the riparian zone is fully capable of retaining the banks and preventing other sources of sediment from entering the system.

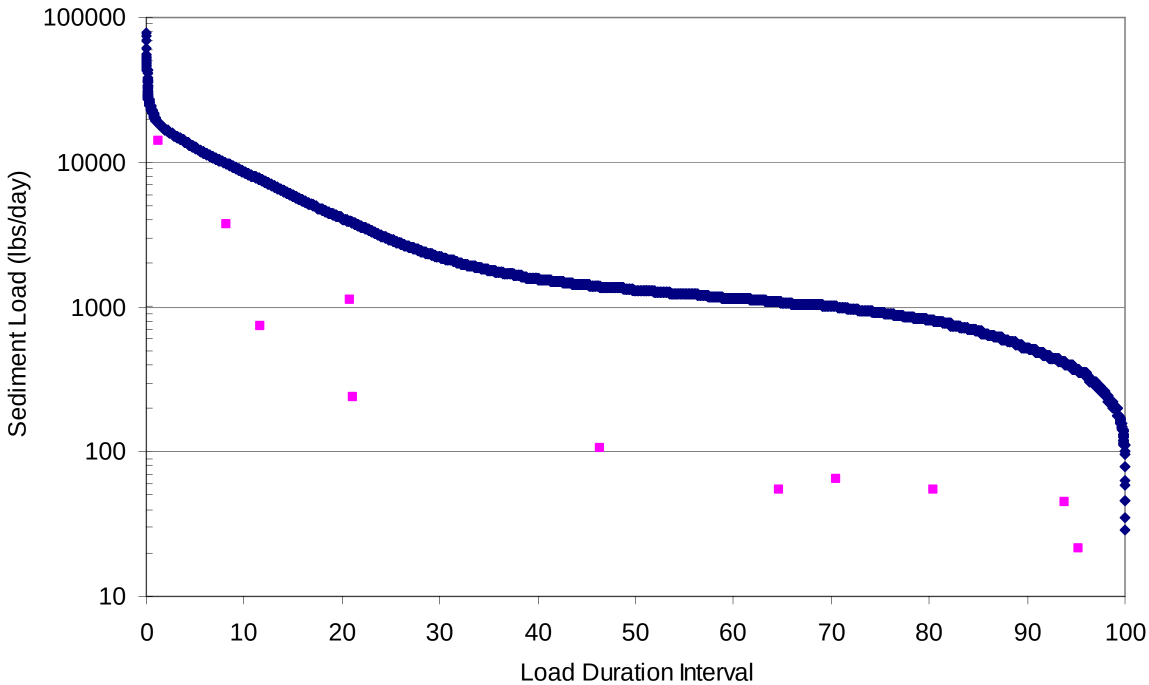


Figure 79. Shoshone Creek Near Pole Camp Sediment Duration Curve.

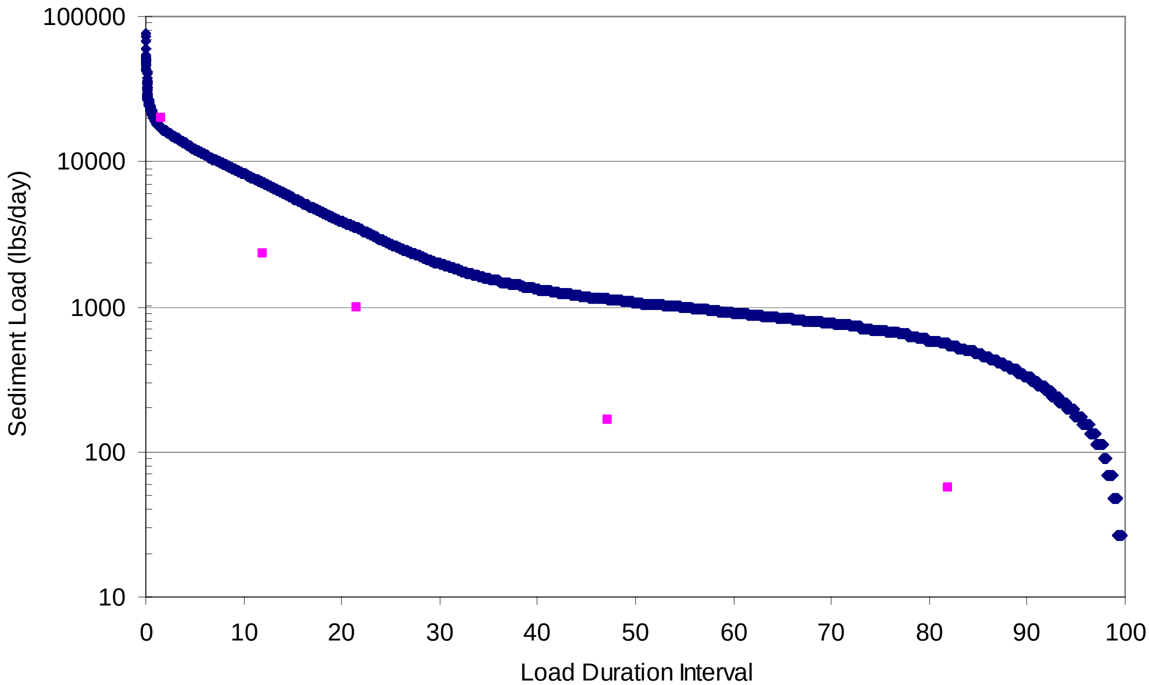


Figure 80. Shoshone Creek Near Cottonwood Creek Sediment Duration Curve.

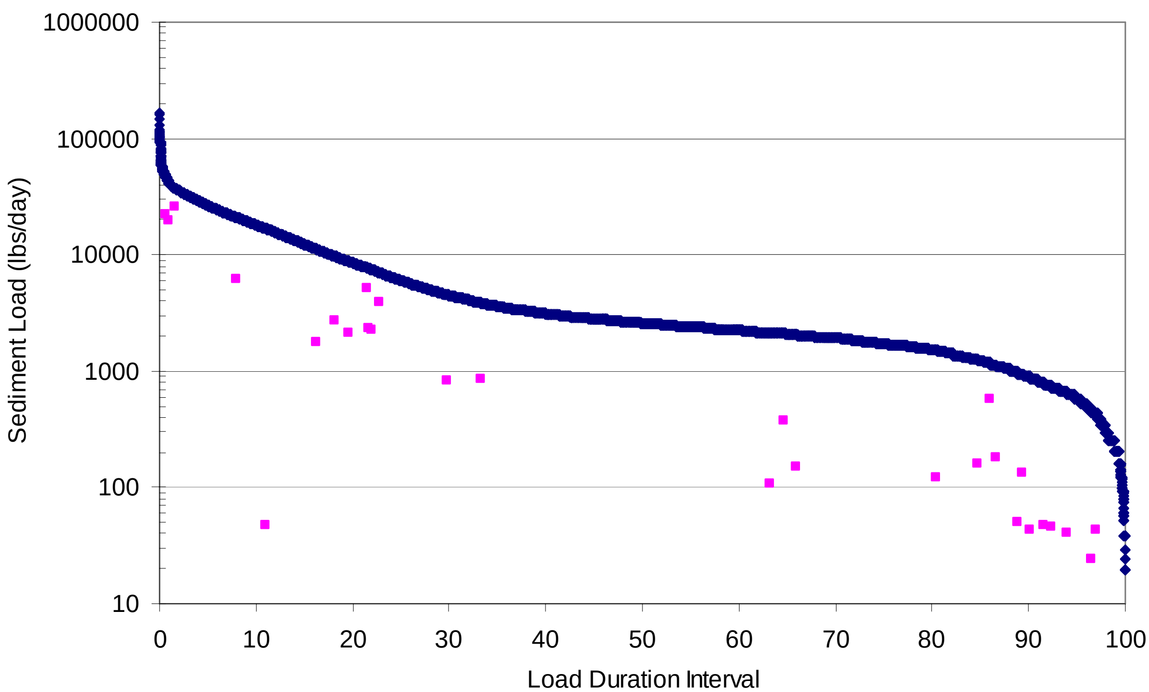


Figure 81. Shoshone Creek Near Three Bridges Sediment Duration Curve .

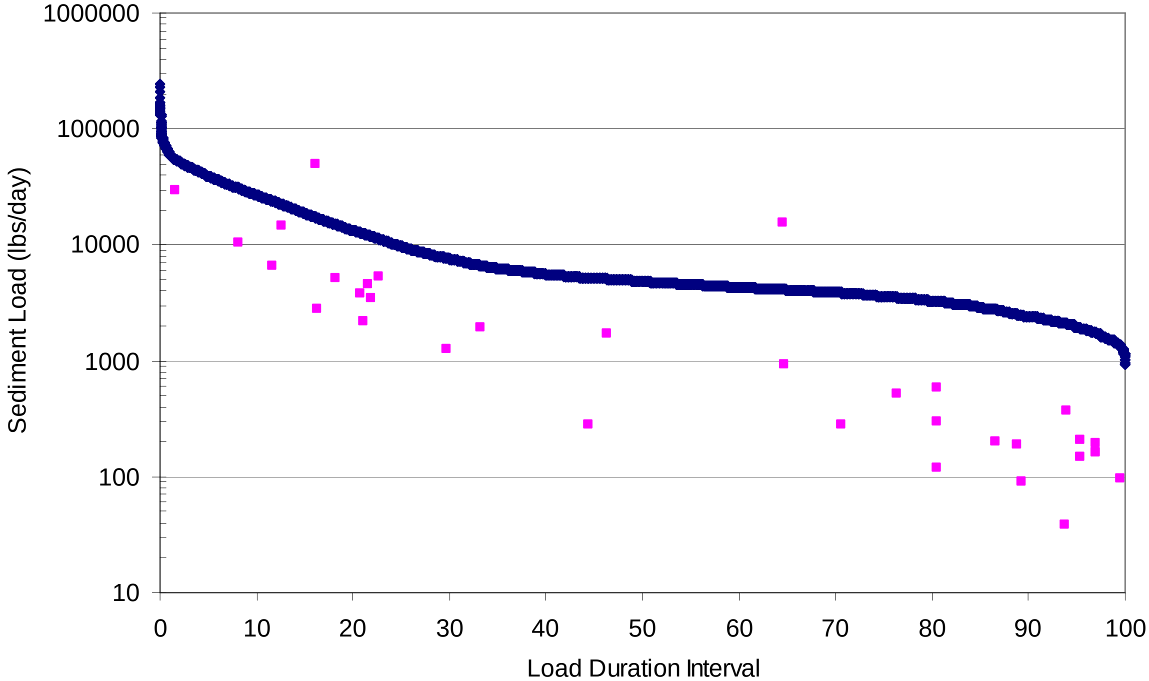


Figure 82. Shoshone Creek Near Hot Creek Sediment Duration Curve.

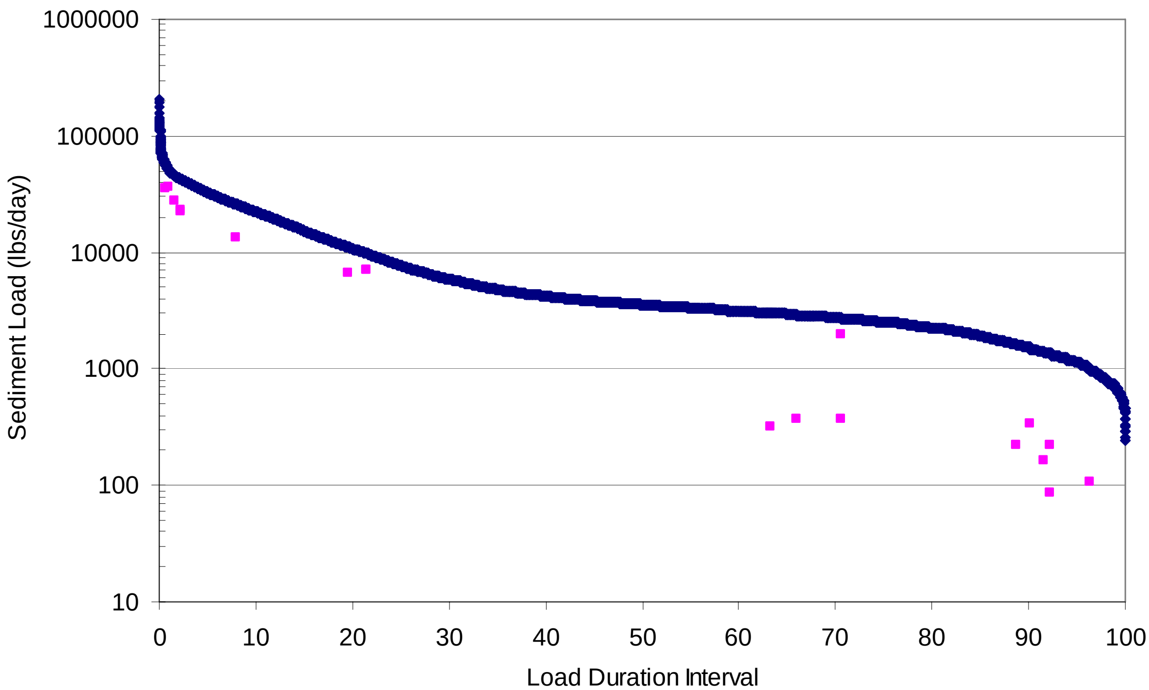


Figure 83. Shoshone Creek Near State Line Sediment Duration Curve.

Total phosphorus, while exhibiting a similar pattern of elevation under wet conditions than under dry conditions, was somewhat higher overall than sediment in that TP plotted much closer to the various load capacity curves at all locations (Figures 84-88). Although, the number of times TP was very elevated were similar in comparison with the sediment data. Overall, the average TP concentration in Shoshone Creek was approximately 0.055 mg/L. At the Pole Camp location, TP averaged approximately 0.074 mg/L. At all the other locations the individual TP averages were less than 0.06 mg/L. Guidelines that DEQ has used in the past for river and stream systems are no more than 0.160 mg/L TP in any single sample, 0.1 mg/L TP in any average monthly sample, and 0.100 mg/L TP as a period of record average (Lay 2000, Lay 2001). These guidelines were exceeded once at the Pole Camp location, and once at the Hot Creek sampling location. Both occurred on May 4, 2005 and were under high flow conditions.

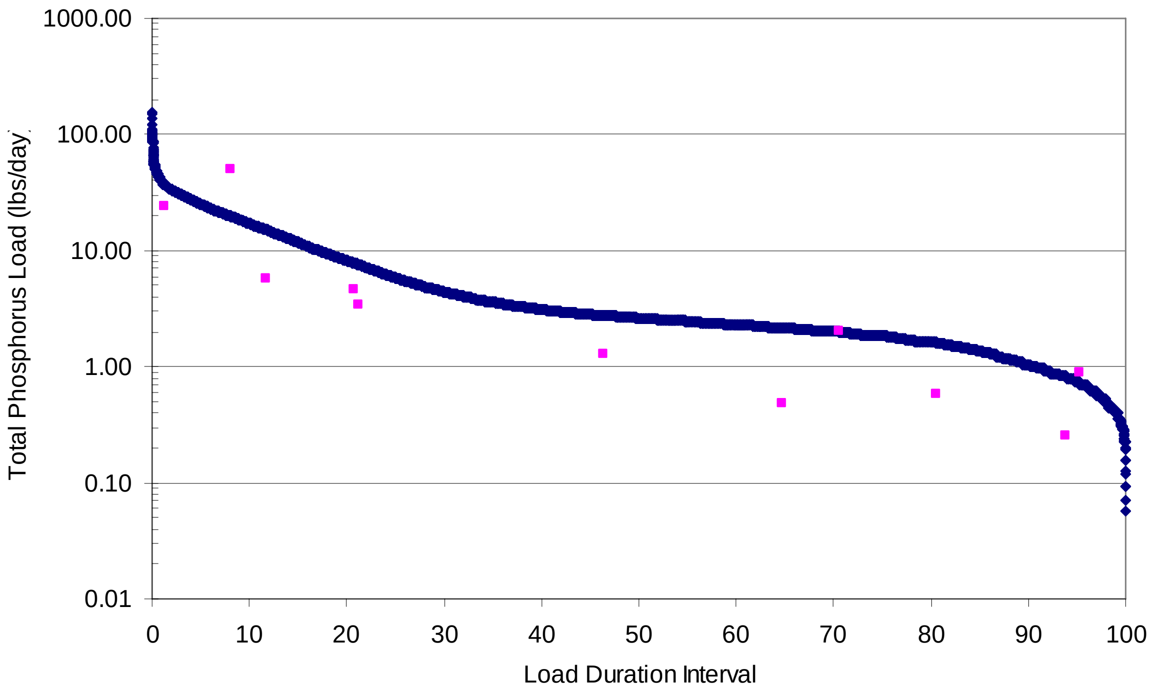


Figure 84. Shoshone Creek Near Pole Camp Total Phosphorus Duration Curve.

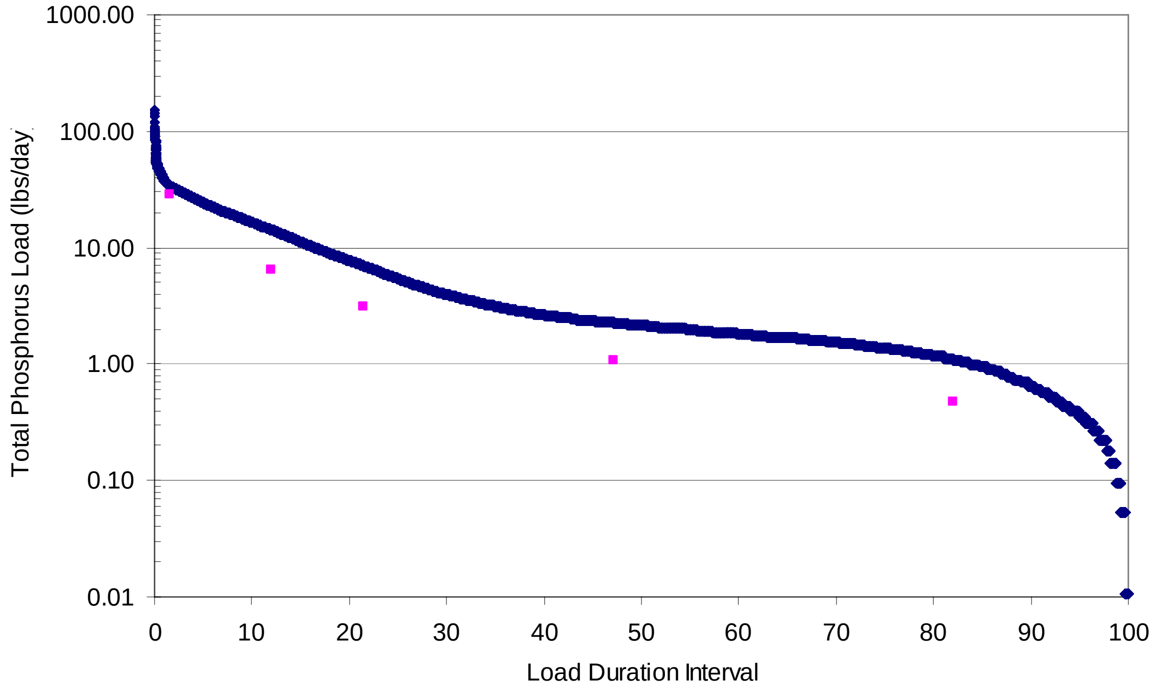


Figure 85. Shoshone Creek Near Cottonwood Creek Total Phosphorus Duration Curve.

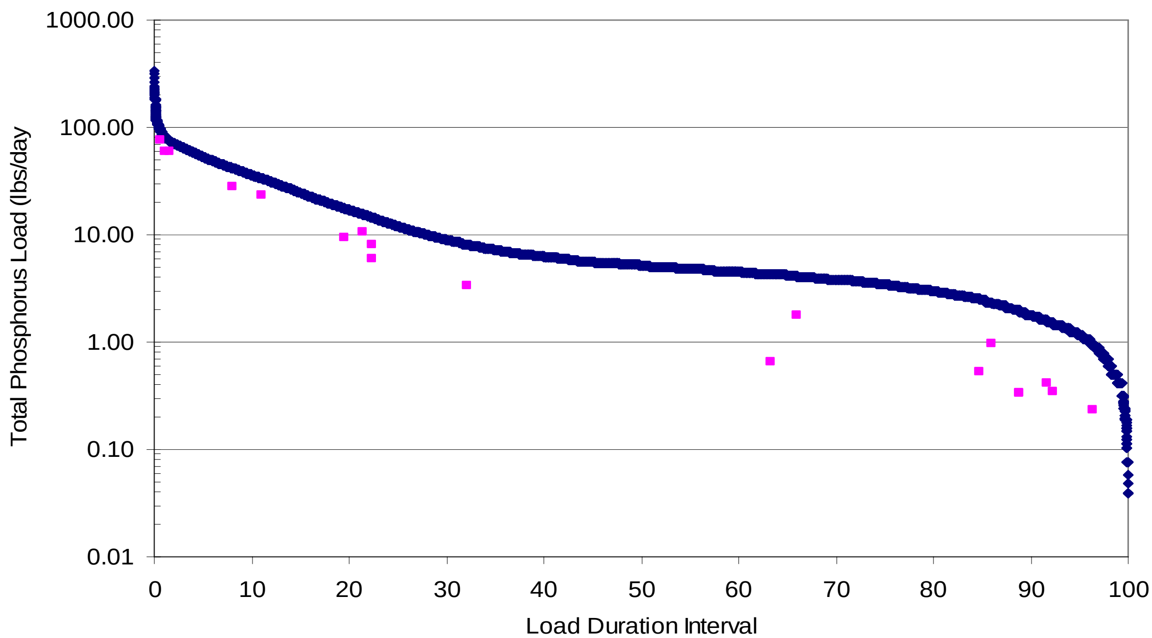


Figure 86. Shoshone Creek Near Three Bridges Total Phosphorus Duration Curve .

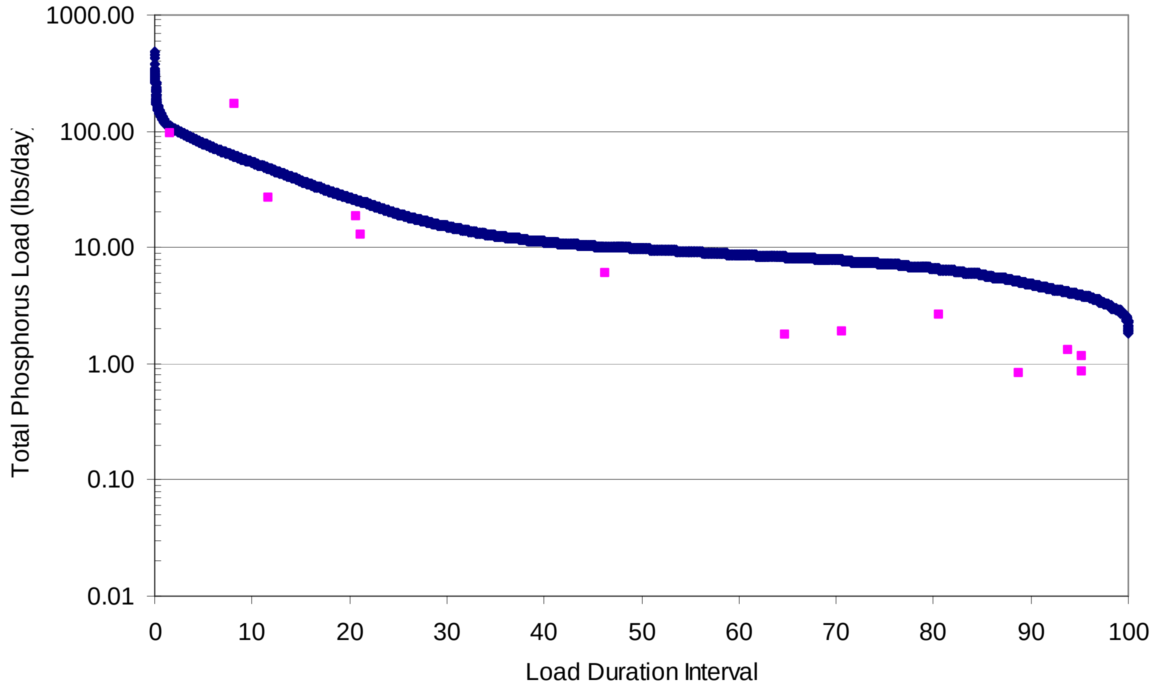


Figure 87. Shoshone Creek Near Hot Creek Total Phosphorus Duration Curve.

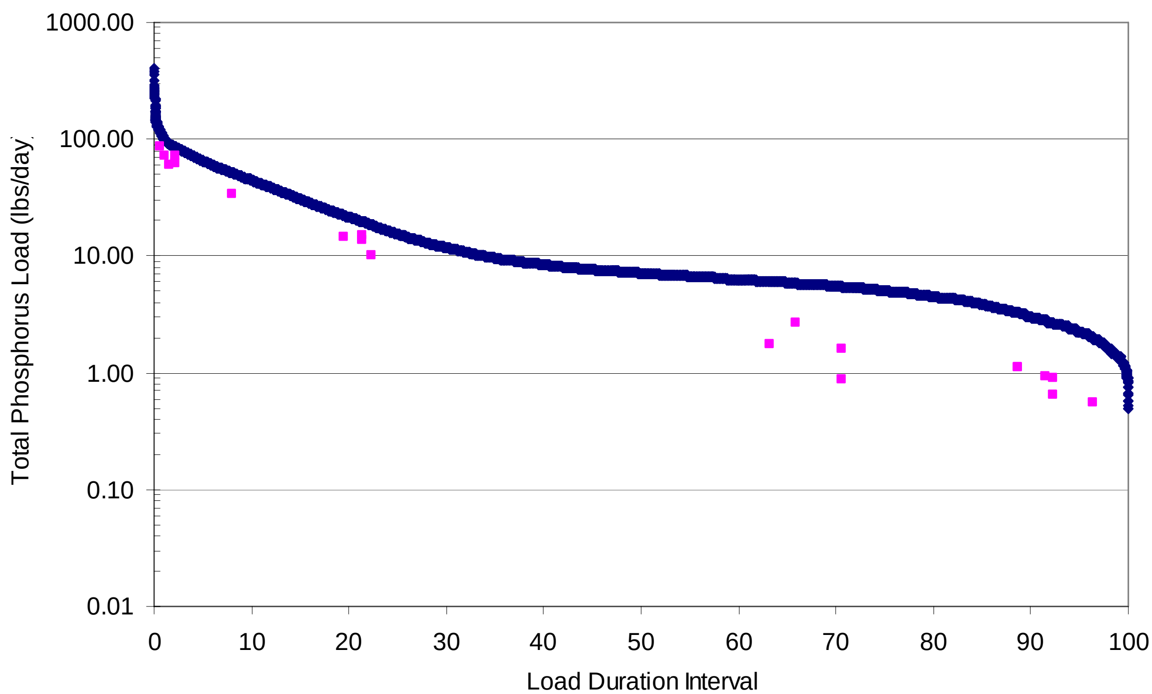


Figure 88. Shoshone Creek Near State Line Total Phosphorus Duration Curve.

Instantaneous temperature measures were also collected in the assessment unit. In the current data sets, instantaneous temperature samples exceeded water quality standards of 22 °C seven times (7.86 percent). Three of these events occurred at the lower Shoshone Creek sample location. However, the highest recorded temperature, 25.7 °C was recorded at the Pole Camp Creek location in early July of 2005. It appears that limited temperature issues exist within the assessment unit. However, due to the sparse temperature data collected DEQ used a potential natural vegetation approach to understand the temperature issues of the assessment unit. Temperature issues will be addressed in Upper Salmon Falls Creek Assessment Unit.

Instantaneous dissolved oxygen DO was also collected at all of the monitoring locations within the system. In almost all cases DO was above 6.0 mg/L. Twelve events where DO fell below 6 mg/L were recorded across all locations. Dissolved oxygen depression was most common at the Three Bridges location, where DO was less than 6 mg/L in nearly 26 percent of the data. This was also the case at the Pole Camp location were nearly 36 percent of the time DO was less than 6 mg/L. Of the three remaining samples which fell be low the criteria, one occurred in the lower sampling location and the remaining two were from the IASCD sampling location near Cottonwood Creek. Almost all of the depressed DO concentrations were seen during late July and early August when the amount of water found within the system was at a minimum, and may be the result of elevated BOD caused by the die-off of the aquatic vegetation that had grown under more favorable higher water conditions.

Bacteria samples were also collected with the water chemistry samples (see Figures 89-93). A single sample collected at the Pole Camp Creek location exceeded secondary contact recreation standards. The magnitude of this exceedance was quite large. The few samples collected at the Cottonwood Creek location were free from elevated *E. coli* numbers. However, bacterial contamination was relatively common at the Three Bridges location. Five of nineteen samples were above 576 cfu/100ml at this location, indicating significant bacteria contamination. These elevated samples were collected across several years beginning in 2000. However, most of the exceedances occurred in mid to late June. Which seems to indicate that the exceedances are the result of a common, consistent land use practice in the area. Bank stability, riparian constitution, and, land use patterns in the grazing system may account for the exceedances at Three Bridges. At the remaining locations downstream from Three Bridges bacteria concentrations were generally very low. Based on the data, DEQ concludes that bacteria do not impair the beneficial uses of the assessment unit and that the exceedances of the instantaneous standards at Three Bridges would be minimized by implementing BMPs similar to those in place at the upstream and downstream locations. However, a TMDL should be completed to ensure that such implementation occurs.

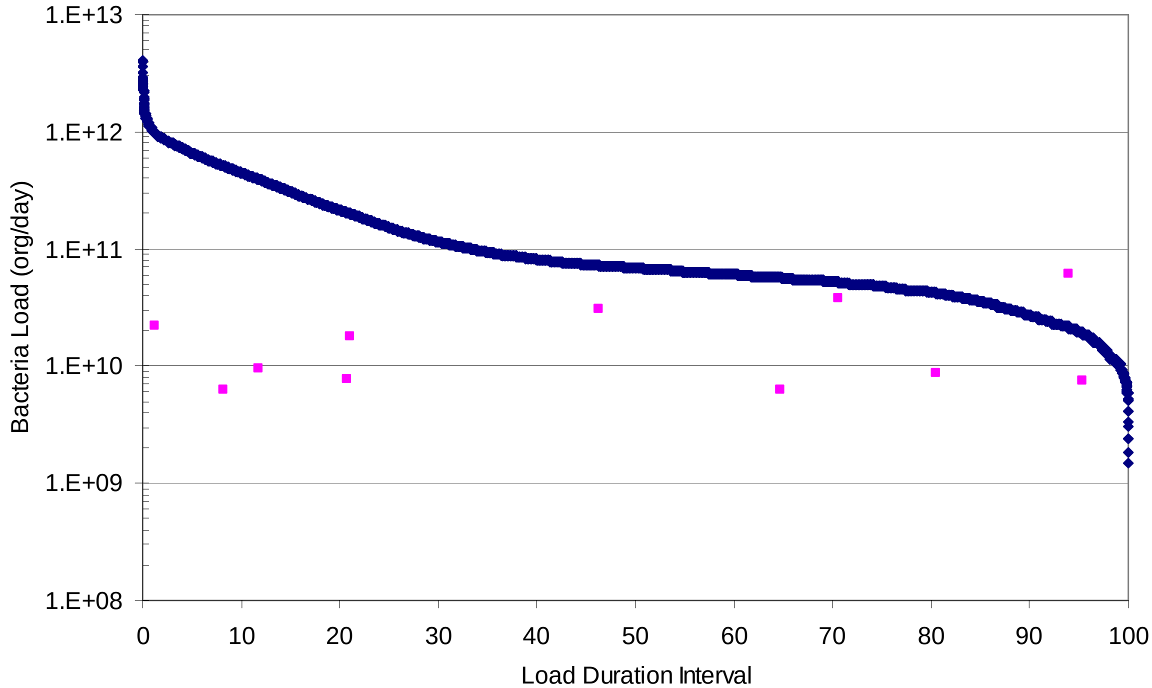


Figure 89. Shoshone Creek Near Pole Camp Bacteria Duration Curve.

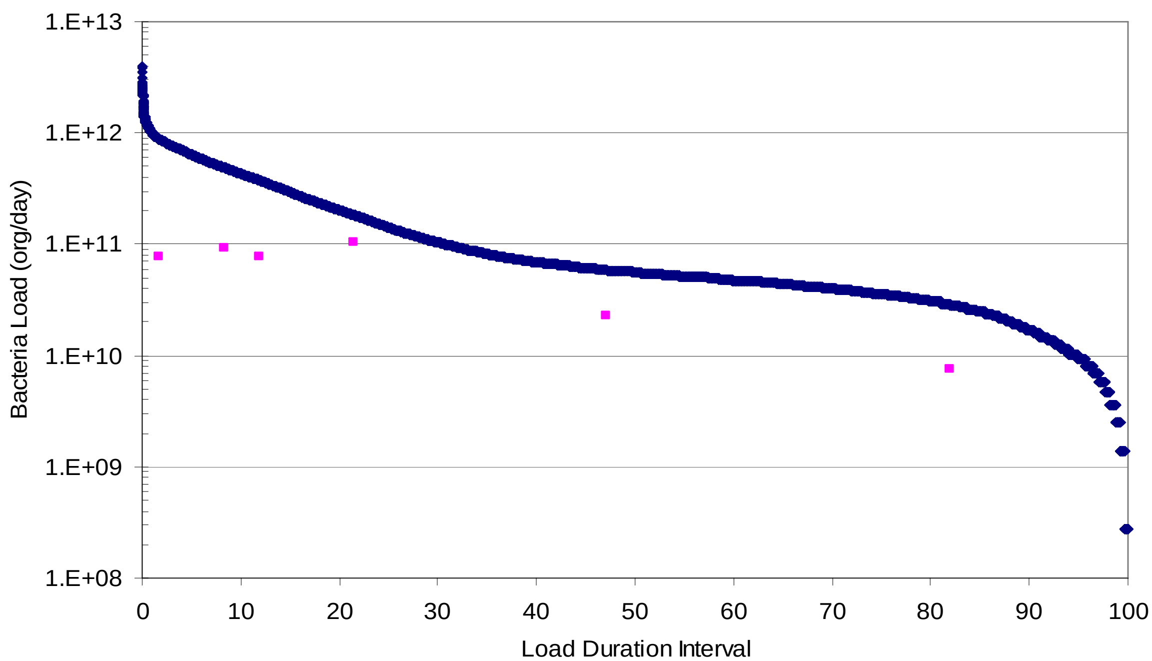


Figure 90. Shoshone Creek Near Cottonwood Creek Bacteria Duration Curve.

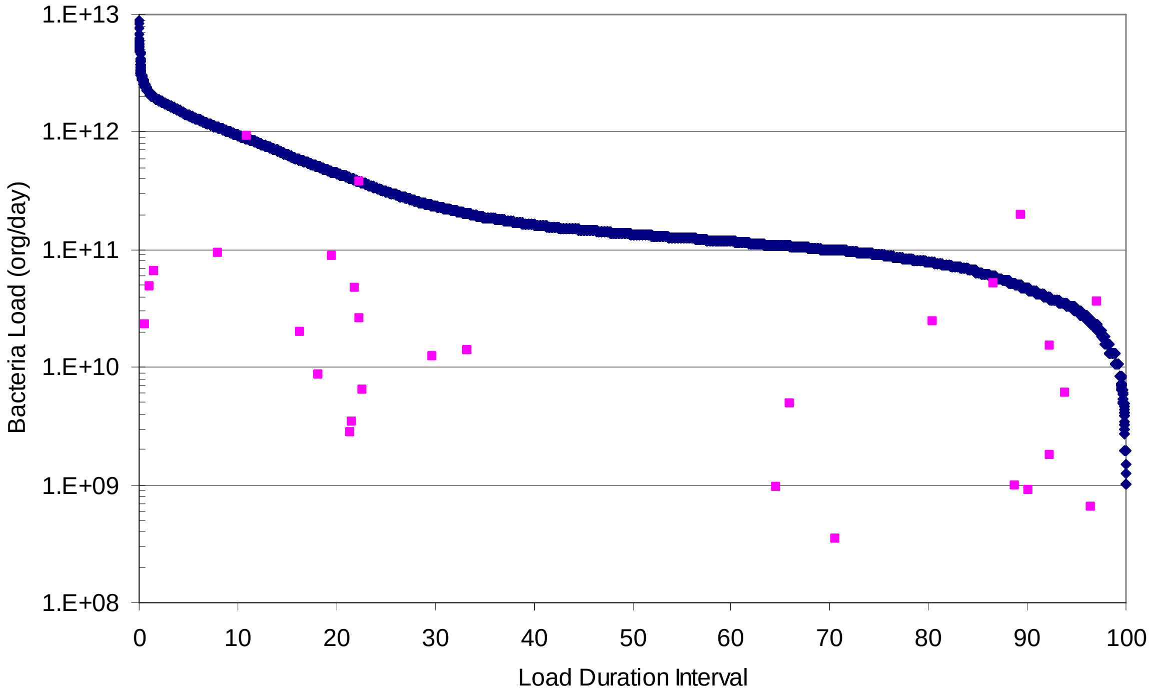


Figure 91. Shoshone Creek Near Three Bridges Bacteria Duration Curve .

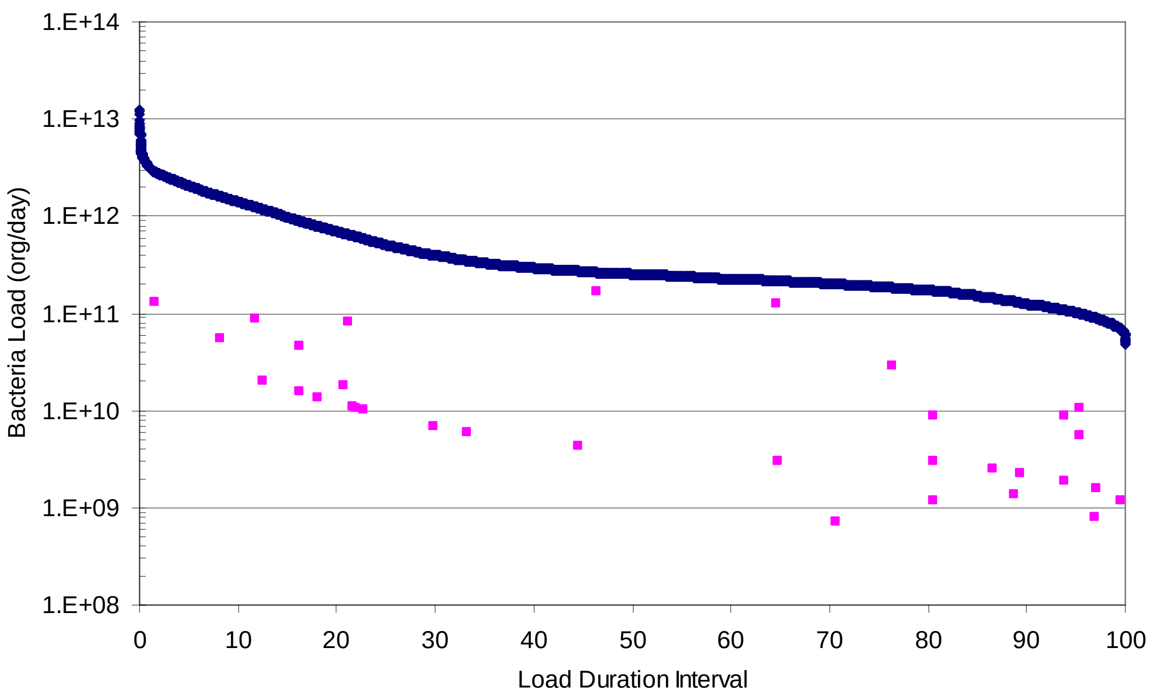


Figure 92. Shoshone Creek Near Hot Creek Bacteria Duration Curve.

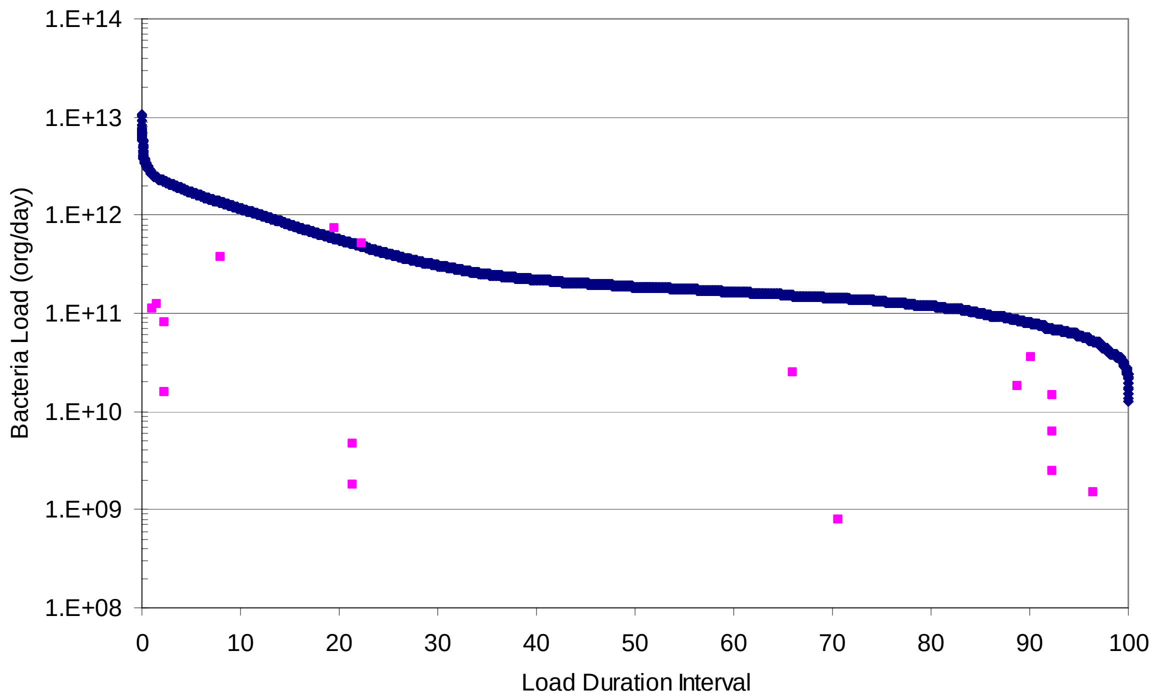


Figure 93. Shoshone Creek Near State Line Bacteria Duration Curve.

From suspended sediment sampling it was determined that the suspended fraction of the sediment load was not impairing beneficial uses during mid-range and low-flow conditions. Because this sampling for suspended sediments in the Shoshone Creek system was limited, DEQ took additional measures to determine if other forms of sediment were impairing beneficial uses.   A series of McNeil cores for depth-fines were collected to determine if bedload sediment might be impairing beneficial uses. See the McNeil sediment core sample protocols used as outlined in the Cottonwood Creek Assessment Unit.

At the lower sampling point in Shoshone Creek percent depth fines ranged from 15 to 38 percent of the total volume. Overall depth fines averaged 28 percent at this location, generally supporting the conclusion that aquatic life beneficial uses of the segment below Hot Creek are fully supported. Percent fines were also collected in two upper locations - the South Fork of Shoshone Creek and near Three Bridges. Percent fines at South Fork ranged from 52 to 64 and averaged 567. Percent fines at Three Bridges ranged from 46 to 67 and averaged 56 At these upper locations average depth fines were well above the 28 percent target established to be protective of salmonid spawning in other Idaho TMDLs.

Mercury

Total mercury samples were collected monthly from the lower sampling location on Shoshone Creek from August of 2005 until November of 2006. Sample design included weekly sample collection during the spring runoff period as well as samples collected from upstream geothermal springs. The geothermal springs were thought to be a significant contributor of the mercury load in Shoshone Creek.

During base flow mercury concentrations were very low, while during high flow events concentrations increased dramatically. This can be described using a load duration curve, where the y axis is mercury load and the x axis is percent of time. In this graph (Fig. 92) a 12 ng/L concentration in water is used for calculating a reference Hg load duration curve as a basis for comparing observed Hg loads[2]. However, any TMDL developed from this data will be calculated using Idaho's methylmercury criterion of 0.3 mg/Kg fish tissue, not the 12 ng/L mercury concentration in water.

As can be seen in Figure 94 mercury load in Shoshone Creek approaches the reference load duration curve only under high flow conditions and is well below the curve in wet, midrange, dry, and low flow conditions. The nature of the mercury load in Salmon Falls Creek can also be inferred from the load duration curve. Data points plotting near or above the load duration curve in the 0 to 40 percent duration interval describe wet weather and high flow contributions associated with sheet and rill erosion, wash-off processes, and potentially stream bank erosion. Additionally, the very low position of the data on the load duration curve is consistent with the fish tissue information collected from the game fishes within the Shoshone Creek system and the low bioaccumulation seen in them (see the following discussion of fish tissue). Furthermore, if the geothermal springs were a significant source of mercury to Shoshone Creek the relative position of the data collected in the midrange to dry LDIs would be much different. For example, the presence of a constant source of mercury would elevate the loads seen in the midrange and dry LDIs, thus making the loads less flow dependant.

Given that the geothermal springs are expected to be a steady source of mercury, if they were a significant source the data should plot closer to the load capacity curve during the dry periods when springs should be isolated from runoff and bank erosional processes, the pattern seen with point source dischargers. The relative percent difference between the observed mercury load and the assessment criteria load illustrates this point well. The relative percent difference in the high flow period (LDI < 10) averaged 116 percent. Under dry conditions (LDI > 70) the relative percent difference averaged 173. This is somewhat similar to Salmon Falls Creek backwater area, where the relative percent difference during wet conditions averaged 37 and in dry conditions averaged 163 percent. With a constant source, the relative percent difference would be smaller during the dry period and larger during the wetter periods. Data from both locations illustrate that wash-off, sheet, rill erosion, and other watershed erosional processes such as bank erosion are the likely source of mercury rather than a steady loading as would be expected from geothermal sources.

[2] Twelve ng/l total Hg is a concentration somewhat above background in many waters. It corresponds to the CCC recommended by EPA prior to 1995 and at one time in Idaho's WQS.

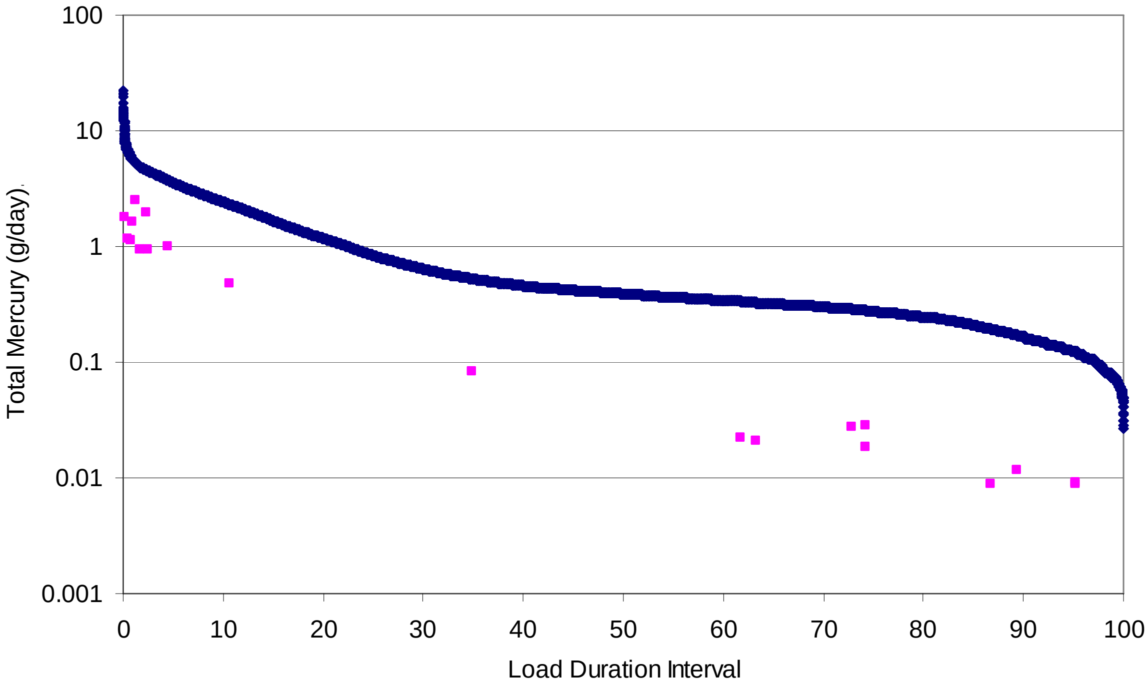


Figure 94. Shoshone Creek Near State Line Total Mercury Load Duration Curve.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that game have been stocked in Shoshone Creek as far back as 1968 and ended in 1989. brown trout were stocked annually from 1973 to 1989; rainbow trout were stocked at least annually, sometimes more, from 1968 to 1989; and cutthroat trout were stock intermittently from 1968 to 1987.

The IDFG has surveyed the fishery in Shoshone Creek at least nine times since 1971. Fish and Game electrofishing efforts have occurred in two general areas of Shoshone Creek; the first near the confluence of Hot Creek and Big Creek; and secondly in the South Fork and Bear Gulch area.

Beginning in 1971, the Hot Creek reach of Shoshone Creek was sampled in late July of 1971. At that time only two hatchery rainbow trout were collected. However, a very limited reach of 250 feet was sampled.

Following this initial effort Shoshone Creek was again sampled in 1982. At that time only three rainbow trout were collected. However, the report references data collected in 1974. The original 1974 information is unavailable at this time. It was estimated that in 1974 up to forty rainbow trout and cutthroat trout, 4-14 inches in length, and eighteen brown trout, 3.5

to 13 inches in length, were collected (Bell 1983) in or near the Hot Creek reach of Shoshone Creek. Hook and line sampling later that evening resulted in another 30 trout being captured. Bell (1983) indicates that the trout populations have decreased dramatically between 1982 and 1974 due to a prolonged drought and extreme low waters in 1977. A lack of riparian vegetation and over grazing was also noted (Bell 1983).

Fish and Game personnel again electrofished the Hot Creek reach of Shoshone Creek in 1988. At that time 2 brown trout and 4 rainbow trout were collected. In 1993, several years following the curtailment of trout stocking into Shoshone Creek, the reach was again electrofished and no trout were collected. The 1993 effort was a relatively intensive monitoring effort in comparison with previous years efforts, and included sites near the lower Shoshone Creek water chemistry sampling location, two near the Hot Creek chemistry monitoring location and one between the Cottonwood Creek and Big Creek monitoring locations.

The second major location in which Fish and Game actively monitored was in the South Fork Shoshone Creek area. This general are was sampled in 1989 and 1996. In the earlier effort, 57 wild rainbow trout were collected. Size frequency distribution information indicates that as many as three size classes of trout were present including young-of-year. While in 1996, only 11 wild rainbow trout were collected. Length Frequency data again indicate the presence of young-of-year trout as well as several old cohorts.

Salmonid spawning, as an existing use, is clearly demonstrated by the IDFG electrofishing data throughout Shoshone Creek. However, more disturbing is the almost completed removal of salmonids from the system under drought conditions of the past and the continued absence of salmonids through to 1993. The drought conditions may have been exacerbated by the lack of riparian zone as noted by Bell (1983). Although, the area in which the majority of IDFG samples were collected has been excluded from grazing as part of a long term BLM enclosure, and riparian conditions seen today are greatly improved in comparison with 1983 conditions.

More recently, DEQ has electrofished within the Shoshone Creek system in as many as 20 times. Similar to the Fish and Game efforts, DEQ has electrofished in two general areas of Shoshone Creek: in the upper portions of the system, near the South Fork, and in the lower portions of the system, below the Hot Creek confluence.

Department electrofishing efforts in the upper portion of the system began as early as 1994 and have occurred occasionally until 2005. Years sampled include 1994, 1997, 2002, and 2005. Fishes collected in this portion of the system include speckled dace, redside shiners, sucker sp., sculpin sp, and rainbow trout. Also noted as present in the early data sets are young-of-year rainbow trout. Many of the samples are dominated by hundreds of shiners and dace. However, rainbow trout are absent from the samples collected in three of four samples spanning 2002 and 2005. In addition to the usual numbers of dace and shiners a single trout was collected from the South Fork Shoshone Creek in 2005.

Electrofishing efforts in the lower portion of the system span a similar time frame as well. Years sampled include 1994, 1995, 1996, 1998, 2002, and 2005. Fishes collected in the lower reach include smallmouth bass, northern pikeminnow, chiselmouth chub, redside shiner, speckled dace, sucker sp, sculpin sp, and rainbow trout. The incidence of trout in the samples are much lower numbers and frequency than observed in the upper portion of the system. Additionally, the numbers of shiners and dace are significantly lower as well. Furthermore, the presence of young-of-year trout were noted, but only rarely in the data set. In this area of the system water quantity is much greater and water quality is somewhat improved, but so are the numbers and types of fishes that would be competitors and predators of small trout, shiners, and dace.

Salmonid spawning, while it appears to be an existing beneficial use in Shoshone Creek, does not appear to be sufficient to establish a strong presence of trout within the system. Based on the Idaho Stream Fish index most sites were below threshold values indicating a water quality impairment of the fisheries portion of the cold water aquatic life. The limited salmonid population in Shoshone Creek may be the result of fine sediment impacts to spawning substrates, as evidenced by the McNeil core information presented above and bank stability estimates of sediment production presented in following sections. Additionally, competition or predation issues from the large population of smallmouth bass and northern pikeminnow may preclude the establishment of a salmonid fishery in Shoshone Creek.

Fish tissue analysis for total mercury concentration was conducted on the fishes collected by DEQ in 2005 near the Hot Creek Confluence. Fish tissues from 10 smallmouth bass and 10 rainbow trout were analyzed for total mercury. The average mercury concentration found in the rainbow trout was 0.173 mg/kg. The range in mercury concentration was from 0.0624 to 0.472 mg/kg. The average mercury concentration found in the smallmouth bass was 0.157 mg/kg. The range in mercury concentration was from 0.102 to 0.285 mg/kg.

The overall average mercury concentration in Shoshone Creek was 0.165 mg/kg. Typically a consumption based weighted average is used to determine water quality compliance in regards to mercury concentration (See Salmon Falls Upper assessment), but given that the smallmouth bass and rainbow trout exist within the same trophic level within Shoshone Creek the overall average mercury concentration and a consumption based weighted average would be identical. In general, the mercury concentrations in the fishes of Shoshone Creek appear to be below levels indicative of mercury contamination. However, the presence of two very large trout with elevated levels indicates that some methylation and bioaccumulation of mercury is occurring within the Shoshone Creek watershed. As the fish were collected in the proximity of the geothermal waters of Magic Hot Springs it may simply be the result of the elevated mercury found there.

Macroinvertebrates

DEQ has collected macroinvertebrates in the Shoshone Creek Assessment Units seven times. Macroinvertebrates were collected from the lower reaches of the system in 1994, 1995, 1996, 1998, and 2002. Macroinvertebrates were collected in the upper reach near the South Fork of Shoshone Creek in 1994, 1995, 1997, and 2002. In both reaches, macroinvertebrates were also collected in 2004, 2005, and 2006, but this data is not available for analysis at this time. As a result two data sets are available for interpretation one near the confluence with Hot Creek, and another above the Cottonwood Creek confluence.

The macroinvertebrate scores from the Three Bridges area of Shoshone Creek exhibited a slightly improving trend in metric values from 1996 to 1998; more recent data were unavailable. Taxa richness in this area improved the most dramatically. Additionally, the numbers of EPT taxa also increased over this time period. The data from those portions of Shoshone Creek near Hot Creek were the most consistent of any of the data collected from Shoshone Creek, likely due to the consistent flow from the Big Creek watershed stabilizing the hydrology of this area. Some of the highest SMI scores were recorded in this reach of the system.

Overall, the macroinvertebrate assemblage suggest moderate to good water quality in the more recent years. The macroinvertebrate data from area below Hot Creek to the Nevada border presents a contrasting picture in comparison with of the macroinvertebrate assemblages from the Hot Creek reaches. Six samples were available for interpretation from the lower reach. The macroinvertebrates from the uppermost site (collected in 2002), from just below the Magic Hot Springs area, had good representation of the key EPT taxa as well as relatively high numbers in all metrics. As a result, this site scored well on the SMI (51.99).

Approximately one mile further downstream, the stream was sample three more times. Once each in 1995, 1998, and 2002. It was in this area that the stream exhibited the most fluctuations in macroinvertebrate assemblage composition as reflected in SMI score. The SMI scores went from indicating poor water quality in 1995 (38.68) to good water quality (58.68) in 1998 and a slight decrease to moderate water quality (50.31) in 2002. The reasons for this variability are unknown at this time. A third sample location, approximately 1 mile further downstream yet again was sampled twice. The 1994 data was much lower than that collected in 2002.

Overall, these three locations within the lower portions of Shoshone Creek seem to indicate that water quality has improved tremendously in the area since 1994-95, and supports the more recent water chemistry data collected that indicates that the beneficial uses are fully supported in this reach of Shoshone Creek.

Aquatic Vegetation

At the various BURP locations in the upper, lower, and middle reaches of Shoshone Creek field crews noted the presence of some macrophytes and epiphytes. At all the locations aquatic plant communities were limited and no mention of dense macrophyte growth were noted. Over the many years of BURP sampling in the Shoshone Creek system, no trend in macrophyte observation could be determined from the field notes. A few sestonic chlorophyll *a* samples were collected at the Three bridges location and at the lower Shoshone Creek location. These samples were collected during the peak of the summer growing period to determine if nuisance conditions existed. The samples collected in the Three Bridges area averaged 10.40 µg/L of chlorophyll *a*. Chlorophyll *a* samples from the lower sampling location averaged 7.91 μg/L. Although limited in numbers, this supports the BURP observations of the presence of some limited amounts of aquatic vegetation throughout the system. These sample values also confirm the nutrient assessment that indicated TP is not in excess, and that reductions in Big Cottonwood Creek will likely lower the overall presence of aquatic vegetation throughout the lower portion of Shoshone Creek.

Bank Stability

Bank stability measures were collected at three general locations within the Shoshone Creek system. The first of these was in the South Fork and North Fork area of Shoshone Creek, the second was between Cottonwood Creek and Three Bridges, and the third was in the lower reaches of Shoshone Creek between the large BLM exclosure near Hot Creek and the Idaho/Nevada border. In the 1.55 miles of the North Fork system, measured bank stability averaged 85.3 percent. In the 3 miles of the South Fork average bank stability was 83.8 percent. In comparison, bank stability measures collected in the same general area following BURP protocols averaged 44.75 percent stable.

However, these measures were collected in 1997 and may not reflect the current conditions. Stream erosion and recession rate estimates indicate that these portions of the stream are not contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 4.24 tons of sediment per year from the North Fork and 24.79 tons per year from the South Fork is delivered to the downstream reach; while the proposed sediment delivery rate for these reaches are 5.76 and 30.57 tons per year respectively.

Bank stability measures collected in the 7.5 miles of Shoshone Creek between the South Fork and Cottonwood Creek indicate that bank sediment is being delivered to the downstream reach in excessive quantities. Bank stability in this region averages 68.9 percent. Beneficial Use Reconnaissance Program bank stability data averaged 49.8 percent. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 75.43 tons of sediment per year is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 48.48 tons per year.

Bank stability measures collected in the 19.8 miles between Cottonwood Creek and Hot Creek again indicate that bank sediment is being delivered to the downstream segments of the system in excessive quantities. Bank stability in this region averages 68.5 percent. Again for comparison, BURP data collected in this reach averaged 52.6 percent stable. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 58.27 tons of sediment per year is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 37.00 tons per year.

Bank stability measures collected in the 22.9 miles between Hot Creek and the Idaho/Nevada border also indicate that bank sediment is being delivered to the downstream segments of the system in excessive quantities. Bank stability in this region averages 67.8 percent. BURP data collected in this reach averaged 74.6 percent stable. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 211.47 tons of sediment per year is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 75 tons per year. Overall Shoshone Creek would require a 47.40 percent reduction in sediment in the lower reach to meet existing criteria and targets.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

The above data suggest that the existing beneficial use, secondary contact recreation is not impacted. However, it can be clearly demonstrated that cold water aquatic life is not fully supported. The impacts to cold water aquatic life are two fold, the first and only marginally impacting the beneficial use is from nutrients. This impact is largely from the Big Creek and Cottonwood Creek Watersheds and will be addressed in the nutrient TMDL in those assessment units. The second pollutant of concern is sediment, specifically fine sediments stored within the system impacting the spawning and rearing habitats within the system. From the DEQ data sets it appears that the source of the sediment is poor bank stability in the reaches of Shoshone Creek below the South Fork of Shoshone Creek.

Conclusions

Based upon the above assessment, a bank stability based sediment and PNV based temperature TMDLs will be developed for the upper, middle, and lower assessment units of Shoshone Creek. It is highly likely that the BMPs used to address both the sediment and temperature issues within the system will also alleviate the sporadic bacteria exceedances seen in the Three Bridges portion of the assessment unit while the nutrient reduction proposed for Big Creek and Cottonwood Creek will address the limited nutrient issues seen within the system.

Big Creek Assessment Units

Physical Characteristics

The Big Creek Assessment Unit ID17040213SK014_02 includes the first and second order streams which flow from the western side of the Cassia Mountains towards Shoshone Creek and Assessment Unit ID17040213SK014_03, the third order segment of Big Creek. Systems considered in this assessment unit are Big Creek and Hanna’s Fork. The systems of the assessment unit flow through the dry, Northern Basin and Range ecoregion. Mean annual precipitation in the area is low and for the most part the other streams of the system have very small contributing watersheds (see Table 32). As a result. unless there is a significant spring system, such as with Hanna's Fork and Big Creek, it is highly likely that the streams are intermittent in nature. Therefore. the main discussion will center on Big Creek and Hanna's Fork. The Figure (95) below is a graphical representation (not to scale) of the Big Creek Assessment Unit and the approximate locations within the system of the monitoring locations.

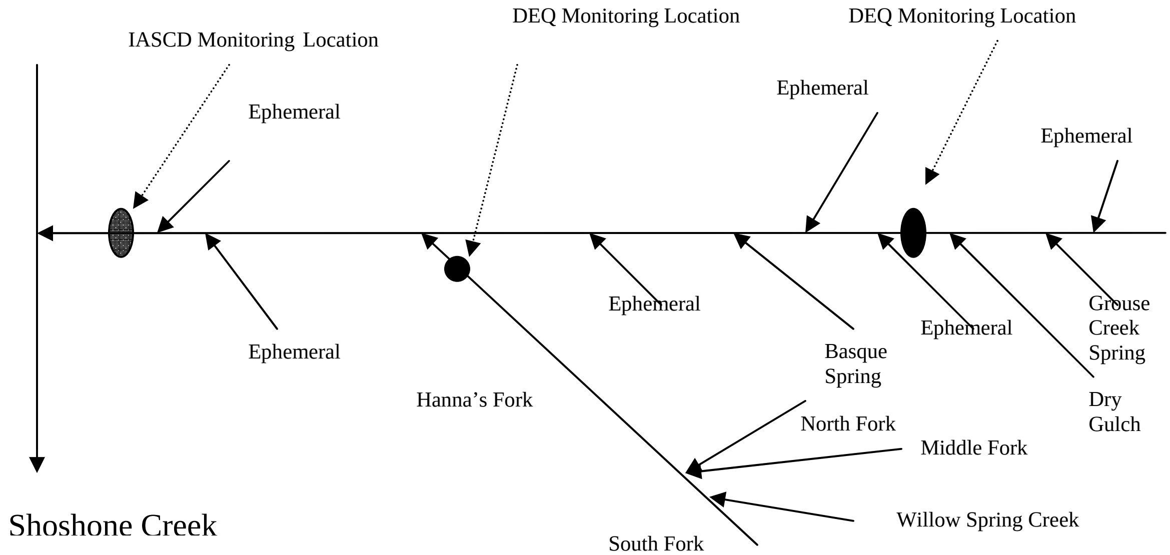


Figure 95. Diagram of the Big Creek Monitoring Locations and the Relative Position of Major Tributaries.

Big Creek begins on the western side of the Cassia Mountains and terminates at the confluence of Shoshone Creek. Big Creek is predominantly a spring fed system but receives a small amount of runoff discharge from the watershed. The contributing watershed area for Big Creek is 25.9 miles^2 and includes the 5.8 miles^2 watershed of Hanna's Fork. The upper portion of the assessment unit includes the first and second order sections of Big Creek with a contributing watershed of 7.1 miles^2 or 27.30 percent of the Big Creek total watershed. Characteristics of the above mentioned watersheds were found at the USGS StreamStats Web site (http://water.usgs.gov/osw/streamstats/) and are presented in the Table 32.

Table 32. Big Creek Watershed Characteristics.

Parameter	Big Creek	Upper Big Creek	Hanna's Fork
Area mi^2	25.6	6.99	5.75
Area km^2	66.30	18.10	14.89
Relief ft	1,870	1,430	1,780
Average elevation ft	6,340	6,780	6,540
Maximum elevation ft	7,520	7,460	7,520
Minimum elevation ft	5,650	6,030	5,740
Average area slope in percent	14.2	22.5	17.6
Percent of area with slope greater than 30%	11.9	24.9	17.2
Percent of area with slope greater than 30% and facing North	2.44	4.20	3.67
Percent of area covered by forest	2.08	7.24	0.28
Mean annual precipitation in	11.7	16.1	10.0

Flow Characteristics

Neither Big Creek nor Hanna's Fork have been gauged in the past, and the closest USGS operated gauge is located in Nevada just south of Jackpot called the San Jacinto Gauge (#13101000). Due to the limited hydrological information concerning the systems of the assessment unit, the hydrology of the various systems will be based upon discharge measurements collected at the USGS and a statistical relationship with the limited measured discharge recorded for Big Creek and Hanna's Fork. See Figure 96 for monthly average stream discharge.

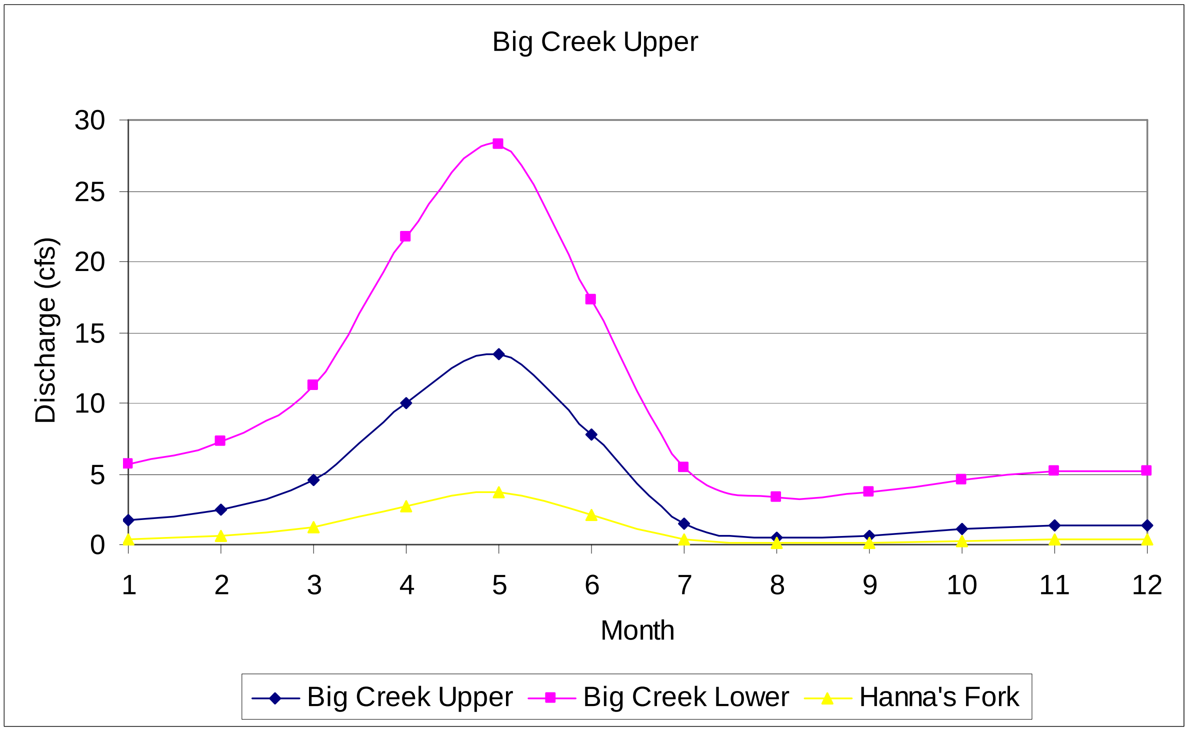


Figure 96. Big Creek and Hanna's Fork Monthly Average Discharge.

The flow duration curves for the three systems are most telling of the hydrological regimes seen within a system. Due to the wide range of variability that occur in the Big Creek Assessment Unit systems, knowing the percentage of days in a year when given flows occur is essential to understanding a system. The flow duration curves also provide a visual indication of the potential for a stream to be perennial.

Figures 97-99 presents a flow duration curves using data from Salmon Falls Creek near Jackpot, NV and linear regressions of flow data collected from the various systems. The figures illustrate the effects of the small watersheds and low precipitation in the upper Big Creek watershed and Hanna's Fork. While in the Lower Big Creek system, the effects of the numerous spring systems can be seen in the stabilization of flow in the high flow duration interval zones. The average flow duration intervals seen when the systems are predicted to have 1 cfs or greater illustrate these flow regimes well.

Big Creek, the largest system of the assessment unit and containing many springs had a FDI of 100 at 1.98 cfs, while the upper portion of the system and Hanna's Fork had average FDIs of 72.10 and 24.98 respectively. Median flows for the various systems within the assessment unit were lower; Big Creek 5.39 cfs, upper Big Creek 1.50 cfs, and Hanna's Fork 0.39 cfs. Coupled with the annual average hydrographs and the flow duration curves it is apparent that upper Big Creek and Hanna's Fork are typically perennial streams. The Upper portion of Big Creek has less than 0.1 cfs or is dry only 3.64 percent of the time while Hanna's Fork is less than 0.1 cfs 12.86 percent of the time.

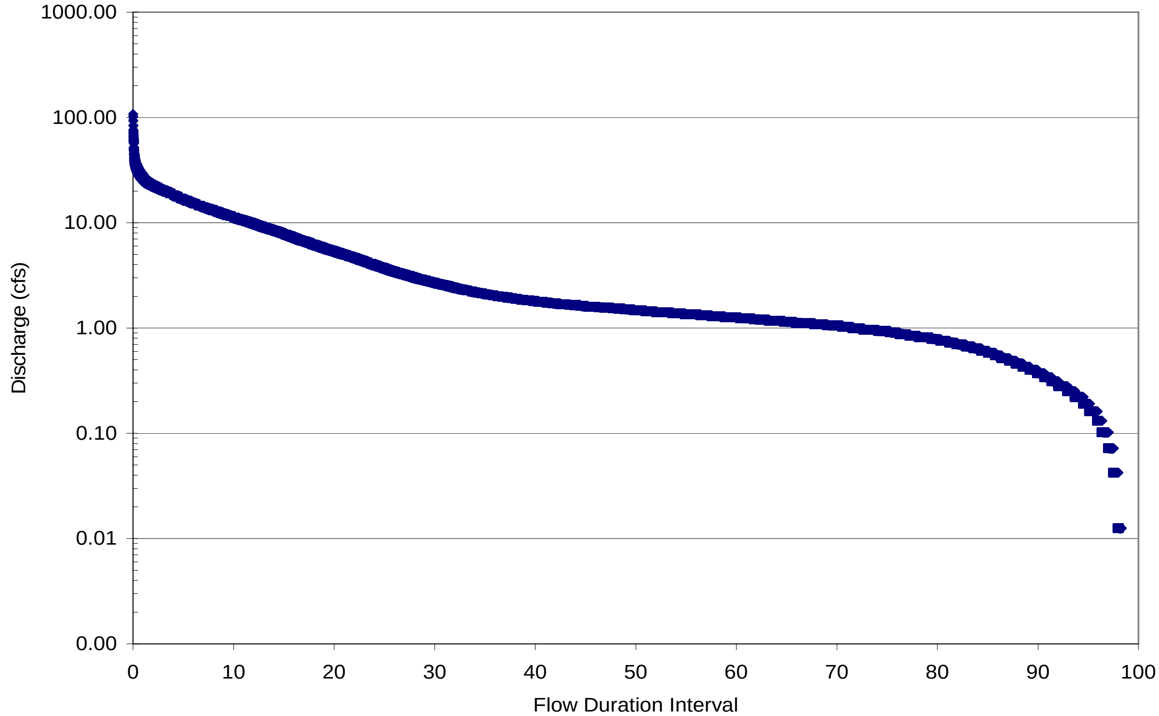


Figure 97. Big Creek Upper Flow Duration Curve.

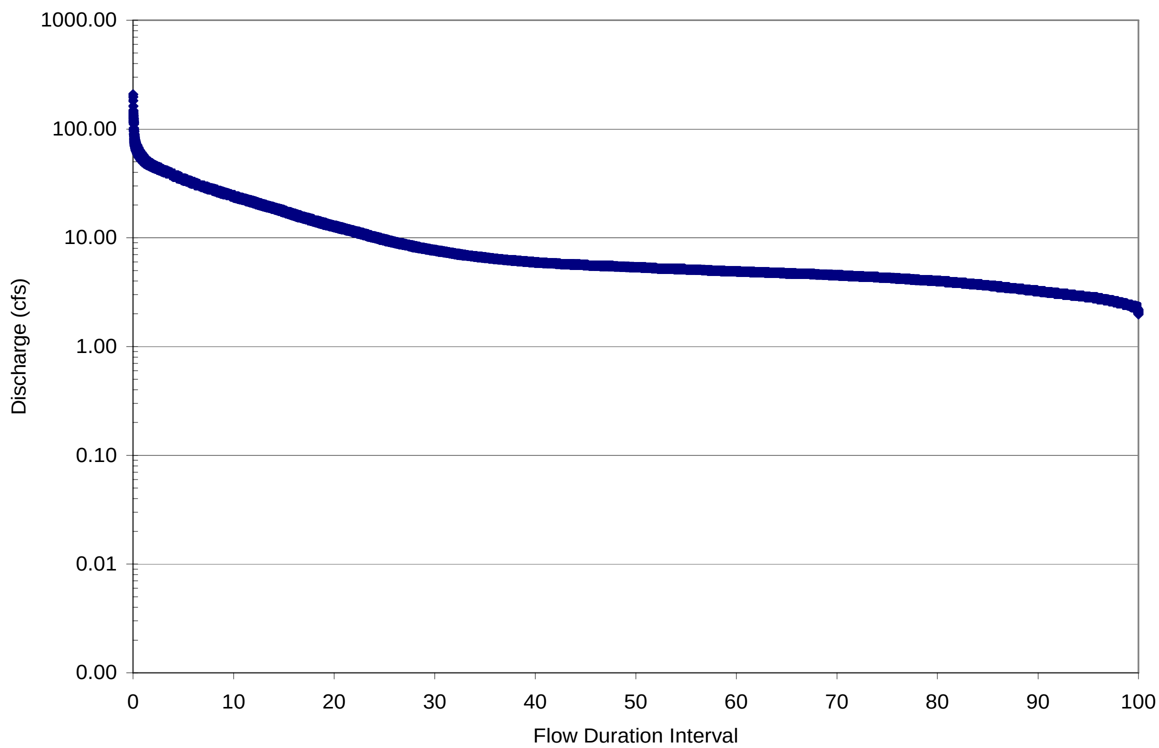


Figure 98. Big Creek Lower Flow Duration Curve.

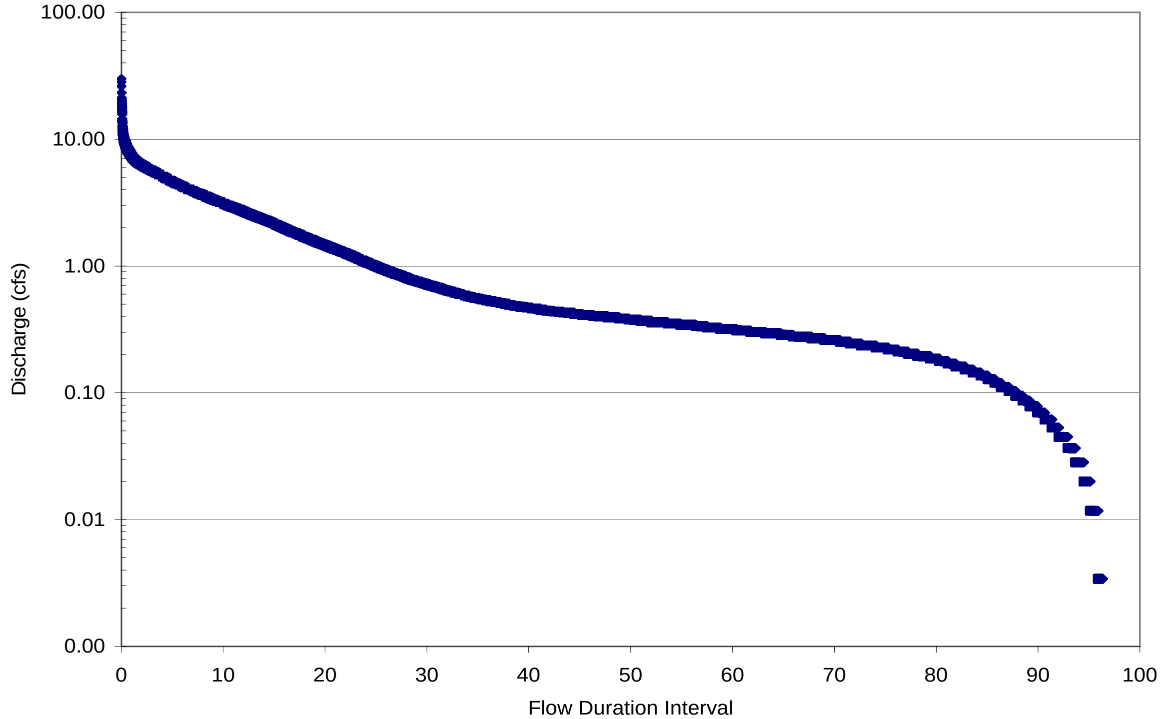


Figure 99. Hanna's Fork Flow Duration Curve.

Load duration or load capacity curves for the systems were also created from the different flow duration curves and any applicable water quality criterion or target and a conversion factor. Load duration curves for the assessment unit systems are shown in Figure 101-109, using a target of 0.1 mg/L TP, 1.5 mg/L TN, 50 mg/L SSC, 576 cfu/100ml ecoli, and 6 mg/L DO. These figures also display the observed loads, which are calculated by multiplying the sampled constituents by the predicted daily mean flow associated with the sample. Points plotting above the curve represent exceedances of the target and are therefore unallowable loads. Those plotting below the curve represent compliance with the target and allowable daily loads (except in the case of DO were compliance is considered in the points plot above the curve).

Water Column Data

Water quality samples collected within the Big Creek assessment unit systems are rare. These samples are limited to the current DEQ data set collected in 2005 and 2006 and the IASCD data set collected over roughly the same time period. To assist in the determination of seasonal components and appropriate critical conditions, the data will be interpreted from the load duration curves. For those cases when a parameter was below detection limits, half the detection limit was used in the loading analysis.

The primary DEQ sampling location for Big Creek was near the confluence with the Dry Gulch with sampling beginning in May 2005 (see Figure 100). The site was used to determine concentrations and loads for the stream. An additional site sampled by the IASCD was at the Big Creek Bridge, near the confluence with Shoshone Creek. The Hanna's Fork sampling location was near the crossing of the Shoshone Basin Road.

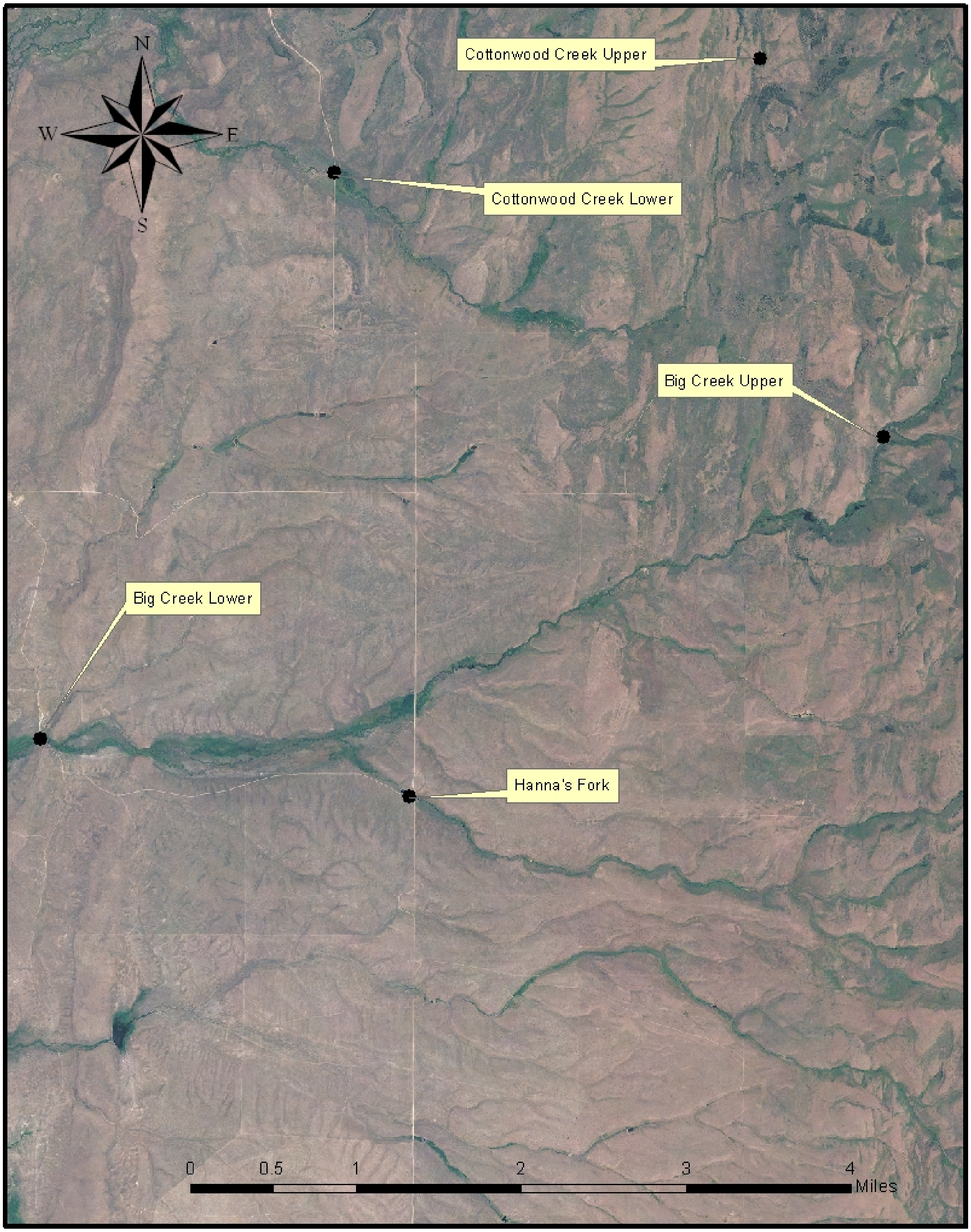


Figure 100. Big Creek Assessment Unit Monitoring Locations.

In general, it appears that current land uses are sufficient to be protective of water quality in most of the Big Creek Assessment Unit. This can be seen in the comparison of existing loads with criteria or guideline loads. In almost all cases, the existing loads were below the criteria or guidelines used in this assessment. When an exceedance occurred, they typically occurred in the Hanna’s Fork data. At the other locations, these increases were of a small magnitude and infrequent in nature suggesting some type of natural variability not associated with land management or practice. Furthermore, the Big Creek system’s loads were expressed in a similar fashion at both locations—an indication that land use practices in the general area are balanced between those lands managed and administered by the USFS in the upper watershed and those lands managed and administered by the BLM in the lower portion of the watershed.

However, the loads based on the Hanna’s Fork data were expressed in such a fashion to indicate land use impacts to the water quality. For example, the suspended sediment concentration at upper and lower Big Creek was approximately 7 mg/L at each location. While in Hanna’s Fork SCC averaged 27.14 mg/L. In addition, one sample collected at Hanna’s Fork was 216 mg/L. This sample was collected following a heavy precipitation event in the Shoshone Basin. If this extreme event is excluded from the data set, SSC still averages 13.65 mg/L. Although the SCC data from Hanna’s Fork is nearly twice that of the Big Creek samples it is still lower than the assessment criteria. The differences in the data are noted because it may speak to the differences in land use management and practices in the two watersheds

Total suspended sediment appears to be a non-factor effecting beneficial uses. However, given the continued drought cycles and the weak hydrological regime of many of the systems much of the sediment stored in the streams is still in place and not transported out of the reach as a suspended load. In a higher water year, the data from the suspended fraction may support the contention that sediment TMDLs are required.

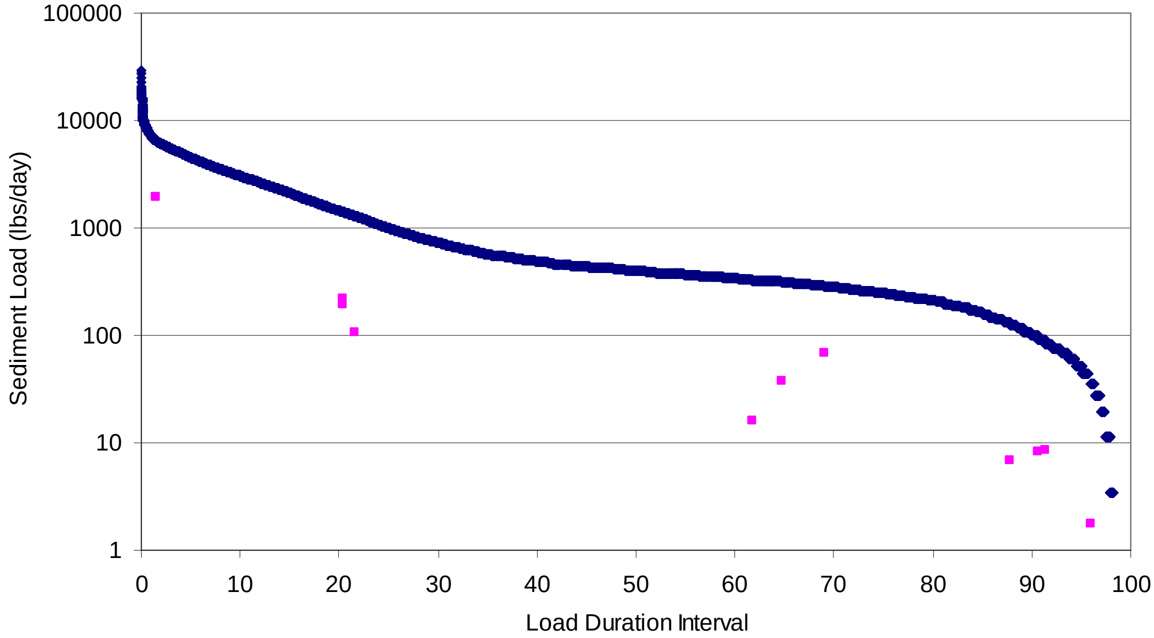


Figure 101. Sediment Load Duration Curve Big Creek Upper.

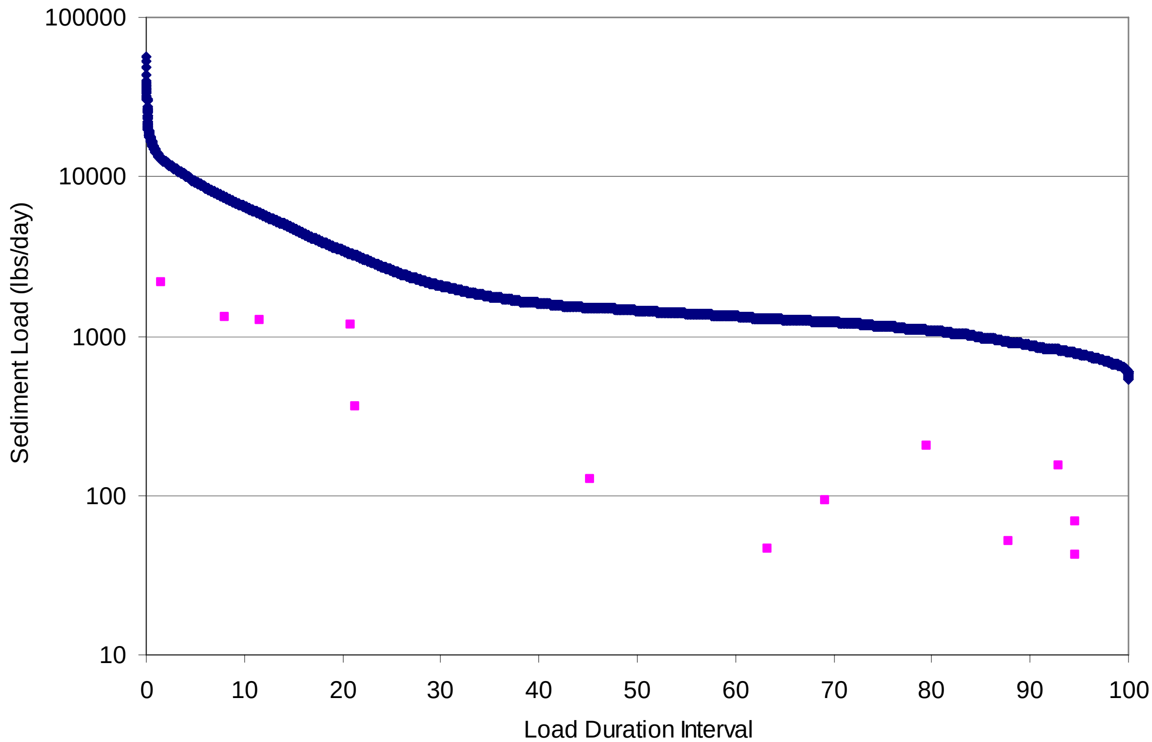


Figure 102. Sediment Load Duration Curve Big Creek Lower.

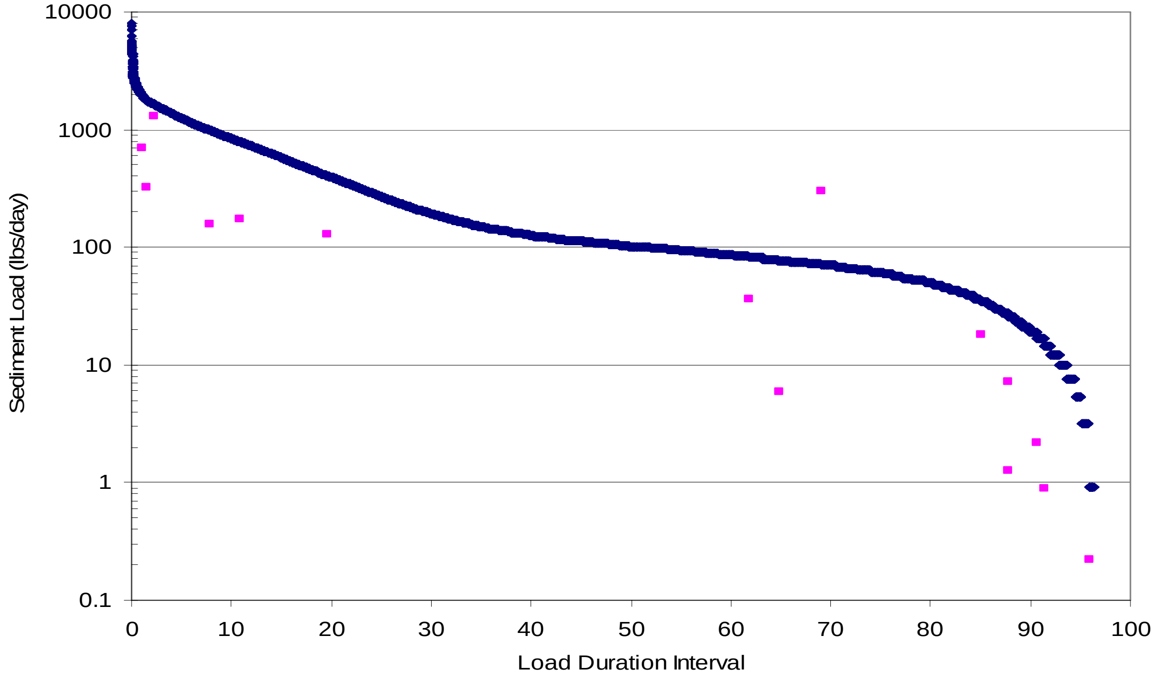


Figure 103. Sediment Load Duration Curve Hanna's Fork.

Total phosphorus varied across the systems in a similar fashion as well. At the upper and lower Big Creek locations TP average approximately 0.07 mg/L and at Hanna’s Fork TP average was 0.123 mg/L. Guidelines that DEQ has used in the past for river and stream systems are no more than 0.160 mg/L TP in any single sample, 0.1 mg/L TP in any average monthly sample, and 0.100 mg/L TP as a period of record average (Lay 2000, Lay 2001). These guidelines were commonly exceeded at Hanna’s Fork during high flow events and into the mid flow range of the flow duration curve, FDI <50 (see Figure 106). In order to be protective of the stream’s beneficial uses, DEQ concludes that a TMDL for nutrients is warranted for Hanna’s Fork.

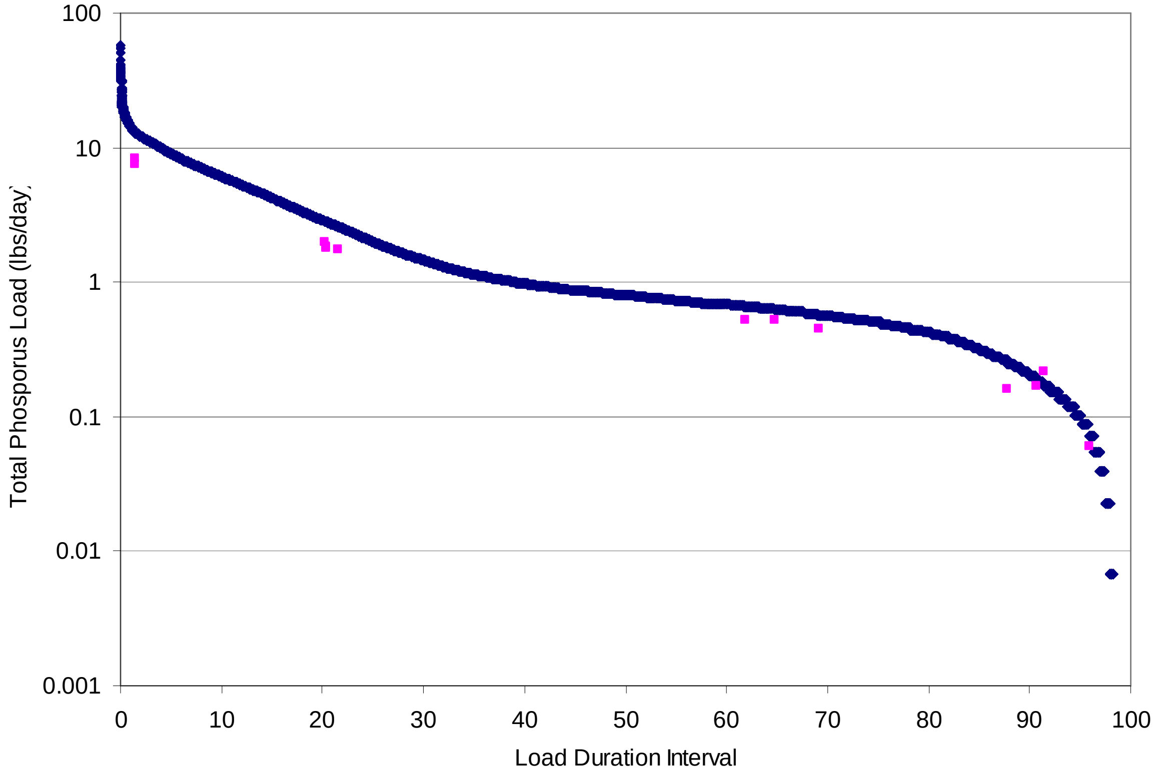


Figure 104. Total Phosphorus Load Duration Curve Big Creek Upper.

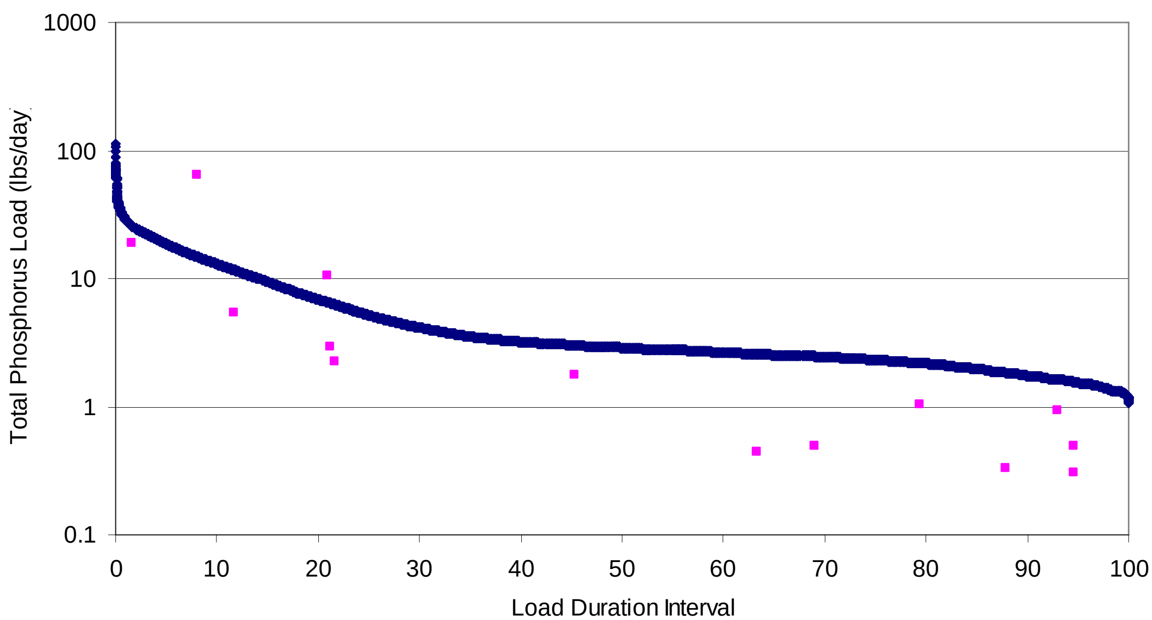


Figure 105. Total Phosphorus Load Duration Curve Big Creek Lower.

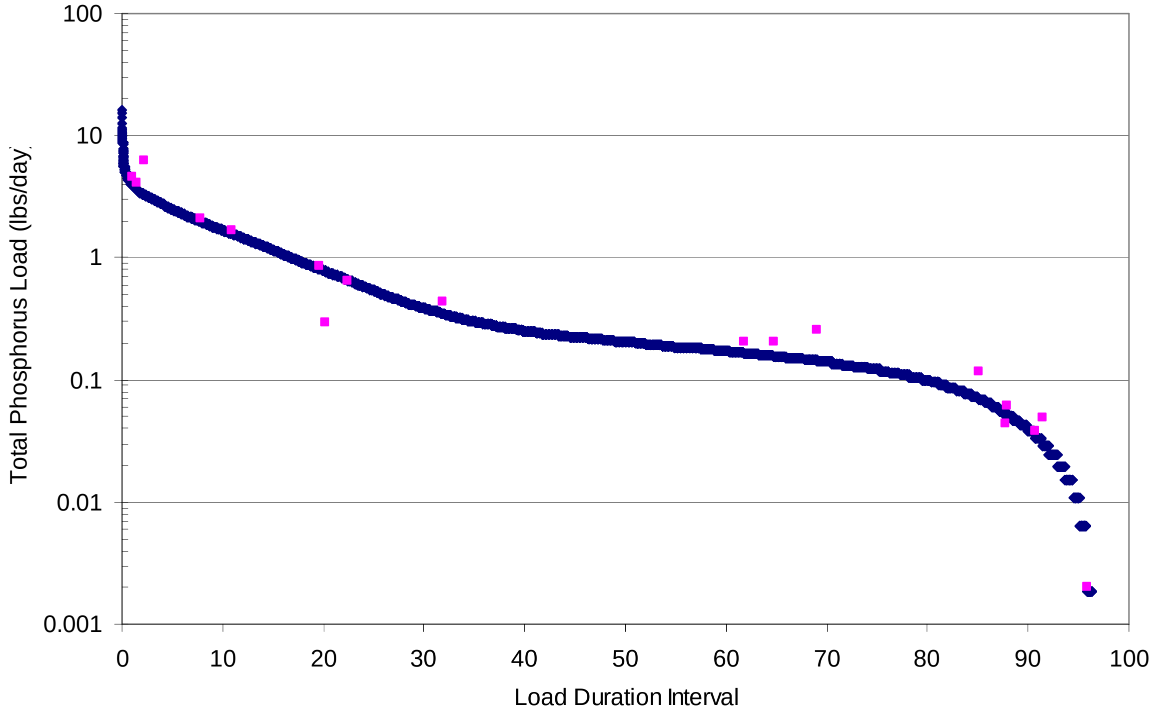


Figure 106. Total Phosphorus Load Duration Curve Hanna's Fork.

Instantaneous temperature measures were also collected in the assessment unit. In the current DEQ data set instantaneous temperature samples exceeded water quality standards of 22 °C one time (6.67 percent) and the lower Big Creek Sample location. It appears that limited temperature issues exist within the assessment unit. However, due to the sparse temperature data collected DEQ used a potential natural vegetation approach to understand the temperature issues of the assessment unit. Temperature issues will be addressed in Upper Salmon Falls Creek Assessment Unit.

Instantaneous dissolved oxygen DO was also collected in all of the systems of the assessment unit. In almost all cases DO was above 6.0 mg/L. Four events where DO fell below 6 mg/L were recorded across all three locations. One of the events was less than 1 mg/L. However, this was very likely an error with the Hydrolab as all samples collected from the Salmon Falls Subbasin with that machine were also depressed in comparison with in-creek averages collected previously. Of the three remaining samples that fell below the criteria, one occurred in the upper Big Creek system and the remaining two were from the IASCD sampling location. The sporadic nature of the events and the quality of other parameters collected concurrently begs the question as to the cause of the depressed DO on those dates.

Bacteria samples were also collected with the water chemistry samples (see Figures 107-109). No single sample collected at the lower Big Creek location indicated significant bacteria contamination. While in the upper reach bacteria concentrations were elevated several times, once at the end of July and again in early August of 2005. The magnitude of these exceedance was quite large. Coupled with the proximity in time of the collections indicates that secondary contact recreation was likely impacted during July and August. Hanna's Fork also had a several exceedances. These occurred in temporally different time periods. Two occurred in June and a third in October of 2005. The magnitude of the June exceedances (610 to 650 cfu/100ml) were small in comparison with the secondary contact recreation instantaneous standard, while the exceedance in October was striking (3,100 cfu/100ml). It should be noted that the October sample coincided with the extreme SSC sample collected from Hanna's Fork. Bank stability, riparian constitution, and, land use patterns in the grazing system may account for the exceedances in Hanna's Fork. Based on the data, DEQ concludes that bacteria do not impair the beneficial uses of the assessment unit and that the few exceedance of the instantaneous standards would be minimized by implementing BMPs for other constituents that exhibit more dramatic exceedances of criteria such as TP in Hanna's Fork.

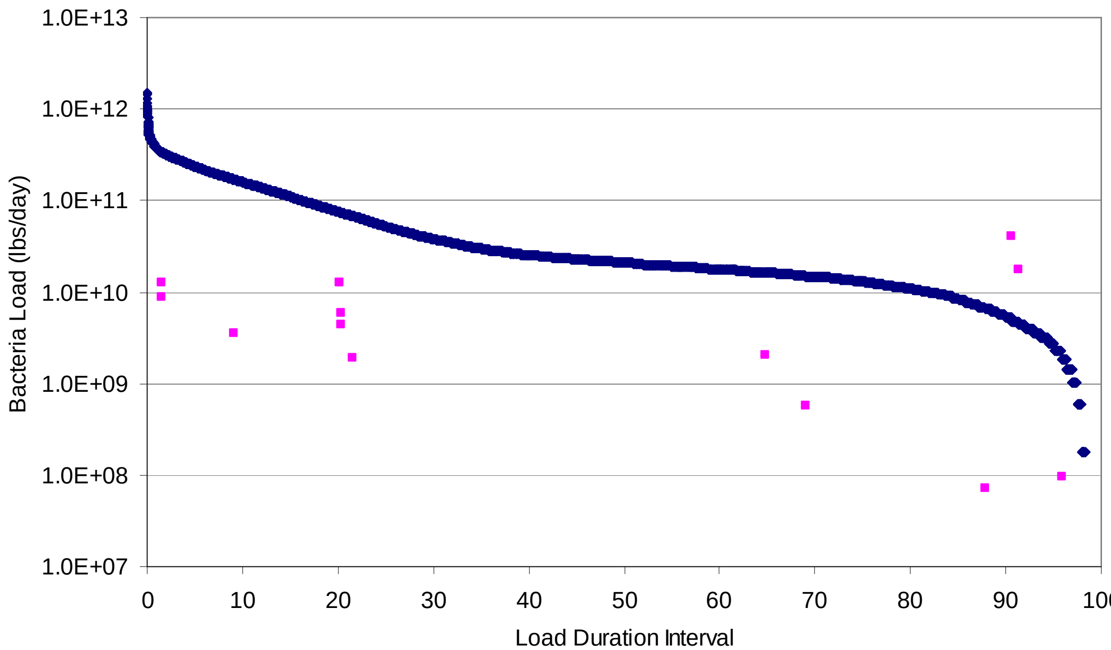


Figure 107. Bacteria Load Duration Curve Big Creek Upper.

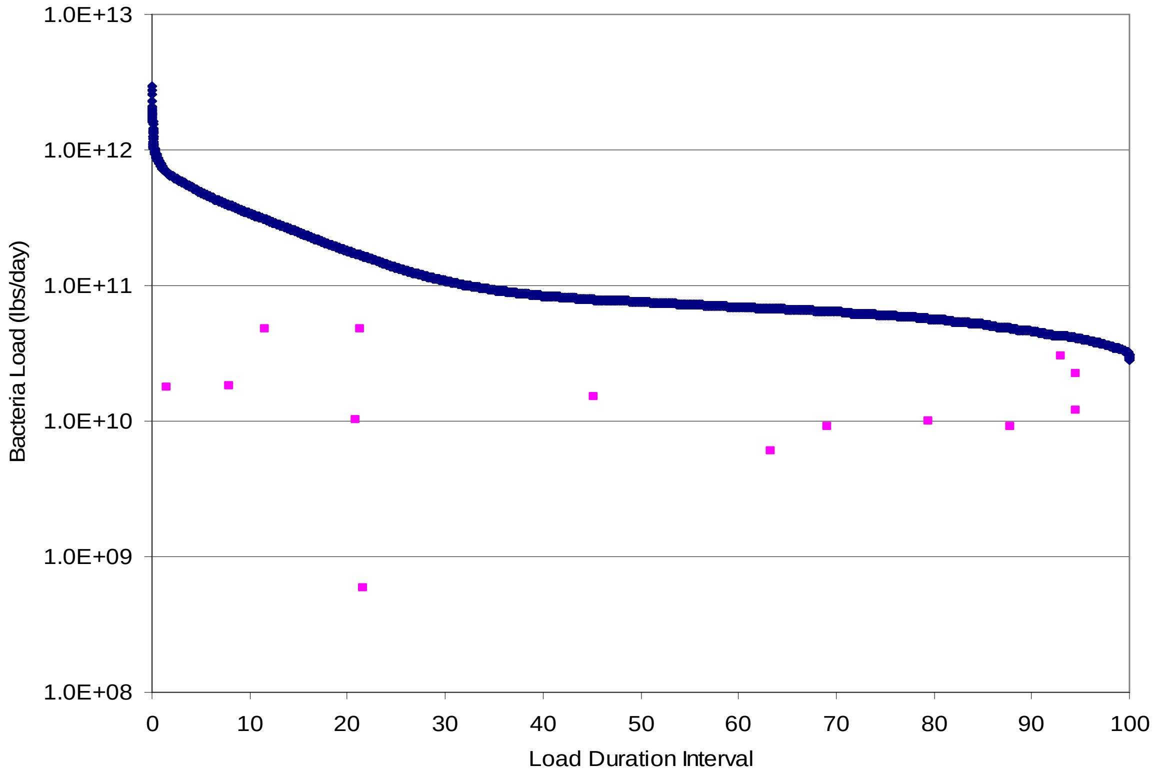


Figure 108. Bacteria Load Duration Curve Big Creek Lower.

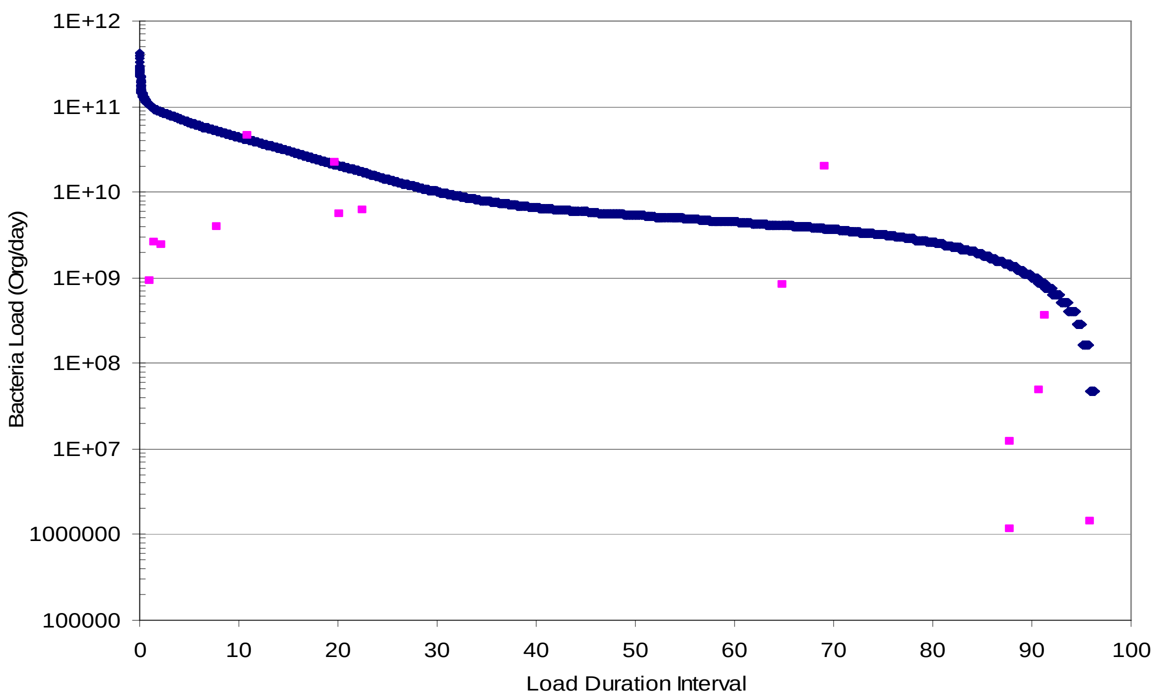


Figure 109. Bacteria Load Duration Curve Hanna's Fork.

Due to DEQ's limited sampling for suspended sediments in the Big Creek systems, additional measures were taken to determine if other forms of sediment were impairing the beneficial uses in the fish bearing streams. From DEQ's sampling regime, it was determined that the suspended fraction of the sediment load was not impairing the beneficial uses. Therefore, a series of McNeil cores for depth-fines were collected in each of the systems of the assessment units to determine if bedload sediment was impairing beneficial uses. See the McNeil sediment core sample protocols used as outlined in the Cottonwood Creek Assessment Unit.

In the lower portion of Big Creek, the percent depth fines ranged from 35.41 to 43.58 percent of the total volume. The overall average depth fines in lower Big Creek was 40.32 percent. Percent fines were not collected in the upper portion of Big Creek nor Hanna's Fork as these systems were determined not to contain salmonid spawning as an existing use. At the lower location the average depth fines were well above the 28 percent depth fines target established to be protective of salmonid spawning in other Idaho TMDLS.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that game have been stocked in Big Creek as far back as 1968 to 1989. brown trout were stocked annually from 1973 to 1989, rainbow trout were stocked at least annually, sometimes more, from 1968 to 1989, and cutthroat trout were stock intermittently from 1968 to 1985.

The IDFG has not surveyed the fishery in Big Creek.

DEQ has electrofished within the Big Creek Assessment Unit once in 1996. No salmonids were captured at the time of sampling. The only fishes collected were suckers, dace and shiners. The DEQ electrofishing location on Big Creek was a few hundred meters from the confluence with Shoshone Creek.

Salmonid spawning does not appear to be an existing beneficial use in Big Creek. However, the upstream portion of the system has not been surveyed. Department of fish and game curtailment of brown trout stocking in Hot Creek and Shoshone Creek were due to no reproduction within those systems as per the annual reports referenced for those systems. It is likely the same reason for the curtailment of fish stocking in Big Creek.

The depauperate fish population in Big Creek may be the result of fine sediment impacts to spawning substrates, as evidenced by the McNeil core information presented above, in conjunction with beaver ponds which may act as migration barriers to upstream movements of fish, and periods of very low flow. At this time DEQ cannot document salmonid spawning as an existing use. Further investigations are required.

Macroinvertebrates

DEQ has collected macroinvertebrates in the Big Creek Assessment Unit seven times. Macroinvertebrates were collected from the lower reaches of the system in 1994, 1996, and 2002. Macroinvertebrates were collected in the middle reach near the Shoshone Basin Road in 1998. Hanna's Fork was also surveyed but was dry at the time of the survey (July 31, 2002). In the upper reach, macroinvertebrates were collected in 1996, 2002, and 2006, but the 2006 data are not available for analysis at this time. As a result three data sets are available for interpretation near the confluence with Shoshone Creek, two above the Shoshone Basin Road, and one near Hanna's Fork Confluence.

The macroinvertebrate scores from the lower reaches of Big Creek exhibited a slightly improving trend in metric values from 1994 to 2002. Most notably, the percent dominance of the top five taxa decreased temporally while taxa richness increased. The oldest data was also the poorest in metric values, which suggests an improving trend in water quality in the lower reach of Big Creek. Overall the macroinvertebrate assemblage suggest moderate to good water quality in the more recent years. The single sample collected from the middle portion of the system is similar in many ways with the samples collected from the lower reach, and suggests a stabilization of water quality throughout much of Big Creek over the period of 1996 to 2002.

The macroinvertebrate data from Big Creek in the headwaters area presents a contrasting picture in comparison with of the macroinvertebrate assemblages from the lower reaches. Two samples were available for interpretation from the upper reach. The macroinvertebrates from the uppermost site (collected in 1996), just below the confluence with Dry Gulch, had the best representation of the key EPT taxa as well as relatively high numbers in all metrics. As a result, this site scored the best on the SMI of the two. In fact this sample scored the best on the SMI of all samples collected in the entire Salmon Falls Creek Subbasin. The macroinvertebrates from the next site were collected at nearly the same location, but in 2002. Again this site scored well on the SMI and had a good representation of the key EPT taxa as well as relatively high numbers in all metrics. The results from the upper reaches indicate that water quality is sufficient to support the cold water aquatic life beneficial use.

Aquatic Vegetation

At the various BURP locations in the lower and middle reaches of Big Creek field crews noted the presence of macrophytes and epiphytes. At the upper locations aquatic plant communities were limited and no mention of macrophyte growth were noted. However, the high water clarity was noted in the upper reach on several occasions. A few sestonic chlorophyll *a* samples were collected during the peak of the summer growing period to determine if nuisance conditions existed. The samples collected in the upper Big Creek watershed averaged 9.0 μg/L of chlorophyll *a*. Two chlorophyll *a* samples were available from the lower Big Creek reach: 7.43 and 18.84 μg/L. Although limited in numbers, this supports the BURP observations of increased aquatic vegetation in the lower reaches in comparison with the upper reaches. The lower reach average conditions were near the 15 µg/L value suggested to indicate nuisance aquatic vegetation growths and one exceeded this value. These sample values confirm the nutrient assessment that indicated TP may be in excess as a result of the contribution from Hanna's Fork. In order to be protective of the instream beneficial uses a nutrient TMDL is warranted for Hanna's Fork.

Bank Stability

Bank stability measures were collected at four locations within the Big Creek system. The first of these was near Shoshone Creek, the second was in the middle reaches of the system below the Dry Gulch confluence, and the third was in the upper reaches of Big Creek above Dry Gulch, and the fourth was on Hanna's Fork near the Shoshone Basin Road. In the upper 5.4 miles of the system measured bank stability averaged 72.5 percent. In comparison, bank stability measures collected following BURP protocols averaged 66 and 67 percent stable on the right and left banks. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 47.83 tons of sediment per mile per is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 17.41 tons per mile per year.

Bank stability measures collected in the middle 4.4 miles indicate that bank sediment is not being delivered downstream in excessive quantities. Bank stability in this region averages 85.6 percent. Again for comparison BURP data collected in this reach averaged 66.67 and 56.33 percent stable on the right and left banks. Stream erosion and recession rate estimates indicate that this portion of the stream is not contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 6.72 tons of sediment per mile per year is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 7.44 tons per mile per year.

Bank stability measures collected in the lower 3.2 miles indicate that bank sediment is being delivered downstream and to Shoshone Creek in excessive quantities. Bank stability in this region averages 47.0 percent. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 27.94 tons of sediment per mile per year is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 6.03 tons per mile per year.

Bank stability measures collected in the 6.2 miles of Hanna's Fork (including the North Fork) indicate that bank sediment is not being delivered to the downstream reach in excessive quantities. Bank stability in this region averages 81.0 percent. Beneficial Use Reconnaissance Program data was not available for comparison. Stream erosion and recession rate estimates indicate that this portion of the stream is not contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 13.12 tons of sediment per year is delivered to the downstream reach; while the proposed sediment delivery rate for this reach is 13.79 tons per year.

Overall the Big Creek system would require a 59.06 percent reduction in sediment to meet existing criteria and targets.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment and TMDL.

Status of Beneficial Uses

The above data suggest that the existing beneficial use, secondary contact recreation is not impacted. However, it can be clearly demonstrated that cold water aquatic life is not fully supported and impacted marginally by nutrients sediment. Additionally, it appears that the source of the sediment is poor bank stability in the Big Creek reaches of the system. Furthermore, nutrients form Hanna's Fork, are impacting Hanna's Fork itself, and are likely impacting the receiving water, Big Creek, and therefore will be addressed in a TMDL.

Conclusions

Based upon the above assessment, a bank stability based sediment TMDL will be developed for the upper and lower Big Creek reaches. Additionally, to be protective of the Hanna's Fork as well as the downstream receiving water body of Big Creek a nutrient TMDL will also be completed for Hanna's Fork. It is highly likely that the BMPs used to address the nutrient issues within Hanna's Fork will also alleviate the sporadic bacteria exceedances seen in that portion of the assessment unit.

China Creek Assessment Units

Physical Characteristics

The China Creek Assessment Units ID17040213SK008_02 and _03 includes the first and second order streams which flow from the eastern side of Browns Beach towards Salmon Falls Creek Reservoir and the third order segment of China Creek. Systems considered in this assessment unit are China Creek, Browns Creek, Player Creek, Corral Creek, and Whiskey Slough. Most of these other systems will be shown to be intermittent. Therefore the main discussion will center on China Creek.

China Creek begins on the eastern side of Browns Bench near the Idaho/Nevada border and terminates at the confluence of the Salmon Falls Creek Reservoir. China Creek is a spring fed creek but receives a small amount of runoff discharge from the relatively small upper watershed. The contributing watershed area for China Creek is 33.7 $miles^2$ and includes the 5 $miles^2$ watershed of Player Creek. The upper portion of the assessment unit includes the first and second order sections of China Creek with a contributing watershed of 2.5 $miles^2$ or 7.42 percent of the China Creek total watershed. Also included in this assessment are

Brown's Creek with a 7.8 miles^2 watershed, Corral Creek with its 2.2 miles^2 watershed, and the 9.8 miles^2 watershed of Whiskey Slough.

Characteristics of the above mentioned watersheds were found at the USGS StreamStats Web site and are presented in the following Table (33).

Table 33. China Creek Assessment Unit Watershed Characteristics.

Parameter	China Creek	Browns Creek	Player Creek	Upper China Creek	Corral Creek	Whiskey Slough
Area mi^2	33.40	7.73	4.91	2.48	2.21	9.72
Area km^2	86.51	20.02	12.72	6.42	5.72	25.17
Relief ft	2,510	2,380	1,860	2,190	2,010	2,050
Average elevation ft	5,950	6,060	6,280	6,610	5,570	5,680
Maximum elevation ft	7,540	7,420	7,220	7,540	7,030	7,070
Minimum elevation ft	5,030	5,030	5,350	5,350	5,020	5,020
Average area slope in percent	15.2	17.7	20.4	23.4	17.8	11.0
Percent of area with slope greater than 30%	17.4	22.2	25.6	32.7	26.2	11.5
Percent of area with slope greater than 30% and facing North	3.08	3.59	5.39	5.42	1.30	1.29
Percent of area covered by forest	0.46	1.20	0.24	1.09	0.13	0.30
Mean annual precipitation in	10.8	10.1	10.6	10.0	10.0	10.0

Flow Characteristics

The streams of the assessment unit flow through the Northern Basin and Range ecoregion. Mean annual precipitation is low and many streams have very small contributing watersheds (see Table 33 above). As a result unless there is a significant spring system within the stream it is highly likely that the streams are intermittent in nature. None of the streams have been gauged in the past, and the closest USGS operated gauge is located in Nevada just south of Jackpot called the San Jacinto Gauge (#13101000). Due to the limited hydrological information concerning the systems of the assessment unit, the hydrology of the various systems will be based upon discharge measurements collected by the USGS and a statistical relationship with the limited measured discharge from the various streams of the assessment unit. See Figure 110 for monthly average stream discharge.

Player Creek (the lower spring) and Whiskey Slough are both spring driven systems that did not correlate with Salmon Falls Creek discharge measures. Flow in these two systems was relatively constant, regardless of season, as would be expected from such small watersheds and their spring sources. In addition the flow from these systems was also very small. The average flow from Player Creek was 0.44 cfs with a standard deviation of 0.14. Whiskey slough was much more volatile with an average discharge of 0.69 cfs and a standard deviation of 0.33. Zero flow at Whiskey Slough was not uncommon during the summer months.

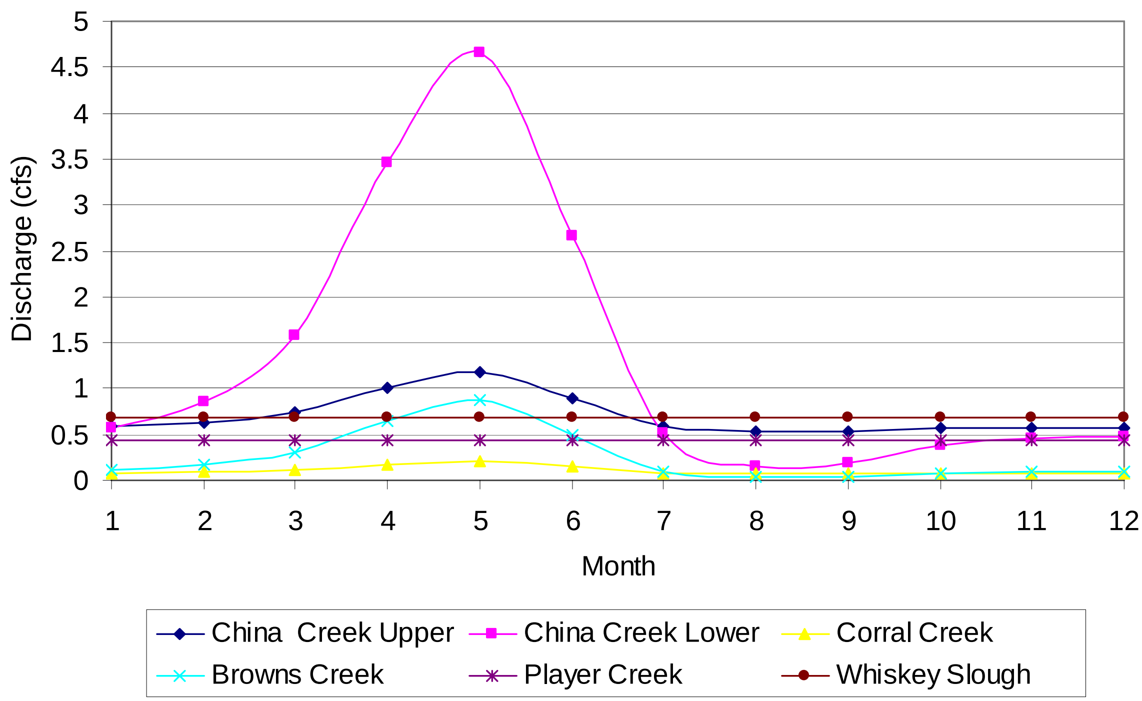


Figure 110. China Creek Assessment Unit Monthly Average Discharge.

The flow duration curves for the various systems are most telling of the hydrological regimes seen within a system. Due to the wide range of variability that occur in the China Creek Assessment Unit systems, knowing the percentage of days in a year when given flows occur is essential to understanding a system. The flow duration curves also provide a visual indication of the potential for a stream to be perennial.

Figures 111-114 presents a flow duration curves using data from Salmon Falls Creek near Jackpot, NV and linear regressions of flow data collected from the various systems. The figures illustrate the effects of the small watersheds and low precipitation. The flow duration intervals, seen when the systems are predicted to have 1 cfs or greater, are very low. For example, China Creek, the largest system of the assessment unit had a FDI of 28.72 at 1 cfs, while the upper portion of the system, Browns Creek, and Corral Creek have FDIs of 12.01, 5.8, and 0.01 respectively. Median flows for the various systems within the assessment unit were Lower China Creek 0.51 cfs, upper China Creek 0.58 cfs, Browns Creek 0.10 cfs and Corral Creek 0.08 cfs. Coupled with the annual average hydrographs and the flow duration curves it is apparent that Browns Creek and Corral Creek are intermittent streams. Furthermore, given the volatility seen in the limited flow record of Whiskey Slough and the extended period of zero flow that system is also intermittent. Player Creek for the most part is a dry channel as well, except for the portion of the system below the lower spring which has a very constant 0.5 cfs discharge regardless of season.

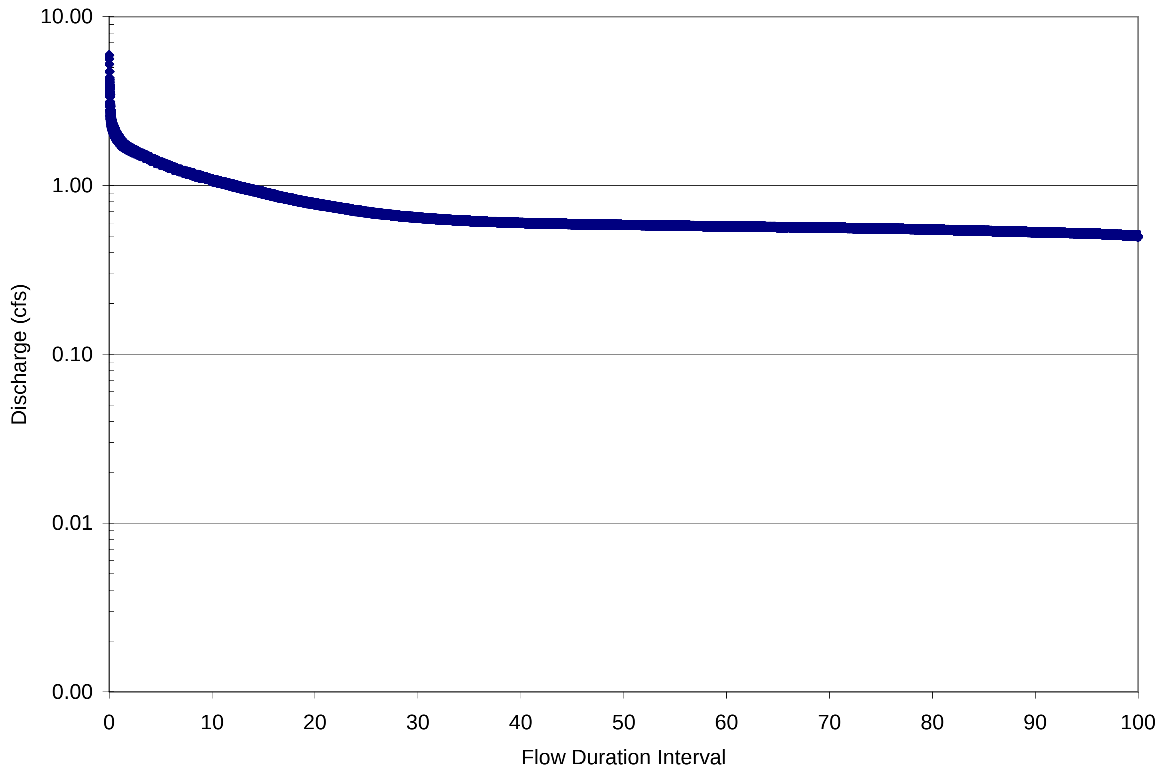


Figure 111. Upper China Creek Flow Duration Curve.

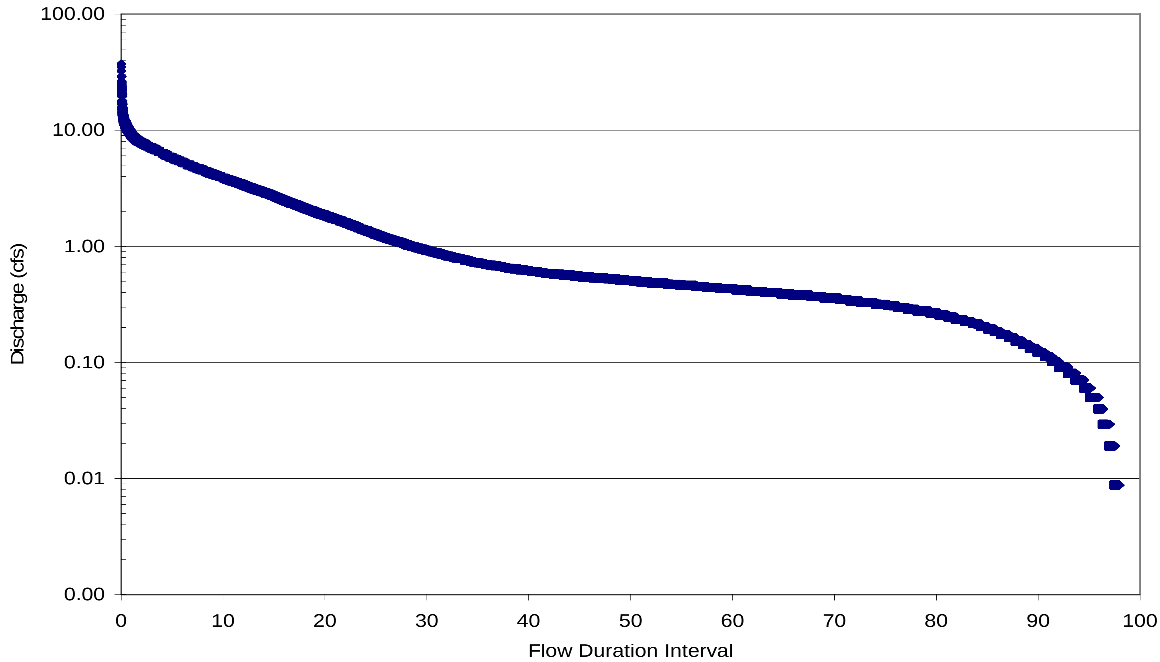


Figure 112. Lower China Creek Flow Duration Curve.

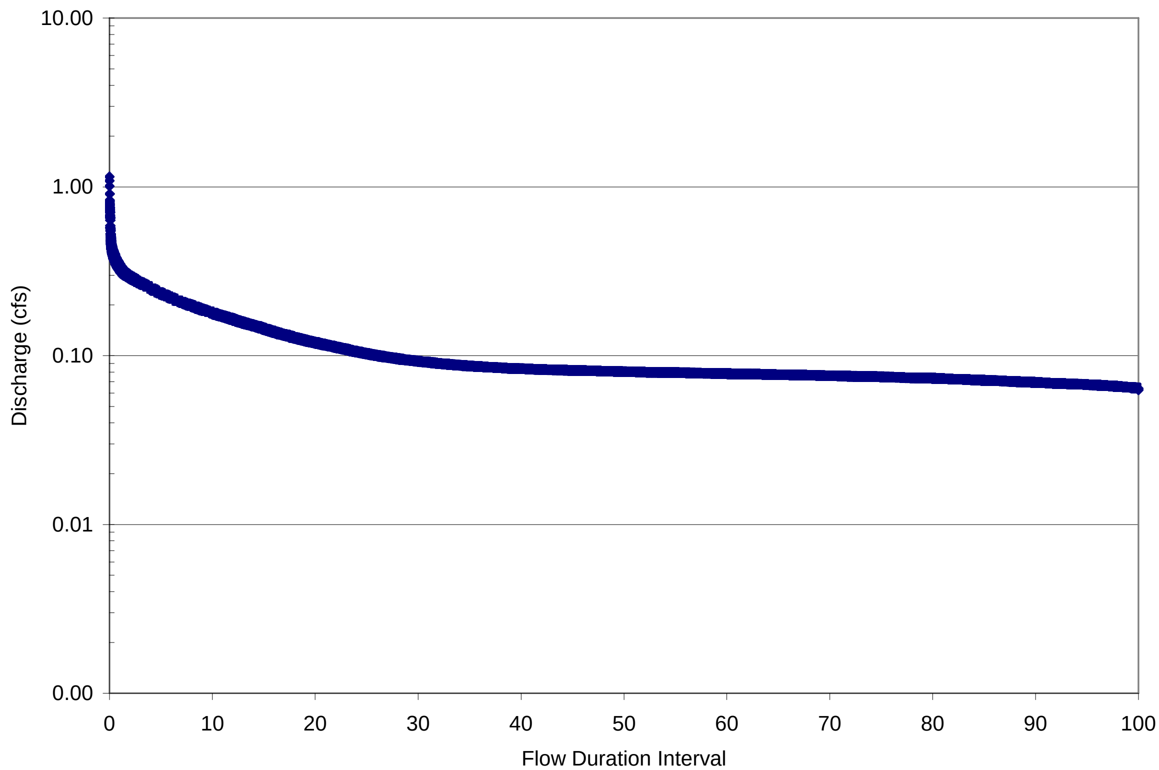


Figure 113. Corral Creek Flow Duration Curve.

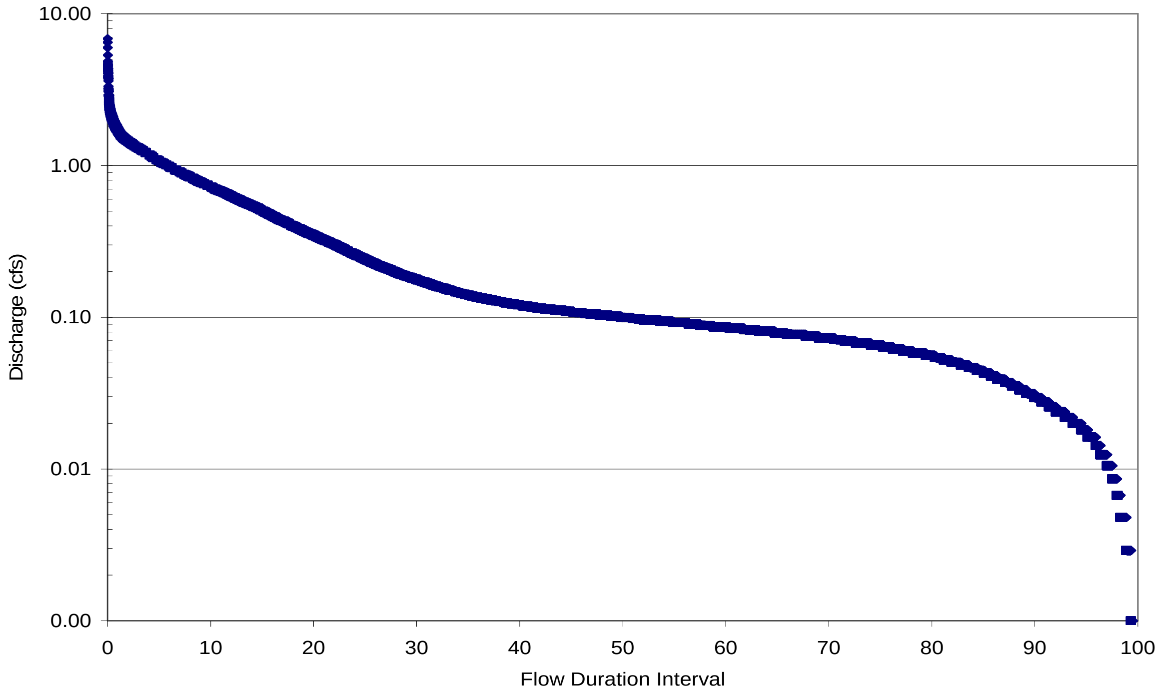


Figure 114. Browns Creek Flow Duration Curve.

Load capacity duration curves were calculated multiplying flow duration curves for each system by the applicable water quality criterion or target and a conversion factor. These curves are shown in Figure 116-124, using a target of 0.05 mg/L TP, 1.5 mg/L TN, 50 mg/L SS, 576 cfu/100ml *E. coli*, and 6 mg/L DO. These figures also display the observed loads, which are calculated by multiplying measured constituents concentrations by the predicted daily mean flow associated with a sample. Points plotting above the curve represent exceedances of the target and are therefore unallowable loads. Those plotting below the curve represent compliance with the target and allowable daily loads. An exception is the case of DO where compliance is indicated when the points plot above the curve.

Water Column Data

Water quality samples for the China Creek assessment units are limited to the current DEQ data set collected in 2005 and 2006. To determine seasonality and appropriate critical conditions, the data was interpreted using load duration curves. For those cases when a parameter was below detection limits, half the detection limit was used in the loading analysis.

The primary sampling location for China Creek was near its confluence with the reservoir and sampling there began in May 2005 (Figure 115). This site was used to determine loads from the entire watershed. An additional site near the canyon mouth (BLM boundary) was sampled to determine loading from the upper portions of the watershed as well as the net change in loads in the lower portion of the system. The Player Creek sampling location was near the confluence of the rivulet from the lower spring and China Creek, while Browns and

Corral Creeks were sampled near crossings of China Creek Road. Whiskey Slough was sampled at the secondary road crossing approximately 0.9 miles above the reservoir.

Effects of land uses can be seen in the slightly elevated levels of some of the measured constituents in the various streams in comparison with criteria or guideline loads. These increases are in most cases small, indicating similar use and degradation within an assessment unit. However, among units several of the systems did show somewhat dramatic differences from each other. For example, the suspended sediment concentration at Lower China Creek, Browns Creek, Corral Creek, and Whiskey Slough was approximately 6 mg/L in each stream, while in Player Creek and upper China Creek SS nearly doubled to 11.5 mg/L. This increase may simply be the result of increased gradient at the latter two creeks, or it may also be an expression of a land use difference. However, the levels recorded in 2005 through 2006 are very low and below levels indicative of beneficial use impairment.

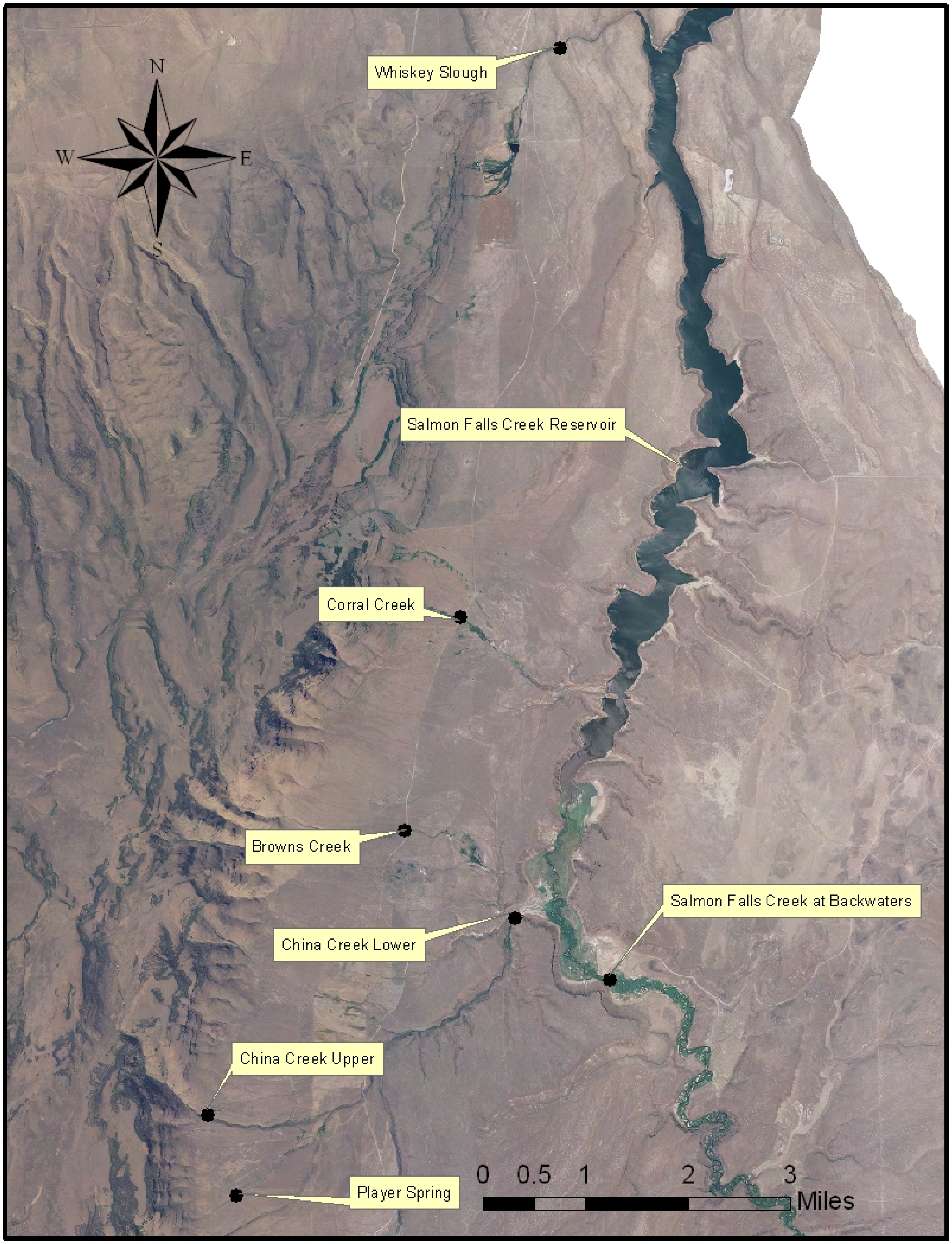


Figure 115. China Creek Assessment Unit Monitoring Locations.

Total phosphorus varied across the systems in some cases as well. At the lower China Creek and Whiskey Slough locations TP average approximately 0.140 mg/L and at all the other locations TP was near 0.035 mg/L. The only striking difference these systems have from one another is that each of the systems with elevated TP values have a greater percentage of impounded water and wetlands than the other systems do. Lower China Creek has numerous beaver dam complexes beginning nearly at the reservoir and continuing up through the system to the China Creek Road crossing, while Whiskey Slough has a relatively large impoundment (5.28 acre) approximately 0.6 mile upstream from the sample location (near the China Creek Road). Additionally, both systems contain some level of agricultural production within the watershed in addition to the typical range activities that occur in all of the watersheds.

Monthly concentrations of TP were not indicative of excess nutrients that may cause impairment (nuisance aquatic vegetation) to the river system itself. However, concentrations of TP seen in China Creek and Whiskey Slough may in fact be a source of some minor impairment to the reservoir system. Guidelines that DEQ has used in the past for river and stream systems that discharge into lakes and reservoirs are no more than 0.08 mg/L TP in any single sample, 0.05 mg/L TP in any average monthly sample, and 0.05 mg/L TP as a period of record average (Lay 2000, Lay 2001). These guidelines were commonly exceeded, at both sample locations, during high flow events and into the mid flow range of the flow duration curve, FDI <50 (see Figure 117). In order to be protective of the reservoir's beneficial uses DEQ concludes that a TMDL for nutrients is warranted for China Creek, Whiskey Slough, and Corral Creek.

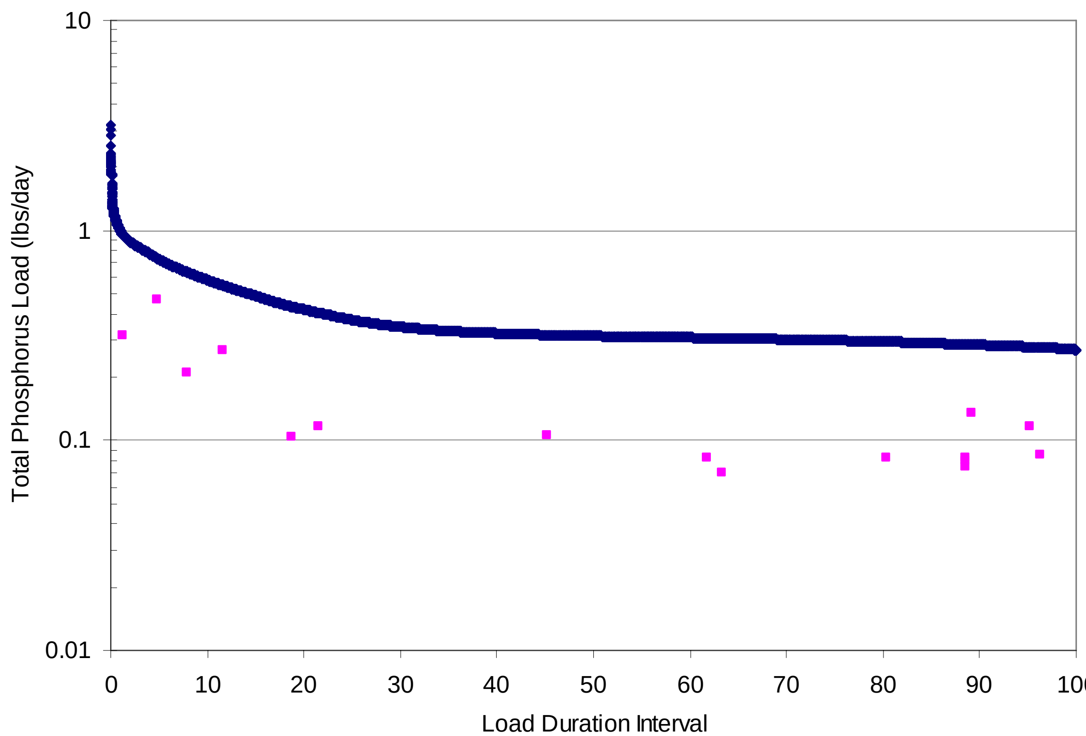


Figure 116. Upper China Creek Total Phosphorus Load Duration.

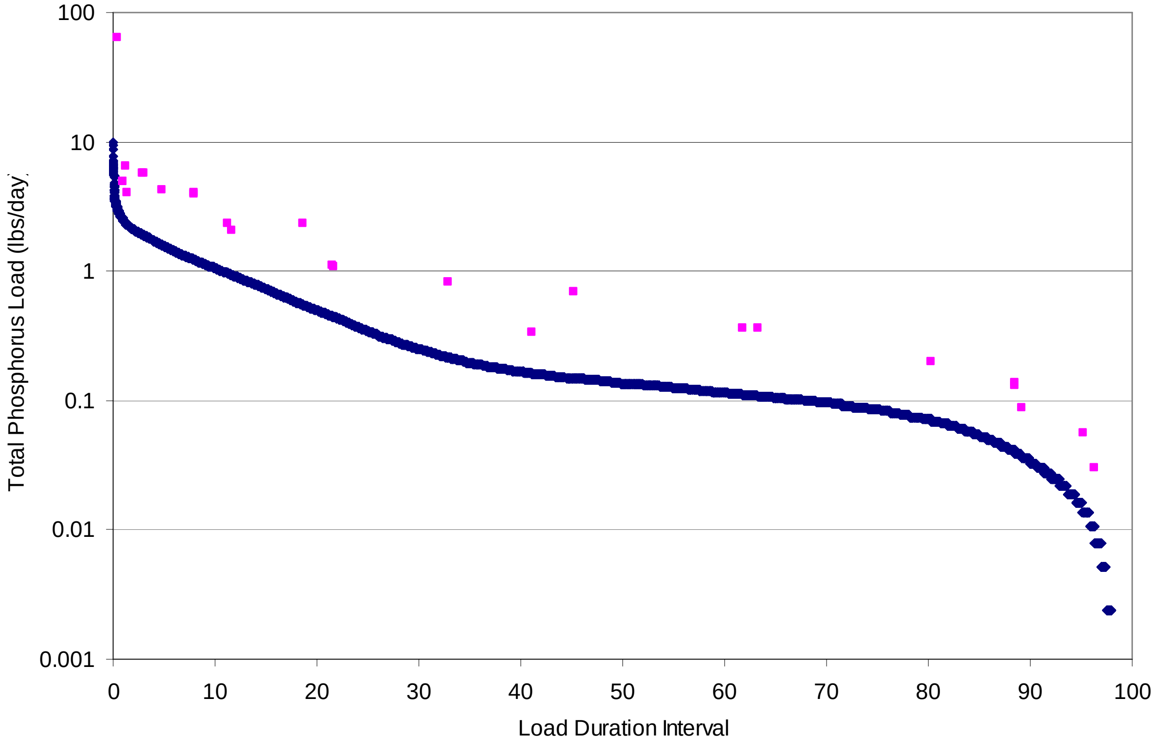


Figure 117. Lower China Creek Total Phosphorus Load Duration.

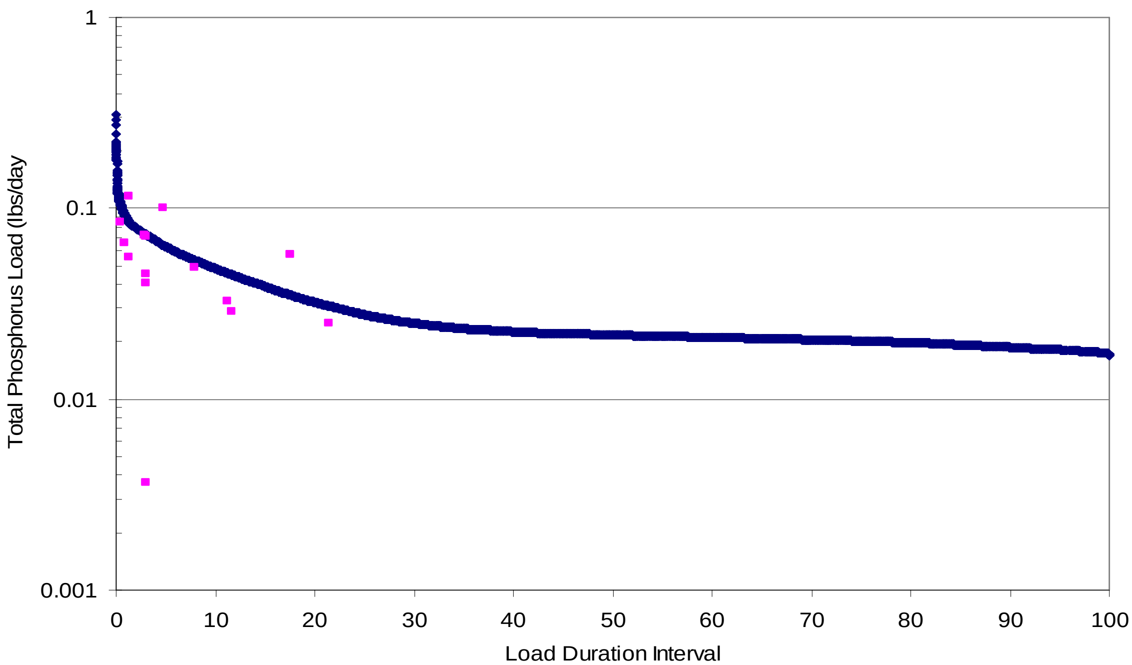


Figure 118. Corral Creek Total Phosphorus Load Duration.

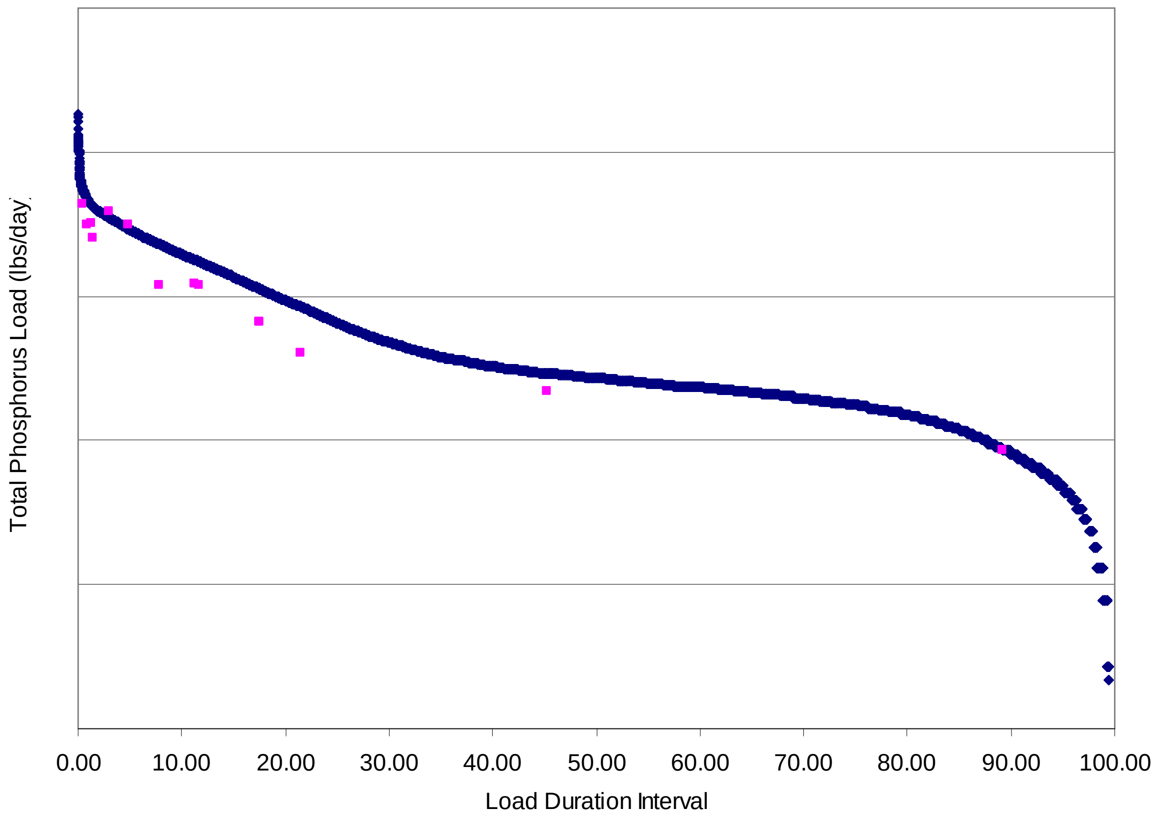


Figure 119. Browns Creek Total Phosphorus Load Duration.

Instantaneous temperature measures were also collected in the assessment unit. In the current DEQ data set instantaneous temperature samples exceeded water quality standards of 22 °C at Player Creek and Corral Creek. Corral Creek temperature exceedances occurred as the discharge in the system decreased to below 0.2 cfs while in Player Creek, with the constant flow from the spring, saw the frequency of exceedances increase as the summer progressed. The other systems either dried more quickly than did Corral Creek or maintained sufficient flow coupled with higher levels of shade in comparison with Player Creek. Temperature issues will be addressed in Upper Salmon Falls Creek Assessment Unit.

Instantaneous dissolved oxygen DO was also collected in all of the systems of the assessment unit. In almost all cases DO was above 6.0 mg/L. Player Creek was the only exception to this finding. Several times throughout the monitoring events DO fell to low levels. Additionally data collected on 4/13/2006 appears to be corrupted as the DO values seen on this day were abnormally depressed across all sample sites. The depressed DO levels in Player creek may be influenced by the low groundwater DO levels and not as a result of oxygen demanding materials within the system as nutrient levels are near background in this system. Further investigations are needed.

As mentioned above, bacteria samples were also collected with the water chemistry samples (see Figures 120-123). No single sample collected at the lower China Creek location indicated significant bacteria contamination. While in the upper reach bacteria concentrations were elevated several times, once in June and twice in July of 2005. Browns Creek also had a single exceedance in May of 2005. The most dramatic of bacteria problems occurred in Corral Creek. All of the samples collected in 2005 (N = 5) exceeded the instantaneous secondary contact recreation standard of 576 cfu/100ml. However, the following year none of the samples did (N = 7). Land use patterns in the grazing system may account for the temporal difference at Corral Creek. However, in the intermittent streams the water quality standards for recreation are only applicable during periods were discharge is greater than 5 cfs at no time were any of these intermittent streams near 5 cfs. In the perennial stream, China Creek, secondary contact recreations standards were never exceeded. Therefore, DEQ concludes that bacteria do not impair the beneficial uses of the assessment unit.

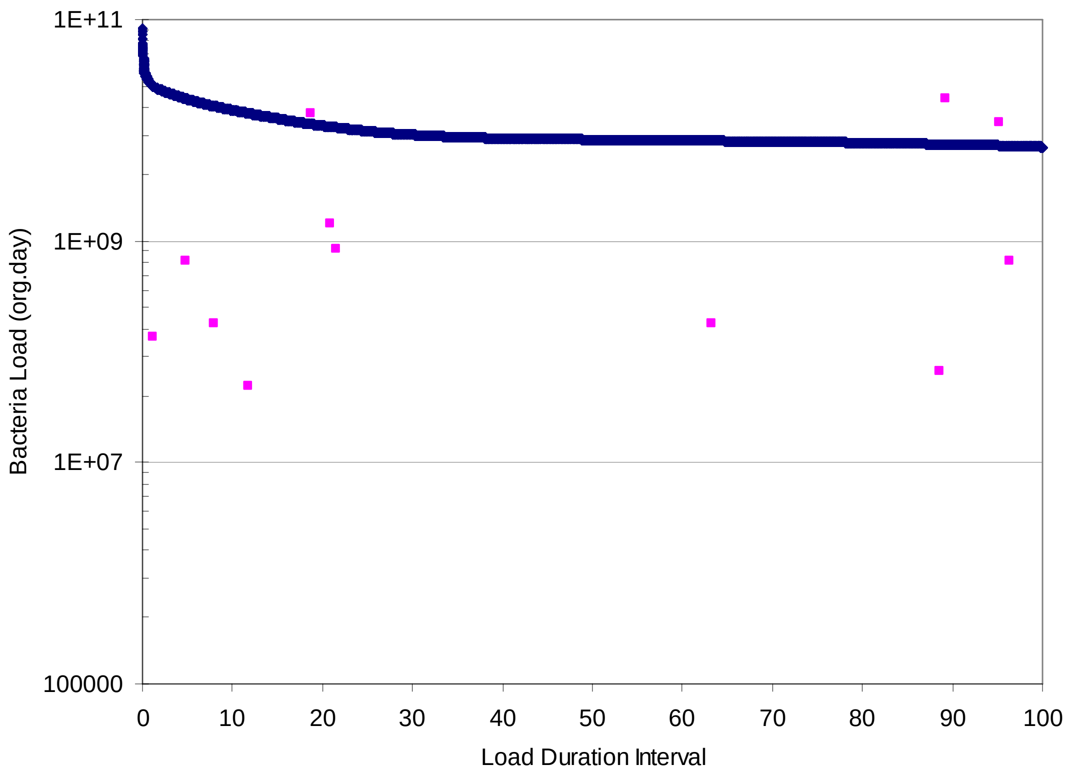


Figure 120. Upper China Creek Bacteria Load Duration.

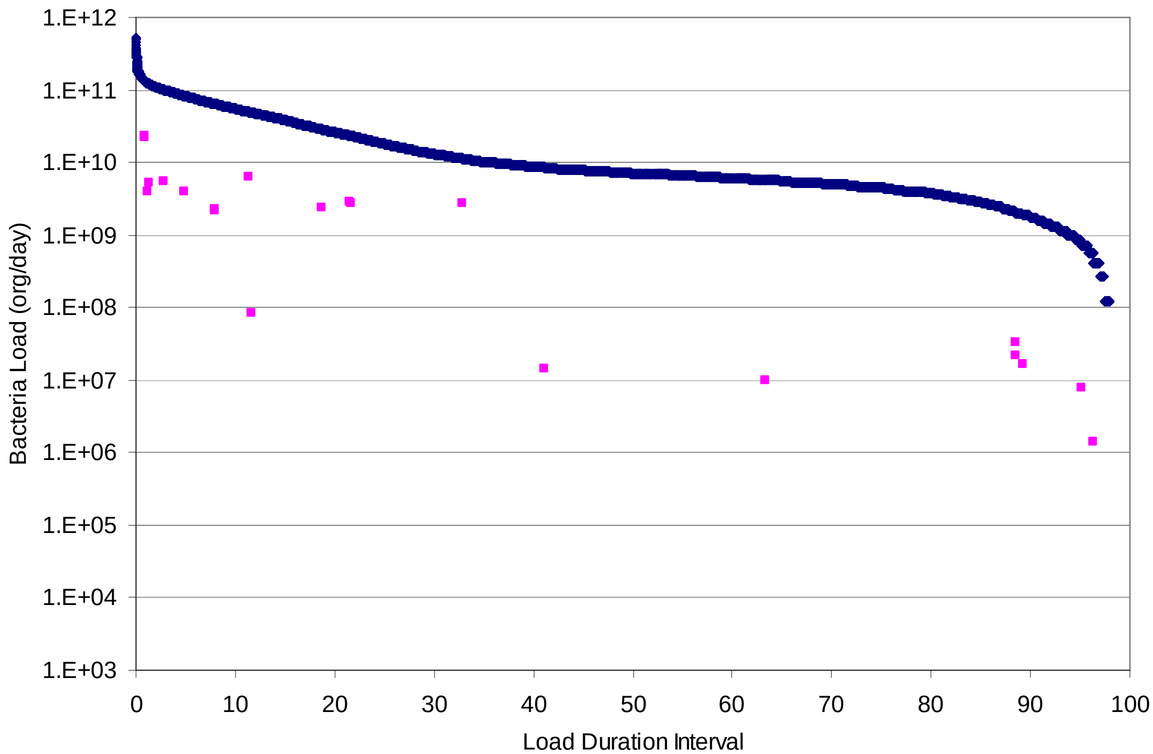


Figure 121. Lower China Creek Bacteria Load Duration.

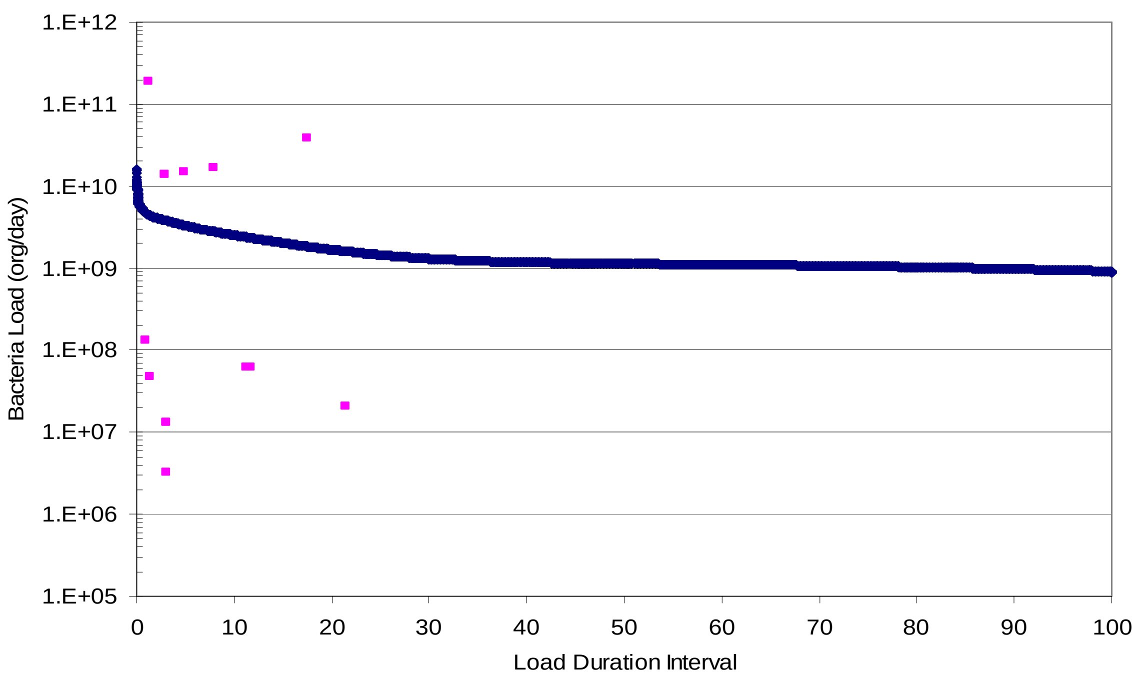


Figure 122. Corral Creek Bacteria Load Duration.

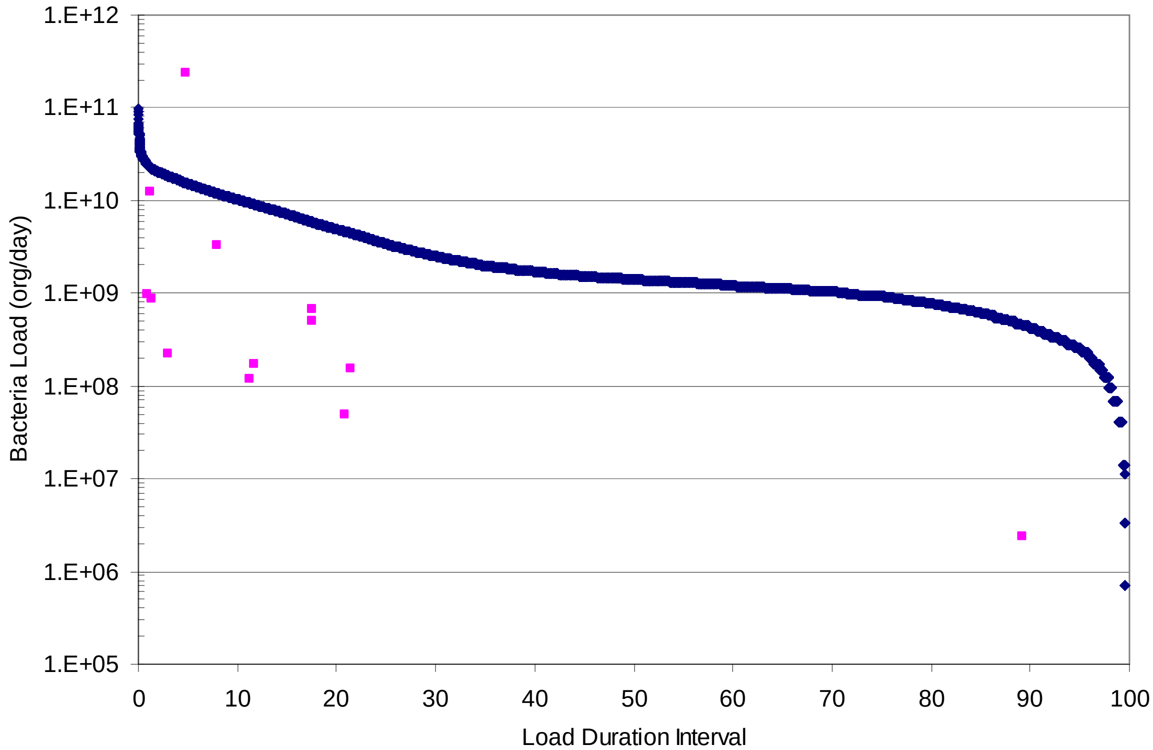


Figure 123. Browns Creek Bacteria Load Duration.

As discussed above, total suspended sediment also appears to be a non-factor effecting beneficial uses. However, given the continued drought cycles and the weak hydrological regime of many of the systems much of the sediment stored in the streams is still in place and not transported out of the reach as a suspended load. In a higher water year, the data from the suspended fraction may support the contention that sediment TMDLs are required.

Due to DEQ's limited sampling for suspended sediments in the China Creek systems, additional measures were taken to determine if other forms of sediment were impairing the beneficial uses in the fish bearing streams. From DEQ's sampling regime, it was determined that the suspended fraction of the sediment load was not impairing the beneficial uses. Therefore, a series of McNeil cores for depth-fines were collected in each of the systems of the assessment units to determine if bedload sediment was impairing beneficial uses. See the McNeil sediment core sample protocols used as outlined in the Cottonwood Creek Assessment Unit.

The lower portion of China Creek's percent depth fines ranged from 52.97 to 93.64 percent of the total volume. The overall average depth fines in lower China Creek was 70.69 percent. In the upper portion of China Creek the only other system that is perennial and may contain fishes, the depth fines ranged from 37.79 to 56.57 and averaged 45.28 percent. At both locations the average depth fines were well above the 28 percent depth fines target established to be protective of salmonid spawning in other Idaho TMDLS.

Mercury

Monthly total mercury samples were collected in the China Creek area near the confluence with the reservoir beginning in August of 2005 and continuing until November of 2006. Sample design included weekly sample collection during the spring runoff period. In general, total mercury concentration in China Creek was very low. Limited fluctuations occurred during high flow events in contrast with Salmon Falls Creek where mercury concentration increased dramatically relative to the base flow concentrations. A load duration curve provides the best description of the mercury variability in relationship to flow. The y axis is mercury load and the x axis is the load duration interval. A 12 ng/L assessment target was chosen to determine the magnitude of the mercury load. However, any TMDL developed from this data will ultimately be calculated using Idaho's fish tissue criteria and not the 12 ng/L mercury concentration in water. Nevertheless, the 12 ng/L provides an assessment framework to help understand the mercury concentrations seen within the stream system.

As can be seen in Figure 124 mercury load in China Creek never approaches the assessment load duration curve under any flow condition and is well below the curve in moist, midrange, dry, and low flow conditions. The nature of the mercury load in China Creek can also be inferred from the load duration curve. Data points plotting near or above the load duration curve in the 0 to 40 LDI describe wet weather and high flow contributions associated with sheet and rill erosion, wash-off processes, and potentially stream bank erosion. Stream bank erosion is very limited within this system as will be shown in following sections of this assessment unit description.

Points plotting near the load duration curve in the 60 to 70 LDI range may be indicative of geothermal or geological sources which would behave in a constant source of the pollutant that would be diluted under higher flow conditions—a situation similar to what a point source discharge would express on a load duration curve. Mercury in China Creek does not appear to follow either pattern well. The average relative percent difference of the existing mercury load and the assessment load duration curve describes this well. The overall relative percent difference between the assessment duration curve and the existing load was 141.4 percent. During wet weather conditions (LDI < 30) the RPD was 142.3. During dry weather conditions (LDI > 60) the RPD was 141.3. Although it can be seen that when flows increase in China Creek the RPD increases indicating a dilution effect occurring, and when flows decrease the RPD decreases as well indicating an increasing concentration of mercury (Figure 124). At base flow conditions, the RPD is somewhat constant, albeit very large. As a result of this interpretation of the data, it appears that the source of mercury with the China Creek watershed is a relatively constant but very small source that is inversely proportional to flow.

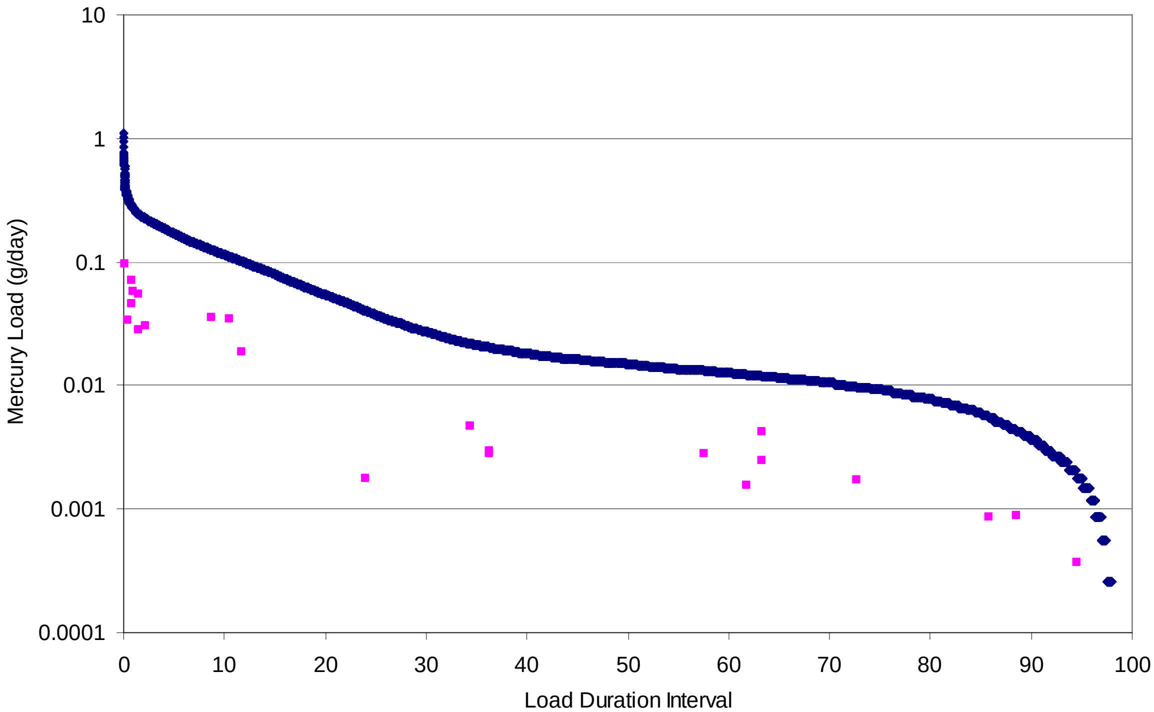


Figure 124. China Creek Total Mercury Load Duration.

Biological and Other Data

Fisheries

Idaho Department of Fish and Game stocking records indicate that no game have been stocked in China Creek as far back as 1967 to date. Additionally, the IDFG has not surveyed the fishery in China Creek.

DEQ has electrofished the systems of the China Creek Assessment Unit twice, once in China Creek 1999, and once in Browns Creek in 1998. Browns Creek was fishless at the time of sampling. China Creek was sampled June 14, 1999. In that event only 11 rainbow trout were collected. Over half (six) of the fish captured appeared to be spawning fish that had moved upstream from the reservoir. Five of these fish were ripe females. The remaining fish were small juvenile fish (<160 mm in length) that may have originated within the China Creek system. The only other organism noted as present was crayfish. The DEQ electrofishing location on China Creek was a few hundred meters from the confluence with the reservoir.

Salmonid spawning (rainbow trout) appears to be an existing beneficial use in China Creek. However, the upstream portion of the system has not been surveyed. A potential fish migration barrier exists at the mouth of the China Creek Canyon that may have excluded fishes from the extreme upper boundaries of the system.

The depauperate fish population in China Creek may be the result of fine sediment impacts to spawning substrates, as evidenced by the McNeil core information presented above, in conjunction with beaver ponds, which may act as migration barriers to upstream movements of fish, and periods of very low flow.

Macroinvertebrates

DEQ has collected macroinvertebrates in the China Creek Assessment Unit fourteen times. Macroinvertebrates were collected in 1998 once each from Browns Creek and Corral Creek, twice (1998 and 2002) from Player Creek, four times between the China Creek Road and Salmon Falls Creek Reservoir, four times between Player Creek and the China Creek Road, and twice above Player Creek. These sampling events cover the period between 1997 and 2006. However, only data from 1997 to 2004 are available for interpretation at this time. As a result three data sets are available near the reservoir, and three above the China Creek road, while none are available above Player Creek.

The macroinvertebrate scores from Player Creek, at the headwaters and at the spring, and Browns Creek exhibited similar issues with poor metric values in the numbers of Ephemeroptera, Trichoptera and Plecoptera taxa. These poor values are also expressed in lower numbers of scraper and clinger taxa. As a result, these systems scored poorly in the Stream Macroinvertebrate Index. However, it is likely the result of the ephemeral or spring system nature of these systems rather than an expression of water quality.

A comparison of the China Creek data from below the China Creek Road presents a contrasting picture of the macroinvertebrate assemblages. Three locations were available for interpretation. The macroinvertebrates from the uppermost site, just below the China Creek road, had the best representation of the key EPT taxa as well as relatively high numbers in all metrics. As a result, this site scored the best on the SMI of the three. The macroinvertebrates from the next lowest site were collected midway between the China Creek Road and the Reservoir. This area is dominated by beaver ponds and large pools. Additionally, percent fines in this area is much higher due to the decreasing gradient as well as the quiescent zones provided by the beaver ponds.

As would be expected in this type of habitat, the key EPT taxa were nearly absent. Furthermore, the numbers of macroinvertebrates collected at the site were very low. Again, this was probably an expression of the habitat type and the predominance of fine sediments as seen in the McNeil depth fines analysis. The final site was just upstream from the reservoir area. This area is after the heavily ponded area, and is of slightly steeper gradient. As a result, the macroinvertebrate assemblage in this area is more indicative of water quality impacts than the middle site. In this are a the key taxa are again present, albeit in slightly lower numbers that the upper most site. This site does show an expression, in the assemblage, of the impacts from increased nutrients in the system in that the numbers of clinging taxa are low.

The data collected from China Creek above the China Creek Road is very similar to the upper most site in the lower section of China Creek. At all three location the key EPT taxa were present in relatively high numbers, the clinger and scraper taxa were also well represented. As a result these three sites scored well on the SMI and would indicate that water quality is sufficient to support the cold water aquatic life beneficial use. The single anomalous factor is the difference between two collections that were made at the same location, but in different years. The location just upstream from the China Creek Road was sampled once in 1997 and again in 1999. The macroinvertebrates collected in 1997 scored higher that those collected in 1999. The biggest difference was in the clinger and Trichoptera taxa. However, this may be an expression of water volume rather than a change in water quality as 1997 was an exceptionally wet year in most of southern Idaho while 1999 was near the beginning of several drought years

Aquatic Vegetation

At the various BURP locations in the lower reaches of China Creek field crews noted the presence of abundant aquatic vegetation. At the upper locations, aquatic plant communities were limited. A few sestonic chlorophyll *a* samples were collected during the peak of the summer growing period to determine if nuisance conditions existed. The samples collected in the upper China Creek watershed averaged 8.7 μg/L of chlorophyll *a* while in the lower China Creek reach chlorophyll *a* averaged 15.20μg/L. This supports the BURP observations of increased aquatic vegetation in the lower reaches in comparison with the upper reaches. The lower reach average conditions were near the 15 μg/L value suggested to indicate nuisance aquatic vegetation growths and often exceeded this value. These sample values confirm the nutrient assessment that indicated TP was in excess. In order to be protective of both the instream and downstream reservoir beneficial uses a nutrient TMDL is warranted.

Bank Stability

Bank stability measures were collected at three locations within the China Creek system. The first of these was near the reservoir, the second was near the China Creek Road, and the third was in the upper reach of China Creek above the Player Creek confluence. In the upper 4.9 miles of the system measured bank stability averaged 99.7 percent. In comparison, bank stability measures collected following BURP protocols in 2006 were 91 and 94 percent stable on the right and left banks. Stream erosion and recession rate estimates indicate that this portion of the stream is not contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 0.04 tons of sediment per year is delivered to the downstream reach. While the proposed sediment delivery rate for this reach is 2.32 tons per year.

Bank stability measures collected in the middle 6.8 miles also indicate that bank sediment is not being delivered to the downstream reach in excessive quantities. Bank stability in this region averages 85.6 percent. Again for comparison BURP data collected in this reach averaged 87 and 88 percent stable on the right and left banks. Stream erosion and recession rate estimates indicate that this portion of the stream is not contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 13.96 tons of sediment per year is delivered to the downstream reach. While the proposed sediment delivery rate for this reach is 15.47 tons per year.

Bank stability measures collected in the lower 9.7 miles indicate that bank sediment is being delivered to the reservoir and downstream in excessive quantities. Bank stability in this region averages 77.8 percent. Again for comparison BURP data collected in this reach averaged 59.7 and 74.7 percent stable on the right and left banks. Stream erosion and recession rate estimates indicate that this portion of the stream is contributing sediment into the system from poor bank stability. Based upon the bank stability measures and recession rate information collected it is estimated that 36.74 tons of sediment per year is delivered to the downstream reach. While the proposed sediment delivery rate for this reach is 33.17 tons per year. Overall China Creek would require a 9.73 percent reduction in sediment in the lower reach to meet existing criteria and targets.

Temperature

See Upper Salmon Falls Creek Assessment Unit for potential natural vegetation assessment.

Status of Beneficial Uses

The above data suggest that the existing beneficial use, secondary contact recreation is not impacted. However, it can be clearly demonstrated that cold water aquatic life and salmonid spawning are not fully supported and are impacted marginally by sediment and to a lesser extent excessive nutrients in the form of TP. Additionally, it appears that the source of the sediment is poor bank stability in the lower reaches of the system. Furthermore, nutrients, are impacting China Creek itself, and are likely impacting the receiving water, Salmon Falls Creek Reservoir and therefore should be addressed in a TMDL. Similarly mercury has been show to have limited impact within the China Creek system, yet may have a profound effect in the receiving water’s biota. As a result a mercury TMDL should be undertaken (see the assessment of Salmon Falls Creek Reservoir in following sections for more information).

Conclusions

Based upon the above assessment, a sediment TMDL should be developed for the lower China Creek Reach. Additionally, to be protective of the downstream receiving water body, nutrient and mercury TMDLs should also be completed for the assessment units.

2.5 Data Gaps

This section contains a description of the informational gaps concerning pollution sources and transport as well as physical data gaps. The informational and data gaps will be identified for the subbasin rather than for individual water bodies.

Due to the brevity of the assessment period and drought situations, sources and transport mechanisms are weakly understood. Previous TMDLs have simply used land use as the tool to allocate loads. This approach relies heavily on post-TMDL monitoring and adaptive management to refine the load allocations once better information such as pollutant transport mechanisms are developed. Adaptive management is necessary in the Salmon Falls Creek Subbasin because little is known concerning the relative yield of pollutants from identified sources (by source type and/or subwatershed). An equivalent percentage has been applied in past TMDLs. Post-TMDL refinement will allow us to better understand the seasonality of pollutant loads. Currently, little is known about seasonal pollutant delivery from identified sources. It is assumed that the seasonal component corresponds with the critical periods identified in the stream assessments. Adaptive management will also allow us to define the relationships between pollutants specific to identified sources (i.e. physical or chemical associations). One of the final informational gaps in the Salmon Falls Creek Subbasin Assessment concerns the specific stream reaches within a water body most sensitive to impairment. The overall conceptual goal of adaptive management and refinement of the assessments and TMDLs is a further refinement and identification of critical areas.

Relative to specific data gaps, a limited amount of data was collected in the Salmon Falls Creek Subbasin. Therefore, physical data gaps abound. The most significant of these is the overall lack of data in wet or even normal water years. Consequently, any conclusions drawn from the current data set could be viewed as incomplete. However, a lack of data has not been viewed as a legal reason not to proceed with TMDL development.

Excess nutrients are a listed pollutant in many of the streams within the subbasin. However, current water quality data do not support the listing of most streams for excess nutrients. Chlorophyll *a* information also supports the contention that nutrients are not degrading the water quality in most streams in the subbasin. However, the chlorophyll *a* data were very limited, a fuller collection of both sestonic and benthic chlorophyll *a* is needed to make the subbasin assessment conclusions more robust.

A final data gap concerning biological communities exists. Fisheries information is very weak within the subbasin. It is unclear if some streams contain, or ever contained, salmonids. Current fisheries information needs to be collected to determine if salmonid spawning is indeed an existing use.

3. Subbasin Assessment – Pollutant Source Inventory

There are three categories of potential pollution inputs to the waters of the Salmon Falls Creek Subbasin: background, point sources, and nonpoint sources.

There are several types of point sources within Idaho portion of the subbasin. Notably these are confined animal feeding operations and municipal wastewater. However, all of these sources are total containment facilities and thus their discharge of pollutants have already been set at zero through the various permits required for their operation. Additionally there are no land application permitted sources within the Idaho portion of the subbasin.

Nonpoint sources such as septic systems, activities such as farming, and grazing all have the potential to produce pollutants in the watershed. Total surface discharges from these activities are minimal (with the exception of the growing season return flows from irrigated agriculture) and have varying degrees of impacts to the streams. The region is arid, and most surface flow is intercepted and consumed in the agricultural process, evapotranspired, or infiltrated to the subsurface.

The contributions of the nonpoint source impacts; however, are often integrated from the many entry sites into the larger discrete flows of the tributaries and drains. This integration often hides the magnitude of the impacts of single activities or sources. For example, home sewer systems and animal feedlots are legally forbidden to produce direct surface discharges. However, manure from the latter is eventually spread on agricultural lands as fertilizer and becomes inseparable from other nutrient production that results from application of chemical fertilizer in the agricultural process. The great majority of lands used exclusively for grazing in this arid area produce no surface runoff at all, although rangelands comprise approximately 85 percent of the land use of the subbasin. Where grazing (post-harvest) occurs in combination with agriculture, the effects of manure and trampling of riparian areas may be inseparable from, and concurrent with, the effects of fertilizer application and plowing up to the stream sides.

Natural erosive processes by the streams in the subbasin include scouring stream banks and beds, overland sediment transport, and mass wasting (earth movement down-gradient). The natural introduction of nutrients and sediment into the watershed includes nutrients and sediment transported by precipitation, wind, and ground water (in the case of nutrients). Most of these natural processes are also, to some respect, enhanced or accelerated by human alterations of the landscape (e.g., grazing and farming operations that effect riparian growth and streamside cover), often making specific attribution of pollutant production difficult.

3.1 Sources of Pollutants of Concern

The following sections will discuss the point sources and major nonpoint sources of the Salmon Falls Creek Subbasin. These sources or land uses will serve as the basis for the load allocations in the required TMDLs

Point Sources

As stated previously, there is one known total containment wastewater treatment facility located within the subbasin. This facility is operated by the town of Castleford Idaho. Operationally this facility is required to conduct a leak test once every five years beginning July 1 2007. The total containment lagoons are not located near any perennial streams, but a surface water connection could be made to Salmon Falls Creek near Balanced Rock through several agricultural drains in the event of a lagoon breach. However, this type of event is very unlikely.

Two dairies exist within the subbasin, as identified by the Idaho Department of Lands GIS shapefile. Both are small operations, between 150 and 220 animal units, and are not located near perennial water bodies.

Several feedlots have been identified from the IDL GIS shapefile as well. For the most part these feedlots are ranching operations located within the subbasin and for the majority of the year the livestock are moved to the rangelands where they are covered under the BLM and Forest Service grazing permits.

Construction storm water runoff is minimal or nearly nonexistent within the subbasin at this time due to limited growth occurring in the sparsely populated subbasin.

Nonpoint Sources

Assessment Units and Nonpoint Sources

Water quality in the various assessment units are influenced by the nearby land use and land ownership that occurs at the sixth field HUC level. In order to estimate what nonpoint sources contribute to water quality issues within each assessment unit the land use within the sixth field HUCs was calculated from GIS coverages. The land use within this watershed is assumed to contribute to the specific water body because it is the pour point of the watersheds. The land uses (from GIS) for the different watersheds are presented in Table 34.

Table 34. Land Use Percentage of the Assessment Unit Watersheds.

		LAND USE PERCENTAGE			
System	**Assessment units**	**Range**	**Riparian**	**Agriculture**	**Urban**
China Creek	ID17040213SK008_02 ID17040213SK008_03	96.99	1.64	1.38	
Salmon Falls Creek below reservoir	ID17040213SK001_06	65.58	9.52	24.91	
Salmon Falls Creek Reservoir	ID17040213SK007_L	93.84	5.77	0.10	0.29
Cedar Creek Reservoir	ID17040213SK004_L	100			
Cedar Creek	ID17040213SK005_3	100			
House Creek	ID17040213SK006_03	97.95		2.05	

		LAND USE PERCENTAGE			
Salmon Falls Creek above reservoir	ID17040213SK009_06	87.47	12.53		
Shoshone Creek upper	ID17040213SK016_02 ID17040213SK016_03	96.43	3.57		
Shoshone Creek mid	ID17040213SK013_04	90.08	9.92		
Shoshone Creek lower	ID17040213SK011_04	92.86	7.14		
Shoshone Creek Bull Springs	ID17040213SK011_02	100			
Hot Creek	ID17040213SK012_02 ID17040213SK012_03	99.87	0.13		
Big Creek	ID17040213SK014_02 ID17040213SK014_03	99.70	0.30		
Cottonwood Creek	ID17040213SK015_02 ID17040213SK015_03	99.70			
Cedar Creek below reservoir	ID17040213SK000_04	97.10	0.35	2.55	

For the most part, land use in the Salmon Falls Creek Subbasin is dominated by a single landuse. This domination by a single landuse roughly means that nonpoint source loads could be a single allocation if the allocation mechanism were based on landuse. However, based upon past experience, simple allocations such as this have presented problems concerning the implementation of TMDLs due to specific landuse management agencies and other stakeholders not fully understanding their portion of the simplified allocation. Therefore, allocations based upon land ownership would allow the land management agencies to more fully understand their contributions to the water quality of the systems. Watershed scale landownership may then be a more appropriate allocation model for gross load allocations.

Prior to DEQ adopting the assessment unit approach to defining stream segments, further refinement of the load allocation model would have been considered for the following reasons. Nonpoint pollutant sources in addition to general land uses sources include pollutants derived from unstable banks, reentrainment from within the system, and wash-off via overland flow. These sources typically occur much closer to the stream system than the watershed scale would indicate. Also, at the watershed scale the percentage of the various land ownership categories may reflect a similar dominance by a single category. At a much closer scale, that would capture the proximity effects seen from the near system sources, that same ownership category may be much lower. Therefore, DEQ may elect to allocate nonpoint sources based upon a 1 mile buffer surrounding the assessment units of the subbasin. This was done ultimately to determine what nonpoint sources contribute to water quality issues within the critical area of each stream segment. To that end, the land ownership within the stream corridor buffer was calculated from GIS coverages.

Following the adoption of assessment units the 1 mile buffer corridor approach became unworkable. A one mile buffer surrounding all the streams of an assessment unit is almost equivalent to the 6th field watershed, very little if any land is excluded in this method. Therefore the following Table (35) contains the percentage of landownership by category for the 6th field watersheds in which the listed Assessment Units reside.

Table 35. Land Ownership of the Assessment Unit Watersheds.

		LAND OWNERSHIP PERCENTAGE			
SYSTEM	ASSESSMENT UNITS	BLM	PRIVATE	STATE	USFS
China Creek	ID17040213SK008_02 ID17040213SK008_03	82.50	13.83	3.68	
Salmon Falls Creek below reservoir	ID17040213SK001_06	74.82	20.16	5.02	0.01
Salmon Falls Creek Reservoir	ID17040213SK007_L	80.73	6.67	12.60	
Cedar Creek Reservoir	ID17040213SK004_L	86.62	3.59	9.80	
Cedar Creek	ID17040213SK005_3	66.56	25.47	7.97	
House Creek	ID17040213SK006_03	35.44	55.17	9.39	
Salmon Falls Creek above reservoir	ID17040213SK009_06	92.98	0.91	6.11	
Shoshone Creek upper	ID17040213SK016_02 ID17040213SK016_03	0.25	30.35		69.40
Shoshone Creek mid	ID17040213SK013_04	30.93	61.39	7.68	
Shoshone Creek lower	ID17040213SK011_04	89.78	8.10	2.12	
Shoshone Creek Bull Springs	ID17040213SK011_02	66.19	29.59	4.23	
Hot Creek	ID17040213SK012_02 ID17040213SK012_03	29.34	42.74	3.06	24.86
Big Creek	ID17040213SK014_02 ID17040213SK014_03	4.69	42.06	2.07	51.18
Cottonwood Creek	ID17040213SK015_02 ID17040213SK015_03	0.44	23.86		75.70
Cedar Creek below reservoir	ID17040213SK000_04	90.39	4.82	4.80	

3.2 Pollution Source Data Gaps

Pollution source data gaps exist within the Salmon Falls Creek Subbasin. Most notably is the actual sources of atmospheric mercury, and the sources of nutrient enrichment in the China Creek and Big Creek Assessment Units. Sediment and temperature sources are well defined within the system and should serve as the backbone of the implementation plans for the subbasin as most BMPs that would reduce sediment and increase shade would have positive effects on the remaining pollutant loads.

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

Past and present pollution control activities in the Salmon Falls Creek Subbasin have involved both public and private entities. Some of the activities have included changes in grazing management regimes, building off-creek water troughs, fencing, and reducing numbers of animals or time spent on the range.

The most recent pollution control efforts on private lands have focused on the reduction of sediment discharge to Salmon Falls Creek below the reservoir associated with croplands and sediment delivery from unstable banks in the Shoshone Creek, Pole Camp Area. However, throughout most of the Salmon Falls Creek Subbasin land use is dominated by rangeland activities, so sediment reduction from cropland would have a negligible effect on the majority of streams.

Pollution control efforts on public lands have been geared toward maintaining the integrity of streams to restore or protect water quality and to support beneficial uses. The USFS and BLM manages livestock grazing, recreational activities, fire regimes, and road densities in an attempt to reduce impacts to streams. Furthermore the Federal Land Policy and Management Act of 1976 (FLPMA) provides for compliance with applicable pollution control laws, including State and Federal air, water, noise, or other pollution standards or implementation plans.

The Sawtooth National Forest Land and Resources Management Plan completed by the Sawtooth National Forest in July 2003 describes management goals of the agency in regards to soil, water, riparian, and aquatic resources.

- Design and implement watershed management programs and plans that will restore water quality and watershed function to support beneficial uses.
- Meet or surpass State water quality standards by planning and designing land management activities that protect water quality
- Provide water quality for stable and productive riparian and aquatic ecosystems while fully supporting appropriate beneficial uses.
- Manage water quality to meet requirements under the Clean Water Act and Safe Drinking Water Act, with special emphasis on de-listing water quality limited water bodies under Section 303(d) and supporting state development and implementation of TMDLs.
- Promote integration of planning, analysis implementation, and monitoring efforts that support the Endangered Species Act (ESA), Magnuson-Stevens Act, and Clean Water Act requirements.

Various projects that have been undertaken by the USFS that work towards meeting these goals an objectives and will be included in the USFS Implementation Plan for water quality impacted streams in the Salmon Falls Creek Subbasin.

The Jarbidge Resource Management Plan is currently under revision and should detail the past and present pollution control activities of the BLM. BLM will continue to manage the grazing resources of the Salmon Falls Creek Subbasin following the BLM Riparian Grazing Management Technical report (TR 1737-14) and the Idaho Standards for Rangeland Health and Guidelines for Livestock Grazing Management. Fire, fuels and vegetation management activities will be conducted to protect or improve water quality, and will comply with Clean Water Act, Idaho DEQ Total Maximum Daily Load Program, Idaho Non-Point Source Management Program Plan, and will apply best management practices as outlined in the Upper Snake Fire, Fuels and Vegetation Management Plan.

Various projects that have been undertaken by the BLM that work towards meeting these goals an objectives and will be included in the BLM Implementation Plan for water quality impacted streams in the Salmon Falls Creek Subbasin.

5. Total Maximum Daily Loads

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 load allocation but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the MOS 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 loading analysis is conducted. First, the LC is determined. Then the LC is broken down into its components: the necessary MOS is determined and subtracted; then NB, 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 LC.

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

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

5.1 Instream Water Quality Targets

In general, instream water quality targets are the basis for load calculations for the Salmon Falls Creek Subbasin. Several exceptions to this generality are the load calculation for sediment based on bank stability measures, shade and the resulting reductions in thermal loading; and the load reductions in mercury based upon fish tissue concentrations of mercury. In stream water quality targets were used for bacteria, TP, TSS, and TN. Although TMDLs are expressed in a mass per unit time, as required by the CWA and EPA, the instream targets are typically what the local stakeholders look to when they assess data collected on their streams of concern. As a result, instream water quality targets should be something understandable such as water quality standards or other straightforward targets. Complex targets can be just as confusing and as unworkable as load calculations and were avoided when possible.

Instream water quality targets for the Salmon Falls Creek Subbasin were chosen from a variety of sources. Principally, the Idaho Water Quality Standards were used to set instream targets. When water quality standards related beneficial use impairment to a narrative standard (e.g., IDAPA 58.01.02.200.03 "...surface waters shall be free from deleterious materials in concentrations that impair beneficial uses."), other sources were consulted to determine appropriate instream water quality targets. Other sources used to determine appropriate instream water quality targets were the Clean Water Act, the Code of Federal Regulations, EPA technical support documents and guidelines, other states' water quality standards, other TMDLs written by the state of Idaho and submitted to or approved by EPA, and scientific papers from refereed journals. Instream water quality targets developed from sources other than the state of Idaho's water quality standards will be reviewed at such time that numeric standards are adopted and codified by the state of Idaho following negotiated rule making.

Targets were developed for seven pollutants found to be impairing the beneficial uses of the listed water bodies identified in previous sections of the SBA. These pollutants are total phosphorus, total nitrogen, bacteria, bed load sediment, suspended sediment, temperature, and mercury. Other pollutants have been demonstrated to be not degrading the beneficial uses in the various listed water bodies.

Cedar Creek, below Cedar Creek Reservoir, is impaired due to a lack of flow; however, EPA does not believe that flow (or lack of flow) is a pollutant as defined by CWA Section 502(6). Since TMDLs are not required to be established for water bodies impaired by pollution but not pollutants, a TMDL has not been established for Cedar Creek, below Cedar Creek Reservoir, for flow.

For the Salmon Falls Creek Subbasin 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. See Appendix B for further discussion of water quality standards and background provisions. The PNV approach is described below. Additionally, the procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in this section. For a more complete discussion of shade and its affects on stream water temperature, the reader is referred to the South Fork Clearwater Subbasin Assessment and TMDL (IDEQ, 2004)

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 factors influencing shade, which are most likely to have been influenced by anthropogenic activities, and which 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, that shade provided by all objects 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 can be measured using a densiometer, or estimated visually either on site or on aerial photography. All of these methods tell us information about how much 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 has grown 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 by disturbance either naturally (wildfire, disease/old age, wind-blown, wildlife grazing) or anthropogenically (domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade producing vegetation. Anything less than PNV results in the stream heating up from anthropogenically created additional solar inputs.

We can estimate PNV from models of plant community structure (shade curves for specific riparian plant communities), and we can measure existing vegetative cover or shade. Comparing the two will tell us how much excess solar load the stream is receiving, and what potential there is to decrease solar gain. Streams disturbed by wildfire require their own time to recover. Streams that have been disturbed by human activity may require additional restoration above and beyond natural recovery.

Existing shade or cover was estimated for Salmon Falls Creek, Shoshone Creek, and their major tributaries from visual observations of aerial photos. These estimates were field verified by measuring shade with a solar pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width.

Existing and PNV shade was converted to solar load from data collected on flat plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations collecting these data. In this case, an average of the Boise and Pocatello stations was used because of the subbasin's location between these two weather stations. The difference between existing and potential solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are assumed to be natural (so long as there are no point sources or any other anthropogenic sources of heat in the watershed), and are thus considered to be consistent with the Idaho water quality standards, even though they may exceed numeric criteria.

Design Conditions

Typically, design conditions are based upon the critical periods for specific beneficial uses respective of the pollutants and water bodies or upon some reference system within the subbasin or creek. Design conditions often vary from stream to stream for various pollutants. One of the reasons for such variability is the different land use practices along each stream. Other factors also increase loadings at different times of the year from pollutant to pollutant. For example, TP and sediment may impair a beneficial use on a stream at different times of the year. Typically, sediment is more likely to impact a system in the spring runoff during higher flow, while TP will impact a stream during summer growing seasons. The critical periods for each stream and each pollutant were discussed at great length and were graphically represented by the load duration curve information presented for each stream in the preceding section of this document.

In general, the streams of the Salmon Falls Creek subbasin are relatively homogeneous in respects to land uses. Morphologically and hydrologically, the streams are also very similar, in that they all flow through similar parent material; have similar sources of water although the quantity may be different; and the timing of runoff is very similar. Politically the streams are also very homogenous. For the most part a federal land management agency has jurisdiction over the majority of the landscape followed by private holdings and then state lands. However, politically Salmon Falls Creek itself is very complex. Mainly this is because it flows from Nevada into Idaho. In the process it changes EPA jurisdiction twice as well as two different state agencies involved in water quality. Currently Salmon Falls Creek resides on both the Idaho and the Nevada §303(d) list. The Nevada 2002 lists can be found at http://ndep.nv.gov/bwqp/303list.pdf. It is listed for temperature, TP, TSS, total iron, and turbidity.

Flow Duration Curve Design

The flow duration approach allows for the water quality of a stream to be characterized at different flow regimes. With the duration curve design, the magnitude and frequency of instream water quality target and assessment criteria exceedances are easily seen. Furthermore the various loading allocations and load reductions are presented graphically over the whole of the flow regime rather than simplified to a single value typical of past TMDLs. This design is especially applicable in the Salmon Falls Creek Subbasin because flow data is an important factor in the determination of loading capacities.

The flow duration curve design accounts for variable flow patterns and how such patternsey affect water quality over the course of a year. In effect, the flow duration curve design accounts for all of the seasonal variation of a system. In the past DEQ has struggled to define seasonal variation in many TMDLs. The flow duration design also provides a method to link water quality concerns with watershed processes, which are important considerations in developing a TMDL. The flow duration curve design is also flexible enough to be used on a variety of pollutants and instream water quality targets such as TP, TN, DO, TSS, mercury, and bacteria.

Bank Stability Design

Sediment also impairs the beneficial uses of almost every system in the Salmon Falls Creek Subbasin. Furthermore, it is the elevated suspended load that occurs during the high spring flows that impairs the uses. These flows also redistribute the bed load stored within the system throughout the year. Much of this load is coming from bank erosion and overland wash off processes. Load allocations will be developed using bank erosion rates developed by the NRCS and refined for TMDL use by the Idaho Falls DEQ Regional office staff. The loads to the creeks are derived from high flow events eroding unstable banks throughout the system. These loads can be estimated from bank heights, the percent unstable bank length within a system, and an estimation of the bank recession rate. The loads would then be reflective of average peak flow from the annual average hydrograph calculated from USGS data. This equates to discharge with a recurrence interval of once every three years.

Shade and Stream Temperature Design

In the case of Salmon Falls Creek Subbasin temperature issues, cold water aquatic life is an existing use on all streams, and a designated beneficial use on some. This beneficial use is affected by increased temperature which is rooted in a lack of shade across many streams. Salmonid spawning is also an existing or designated beneficial use in many of the streams of the subbasin. The salmonid population of the subbasin consists or consisted of stocked and naturalized populations of rainbow trout, as well as native populations of whitefish. Currently it is unknown if native trout inhabit any of the Salmon Falls Creek Subbasin's streams as only naturalized or hatchery rainbows were found within the water bodies. Additionally, the IDFG have been stocking triploid rainbows within the subbasin, which may preclude the existence of salmonid spawning at least in the river system feeding the reservoir.

The spawning and incubation periods of the salmonids that were presumed to naturally exist within the system range from early spring to the middle of the summer. These times should be considered the critical period for the beneficial uses of the streams. Temperature exceedances, of both the cold water aquatic life use and salmonid spawning, typically occur throughout the summer months. This period also corresponds with the end of spawning and incubation period of the rainbow and cutthroat trout. Discharge during the critical months of June and July will be used in any temperature TMDLs for the Salmon Falls Creek Subbasin.

The land use practices along the stream reaches may have long term effects on the ability of the streams to meet state water quality standards. Agricultural practices have removed significant portions of the riparian vegetation, changing the existing shade of the streams. These land use practices do not necessarily occur only during the critical period but have occurred throughout the year and over the past several decades. As a result, the existing vegetation along much of the systems may be grasses, and rangeland communities rather than a taller willow dominated riparian community. The temperature target selection will need to reflect the potential riparian community and not the historical existing riparian community.

The determination of potential natural riparian vegetation along tributaries in this subbasin is complex due to changes in elevation and geology. In general, those streams that drain north from Nevada, or in the case of Shoshone Creek southwest from Magic Mountain area, descend from over 7000 ft. in elevation to the agricultural lowland near 3000 ft. Along the way they may pass a variety of riparian vegetation types from conifer dominated woodlands and alpine-like shrub meadows, through aspen, cottonwood and alder communities, to water birch and a rich diversity of riparian shrubs. At lower elevations, smaller foothill streams may be surrounded by various shrubs such as hawthorns, coyote willow, or dogwoods.

Shoshone Creek and its major tributaries headwater in a variety of vegetation dominated by trees, mostly conifers and shrubs. At about 5,700 feet in elevation the riparian plant community along Shoshone Creek gives way to mostly shrub (willows) dominated. Salmon Falls Creek enters Idaho from Nevada at a point with over 1400 square miles of drainage area behind it. The stream before entering Salmon Falls Reservoir flows through a confined gravel plain with xeric fluvaquant soils. Salmon Falls Creek, after it leaves the reservoir and most of its tributaries, is found in deep, narrow basalt canyons with little space for riparian vegetation between the rock outcrop and the stream margin. The vegetation that grows in these narrow canyons is predominantly deciduous shrubs (willows, alders, dogwoods), some of which reaches small tree status (birch, aspen) on tributaries at higher elevations. At various locations along some tributaries grass meadows are encountered resulting from spring-like seeps or access to shallow aquifers.

For shade target development, three basic vegetation types are used to describe the riparian vegetation in this subbasin. They are:

1) **Meadow** (above 5,500 ft.) – short stature shrubs and graminoids, various grasses, sedges and forbs. Heights to 1.5m (5 ft.).
2) **Mixed Tree/Shrub** (7,500 to 5,500 ft.) – may include conifers of various kinds, quaking aspen (*P. tremuloides*), mountain alder (*Alnus incana*), and willows (*Salix bebbiana, S. boothii, S. drummondiana, S. geyeriana*) in various combinations, and occasionally narrowleaf or black cottonwood (*Populus angustifolia, P. trichocarpa*). Heights to 15m (49 ft).
3) **Mixed Deciduous Shrub** – at any elevation, lacks tree component, but may include alders, dogwoods, hawthorns, willows, or other shrubs in various combinations. Heights 3 to 6m (10 to 20 ft.).

Target Selection

Nutrients

Six assessment units within the Salmon Falls Creek Subbasin do not meet the narrative standard for nutrients. Therefore, these water bodies will have TMDLs developed for restoration and protection of designated beneficial uses. These assessment units include, Salmon Falls Creek Reservoir, Cedar Creek Reservoir, Salmon Falls Creek below the reservoir, Cottonwood Creek, China Creek, Shoshone Creek, and Big Creek.

Water quality will be restored through the TMDL process and the subsequent implementation plans developed by the land management agencies. The TMDLs will establish a limit on the quantity of nutrients that may enter the segments from sources in the local watersheds. The nutrient limits will be set at a level such that the segments will not exceed the estimated load capacities supportive of a good to excellent fisheries, and will allow the water quality to improve to restore degraded beneficial uses. These targets shall be a daily maximum of 0.05 mg/L of TP within the flow duration of the stream to allow for natural variability in the tributaries to Cedar Creek Reservoir and Salmon Falls Creek Reservoir, specifically Salmon Falls Creek, China Creek, House Creek and Cedar Creek. The average monthly target is within the range identified by the EPA as supporting beneficial uses of water flowing into lakes and reservoirs. This will restore the beneficial uses of Salmon Falls Creek Reservoir and Cedar Creek Reservoir. TP targets for Cottonwood Creek, Big Creek, and Salmon Falls Creek below the reservoir shall be set at 0.100 mg/L TP daily maximum within the flow duration of the stream to allow for natural variability in those streams. The average monthly target in within the range identified by the EPA as supporting beneficial uses of free flowing streams and rivers.

Total nitrogen targets for Salmon Falls Creek below the reservoir shall be set at 1.5 mg/L of TN as a daily maximum. This value conforms to water quality criteria from other arid states such as Arizona (2 mg/L daily max), as well as TN target values set in other TMDLs such as California (1.0 mg/L). Furthermore the target selection conforms with the Redfield ratio of approximately 16:1 for TN:TP. This ratio is thought to indicate that nutrients are balanced and the primary production of a system is neither nitrogen nor phosphorus limited.

Nutrient target values do not imply that degradation by TP or TN may occur up to the target value. Rather, the values should be less than the respective targets on an average monthly basis and daily maximum, which will allow for some exceedances of the instream standards to account for seasonal and daily variation. However, it is DEQ's administrative policy, under IDAPA 58.01.02.050.01, that the adoption of water quality standards and the enforcement of such standards is not intended to conflict with the apportionment of water to the state through any of the interstate compacts or court decrees, or to interfere with the rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations which have been granted to them under the statutory procedure.

IDAPA 58.01.02.50.02.a states: "Wherever attainable, surface waters of the state shall be protected for beneficial uses which for surface waters includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic biota." The existing and designated beneficial uses of these segments will be protected through the TMDL process as legally described. Other activities that may cause degradation but which are outside the scope of IDAPA 58.01.02.050.01 and for which there is foreknowledge of the event's occurrence, will require a formal written letter from the individual, organization, or agency to DEQ-TFRO about the nature of the potential event. If the activity violates IDAPA 58.01.02.350.02.b.i, such that it will occur in a manner not in accordance with approved BMPs, or in a manner which does not demonstrate a knowledgeable and reasonable effort to minimize the resulting adverse water quality impacts, then DEQ-TFRO will seek intervention by the Administrator of DEQ for preparation of a compliance schedule (as provided in Idaho Code 39-116). DEQ may also institute administrative or civil proceedings including injunctive relief as provided in Idaho Code 39-108.

Beneficial uses may be fully supported at higher or lower rates of nutrient loading. The implementation strategy for the nutrient impaired streams is to establish a declining trend in nutrient load indicator targets (chlorophyll *a* and TP), and to regularly monitor water quality and beneficial uses support status. If it is established that fully supported uses are achieved at intermediate nutrient loads above natural background levels, and that the narrative nutrient standards are being met the TMDL will be revised accordingly.

Temperature

To determine potential natural vegetation shade targets for the Salmon Falls Creek subbasin, effective shade curves from several existing temperature TMDLs were examined. These TMDLs had previously used vegetation community modeling to produce these shade curves. 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. Although these TMDLs reflect a wide variety of geomorphologies and topographies, effective shades at the same stream width were remarkably similar. For the Salmon Falls Creek subbasin curves for the most similar vegetation type were selected for shade target determinations. Because no two landscapes are exactly the same, shade targets were derived by taking an average of the various shade curves available. Thus, the selected shade curves represent a range of shade conditions that presumably the riparian community of interest in this TMDL falls into.

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 loadings affect salmonids spawning temperatures in spring and fall. Thus, solar loading in these streams is evaluated from spring (April) to early fall (September).

Shade Curves

Three shade curves were useful in describing shade targets for the meadow vegetation type (Table 36). Used were the tufted hairgrass meadow type from the Crooked Creek TMDL in the Salmon basin (average height = 2ft. and canopy cover = 42%), the Ow geomorphic unit from the Willamette Basin TMDL (average height = 6.2 ft, density = 74%, composition = 0% forest, 5% savanna, 95% prairie), and the co-dominant mesic graminoid-willow community from the Alvord Lake TMDL (average height = 8.5 ft. and density = 10%). Table 36 below shows expected shade levels (%) for a 1-m , 2-m, and a 3-m wide stream.

Table 36. Shade Targets as 10% Class Intervals for the Meadows Vegetation Type at Various Stream Widths.

Meadow	1m	2m	3m
tufted hairgrass (IDEQ, 2002)	43	30	17
Ow (ODEQ, 2004a)	74	51	36
graminoid/willow (ODEQ, 2003)	39	26	18
Average	52	35.67	23.667
Target (%)	**52**	**36**	**24**

Mixed tree/shrub shade targets (Table 37) are an average of the deciduous-conifer zone of the Walla Walla River TMDL (height = 82 ft and density = 80%), the cottonwood/Pacific willow community of the Alvord Lake TMDL (average height = 40 ft. and density = 80%), and the alder/cottonwood/willow community of the Alvord Lake TMDL (average height = 28 ft. and density = 75%).

Table 37. Shade Targets as 10% Class Intervals for the Mixed Tree/Shrub Vegetation Type at Various Stream Widths

Mxd Tree/Shrub	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m	14m	15m	16m
Deciduous-Conifer zone (ODEQ, 2004b)	95	93	92	90	89	87	85	84	82	80	78	78	76	73	70	68
cottonwood/Pacific willow (ODEQ, 2003)	91	88	84	80	75	72	69	65	61	57	54	49	47	45	41	40
alder/cottonwood/willow (ODEQ, 2003)	84	81	76	69	65	59	53	49	45	40	36	33	32	29	26	25
Average	90	87.33	84.00	79.67	76.33	72.667	69.00	66.00	62.67	59.00	56.00	53.33	51.67	49	45.667	44.333
Target (%)	**90**	**87**	**84**	**80**	**76**	**73**	**69**	**66**	**63**	**59**	**56**	**53**	**52**	**49**	**46**	**44**

The mixed deciduous shrub type represents a wide variety of shrub dominated riparian types in the subbasin where trees (cottonwoods, conifers, etc.) are not present. The average of three shade curves was used for shade targets for this type (Table 38). Curves included the mountain alder (average height = 25 ft. and density = 30%) and the willow/alder (average height = 24 ft. and density = 75%) communities from the Alvord Lake TMDL, and the sagebrush/bunchgrass vegetation response units (VRU 12/16) of the SF Clearwater TMDL (average height 8.4 ft, composition = 80% shrub and 20% grass).

Table 38. Shade Targets as 10% Class Intervals for the Mixed Deciduous Shrub Vegetation Type at Various Stream Widths

Deciduous Shrub Mix	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m	14m	15m	20m
mountain alder (ODEQ, 2003)	91	89	85	80	72	63	60	54	50	47	45	42	41	40	38	30
willow/alder (ODEQ, 2003)	90	86	79	70	65	57	51	50	44	40	36	33	31	29	26	20
VRU12/16 (IDEQ, 2004)	87	71	45	37	33	26	23	21	19	17	16	14	13	12	11	10
Average	89.333	82	69.667	62.333	56.667	48.667	44.667	41.667	37.67	34.667	32.33	29.667	28.33	27	25	20
Target (%)	**89**	**82**	**70**	**62**	**57**	**49**	**45**	**42**	**38**	**35**	**32**	**30**	**28**	**27**	**25**	**20**

Shade targets were modified for special circumstances in some stream systems. When beaver ponds were encountered on Big Creek, the width of the stream used to derive the target was doubled from four meters to eight meters resulting in shade target reduction for these ponds of 20%. Additionally, streams in canyons benefit from added topographic shade resulting from steep canyon walls. Devil Creek in the Salmon Falls drainage received shade targets that were 10% higher than those based on vegetation and bankfull width to account for topographic shade.

Bacteria

The state of Idaho has a water quality standard for *E. coli* that covers both primary and secondary contact recreation. All of the systems in the subbasin are undesignated water bodies except Salmon Falls Creek and Salmon Falls Creek Reservoir. These undesignated water bodies are afforded protection for primary and secondary contact recreation according to IDAPA 58.01.02.101.01.a. After a review of the physical properties of the listed systems, DEQ-TFRO has determined that likely recreational activities include fishing, wading, and infrequent swimming. These recreational activities are descriptive of the existing uses consistent with secondary contact recreation. As a result, the water quality bacteria targets will be those water quality criteria for secondary contact recreation. Thus, the number of organisms of *E. coli* shall not exceed a single instantaneous sample of 576 org/100 ml and the geometric mean of five samples collected in a 30 day period of 126 org/100 ml.

Additionally, the target bacteria load (576 org/100 ml) will be converted into organisms per day similar to a mass per unit time conversion for other numeric targets and allocated by watershed. If further refinement in allocation is required the percent land ownership of a watershed is the most practical. Under this allocation scheme if 40 percent of the land use is attributable to private lands, then 40 percent of the target may be distributed to private land owners. The remainder may be distributed to the other land ownership classes where appropriate. An essential assumption in this method of distribution is that the water quality standard is the load capacity of a system. By using a percentage of the target or “load capacity”, the calculations become unitless percentages, which overcomes the inherent problems of calculating loads from a parameter which does not lend itself to loading calculations. Allocations can then be made from this percentage of the load according to land ownership in the watershed if needed.

Overall compliance with the water quality standards and the TMDL will be based on the geometric mean (126 cfu/100 ml) for secondary contact recreation as described in the IDAPA regulations. Because the major exceedances occur primarily during the grazing season (April through September), monitoring of the water bodies will occur primarily during the grazing season, although year-round monitoring may be developed so that comparisons between the grazed and nongrazed seasons can be assessed. It is recognized that bacteria is a singular parameter that has statistical significant linkage to total suspended solids. (See Upper Snake Rock TMDL for review of surrogate use of TSS for bacteria reductions.) During the implementation phase of this TMDL, land management agencies will provide guidance as to site-specific BMPs that will effectively reduce *E. coli*, such that in conjunction with total suspended solids reductions will yield *E. coli* reductions, and eventually reach beneficial uses and/or state water quality standards.

Sediment

The antidegradation policy for the state of Idaho (IDAPA 58.01.02.051(01)) indicates that the existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected. Most of the listed assessment units in the Salmon Falls Creek Subbasin appear to be meeting the narrative standard for suspended sediment although they are not meeting the assessment criteria (percent depth fines) for bedload sediments. Because of this, higher water quality for suspended sediment degradation of the water quality beyond these conditions shall not occur but shall be maintained at or below these levels throughout the implementation of the TMDL.

The sediment limit, in the listed segments of the subbasin, will be set at a level such that the rivers and streams will not exceed the estimated load capacity (duration) supportive of a good fishery, and will not allow the water quality to degrade worse than current levels. This target shall be a daily maximum of 50 mg/L. The target is within the range identified by the European Inland Fisheries Advisory Commission (EIFAC 1965) and the Committee on Water Quality Criteria from the Environmental Studies Board of the National Academy of

Science and National Academy of Engineers (NAS/NAE 1973) as supporting a moderate fishery. TSS values <50 mg/L does not imply that degradation by TSS may occur up to 50 mg/L. Rather, TSS values should be < 50 mg/L on an average daily basis, while the load duration curve methodology will allow for the in-stream standard to account for seasonal variation.

However, it is DEQ's administrative policy under IDAPA 58.01.02.050.01 that the adoption of water quality standards and the enforcement of such standards is not intended to conflict with the apportionment of water to the state through any of the interstate compacts or court decrees, or to interfere with the rights of Idaho appropriators, either now of in the future, in the utilization of the water appropriations which have been granted to them under the statutory procedure. Yet, IDAPA 58.01.02.50.02.a states "Wherever attainable, surface waters of the state shall be protected for beneficial uses which for surface waters includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic biota."

The existing and designated beneficial uses of the subbasin will be protected through the antidegradation as previously described. Other activities that may cause degradation but which are outside the scope of IDAPA 58.01.02.050.01 and which there is foreknowledge of the event's occurrence will require a formal written letter from the individual, organization, or agency to DEQ-TFRO about the nature of the potential event. If the activity violates IDAPA 58.01.02.350.02.b.i, such that it will occur in a manner not in accordance with approved BMPs, or in a manner which does not demonstrate a knowledgeable and reasonable effort to minimize the resulting adverse water quality impacts then DEQ-TFRO will seek intervention by the Administrator of DEQ for preparation of a compliance schedule (as provided in Idaho Code 39-116). DEQ may also institute administrative or civil proceedings including injunctive relief as provided in Idaho Code 39-108.

Loads for the bedload fraction of sediment will be developed to meet the beneficial uses of the streams and maintain the above TSS targets using a stream bank erosion estimate developed by the NRCS and refined for TMDLs by the Idaho Falls DEQ Regional office. The current state of science does not allow precise statement of a sediment load or load capacity that would translate into characteristics (e.g. TSS percent depth fines) known to support beneficial uses for cold water aquatic life and salmonid spawning and thus meet Idaho's narrative criterion for sediment. The load capacity lies somewhere between current loading and levels that relate to natural stream bank erosion levels. It is assumed that beneficial uses were or would be fully supported at natural background sediment loading rates. These rates were assumed to equate to the 80 percent bank stability regimes and taken to meet state water quality standards.

Aquatic life uses may be supported at higher or lower rates of sediment loading. The strategy is to establish a declining trend in sediment load as measured by TSS and percent depth fines, and to regularly monitor these water quality indicator targets as well as the stream biota (biomonitoring) . If it is established that aquatic life uses are supported at an intermediate sediment load above natural background levels, then Idaho's narrative sediment standard is met and the TMDL will be revised accordingly.

Mercury

The State of Idaho has adopted EPA's recommended fish tissue criterion for methyl mercury, and developed a guidance document to explain the implementation of this novel water quality criterion. Due to its complexity the reader is referred to *The Implementation Guidance for the Idaho Mercury Water Quality Criteria.* This document can be found at http://www.deq.state.id.us/water/data_reports/surface_water/monitoring/idaho_mercury_wq_guidance.pdf, portions of which are paraphrased below:

> Idaho will rely on a simple percent reduction approach where mercury TMDLs will be expressed as a percent reduction required to achieve 0.3 mg/kg methylmercury fish tissue values. Water column concentrations of methylmercury in the impaired water body would need to be reduced by the same percentage. The relationship between fish tissue methylmercury levels mercury loads to the water body has been assumed to be linear, consistent with numerous other cases (EPA Region 6 and Louisiana DEQ 2001, FTN 2002, Parsons 2003). In addition, EPA models in the Florida Everglades have shown that the relationship between current atmospheric deposition rates and current fish tissue concentrations is approximately linear (Florida DEP 2003). This approach is consistent with TMDL rules that clearly indicate TMDLs can be expressed in terms of either mass per unit time, toxicity, or other appropriate measures (40 CFR 130.2(I)).

By using proportionality of the target tissue concentration to loading, calculation of load capacity becomes a unitless percent reduction. This overcomes the inherent problems of calculating loads for fish tissue which does not lend itself to traditional loading calculations (flow x concentration). The resulting load reduction percentage can then be allocated among mercury sources. An explicit 20 percent MOS is used, reducing the target fish tissues concentration value, prior to determining the percent load reduction needed to reach it.

Monitoring Points

The following are the compliance points to be used to determine if the various load allocations and waste load allocations are being met following implementation of the TMDLs. In most cases, the compliance points for the various TMDLs will be the same monitoring locations used to determine the existing loads of the systems. In some cases, such as Big Creek, China Creek, and Cottonwood Creek, where there was upper watershed monitoring and a lower sampling location, the compliance point will be moved to the lower sampling location.

Monitoring methodology for pollutants of concern (i.e nutrients, specifically total phosphorus and total nitrogen, bacteria (*E. coli*), total mercury, and fish tissue concentration of mercury) will follow the accepted methodologies as outlined in the Salmon Falls Subbasin Quality Assurance Project Plan. For sediment TMDLs, percent bank stability and bank recession rate estimates, as described in previous sections, will serve as the surrogate measure for sediment delivery. Methodologies for bank stability will follow the same methodologies as outlined. The temperature surrogate in the Salmon Falls Creek Subbasin is percent shade and will be measured in the future and in any follow-up monitoring as outline below.

Potential Natural Vegetation Monitoring Locations

The accuracy of the aerial photo interpretations were field verified with a solar pathfinder at 24 sites throughout the subbasin. The results of these data showed that in general our aerial photo estimates of existing shade were high an average of 18% ± 9.5 (mean ± 95% C.I.). We then corrected the aerial estimate at those specific sites to match the pathfinder results, then used the results to calibrate our eye and to re-examine the remaining unverified portions of the analysis. Existing shade used in this document in loading tables and in figures represents these corrected values. In the future, effective shade monitoring can take place on any reach throughout the subbasin and compared to estimates of existing shade. Those areas with the largest disparity between existing shade estimates and shade targets should be monitored with solar pathfinders to verify the existing shade levels and to determine progress towards meeting shade targets. It is important to note that many existing shade estimates have not been field verified, and may require adjustment during the implementation process. Stream segments for each change in existing shade vary in length depending on land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade towards target levels. Ten equally spaced solar pathfinder measurements within that segment averaged together should suffice to determine new shade levels in the future.

Salmon Falls Creek

The upper reaches of Salmon Falls Creek will be monitored near confluence with the Salmon Falls Creek Reservoir in the area known as “The Backwaters”. The lower reaches of Salmon Falls Creek will be monitored near the USGS gauge for compliance with the TMDLs. Various monitoring locations throughout the stream will be required for the bedload TMDL. The locations will be used to determine if bank stability is changing throughout the reach. Overall a minimum of 10 percent of the stream segments length should be surveyed to determine compliance with the TMDL. These values can then be used to extrapolate bank stability conditions to the remainder of the creek. These locations are yet to be determined. Local input via the Mid-Snake Watershed Advisory Group will play a major factor in the location of these monitoring points.

Cedar Creek Reservoir

Cedar Creek Reservoir will be monitored at four locations to determine compliance with the Nutrient TMDL. House Creek and Cedar Creek near the confluence with the reservoir will serve as compliance points for the input from upper watersheds and a location near the Cedar Creek Reservoir Dam at Zmax will determine overall compliance with the nutrient reductions that will need to occur in the upper watersheds. The final monitoring point will be the outlet of the reservoir during the irrigation season to determine the net loading to the reservoir and for future mass balance models to determine the internal loading of nutrients. Bank stability measures in the upper watersheds will follow in a similar fashion as Salmon Falls Creek.

Cottonwood Creek

Cottonwood Creek will be monitored for *E. coli* bacteria near the confluence with Shoshone Creek at the Shoshone Basin Road compliance with the nutrient and bacteria TMDLs. Bank stability measures in the upper watersheds will follow in a similar fashion as Salmon Falls Creek.

Salmon Falls Creek Reservoir

Salmon Falls Creek Reservoir will be monitored at four locations to determine compliance with the nutrient TMDLs. Salmon Falls Creek and China Creek near the confluence with the reservoir will serve as compliance points for the input from upper watersheds; and a location near the Salmon Falls Creek Reservoir Dam at Zmax will determine overall compliance with the nutrient reductions that will need to occur in the upper watersheds. The final monitoring point will be the canal outlet of the reservoir during the irrigation season to determine the net loading to the reservoir, and for refinement of the mass balance model used to determine the internal loading of nutrients. Monitoring for fish tissue concentration will coincide with IDFG fish species management monitoring efforts. Fishes collected by IDFG, following their protocols for the various methods used in the population and abundance surveys, will be used to determine compliance with the mercury reduction TMDL. Additional water column monitoring may occur at the same compliance points for the nutrient reduction TMDL, if the Mid Snake Watershed Advisory Group (WAG) deems it appropriate and funding is available.

Shoshone Creek

Shoshone Creek will be monitored at three locations for compliance with the TMDLs. The first of these will near the Idaho Nevada state line. This location will serve as the compliance point for the lower assessment unit. The second monitoring location will be near the confluence with Hot Creek and will serve as the compliance point for the middle assessment unit. The third monitoring location will be near the confluence with Cottonwood Creek at the Shoshone Basin Road crossing above Langford Flat Creek, and will serve as the compliance point for the upper assessment unit. Bank stability measures in the three assessment units will follow in a similar fashion as Salmon Falls Creek.

Big Creek

The Big Creek Assessment Unit will be monitored in two locations for compliance with the nutrient TMDL. The first of these will be at the lower road crossing of Hanna’s Fork prior to the confluence with Big Creek. The second will be near the confluence with Shoshone Creek at the road crossing with the Basin Cutoff Road. Bank stability measures in the assessment unit will follow in a similar fashion as Salmon Falls Creek.

China Creek

The China Creek Assessment Unit is complex hydrologically speaking (see hydrology section of SBA). In effect, The China Creek Assessment Unit is six water bodies including the upper China Creek System. Monitoring locations for compliance with the nutrient TMDLs will be placed at the mouth of China Creek near the confluence with Salmon Falls Creek Reservoir, at Whiskey Slough near the lower road crossing above the confluence with the reservoir, and Corral Creek near the China Creek Road Crossing. Bank stability measures in the assessment unit will follow in a similar fashion as Salmon Falls Creek Bank Stability will be reassessed on Browns Creek, China Creek, both upper and lower segments, Corral Creek, Player Creek, and Whiskey Slough. Additional total mercury water column monitoring may occur at the China Creek compliance point for the mercury reduction TMDL if the Mid Snake WAG deem it appropriate and funding is available.

5.2 Load Capacity

The Clean Water Act requires that a TMDL be developed from a load capacity. A load capacity is the greatest amount of load that a water body can carry without violating water quality standards. The load capacity and loading analysis models for the various streams and pollutants were derived from load duration approach of monitoring data, upstream monitoring, downstream monitoring, source monitoring, and estimations of loads from that data. Links to the water quality targets and beneficial uses were drawn from other TMDLs completed by the state of Idaho, EPA guidelines and recommendations, and scientific literature sources. In those instances where there are numeric water quality standards, guidelines, or assessment criteria the load capacity or load duration of a water body for different pollutants is very straightforward. The load duration curve then is a representation of the load capacity of a given system at given water quality target, and incorporates the seasonality of that load capacity.   The load duration curve approach also recognizes that the assimilative capacity of a system is highly dependant upon flow, and that the load capacity will vary with flow condition. TMDLs can be expressed as different maximum loads allowable under different flow conditions, rather than a single maximum load value. Most of the pollutants in the Salmon Falls Creek TMDL fit into this category. Some do not, rather they apply to surrogate measures as referenced in this document. These pollutants, such as sediment delivery (via overland flow and bank stability processes), and temperature increase (via increased solar radiation) still represent the load capacity in a required mass per unit time, but the application of the surrogate is in percent shade or percent bank stability.

The load capacity of the various segments and tributaries pollutant combinations in the Salmon Falls Creek Subbasin were tabularized from flow and load duration curves developed from the flow records available from USGS or DEQ. While the pollutant targets were derived from a variety of sources relating concentrations of pollutant to effects on “beneficial uses” or aquatic communities (see section 5.1). Additionally, specific load capacities were tabularized from flow regimes identified as critical periods in the load duration curve methodology. These critical periods or categories were defined as: high flow conditions, where the flow duration interval (FDI) was less than 10 percent; moist conditions, where the

FDI was between 10 and 40 percent; mid-range flows, where the FDI was between 40 and 60 percent; dry conditions, where the FDI was between 60 and 90 percent; and low flow conditions where the FDI was greater than 90 percent. In some cases, the flow regime during the critical period was determined to be at or near zero for several very small intermittent streams. In these cases, the lowest flow that water quality standards apply, which is 5 cfs for recreational uses and 1 cfs for aquatic life uses (IDAPA 58.01.02.070.07) was used to tabularize the load capacity. The tabularized data are presented for ease of understanding the load capacity of a specific water body pollutant combination, but the load duration curve over the entire range of FDIs is considered the load capacity of a system.

Nutrients

The load duration curve for nutrients was determined by calculation using the target of 0.1 mg/L TP, and 1.5 mg/L TN for free flowing streams or natural background concentrations, daily average flow values (calculated from predicted annual hydrographs or USGS data), and a 5.39 conversion factor to convert from mg/L and ft^3/second to lbs per day. For streams flowing into reservoirs the LC was determined using the 0.05 mg/L TP target, daily average flow values (calculated from predicted annual hydrographs or USGS data), and a conversion factor of 5.39.

The nutrient LC are identified for the various flow categories (shown in Table 39 and 40). While these values are helpful in giving a relative understanding of the reductions required, and will apply reasonably over most water years, it should be noted that the absolute level of reduction required will depend on flow and concentration values specific to a given day. The target shown to result in attainment of water quality standards and support of designated uses in the reach is an instream concentration of less than or equal to 0.1 mg/L TP, and 1.5 mg/L TN. Transport and deposition of nutrients, and the resulting algal growth within the reach, is seasonal in nature. The load duration methodology completely accounts for this seasonality.

Due to water column nutrients being more abundant than plant uptake rates, responses by plant communities to management efforts will take time. As nutrient inputs are reduced, plants that obtain nutrients from the water column (such as algae, epiphytes, and *Cerratophyllum sp.*) will likely be the first to decline. Because nutrients persist longer in sediments, plants that obtain nutrients from the sediments will persist longer. Nevertheless, as reductions in nutrients (and sediment) continue, sediment bound nutrients will gradually be depleted as plant uptake outpaces recharge rates.

Table 39. Average TP Load Capacities within Load Duration Categories.

Load duration categories (duration interval)		High 0-10	Moist 10-40	Midrange 40-60	Dry 60-90	Low Flow 90-100
WATER BODY		LBS/DAY	LBS/DAY	LBS/DAY	LBS/DAY	LBS/DAY
Salmon Falls Creek Reservoir						
	Salmon Falls Creek	172.06	45.49	16.92	11.43	4.87

Load duration categories (duration interval)		High 0-10	Moist 10-40	Midrange 40-60	Dry 60-90	Low Flow 90-100
WATER BODY		LBS/DAY	LBS/DAY	LBS/DAY	LBS/DAY	LBS/DAY
	China Creek	1.74	0.43	0.14	0.08	0.01
	Whiskey Slough	0.27	0.27	0.27	0.27	0.27
	Corral Creek	0.27	0.27	0.27	0.27	0.27
Cedar Creek Reservoir						
	House Creek	8.42	3.53	2.43	2.21	1.96
	Cedar Creek	2.52	2.06	1.96	1.94	1.92
Cottonwood Creek		16.80	4.04	1.16	0.60	0.03
Big Creek		20.67	6.08	2.90	2.27	1.53
Hanna's Fork		2.79	0.67	0.21	0.12	0.01
Salmon Falls Creek Lower		165.42	103.03	82.23	58.97	24.55

Table 40. TN Load Capacities and Load Duration Categories.

Load duration categories (duration interval)	High 0-10	Moist 10-40	Midrange 40-60	Dry 60-90	Low flow 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek lower	2,481	1,545	1,233	885	368

Temperature

The loading capacity for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the reaches within that stream (see Figure 29-31). These loads are determined by multiplying the solar load to a flat plat collector (under full sun) for a given period of time by the fraction of the solar radiation that is not blocked by shade (i.e. the percent open or 1-percent shade). In other words, if a shade target is 60% (or 0.6), then the solar load hitting the stream under that target is 40% of the load hitting the flat plate collector under full sun.

We obtained solar load data for flat plate collectors from National Renewable Energy Laboratory (NREL) weather stations near by. In this case, data from both the Boise, ID and Pocatello, ID stations were used. The solar loads used in this TMDL are spring through summer averages, thus, we use an average load for the six month period from April through September. These months coincide with time of year that stream temperatures are increasing and when deciduous vegetation is in leaf. Tables 41 through 61 show the PNV shade targets (identified as Target or Potential Shade) and their corresponding potential summer load (in $kWh/m^2/day$ and kWh/day) that serve as the loading capacities for the streams.

Table 41. Existing and Potential Solar Loads for Shoshone 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)	Shoshone Creek
800	0.4	3.762	0.76	1.5048	-2.26	7	5	5,600	21,067	4,000	6,019	-15,048	mxd tree/shrub
300	0.5	3.135	0.76	1.5048	-1.6302	7	5	2,100	6,584	1,500	2,257	-4,326	
810	0.3	4.389	0.76	1.5048	-2.8842	7	5	5,670	24,886	4,050	6,094	-18,791	
300	0.1	5.643	0.76	1.5048	-4.1382	7	5	2,100	11,850	1,500	2,257	-9,593	
230	0.3	4.389	0.76	1.5048	-2.8842	7	5	1,610	7,066	1,150	1,731	-5,336	
500	0.1	5.643	0.76	1.5048	-4.1382	7	5	3,500	19,751	2,500	3,762	-15,989	
310	0.2	5.016	0.76	1.5048	-3.5112	7	5	2,170	10,885	1,550	2,332	-8,552	
400	0.3	4.389	0.73	1.6929	-2.6961	8	6	3,200	14,045	2,400	4,063	-9,982	
880	0.4	3.762	0.73	1.6929	-2.0691	8	6	7,040	26,484	5,280	8,939	-17,546	
300	0.2	5.016	0.73	1.6929	-3.3231	8	6	2,400	12,038	1,800	3,047	-8,991	
270	0.3	4.389	0.73	1.6929	-2.6961	8	6	2,160	9,480	1,620	2,742	-6,738	
280	0.2	5.016	0.73	1.6929	-3.3231	8	6	2,240	11,236	1,680	2,844	-8,392	
160	0.3	4.389	0.73	1.6929	-2.6961	8	6	1,280	5,618	960	1,625	-3,993	
400	0.2	5.016	0.73	1.6929	-3.3231	8	6	3,200	16,051	2,400	4,063	-11,988	
280	0.4	3.762	0.73	1.6929	-2.0691	8	6	2,240	8,427	1,680	2,844	-5,583	
440	0.3	4.389	0.73	1.6929	-2.6961	8	6	3,520	15,449	2,640	4,469	-10,980	
210	0.1	5.643	0.73	1.6929	-3.9501	8	6	1,680	9,480	1,260	2,133	-7,347	
360	0.3	4.389	0.73	1.6929	-2.6961	8	6	2,880	12,640	2,160	3,657	-8,984	
190	0.5	3.135	0.73	1.6929	-1.4421	8	6	1,520	4,765	1,140	1,930	-2,835	
300	0.3	4.389	0.73	1.6929	-2.6961	8	6	2,400	10,534	1,800	3,047	-7,486	
650	0.6	2.508	0.73	1.6929	-0.8151	8	6	5,200	13,042	3,900	6,602	-6,439	
390	0.3	4.389	0.73	1.6929	-2.6961	8	6	3,120	13,694	2,340	3,961	-9,732	
350	0.6	2.508	0.73	1.6929	-0.8151	8	6	2,800	7,022	2,100	3,555	-3,467	
620	0.4	3.762	0.73	1.6929	-2.0691	8	6	4,960	18,660	3,720	6,298	-12,362	
200	0.3	4.389	0.69	1.9437	-2.4453	8	7	1,600	7,022	1,400	2,721	-4,301	
570	0.2	5.016	0.45	3.4485	-1.5675	8	7	4,560	22,873	3,990	13,760	-9,113	mxd shrub
170	0.3	4.389	0.45	3.4485	-0.9405	8	7	1,360	5,969	1,190	4,104	-1,865	
380	0.2	5.016	0.45	3.4485	-1.5675	8	7	3,040	15,249	2,660	9,173	-6,076	
550	0.1	5.643	0.45	3.4485	-2.1945	8	7	4,400	24,829	3,850	13,277	-11,552	
160	0	6.27	0.45	3.4485	-2.8215	8	7	1,280	8,026	1,120	3,862	-4,163	
460	0.2	5.016	0.45	3.4485	-1.5675	8	7	3,680	18,459	3,220	11,104	-7,355	
1060	0.4	3.762	0.45	3.4485	-0.3135	8	7	8,480	31,902	7,420	25,588	-6,314	
240	0.3	4.389	0.45	3.4485	-0.9405	8	7	1,920	8,427	1,680	5,793	-2,633	
560	0.2	5.016	0.45	3.4485	-1.5675	8	7	4,480	22,472	3,920	13,518	-8,954	
360	0.3	4.389	0.45	3.4485	-0.9405	8	7	2,880	12,640	2,520	8,690	-3,950	
450	0.4	3.762	0.45	3.4485	-0.3135	8	7	3,600	13,543	3,150	10,863	-2,680	
1050	0.3	4.389	0.45	3.4485	-0.9405	8	7	8,400	36,868	7,350	25,346	-11,521	
230	0.2	5.016	0.42	3.6366	-1.3794	8	8	1,840	9,229	1,840	6,691	-2,538	
770	0.3	4.389	0.42	3.6366	-0.7524	8	8	6,160	27,036	6,160	22,401	-4,635	
1900	0.2	5.016	0.42	3.6366	-1.3794	8	8	15,200	76,243	15,200	55,276	-20,967	
1620	0	6.27	0.42	3.6366	-2.6334	8	8	12,960	81,259	12,960	47,130	-34,129	
1560	0.1	5.643	0.42	3.6366	-2.0064	8	8	12,480	70,425	12,480	45,385	-25,040	
470	0	6.27	0.42	3.6366	-2.6334	8	8	3,760	23,575	3,760	13,674	-9,902	
1370	0.1	5.643	0.42	3.6366	-2.0064	8	8	10,960	61,847	10,960	39,857	-21,990	
5830	0	6.27	0.42	3.6366	-2.6334	8	8	46,640	292,433	46,640	169,611	-122,822	
740	0	6.27	0.38	3.8874	-2.3826	9	9	6,660	41,758	6,660	25,890	-15,868	
5540	0.1	5.643	0.38	3.8874	-1.7556	9	9	49,860	281,360	49,860	193,826	-87,534	
1660	0.2	5.016	0.38	3.8874	-1.1286	9	9	14,940	74,939	14,940	58,078	-16,861	
7600	0.1	5.643	0.38	3.8874	-1.7556	9	9	68,400	385,981	68,400	265,898	-120,083	
							Total	**374,130**	**1,965,118**	**348,460**	**1,181,790**	**-783,328**	**-40 % Reduction**

Table 42. Existing and Potential Solar Loads for SF Shoshone 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)	**SF Shoshone Creek**
170	0.5	3.135	0.82	1.1286	-2.01	2	2	340	1,066	340	384	-682	Mxd Shrub
800	0.6	2.508	0.82	1.1286	-1.3794	2	2	1,600	4,013	1,600	1,806	-2,207	
110	0.3	4.389	0.7	1.881	-2.508	3	3	330	1,448	330	621	-828	
500	0.6	2.508	0.7	1.881	-0.627	3	3	1,500	3,762	1,500	2,822	-941	
370	0.5	3.135	0.62	2.3826	-0.7524	4	4	1,480	4,640	1,480	3,526	-1,114	
60	0.3	4.389	0.62	2.3826	-2.0064	4	4	240	1,053	240	572	-482	
							Total	**5,490**	**15,982**	**5,490**	**9,730**	**-6,252**	**-39** **% Reduction**

Table 43. Existing and Potential Solar Loads for Pole Camp 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)	**Pole Camp Creek**
490	0.6	2.508	0.52	3.0096	0.50	1	1	490	1,229	490	1,475	246	meadow
490	0.8	1.254	0.89	0.6897	-0.5643	1	1	490	614	490	338	-277	mxd shrub
160	0.6	2.508	0.89	0.6897	-1.8183	1	1	160	401	160	110	-291	
200	0.3	4.389	0.89	0.6897	-3.6993	1	1	200	878	200	138	-740	
120	0.6	2.508	0.89	0.6897	-1.8183	2	1	240	602	120	83	-519	
210	0.3	4.389	0.89	0.6897	-3.6993	2	1	420	1,843	210	145	-1,699	
180	0.6	2.508	0.89	0.6897	-1.8183	2	1	360	903	180	124	-779	
150	0.7	1.881	0.87	0.8151	-1.0659	2	2	300	564	300	245	-320	mxd tree/shrub
610	0.6	2.508	0.87	0.8151	-1.6929	2	2	1,220	3,060	1,220	994	-2,065	
290	0.7	1.881	0.87	0.8151	-1.0659	3	2	870	1,636	580	473	-1,164	
190	0.8	1.254	0.87	0.8151	-0.4389	3	2	570	715	380	310	-405	
210	0.7	1.881	0.87	0.8151	-1.0659	3	2	630	1,185	420	342	-843	
350	0.3	4.389	0.87	0.8151	-3.5739	3	2	1,050	4,608	700	571	-4,038	
1380	0.6	2.508	0.84	1.0032	-1.5048	4	3	5,520	13,844	4,140	4,153	-9,691	
140	0.3	4.389	0.7	1.881	-2.508	5	3	700	3,072	420	790	-2,282	mxd shrub
340	0.5	3.135	0.7	1.881	-1.254	5	3	1,700	5,330	1,020	1,919	-3,411	
510	0.6	2.508	0.7	1.881	-0.627	5	3	2,550	6,395	1,530	2,878	-3,517	
							Total	**17,470**	**46,881**	**12,560**	**15,087**	**-31,794**	**-68** **% Reduction**

Table 44. Existing and Potential Solar Loads for Langford Flat 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)	**Langford Flat Creek**
1110	0.8	1.254	0.9	0.627	-0.63	1	1	1,110	1,392	1,110	696	-696	mxd tree/shrub
2030	0.1	5.643	0.36	4.0128	-1.6302	2	2	4,060	22,911	4,060	16,292	-6,619	meadow
150	0.7	1.881	0.87	0.8151	-1.0659	2	2	300	564	300	245	-320	mxd tree/shrub
70	0.1	5.643	0.36	4.0128	-1.6302	2	2	140	790	140	562	-228	meadow
90	0.7	1.881	0.87	0.8151	-1.0659	2	2	180	339	180	147	-192	mxd tree/shrub
210	0.3	4.389	0.87	0.8151	-3.5739	2	2	420	1,843	420	342	-1,501	
430	0.1	5.643	0.36	4.0128	-1.6302	2	2	860	4,853	860	3,451	-1,402	meadow
260	0.2	5.016	0.36	4.0128	-1.0032	2	2	520	2,608	520	2,087	-522	
260	0.1	5.643	0.24	4.7652	-0.8778	3	3	780	4,402	780	3,717	-685	
340	0.6	2.508	0.84	1.0032	-1.5048	3	3	1,020	2,558	1,020	1,023	-1,535	mxd tree/shrub
300	0.7	1.881	0.84	1.0032	-0.8778	3	3	900	1,693	900	903	-790	
210	0.3	4.389	0.84	1.0032	-3.3858	3	3	630	2,765	630	632	-2,133	
1140	0.1	5.643	0.7	1.881	-3.762	3	3	3,420	19,299	3,420	6,433	-12,866	mxd shrub
560	0	6.27	0.62	2.3826	-3.8874	4	4	2,240	14,045	2,240	5,337	-8,708	
610	0.1	5.643	0.62	2.3826	-3.2604	4	4	2,440	13,769	2,440	5,814	-7,955	
600	0.3	4.389	0.62	2.3826	-2.0064	4	4	2,400	10,534	2,400	5,718	-4,815	
90	0.1	5.643	0.62	2.3826	-3.2604	4	4	360	2,031	360	858	-1,174	
610	0.2	5.016	0.62	2.3826	-2.6334	4	4	2,440	12,239	2,440	5,814	-6,425	
							Total	**24,220**	**118,635**	**24,220**	**60,069**	**-58,566**	**-49 % Reduction**

Table 45. Existing and Potential Solar Loads for Cottonwood 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)	Cottonwood Creek
320	0.7	1.881	0.9	0.627	-1.25	1	1	320	602	320	201	-401	mxd tree/shrub
180	0.4	3.762	0.9	0.627	-3.135	1	1	180	677	180	113	-564	
360	0.6	2.508	0.9	0.627	-1.881	1	1	360	903	360	226	-677	
600	0	6.27	0.52	3.0096	-3.2604	1	1	600	3,762	600	1,806	-1,956	meadow
950	0.1	5.643	0.52	3.0096	-2.6334	1	1	950	5,361	950	2,859	-2,502	
670	0.2	5.016	0.82	1.1286	-3.8874	2	2	1,340	6,721	1,340	1,512	-5,209	mxd shrub
740	0.3	4.389	0.82	1.1286	-3.2604	2	2	1,480	6,496	1,480	1,670	-4,825	
580	0.2	5.016	0.82	1.1286	-3.8874	2	2	1,160	5,819	1,160	1,309	-4,509	
420	0.1	5.643	0.82	1.1286	-4.5144	2	2	840	4,740	840	948	-3,792	
160	0	6.27	0.36	4.0128	-2.2572	2	2	320	2,006	320	1,284	-722	meadow
890	0.1	5.643	0.82	1.1286	-4.5144	2	2	1,780	10,045	1,780	2,009	-8,036	mxd shrub
580	0.2	5.016	0.7	1.881	-3.135	3	3	1,740	8,728	1,740	3,273	-5,455	
2290	0.1	5.643	0.7	1.881	-3.762	3	3	6,870	38,767	6,870	12,922	-25,845	
540	0.3	4.389	0.62	2.3826	-2.0064	4	4	2,160	9,480	2,160	5,146	-4,334	
2060	0.2	5.016	0.62	2.3826	-2.6334	4	4	8,240	41,332	8,240	19,633	-21,699	
240	0.5	3.135	0.57	2.6961	-0.4389	5	5	1,200	3,762	1,200	3,235	-527	
360	0.2	5.016	0.57	2.6961	-2.3199	5	5	1,800	9,029	1,800	4,853	-4,176	
470	0.3	4.389	0.57	2.6961	-1.6929	5	5	2,350	10,314	2,350	6,336	-3,978	
730	0.2	5.016	0.57	2.6961	-2.3199	5	5	3,650	18,308	3,650	9,841	-8,468	
160	0.1	5.643	0.49	3.1977	-2.4453	6	6	960	5,417	960	3,070	-2,347	
810	0.2	5.016	0.49	3.1977	-1.8183	6	6	4,860	24,378	4,860	15,541	-8,837	
700	0.1	5.643	0.49	3.1977	-2.4453	6	6	4,200	23,701	4,200	13,430	-10,270	
910	0.2	5.016	0.49	3.1977	-1.8183	6	6	5,460	27,387	5,460	17,459	-9,928	
1540	0.4	3.762	0.49	3.1977	-0.5643	6	6	9,240	34,761	9,240	29,547	-5,214	
450	0.2	5.016	0.45	3.4485	-1.5675	7	7	3,150	15,800	3,150	10,863	-4,938	
90	0.1	5.643	0.45	3.4485	-2.1945	7	7	630	3,555	630	2,173	-1,383	
150	0.3	4.389	0.45	3.4485	-0.9405	7	7	1,050	4,608	1,050	3,621	-988	
							Total	**66,890**	**326,460**	**66,890**	**174,880**	**-151,580**	**-46**
													% Reduction

Table 46. Existing and Potential Solar Loads for Big 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)	Big Creek
380	0.8	1.254	0.9	0.627	-0.63	1	1	380	477	380	238	-238	mxd tree/shrub
500	0.5	3.135	0.89	0.6897	-2.4453	1	1	500	1,568	500	345	-1,223	mxd shrub
560	0.6	2.508	0.89	0.6897	-1.8183	1	1	560	1,404	560	386	-1,018	
150	0.3	4.389	0.89	0.6897	-3.6993	1	1	150	658	150	103	-555	
450	0.8	1.254	0.9	0.627	-0.627	1	1	450	564	450	282	-282	mxd tree/shrub
1750	0.7	1.881	0.87	0.8151	-1.0659	2	2	3,500	6,584	3,500	2,853	-3,731	
370	0.5	3.135	0.82	1.1286	-2.0064	2	2	740	2,320	740	835	-1,485	mxd shrub
1980	0.7	1.881	0.82	1.1286	-0.7524	2	2	3,960	7,449	3,960	4,469	-2,980	
1310	0.5	3.135	0.7	1.881	-1.254	3	3	3,930	12,321	3,930	7,392	-4,928	
490	0.6	2.508	0.7	1.881	-0.627	3	3	1,470	3,687	1,470	2,765	-922	
800	0.4	3.762	0.7	1.881	-1.881	3	3	2,400	9,029	2,400	4,514	-4,514	
420	0.6	2.508	0.7	1.881	-0.627	3	3	1,260	3,160	1,260	2,370	-790	
480	0.5	3.135	0.62	2.3826	-0.7524	4	4	1,920	6,019	1,920	4,575	-1,445	
260	0.2	5.016	0.42	3.6366	-1.3794	8	8	2,080	10,433	2,080	7,564	-2,869	beaver ponds
310	0.5	3.135	0.62	2.3826	-0.7524	4	4	1,240	3,887	1,240	2,954	-933	
180	0.2	5.016	0.42	3.6366	-1.3794	8	8	1,440	7,223	1,440	5,237	-1,986	beaver ponds
230	0.6	2.508	0.62	2.3826	-0.1254	4	4	920	2,307	920	2,192	-115	
540	0.5	3.135	0.62	2.3826	-0.7524	4	4	2,160	6,772	2,160	5,146	-1,625	
1130	0.6	2.508	0.62	2.3826	-0.1254	4	4	4,520	11,336	4,520	10,769	-567	
460	0.4	3.762	0.57	2.6961	-1.0659	5	5	2,300	8,653	2,300	6,201	-2,452	
960	0.5	3.135	0.57	2.6961	-0.4389	5	5	4,800	15,048	4,800	12,941	-2,107	
990	0.1	5.643	0.57	2.6961	-2.9469	5	5	4,950	27,933	4,950	13,346	-14,587	
710	0.2	5.016	0.57	2.6961	-2.3199	5	5	3,550	17,807	3,550	9,571	-8,236	
450	0.1	5.643	0.57	2.6961	-2.9469	5	5	2,250	12,697	2,250	6,066	-6,631	
1740	0.1	5.643	0.49	3.1977	-2.4453	6	6	10,440	58,913	10,440	33,384	-25,529	
300	0.2	5.016	0.49	3.1977	-1.8183	6	6	1,800	9,029	1,800	5,756	-3,273	
100	0.3	4.389	0.49	3.1977	-1.1913	6	6	600	2,633	600	1,919	-715	
720	0.2	5.016	0.49	3.1977	-1.8183	6	6	4,320	21,669	4,320	13,814	-7,855	
1360	0.1	5.643	0.45	3.4485	-2.1945	7	7	9,520	53,721	9,520	32,830	-20,892	
310	0.2	5.016	0.45	3.4485	-1.5675	7	7	2,170	10,885	2,170	7,483	-3,401	
570	0.1	5.643	0.45	3.4485	-2.1945	7	7	3,990	22,516	3,990	13,760	-8,756	
							Total	**84,270**	**358,700**	**84,270**	**222,062**	**-136,638**	**-38** **% Reduction**

Table 47 Existing and Potential Solar Loads for Hannah's Fork 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)	Hannahs Fork
440	0.7	1.881	0.89	0.6897	-1.19	1	1	440	828	440	303	-524	mxd shrub
580	0.8	1.254	0.89	0.6897	-0.5643	1	1	580	727	580	400	-327	
1620	0.6	2.508	0.82	1.1286	-1.3794	2	2	3,240	8,126	3,240	3,657	-4,469	
1090	0.4	3.762	0.7	1.881	-1.881	3	3	3,270	12,302	3,270	6,151	-6,151	
480	0.3	4.389	0.7	1.881	-2.508	3	3	1,440	6,320	1,440	2,709	-3,612	
390	0.2	5.016	0.7	1.881	-3.135	3	3	1,170	5,869	1,170	2,201	-3,668	
560	0.3	4.389	0.7	1.881	-2.508	3	3	1,680	7,374	1,680	3,160	-4,213	
							Total	**11,820**	**41,545**	**11,820**	**18,581**	**-22,965**	**-55**
													% Reduction

Table 48. Existing and Potential Solar Loads for Horse 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)	Horse Creek
930	0.7	1.881	0.89	0.6897	-1.19	1	1	930	1,749	930	641	-1,108	coyote willow
1160	0.5	3.135	0.89	0.6897	-2.4453	1	1	1,160	3,637	1,160	800	-2,837	
2020	0.2	5.016	0.36	4.0128	-1.0032	2	2	4,040	20,265	4,040	16,212	-4,053	meadow
1760	0.3	4.389	0.36	4.0128	-0.3762	2	2	3,520	15,449	3,520	14,125	-1,324	
1460	0.1	5.643	0.36	4.0128	-1.6302	2	2	2,920	16,478	2,920	11,717	-4,760	
390	0.3	4.389	0.36	4.0128	-0.3762	2	2	780	3,423	780	3,130	-293	
530	0.1	5.643	0.24	4.7652	-0.8778	3	3	1,590	8,972	1,590	7,577	-1,396	
850	0.2	5.016	0.24	4.7652	-0.2508	3	3	2,550	12,791	2,550	12,151	-640	
							Total	**17,490**	**82,764**	**17,490**	**66,354**	**-16,410**	**-20**
													% Reduction

Table 49. Existing and Potential Solar Loads for Hot 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)	**Hot Creek**
1640	0	6.27	0.52	3.0096	-3.26	1	1	1,640	10,283	1,640	4,936	-5,347	meadow
740	0.4	3.762	0.52	3.0096	-0.7524	1	1	740	2,784	740	2,227	-557	
740	0.3	4.389	0.36	4.0128	-0.3762	2	2	1,480	6,496	1,480	5,939	-557	
350	0.4	3.762	0.36	4.0128	0.2508	3	2	1,050	3,950	700	2,809	-1,141	
210	0.1	5.643	0.36	4.0128	-1.6302	3	2	630	3,555	420	1,685	-1,870	
1510	0	6.27	0.24	4.7652	-1.5048	4	3	6,040	37,871	4,530	21,586	-16,284	
							Total	**11,580**	**64,938**	**9,510**	**39,182**	**-25,756**	**-40** **% Reduction**

Table 50. Existing and Potential Solar Loads for Salmon Falls Creek Above Reservoir.

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)	**Salmon Falls Creek above reservoir**
16770	0.1	5.643	0.2	5.016	-0.63	20	20	335,400	1,892,662	335,400	1,682,366	-210,296	mxd shrub
2140	0	6.27	0.2	5.016	-1.254	20	20	42,800	268,356	42,800	214,685	-53,671	
							Total	**378,200**	**2,161,018**	**378,200**	**1,897,051**	**-263,967**	**-12** **% Reduction**

Table 51. Existing and Potential Solar Loads for Salmon Falls Creek Below Reservoir.

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)	Salmon Falls Creek below reservoir
130	0.8	1.254	0.53	2.9469	1.6929	12	12	1,560	1,956	1,560	4,597	2,641	mxd tree/shrub
160	0.7	1.881	0.53	2.9469	1.0659	12	12	1,920	3,612	1,920	5,658	2,047	
1750	0.6	2.508	0.53	2.9469	0.4389	12	12	21,000	52,668	21,000	61,885	9,217	
2520	0.5	3.135	0.53	2.9469	-0.1881	12	12	30,240	94,802	30,240	89,114	-5,688	
730	0.6	2.508	0.53	2.9469	0.4389	12	12	8,760	21,970	8,760	25,815	3,845	
550	0.4	3.762	0.53	2.9469	-0.8151	12	12	6,600	24,829	6,600	19,450	-5,380	
310	0.6	2.508	0.53	2.9469	0.4389	12	12	3,720	9,330	3,720	10,962	1,633	
170	0.4	3.762	0.53	2.9469	-0.8151	12	12	2,040	7,674	2,040	6,012	-1,663	
2230	0.5	3.135	0.53	2.9469	-0.1881	12	12	26,760	83,893	26,760	78,859	-5,034	
1890	0.6	2.508	0.53	2.9469	0.4389	12	12	22,680	56,881	22,680	66,836	9,954	
570	0.5	3.135	0.53	2.9469	-0.1881	12	12	6,840	21,443	6,840	20,157	-1,287	
2390	0.6	2.508	0.53	2.9469	0.4389	12	12	28,680	71,929	28,680	84,517	12,588	
270	0.1	5.643	0.53	2.9469	-2.6961	12	12	3,240	18,283	3,240	9,548	-8,735	
400	0.4	3.762	0.53	2.9469	-0.8151	12	12	4,800	18,058	4,800	14,145	-3,912	
1250	0.6	2.508	0.53	2.9469	0.4389	12	12	15,000	37,620	15,000	44,204	6,584	
1550	0.5	3.135	0.53	2.9469	-0.1881	12	12	18,600	58,311	18,600	54,812	-3,499	
4900	0.4	3.762	0.53	2.9469	-0.8151	12	12	58,800	221,206	58,800	173,278	-47,928	
1320	0.5	3.135	0.53	2.9469	-0.1881	12	12	15,840	49,658	15,840	46,679	-2,980	
320	0.3	4.389	0.53	2.9469	-1.4421	12	12	3,840	16,854	3,840	11,316	-5,538	
640	0.2	5.016	0.53	2.9469	-2.0691	12	12	7,680	38,523	7,680	22,632	-15,891	
1150	0.4	3.762	0.53	2.9469	-0.8151	12	12	13,800	51,916	13,800	40,667	-11,248	
2850	0.7	1.881	0.53	2.9469	1.0659	12	12	34,200	64,330	34,200	100,784	36,454	
320	0.5	3.135	0.53	2.9469	-0.1881	12	12	3,840	12,038	3,840	11,316	-722	
5160	0.7	1.881	0.53	2.9469	1.0659	12	12	61,920	116,472	61,920	182,472	66,001	
3810	0.6	2.508	0.53	2.9469	0.4389	12	12	45,720	114,666	45,720	134,732	20,067	
450	0.7	1.881	0.53	2.9469	1.0659	12	12	5,400	10,157	5,400	15,913	5,756	
630	0.6	2.508	0.53	2.9469	0.4389	12	12	7,560	18,960	7,560	22,279	3,318	
480	0.7	1.881	0.53	2.9469	1.0659	12	12	5,760	10,835	5,760	16,974	6,140	
650	0.6	2.508	0.53	2.9469	0.4389	12	12	7,800	19,562	7,800	22,986	3,423	
1910	0.5	3.135	0.53	2.9469	-0.1881	12	12	22,920	71,854	22,920	67,543	-4,311	
800	0.6	2.508	0.53	2.9469	0.4389	12	12	9,600	24,077	9,600	28,290	4,213	
1190	0.5	3.135	0.53	2.9469	-0.1881	12	12	14,280	44,768	14,280	42,082	-2,686	
490	0.6	2.508	0.53	2.9469	0.4389	12	12	5,880	14,747	5,880	17,328	2,581	
380	0.4	3.762	0.53	2.9469	-0.8151	12	12	4,560	17,155	4,560	13,438	-3,717	
920	0.5	3.135	0.52	3.0096	-0.1254	13	13	11,960	37,495	11,960	35,995	-1,500	
6710	0.4	3.762	0.52	3.0096	-0.7524	13	13	87,230	328,159	87,230	262,527	-65,632	
90	0.9	0.627	0.52	3.0096	2.3826	13	13	1,170	734	1,170	3,521	2,788	
190	0.3	4.389	0.52	3.0096	-1.3794	13	13	2,470	10,841	2,470	7,434	-3,407	
700	0.4	3.762	0.52	3.0096	-0.7524	13	13	9,100	34,234	9,100	27,387	-6,847	
3530	0.3	4.389	0.49	3.1977	-1.1913	14	14	49,420	216,904	49,420	158,030	-58,874	
680	0.2	5.016	0.49	3.1977	-1.8183	14	14	9,520	47,752	9,520	30,442	-17,310	
380	0.1	5.643	0.49	3.1977	-2.4453	14	14	5,320	30,021	5,320	17,012	-13,009	
870	0.2	5.016	0.49	3.1977	-1.8183	14	14	12,180	61,095	12,180	38,948	-22,147	
790	0.1	5.643	0.49	3.1977	-2.4453	14	14	11,060	62,412	11,060	35,367	-27,045	
980	0	6.27	0.49	3.1977	-3.0723	14	14	13,720	86,024	13,720	43,872	-42,152	
690	0.4	3.762	0.49	3.1977	-0.5643	14	14	9,660	36,341	9,660	30,890	-5,451	
170	0.1	5.643	0.49	3.1977	-2.4453	14	14	2,380	13,430	2,380	7,611	-5,820	
190	0.3	4.389	0.49	3.1977	-1.1913	14	14	2,660	11,675	2,660	8,506	-3,169	
2050	0.2	5.016	0.46	3.3858	-1.6302	15	15	30,750	154,242	30,750	104,113	-50,129	
1180	0.1	5.643	0.46	3.3858	-2.2572	15	15	17,700	99,881	17,700	59,929	-39,952	
730	0	6.27	0.46	3.3858	-2.8842	15	15	10,950	68,657	10,950	37,075	-31,582	
2470	0.2	5.016	0.46	3.3858	-1.6302	15	15	37,050	185,843	37,050	125,444	-60,399	
870	0.1	5.643	0.46	3.3858	-2.2572	15	15	13,050	73,641	13,050	44,185	-29,456	
620	0.2	5.016	0.46	3.3858	-1.6302	15	15	9,300	46,649	9,300	31,488	-15,161	
5800	0.1	5.643	0.44	3.5112	-2.1318	16	16	92,800	523,670	92,800	325,839	-197,831	
730	0	6.27	0.44	3.5112	-2.7588	16	16	11,680	73,234	11,680	41,011	-32,223	
600	0.1	5.643	0.44	3.5112	-2.1318	16	16	9,600	54,173	9,600	33,708	-20,465	
1730	0	6.27	0.44	3.5112	-2.7588	16	16	27,680	173,554	27,680	97,190	-76,364	
630	0.1	5.643	0.44	3.5112	-2.1318	16	16	10,080	56,881	10,080	35,393	-21,489	
450	0	6.27	0.44	3.5112	-2.7588	16	16	7,200	45,144	7,200	25,281	-19,863	
310	0.1	5.643	0.44	3.5112	-2.1318	16	16	4,960	27,989	4,960	17,416	-10,574	
190	0	6.27	0.44	3.5112	-2.7588	16	16	3,040	19,061	3,040	10,674	-8,387	
							Total	**1,045,530**	**4,080,773**	**1,045,530**	**3,263,565**	**-817,208**	**-20 % Reduction**

Table 52. Existing and Potential Solar Loads for North Fork Salmon Falls 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)	NF Salmon Falls Creek
220	0.8	1.254	0.9	0.627	-0.63	1	1	220	276	220	138	-138	mxd tree/shrub
1190	0.8	1.254	0.9	0.627	-0.627	1	1	1,190	1,492	1,190	746	-746	
200	0.1	5.643	0.87	0.8151	-4.8279	2	2	400	2,257	400	326	-1,931	
340	0.8	1.254	0.87	0.8151	-0.4389	2	2	680	853	680	554	-298	
300	0.6	2.508	0.87	0.8151	-1.6929	2	2	600	1,505	600	489	-1,016	
470	0.2	5.016	0.84	1.0032	-4.0128	3	3	1,410	7,073	1,410	1,415	-5,658	
470	0.2	5.016	0.7	1.881	-3.135	3	3	1,410	7,073	1,410	2,652	-4,420	mxd shrub
730	0.5	3.135	0.62	2.3826	-0.7524	4	4	2,920	9,154	2,920	6,957	-2,197	
							Total	**8,830**	**29,682**	**8,830**	**13,277**	**-16,405**	**-55** **% Reduction**

Table 53. Existing and Potential Solar Loads for China 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)	China Creek
280	0.3	4.389	0.89	0.6897	-3.70	1	1	280	1,229	280	193	-1,036	mxd shrub
190	0.5	3.135	0.89	0.6897	-2.4453	1	1	190	596	190	131	-465	
400	0.8	1.254	0.89	0.6897	-0.5643	1	1	400	502	400	276	-226	
780	0.7	1.881	0.89	0.6897	-1.1913	1	1	780	1,467	780	538	-929	
700	0.8	1.254	0.89	0.6897	-0.5643	1	1	700	878	700	483	-395	
980	0.7	1.881	0.82	1.1286	-0.7524	2	2	1,960	3,687	1,960	2,212	-1,475	
520	0.8	1.254	0.82	1.1286	-0.1254	2	2	1,040	1,304	1,040	1,174	-130	
500	0.4	3.762	0.82	1.1286	-2.6334	2	2	1,000	3,762	1,000	1,129	-2,633	
190	0.5	3.135	0.82	1.1286	-2.0064	2	2	380	1,191	380	429	-762	
360	0.6	2.508	0.7	1.881	-0.627	3	3	1,080	2,709	1,080	2,031	-677	
750	0.3	4.389	0.7	1.881	-2.508	3	3	2,250	9,875	2,250	4,232	-5,643	
230	0.5	3.135	0.7	1.881	-1.254	3	3	690	2,163	690	1,298	-865	
940	0.3	4.389	0.7	1.881	-2.508	3	3	2,820	12,377	2,820	5,304	-7,073	
200	0.6	2.508	0.7	1.881	-0.627	3	3	600	1,505	600	1,129	-376	
230	0.3	4.389	0.7	1.881	-2.508	3	3	690	3,028	690	1,298	-1,731	
390	0.5	3.135	0.62	2.3826	-0.7524	4	4	1,560	4,891	1,560	3,717	-1,174	
240	0.4	3.762	0.62	2.3826	-1.3794	4	4	960	3,612	960	2,287	-1,324	
630	0.6	2.508	0.62	2.3826	-0.1254	4	4	2,520	6,320	2,520	6,004	-316	
250	0.3	4.389	0.62	2.3826	-2.0064	4	4	1,000	4,389	1,000	2,383	-2,006	
200	0.6	2.508	0.62	2.3826	-0.1254	4	4	800	2,006	800	1,906	-100	
210	0	6.27	0.62	2.3826	-3.8874	4	4	840	5,267	840	2,001	-3,265	
780	0.1	5.643	0.62	2.3826	-3.2604	4	4	3,120	17,606	3,120	7,434	-10,172	
							Total	**25,660**	**90,363**	**25,660**	**47,589**	**-42,775**	**-47** **% Reduction**

Table 54. Existing and Potential Solar Loads for Player 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)	Player Creek
310	0.6	2.508	0.9	0.627	-1.88	1	1	310	777	310	194	-583	mxd tree/shrub
620	0.8	1.254	0.9	0.627	-0.627	1	1	620	777	620	389	-389	
860	0.7	1.881	0.87	0.8151	-1.0659	2	2	1,720	3,235	1,720	1,402	-1,833	
940	0.4	3.762	0.82	1.1286	-2.6334	2	2	1,880	7,073	1,880	2,122	-4,951	mxd shrub
170	0.8	1.254	0.84	1.0032	-0.2508	3	3	510	640	510	512	-128	mxd tree/shrub
240	0.6	2.508	0.7	1.881	-0.627	3	3	720	1,806	720	1,354	-451	mxd shrub
							Total	**5,760**	**14,308**	**5,760**	**5,973**	**-8,335**	**-58**
													% Reduction

Table 55. Existing and Potential Solar Loads for Browns 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)	Browns Creek
1350	0.8	1.254	0.89	0.6897	-0.56	1	1	1,350	1,693	1,350	931	-762	mxd shrub
200	0.3	4.389	0.89	0.6897	-3.6993	1	1	200	878	200	138	-740	
760	0	6.27	0.89	0.6897	-5.5803	1	1	760	4,765	760	524	-4,241	
650	0	6.27	0.82	1.1286	-5.1414	2	2	1,300	8,151	1,300	1,467	-6,684	
390	0.3	4.389	0.82	1.1286	-3.2604	2	2	780	3,423	780	880	-2,543	
830	0	6.27	0.36	4.0128	-2.2572	2	2	1,660	10,408	1,660	6,661	-3,747	meadow
							Total	**6,050**	**29,319**	**6,050**	**10,602**	**-18,717**	**-64**
													% Reduction

Table 56. Existing and Potential Solar Loads for Whiskey Slough.

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)	Whiskey Slough
3320	0	6.27	0.36	4.0128	-2.2572	2	2	6,640	41,633	6,640	26,645	-14,988	meadow
							Total	**6,640**	**41,633**	**6,640**	**26,645**	**-14,988**	**-36**
													% Reduction

Table 57. Existing and Potential Solar Loads for Cedar Creek Below Cedar Creek Reservoir.

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)	**Cedar Creek Reservoir to mouth**
3960	0.1	5.643	0.57	2.6961	-2.95	6	6	23,760	134,078	23,760	64,059	-70,018	mxd shrub/canyon
670	0.5	3.135	0.55	2.8215	-0.3135	7	7	4,690	14,703	4,690	13,233	-1,470	
160	0.4	3.762	0.52	3.0096	-0.7524	8	8	1,280	4,815	1,280	3,852	-963	
170	0.1	5.643	0.52	3.0096	-2.6334	8	8	1,360	7,674	1,360	4,093	-3,581	
450	0.4	3.762	0.48	3.2604	-0.5016	9	9	4,050	15,236	4,050	13,205	-2,031	
900	0.1	5.643	0.45	3.4485	-2.1945	10	10	9,000	50,787	9,000	31,037	-19,751	
730	0.1	5.643	0.8	1.254	-4.389	3	3	2,190	12,358	2,190	2,746	-9,612	
							Total	**46,330**	**239,652**	**46,330**	**132,225**	**-107,427**	**-45** **% Reduction**

Table 58. Existing and Potential Solar Loads for Cedar Creek Above Cedar Creek Reservoir.

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)	**Cedar Creek above Reservoir**
60	0.9	0.627	0.9	0.627	0.00	1	1	60	38	60	38	0	mxd tree/shrub
120	0.5	3.135	0.9	0.627	-2.508	1	1	120	376	120	75	-301	
140	0.8	1.254	0.9	0.627	-0.627	1	1	140	176	140	88	-88	
140	0.6	2.508	0.9	0.627	-1.881	1	1	140	351	140	88	-263	
190	0.7	1.881	0.9	0.627	-1.254	1	1	190	357	190	119	-238	
130	0.5	3.135	0.9	0.627	-2.508	1	1	130	408	130	82	-326	
410	0.4	3.762	0.9	0.627	-3.135	1	1	410	1,542	410	257	-1,285	
140	0.6	2.508	0.9	0.627	-1.881	1	1	140	351	140	88	-263	
160	0.4	3.762	0.9	0.627	-3.135	1	1	160	602	160	100	-502	
320	0.7	1.881	0.9	0.627	-1.254	1	1	320	602	320	201	-401	
180	0.6	2.508	0.9	0.627	-1.881	1	1	180	451	180	113	-339	
440	0.5	3.135	0.89	0.6897	-2.4453	1	1	440	1,379	440	303	-1,076	mxd shrub
280	0.1	5.643	0.89	0.6897	-4.9533	1	1	280	1,580	280	193	-1,387	
120	0.5	3.135	0.89	0.6897	-2.4453	1	1	120	376	120	83	-293	
150	0.2	5.016	0.89	0.6897	-4.3263	1	1	150	752	150	103	-649	
350	0.5	3.135	0.89	0.6897	-2.4453	1	1	350	1,097	350	241	-856	
320	0.2	5.016	0.89	0.6897	-4.3263	1	1	320	1,605	320	221	-1,384	
70	0.5	3.135	0.89	0.6897	-2.4453	1	1	70	219	70	48	-171	
280	0.2	5.016	0.89	0.6897	-4.3263	1	1	280	1,404	280	193	-1,211	
1520	0.6	2.508	0.89	0.6897	-1.8183	1	1	1,520	3,812	1,520	1,048	-2,764	
540	0.4	3.762	0.82	1.1286	-2.6334	2	2	1,080	4,063	1,080	1,219	-2,844	
1190	0.6	2.508	0.82	1.1286	-1.3794	2	2	2,380	5,969	2,380	2,686	-3,283	
540	0.7	1.881	0.82	1.1286	-0.7524	2	2	1,080	2,031	1,080	1,219	-813	
520	0.6	2.508	0.82	1.1286	-1.3794	2	2	1,040	2,608	1,040	1,174	-1,435	
320	0.7	1.881	0.82	1.1286	-0.7524	2	2	640	1,204	640	722	-482	
725	0.6	2.508	0.82	1.1286	-1.3794	2	2	1,450	3,637	1,450	1,636	-2,000	
450	0.7	1.881	0.82	1.1286	-0.7524	2	2	900	1,693	900	1,016	-677	
1210	0.6	2.508	0.82	1.1286	-1.3794	2	2	2,420	6,069	2,420	2,731	-3,338	
420	0.7	1.881	0.82	1.1286	-0.7524	2	2	840	1,580	840	948	-632	
720	0.6	2.508	0.7	1.881	-0.627	3	3	2,160	5,417	2,160	4,063	-1,354	
410	0.7	1.881	0.7	1.881	0	3	3	1,230	2,314	1,230	2,314	0	
280	0.4	3.762	0.7	1.881	-1.881	3	3	840	3,160	840	1,580	-1,580	
480	0.5	3.135	0.7	1.881	-1.254	3	3	1,440	4,514	1,440	2,709	-1,806	
360	0.7	1.881	0.7	1.881	0	3	3	1,080	2,031	1,080	2,031	0	
250	0.5	3.135	0.7	1.881	-1.254	3	3	750	2,351	750	1,411	-941	
320	0.6	2.508	0.7	1.881	-0.627	3	3	960	2,408	960	1,806	-602	
320	0.1	5.643	0.7	1.881	-3.762	3	3	960	5,417	960	1,806	-3,612	
60	0.4	3.762	0.7	1.881	-1.881	3	3	180	677	180	339	-339	
250	0.7	1.881	0.7	1.881	0	3	3	750	1,411	750	1,411	0	
160	0.4	3.762	0.7	1.881	-1.881	3	3	480	1,806	480	903	-903	
410	0.1	5.643	0.24	4.7652	-0.8778	3	3	1,230	6,941	1,230	5,861	-1,080	meadow
2080	0	6.27	0.24	4.7652	-1.5048	3	3	6,240	39,125	6,240	29,735	-9,390	
							Total	**35,650**	**123,908**	**35,650**	**73,001**	**-50,907**	**-41** **% Reduction**

Table 59. Existing and Potential Solar Loads for House 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)	House Creek
170	0.6	2.508	0.89	0.6897	-1.82	1	1	170	426	170	117	-309	mxd shrub
210	0.2	5.016	0.89	0.6897	-4.3263	1	1	210	1,053	210	145	-909	
150	0.7	1.881	0.9	0.627	-1.254	1	1	150	282	150	94	-188	mxd tree/shrub
130	0.6	2.508	0.9	0.627	-1.881	1	1	130	326	130	82	-245	
1330	0.5	3.135	0.9	0.627	-2.508	1	1	1,330	4,170	1,330	834	-3,336	
410	0.7	1.881	0.9	0.627	-1.254	1	1	410	771	410	257	-514	
260	0.2	5.016	0.9	0.627	-4.389	1	1	260	1,304	260	163	-1,141	
270	0.6	2.508	0.9	0.627	-1.881	1	1	270	677	270	169	-508	
150	0.7	1.881	0.9	0.627	-1.254	1	1	150	282	150	94	-188	
150	0.1	5.643	0.87	0.8151	-4.8279	2	2	300	1,693	300	245	-1,448	
200	0.5	3.135	0.87	0.8151	-2.3199	2	2	400	1,254	400	326	-928	
920	0.6	2.508	0.87	0.8151	-1.6929	2	2	1,840	4,615	1,840	1,500	-3,115	
160	0.4	3.762	0.87	0.8151	-2.9469	2	2	320	1,204	320	261	-943	
1030	0.6	2.508	0.87	0.8151	-1.6929	2	2	2,060	5,166	2,060	1,679	-3,487	
350	0.7	1.881	0.87	0.8151	-1.0659	2	2	700	1,317	700	571	-746	
150	0.6	2.508	0.87	0.8151	-1.6929	2	2	300	752	300	245	-508	
1020	0.7	1.881	0.84	1.0032	-0.8778	3	3	3,060	5,756	3,060	3,070	-2,686	
290	0.5	3.135	0.84	1.0032	-2.1318	3	3	870	2,727	870	873	-1,855	
910	0.7	1.881	0.84	1.0032	-0.8778	3	3	2,730	5,135	2,730	2,739	-2,396	
550	0.6	2.508	0.84	1.0032	-1.5048	3	3	1,650	4,138	1,650	1,655	-2,483	
270	0.5	3.135	0.84	1.0032	-2.1318	3	3	810	2,539	810	813	-1,727	
90	0.1	5.643	0.84	1.0032	-4.6398	3	3	270	1,524	270	271	-1,253	
230	0.3	4.389	0.8	1.254	-3.135	4	4	920	4,038	920	1,154	-2,884	
270	0.6	2.508	0.8	1.254	-1.254	4	4	1,080	2,709	1,080	1,354	-1,354	
750	0.7	1.881	0.8	1.254	-0.627	4	4	3,000	5,643	3,000	3,762	-1,881	
330	0.6	2.508	0.8	1.254	-1.254	4	4	1,320	3,311	1,320	1,655	-1,655	
1400	0.7	1.881	0.8	1.254	-0.627	4	4	5,600	10,534	5,600	7,022	-3,511	
350	0.4	3.762	0.8	1.254	-2.508	4	4	1,400	5,267	1,400	1,756	-3,511	
590	0.5	3.135	0.76	1.5048	-1.6302	5	5	2,950	9,248	2,950	4,439	-4,809	
90	0.2	5.016	0.76	1.5048	-3.5112	5	5	450	2,257	450	677	-1,580	
140	0.5	3.135	0.76	1.5048	-1.6302	5	5	700	2,195	700	1,053	-1,141	
400	0.4	3.762	0.76	1.5048	-2.2572	5	5	2,000	7,524	2,000	3,010	-4,514	
110	0.2	5.016	0.76	1.5048	-3.5112	5	5	550	2,759	550	828	-1,931	
690	0.6	2.508	0.76	1.5048	-1.0032	5	5	3,450	8,653	3,450	5,192	-3,461	
570	0.5	3.135	0.57	2.6961	-0.4389	5	5	2,850	8,935	2,850	7,684	-1,251	mxd shrub
660	0.4	3.762	0.57	2.6961	-1.0659	5	5	3,300	12,415	3,300	8,897	-3,517	
550	0.5	3.135	0.49	3.1977	0.0627	6	6	3,300	10,346	3,300	10,552	207	
370	0.4	3.762	0.49	3.1977	-0.5643	6	6	2,220	8,352	2,220	7,099	-1,253	
230	0.3	4.389	0.49	3.1977	-1.1913	6	6	1,380	6,057	1,380	4,413	-1,644	
170	0.2	5.016	0.49	3.1977	-1.8183	6	6	1,020	5,116	1,020	3,262	-1,855	
150	0.1	5.643	0.49	3.1977	-2.4453	6	6	900	5,079	900	2,878	-2,201	
400	0.5	3.135	0.49	3.1977	0.0627	6	6	2,400	7,524	2,400	7,674	150	
1050	0.2	5.016	0.49	3.1977	-1.8183	6	6	6,300	31,601	6,300	20,146	-11,455	
400	0.3	4.389	0.49	3.1977	-1.1913	6	6	2,400	10,534	2,400	7,674	-2,859	
470	0.4	3.762	0.49	3.1977	-0.5643	6	6	2,820	10,609	2,820	9,018	-1,591	
420	0.6	2.508	0.59	2.5707	0.0627	6	6	2,520	6,320	2,520	6,478	158	mxd shrub/canyon
390	0.5	3.135	0.59	2.5707	-0.5643	6	6	2,340	7,336	2,340	6,015	-1,320	
710	0.6	2.508	0.59	2.5707	0.0627	6	6	4,260	10,684	4,260	10,951	267	
310	0.5	3.135	0.59	2.5707	-0.5643	6	6	1,860	5,831	1,860	4,782	-1,050	
510	0.4	3.762	0.59	2.5707	-1.1913	6	6	3,060	11,512	3,060	7,866	-3,645	
540	0.6	2.508	0.59	2.5707	0.0627	6	6	3,240	8,126	3,240	8,329	203	
300	0.7	1.881	0.59	2.5707	0.6897	6	6	1,800	3,386	1,800	4,627	1,241	
2490	0.6	2.508	0.59	2.5707	0.0627	6	6	14,940	37,470	14,940	38,406	937	
1340	0.1	5.643	0.59	2.5707	-3.0723	6	6	8,040	45,370	8,040	20,668	-24,701	
520	0.5	3.135	0.59	2.5707	-0.5643	6	6	3,120	9,781	3,120	8,021	-1,761	
330	0.4	3.762	0.59	2.5707	-1.1913	6	6	1,980	7,449	1,980	5,090	-2,359	
840	0.6	2.508	0.59	2.5707	0.0627	6	6	5,040	12,640	5,040	12,956	316	
1490	0.5	3.135	0.59	2.5707	-0.5643	6	6	8,940	28,027	8,940	22,982	-5,045	
440	0	6.27	0.59	2.5707	-3.6993	6	6	2,640	16,553	2,640	6,787	-9,766	
							Total	**134,480**	**438,298**	**134,480**	**301,358**	**-136,940**	**-31** **% Reduction**

Table 60. Existing and Potential Solar Loads for Little House 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)	**Little House Creek**
290	0.6	2.508	0.9	0.627	-1.88	1	1	290	727	290	182	-545	mxd tree/shrub
480	0.8	1.254	0.9	0.627	-0.627	1	1	480	602	480	301	-301	
450	0.6	2.508	0.9	0.627	-1.881	1	1	450	1,129	450	282	-846	
290	0.4	3.762	0.52	3.0096	-0.7524	1	1	290	1,091	290	873	-218	meadow
200	0.6	2.508	0.9	0.627	-1.881	1	1	200	502	200	125	-376	mxd tree/shrub
220	0.3	4.389	0.52	3.0096	-1.3794	1	1	220	966	220	662	-303	meadow
430	0.6	2.508	0.9	0.627	-1.881	1	1	430	1,078	430	270	-809	mxd tree/shrub
310	0.6	2.508	0.9	0.627	-1.881	1	1	310	777	310	194	-583	
170	0.7	1.881	0.87	0.8151	-1.0659	2	2	340	640	340	277	-362	
200	0	6.27	0.36	4.0128	-2.2572	2	2	400	2,508	400	1,605	-903	meadow
220	0.2	5.016	0.82	1.1286	-3.8874	2	2	440	2,207	440	497	-1,710	mxd shrub
940	0.4	3.762	0.82	1.1286	-2.6334	2	2	1,880	7,073	1,880	2,122	-4,951	
410	0.6	2.508	0.82	1.1286	-1.3794	2	2	820	2,057	820	925	-1,131	
960	0.3	4.389	0.82	1.1286	-3.2604	2	2	1,920	8,427	1,920	2,167	-6,260	
1220	0.3	4.389	0.24	4.7652	0.3762	3	3	3,660	16,064	3,660	17,441	1,377	meadow
460	0.2	5.016	0.24	4.7652	-0.2508	3	3	1,380	6,922	1,380	6,576	-346	
260	0.4	3.762	0.24	4.7652	1.0032	3	3	780	2,934	780	3,717	782	
780	0.3	4.389	0.24	4.7652	0.3762	3	3	2,340	10,270	2,340	11,151	880	
450	0.4	3.762	0.24	4.7652	1.0032	3	3	1,350	5,079	1,350	6,433	1,354	
							Total	**17,980**	**71,052**	**17,980**	**55,799**	**-15,252**	**-21**
													% Reduction

Table 61. Existing and Potential Solar Loads for Devil 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)	**Devil Creek**
920	0.1	5.643	0.52	3.0096	-2.63	1	1	920	5,192	920	2,769	-2,423	meadow
360	0.4	3.762	0.89	0.6897	-3.0723	1	1	360	1,354	360	248	-1,106	mxd shrub
180	0.4	3.762	0.82	1.1286	-2.6334	2	2	360	1,354	360	406	-948	
110	0.7	1.881	0.87	0.8151	-1.0659	2	2	220	414	220	179	-234	mxd tree/shrub
400	0.6	2.508	0.82	1.1286	-1.3794	2	2	800	2,006	800	903	-1,104	mxd shrub
1300	0.4	3.762	0.36	4.0128	0.2508	2	2	2,600	9,781	2,600	10,433	652	meadow
320	0.3	4.389	0.7	1.881	-2.508	3	3	960	4,213	960	1,806	-2,408	mxd shrub
210	0.5	3.135	0.7	1.881	-1.254	3	3	630	1,975	630	1,185	-790	
230	0.2	5.016	0.24	4.7652	-0.2508	3	3	690	3,461	690	3,288	-173	meadow
3300	0.4	3.762	0.24	4.7652	1.0032	3	3	9,900	37,244	9,900	47,175	9,932	
890	0.5	3.135	0.62	2.3826	-0.7524	4	4	3,560	11,161	3,560	8,482	-2,679	mxd shrub
1640	0.3	4.389	0.62	2.3826	-2.0064	4	4	6,560	28,792	6,560	15,630	-13,162	
1620	0.1	5.643	0.67	2.0691	-3.5739	5	5	8,100	45,708	8,100	16,760	-28,949	mxd shrub/canyon
480	0.2	5.016	0.67	2.0691	-2.9469	5	5	2,400	12,038	2,400	4,966	-7,073	
990	0.5	3.135	0.67	2.0691	-1.0659	5	5	4,950	15,518	4,950	10,242	-5,276	
100	0.8	1.254	0.67	2.0691	0.8151	5	5	500	627	500	1,035	408	
130	0.3	4.389	0.67	2.0691	-2.3199	5	5	650	2,853	650	1,345	-1,508	
1280	0.5	3.135	0.67	2.0691	-1.0659	5	5	6,400	20,064	6,400	13,242	-6,822	
450	0.1	5.643	0.67	2.0691	-3.5739	5	5	2,250	12,697	2,250	4,655	-8,041	
							Total	**52,810**	**216,453**	**52,810**	**144,750**	**-71,703**	**-33**
													% Reduction

Bacteria

The LC for bacteria is based on the state water quality standard for *E. Coli.* The bacteria LC is expressed in terms of organisms per day. However, this is simply an accounting mechanism to convert a unit of measurement (organisms per 100 ml) to a organisms per day measurement because of the impracticality of converting to a mass per unit time measurement. The bacteria load capacity is derived from the following equation:

Bacteria Load Capacity = WQS x flow x unit conversion factor

Where
WQS = the secondary contact recreation water quality standard (576 org/ 100 ml)
flow = the daily average flow (cfs) from predicted or USGS data
unit conversion factor = 24,468,480

The load capacity tabularized from the load duration curve categories are presented in Table 62.

Table 62. Average Bacteria Load Capacities within Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	org/day	org/day	org/day	org/day	org/day
Cottonwood Creek	4.391×10^{11}	1.055×10^{11}	3.029×10^{10}	1.581×10^{10}	7.189×10^{8}

Sediment

The LC for sediment was determined based on the origin of the sediment. In the Salmon Falls Creek Subbasin most of the sediment impacting the beneficial uses is from stream bank erosion. The LC is based on the load generated from banks that are greater than 80% stable. This load (Table 63) defines the LC for the majority of assessment units of the stream the subbasin.

Total Suspended sediments also were elevated and impacting the beneficial uses of two water bodies within the subbasin, Salmon Falls Creek above the reservoir and Salmon Falls Creek below the reservoir. The load duration curve for suspended sediments was determined by calculation using the target of 50 mg/L suspended sediments, daily average flow values (calculated from predicted annual hydrographs or USGS data), and a 5.39 conversion factor to convert from mg/L and ft^3/second to lbs per day. The suspended sediment LC are identified for the various flow categories (shown in Table 64). While these values are helpful in giving a relative understanding of the reductions required, and will apply reasonably over most water years, it should be noted that the absolute level of reduction required will depend on flow and concentration values specific to a given day. The target that has been shown to result in attainment of water quality standards and support of designated uses in the reach is an instream concentration of less than or equal to 50 mg/L TSS. Transport and deposition of sediments, and the resulting degradation of aquatic life habitats within a reach, is seasonal in nature. The load duration methodology completely accounts for this seasonality.

Table 63. Bank Erosion Load Capacities.

Bank Erosion Load capacities		Erosion Rate (t/mi/y)	Total Erosion (t/y)
Water body	Stream reach		
Big Creek	Upper Big Creek	17.41	140.78
Big Creek	Lower Big Creek	7.44	48.01
Hanna's Fork	Hanna's Fork	2.24	13.79
Salmon Falls Creek	San Jacinto Gauge to Weir	8.86	56.32
Salmon Falls Creek	Weir to Salmon Falls Reservoir	17.66	108.86
Cedar Creek	Dam to Siphon	11.67	46.69
Cedar Creek	Siphon to Salmon Falls	5.91	95.31
China Creek	Upper China Creek	1.54	2.32
China Creek	Above China Creek Road	7.44	15.47
China Creek	Below China Creek Road	11.16	33.17
Player Creek	Player Creek	6.40	23.85
Browns	Browns	4.49	21.99
Corral Creek	Corral Creek	1.58	4.69
Whiskey Slough	Whiskey Slough	2.71	16.08
Cottonwood Creek	Upper Cottonwood Creek	10.07	31.92
Cottonwood Creek	Lower Cottonwood Creek	12.41	113.28
Langford Flat	Langford Flat	5.06	30.69
Hot Creek	Upper Hot Creek	7.34	25.03
Hot Creek	Lower Hot Creek	7.59	26.62
North Fork Shoshone Creek	North Fork Shoshone Creek	3.64	5.76
South Fork Shoshone Creek	South Fork Shoshone Creek	10.09	30.57
Shoshone Creek	South Fork to Cottonwood Creek	6.48	48.48

Bank Erosion Load capacities		Erosion Rate (t/mi/y)	Total Erosion (t/y)
Water body	Stream reach		
Shoshone Creek	Cottonwood Creek to Hot Creek	6.12	37.00
Shoshone Creek	Hot Creek to Border	10.73	74.99
House Creek	House Creek above reservoir	8.82	185
Cedar Creek	Cedar Creek above reservoir		

Table 64. Average TSS Load Capacities within Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Upper	172,056	45,492	16,925	11,428	4,870
Salmon Falls Creek lower	82,711	51,513	41,117	29,485	12,275

Mercury

See mercury target selection discussion above. In summary the mercury load capacity is the reduction in current Hg loading which will give 0.24 mg/kg methyl mercury concentration in the fishes of the reservoir, calculated as (0.24 mg/kg existing weighted average tissue methyl mercury concentration) x existing load.

5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR § 130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (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.

There are no existing point sources, that discharge, located within the Salmon Falls Creek Subbasin. Those point sources that do exist within the subbasin are total containment source as a result they have no existing load.

Nutrients

Existing loads in the nutrient TMDLs (Table 65 and 67) come from the 90th percentile of existing loads within the load duration categories as determined by DEQ monitoring data. The complete record of data collected by DEQ, USGS, and the IASCD was presented in the load duration curves developed for individual water bodies found previous sections of this document. As no point sources were know to contribute to the nutrient loads seen in the streams and rivers of the subbasin it is assumed that the existing measured loads comprise nonpoint source and natural background loads. Tables 66 and 68 present the excess load and the percent reduction required to meet the nutrient load capacities of the various systems. Excess load is from natural background and nonpoint source loads. DEQ assumes that the sources of the nonpoint source loads are from the various land uses present within the watershed of each system (see Table 34). Margin of safety considerations may increase the needed percent reduction further.

Table 65. Existing Total Phosphorus Load and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)		HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY		lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Reservoir						
	Salmon Falls Creek	852.13	195.25	26.37	12.82	13.86
	China Creek	12.21	2.33	0.66	0.36	0.05
	Whiskey Slough	1.10	0.30	0.68	dry	Dry
	Corral Creek	0.10	0.05	dry	dry	Dry
Cedar Creek Reservoir						
	House Creek	21.20	7.34	2.52	2.52	2.35
	Cedar Creek	unknown	unknown	unknown	unknown	unknown
Cottonwood Creek		28.44	10.51	5.14	2.65	0.08
Big Creek		59.58	9.01	1.76	0.87	0.85
Hanna's Fork		5.81	1.35	0.44	0.23	0.05
Salmon Falls Creek Lower		323.51	222.25	153.40	100.61	23.49

Table 66. Excess Total Phosphorus Load and Percent Reductions within and Load Duration Categories.

WATER BODY	HIGH FLOW 0-10	Percent Reduction	MOIST 10-40	Percent Reduction	MID RANGE 40-60	Percent Reduction	DRY 60-90	Percent Reduction	LOW FLOW 90-100	Percent Reduction
Salmon Falls Creek Upper	680.1	79.81	149.8	76.70	9.45	35.84	1.39	10.84	8.99	64.86
Salmon Falls Creek Lower	158.1	48.87	119.2	53.64	71.17	46.40	41.64	41.39	0	0
China Creek	10.47	85.75	1.9	81.55	0.52	78.79	0.28	77.78	0.04	80.00
Corral Creek	0.03	30.00	0.02	40.00	0	0	0	0	0	0
Whiskey Slough	0.83	75.45	0.03	10.00	0.41	60.29	0	0	0	0
House Creek	12.78	60.28	3.81	51.91	0.09	3.57	0.31	12.30	0.39	16.60
Cedar Creek		60.28		51.91		3.57		12.30		16.60
Cottonwood Creek	11.64	40.93	6.47	61.56	3.98	77.43	2.05	77.36	0.05	62.50
Big Creek	38.91	65.31	2.93	32.52	0	0	0	0	0	0
Hanna's Fork	3.02	51.98	0.68	50.37	0.23	52.27	0.11	47.83	0.04	80.00

Table 67. Existing Total Nitrogen Load and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek lower	4,469	4,625	3,828	2,267	873

Table 68. Excess Total Nitrogen Load and Percent Reductions within and Load Duration Categories.

WATER BODY	HIGH FLOW 0-10	Percent Reduction	MOIST 10-40	Percent Reduction	MID RANGE 40-60	Percent Reduction	DRY 60-90	Percent Reduction	LOW FLOW 90-100	Percent Reduction
Salmon Falls Creek Lower	1,988	44.48	3,080	66.59	2,595	67.79	1,382	60.96	505	57.85

Temperature

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat plate collector at the NREL weather stations. Existing shade data are presented in Tables 41 through 61. Like loading capacities (potential loads), existing loads in Tables 41 through 61 are presented on an area basis (kWh/m2/day) and as a total load (kWh/day).

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

Loading capacities (kWh/day) vary considerably depending on the size of the creek and the type of shade targets it has. The loading capacity on Shoshone Creek is almost 1.2 million kWh/day for its entire length in Idaho (Table 39). The loading capacity for Salmon Falls Creek is about 1.9 million kWh/day for the 12 miles of creek in Idaho above the Salmon Falls Reservoir (Table 48). Below the reservoir and to its mouth, Salmon Falls Creek loading capacity is a little less than 3.3 million kWh/day (Table 49).

Existing loads for Shoshone Creek and lower Salmon Falls Creek are 1.9 million kWh/day (Table 41) and 4 million kWh/day (Table 51), respectively.

Bacteria

Salmon Falls Creek above the reservoir provides the clearest methods for estimating portions of the bacteria load and has the most samples collected during the noncritical period. Natural background was estimated from average bacteria counts collected during the noncritical period (months 1-5 and 10-12). In Salmon Falls Creek, this average was approximately 24 org/100 ml. The nonpoint source load for the assessment units in question was estimated from the difference in the background concentration, as estimated from Salmon Falls Creek, and average bacteria counts collected during the critical period (months 6-9). The other assessment unit's sampling regimes were very similar, but not as robust during the non-critical period due to access. It should be noted that in other streams in south central Idaho (and the Salmon Falls Creek Subbasin) noncritical period counts of bacteria are near zero. Therefore, the natural background value of 24 org/100 ml used in these TMDLs should be considered part of the implicit MOS. Tables 69 and 70 present the existing bacteria load, excess load, and percent reductions required to meet state water quality standards.

Table 69. Existing Bacteria Load and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	org/day	org/day	org/day	org/day	org/day
Cottonwood Creek	3.577×10^{10}	9.843×10^{10}	2.565×10^{11}	2.603×10^{10}	1.044×10^{9}

Table 70. Excess Bacteria Load and Percent Reductions within and Load Duration Categories.

WATER BODY	HIGH FLOW 0-10	Percent Reduction	MOIST 10-40	Percent Reduction	MID RANGE 40-60	Percent Reduction	DRY 60-90	Percent Reduction	LOW FLOW 90-100	Percent Reduction
Cottonwood Creek	0	0	0	0	2.262×10^{11}	88.19	1.023×10^{10}	39.28	3.251×10^{8}	31.14

Sediment

In Salmon Falls Creek the primary source of sediment is from bank erosion. Existing sediment loads were determined using the bank erosion inventory process. This method provides an estimation of erosion rates within the sampling reaches. This erosion rate was then used to calculate the current instream delivery of sediment within the system. In other TMDLs, the background load was assumed to be similar to that from streams or reaches with slight to moderate bank erosion rates and 80 percent stable banks.

Existing loads in tons/year were summed for the entire stream or portion of stream and are presented in Table 71. Excess load, the difference between load capacity and existing load is also summed and presented in Table 72. The percent reduction are also shown in each table and represents how much total excess load there is in relation to total existing load.

Existing and excess loads in the suspended sediment TMDLs (Tables 73 and 74) come from averages of existing loads as determined by DEQ, IASCD, and USGS monitoring data and presented in the load duration curves developed for individual water bodies found previous sections of this document. As no point sources were known to contribute to the nutrient loads seen in the streams and rivers of the subbasin; it is assumed that the existing measured loads comprise nonpoint source and natural background loads. Suspended sediment concentrations measured in the systems unimpacted by suspended sediment give the best estimation of background concentrations of suspended sediment for the subbasin. These systems average approximately 12 mg/L SSC. Therefore DEQ assumes that these concentration represent background concentrations and will be used to determine background loads and the remainder of the existing load is assumed to be nonpoint source loads. DEQ assumes that the sources of the nonpoint source loads are from the various land uses present within the watershed of each system (see Table 34).

Table 71. Existing Bank Erosion Load .

Bank Erosion Load capacities		Erosion Rate (t/mi/y)	Total Erosion (t/y)
Water body	Stream reach		
Big Creek	Upper Big Creek	47.83	258.93
Big Creek	Middle Big Creek	6.72	29.73
Big Creek	Lower Big Creek	27.94	89.92
Hanna’s Fork	Hanna's Fork	2.13	13.12
Salmon Falls Creek	San Jacinto Gauge to Weir	25.64	162.94
Salmon Falls Creek	Weir to Salmon Falls Reservoir	175.27	1,080.33
Cedar Creek	Dam to Siphon	18.15	72.59
Cedar Creek	Siphon to Salmon Falls	13.47	217.31
China Creek	Upper China Creek	0.03	0.04
China Creek	Above China Creek Road	6.72	13.96
China Creek	Below China Creek Road	12.36	36.74
Player Creek	Player Creek	8.87	33.07
Browns	Browns	4.51	22.08

Bank Erosion Load capacities		Erosion Rate (t/mi/y)	Total Erosion (t/y)
Water body	Stream reach		
Corral Creek	Corral Creek	0.65	1.93
Whiskey Slough	Whiskey Slough	3.15	18.69
Cottonwood Creek	Upper Cottonwood Creek	8.28	26.24
Cottonwood Creek	Lower Cottonwood Creek	87.67	800.14
Langford Flat	Langford Flat	3.69	22.38
Hot Creek	Upper Hot Creek	11.15	38.01
Hot Creek	Lower Hot Creek	4.61	16.16
North Fork Shoshone Creek	North Fork Shoshone Creek	2.67	4.24
South Fork Shoshone Creek	South Fork Shoshone Creek	8.18	24.79
Shoshone Creek	South Fork to Cottonwood Creek	10.08	75.43
Shoshone Creek	Cottonwood Creek to Hot Creek	9.63	58.27
Shoshone Creek	Hot Creek to Border	30.26	211.47
House Creek	House Creek	10.57	221.84
Cedar Creek			

Table 72. Excess Bank Erosion Load and Percent Reduction.

Bank Erosion Load capacities		Erosion Rate (t/mi/y)	Total Erosion (t/y)	Percent Reduction
Water body	Stream reach			
Big Creek	Upper Big Creek	30.42	164.7	63.61
Big Creek	Middle Big Creek	0.00	0.00	0.00
Big Creek	Lower Big Creek	21.91	70.52	78.42
Hanna's Fork	Hanna's Fork	0.00	0.00	0.00
Salmon Falls Creek	San Jacinto Gauge to Weir	16.78	106.62	65.44
Salmon Falls Creek	Weir to Salmon Falls Reservoir	157.61	971.47	89.92
Cedar Creek	Dam to Siphon	6.48	25.9	35.68
Cedar Creek	Siphon to Salmon Falls	7.56	122	56.14
China Creek	Upper China Creek	0.00	0.00	0.00
China Creek	Above China Creek Road	0.00	0.00	0.00
China Creek	Below China Creek Road	1.20	3.57	9.72

Bank Erosion Load capacities		Erosion Rate (t/mi/y)	Total Erosion (t/y)	Percent Reduction
Water body	Stream reach			
Player Creek	Player Creek	2.47	9.22	27.88
Browns	Browns	0.02	0.09	0.41
Corral Creek	Corral Creek	0.00	0.00	0.00
Whiskey Slough	Whiskey Slough	0.44	2.61	13.96
Cottonwood Creek	Upper Cottonwood Creek	0.00	0.00	0.00
Cottonwood Creek	Lower Cottonwood Creek	75.26	686.86	85.84
Langford Flat	Langford Flat	0.00	0.00	0.00
Hot Creek	Upper Hot Creek	3.81	12.98	34.15
Hot Creek	Lower Hot Creek	0.00	0.00	0.00
North Fork Shoshone Creek	North Fork Shoshone Creek	0.00	0.00	0.00
South Fork Shoshone Creek	South Fork Shoshone Creek	0.00	0.00	0.00
Shoshone Creek	South Fork to Cottonwood Creek	3.60	26.95	35.73
Shoshone Creek	Cottonwood Creek to Hot Creek	3.51	21.27	36.50
Shoshone Creek	Hot Creek to Border	19.53	136.48	64.54
House Creek	House Creek	1.75	36.84	16.61
Cedar Creek				16.61

Table 73. Existing TSS Load and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Upper	894,566	134,890	15,811	9,518	893
Salmon Falls Creek Lower	86,774	93,498	67,890	28,971	5,549

Table 74. Excess TSS Load and Percent Reductions within Load Duration Categories.

WATER BODY	HIGH FLOW 0-10	Percent Reduction	MOIST 10-40	Percent Reduction	MID RANGE 40-60	Percent Reduction	DRY 60-90	Percent Reduction	LOW FLOW 90-100	Percent Reduction

Salmon Falls Creek Upper	722,510	80.77	89,398	66.27	0	0	0	0	0	0
Salmon Falls Creek Lower	4,063	4.68	41,985	44.90	26,773	39.44	0	0	0	0

Mercury

The existing mercury load for Salmon Falls Creek Reservoir results in a trophic level/consumption based weighted average methyl mercury concentration measured in the fishes of the reservoir of 0.779 mg/kg. This information was presented in Table 28. Estimates of the existing total mercury loading to the reservoir are presented in Figures 68-74. In summary, it is estimated that 626.85 grams/year of total mercury are stored in the reservoir. Monthly sums are presented in Table 75. The needed percent reduction in loading to the water from all mercury sources combined to meet the fish tissue based load capacity is 69 percent. From this, we estimate the excess mercury load is 433.73 grams per year.

Table 75. Existing Mercury Loading Summary.

Month	Rivers and Streams	Wet Deposition to Reservoir	Dry Deposition to Reservoir	Outlet Losses	Volatilization Losses	Net Load
	Grams Hg	Grams Hg	Grams Hg	Grams Hg	Grams Hg	Grams Hg
Jan	7.61	0.82	1.64	1.36	8.61	0.09
Feb	10.04	0.71	1.31	1.27	6.64	4.15
Mar	105.25	1.01	8.33	1.38	10.81	102.40
Apr	214.70	5.66	8.33	1.80	6.32	220.57
May	295.38	3.24	10.42	30.44	16.12	262.49
Jun	167.97	18.59	17.83	41.10	25.95	137.34
Jul	6.95	8.65	17.83	54.97	20.64	-42.19
Aug	3.02	9.19	22.29	38.85	17.48	-21.82
Sep	3.44	3.08	8.68	7.18	15.14	-7.11
Oct	5.45	3.79	8.68	2.16	16.62	-0.87
Nov	6.26	1.55	8.68	1.57	18.08	-3.17
Dec	6.52	1.60	1.31	1.39	11.90	-3.86
Annual	832.59	57.89	115.32	183.47	174.32	648.02

5.4 Load Allocation

TMDLs must include a margin of safety to take into account seasonal variability and uncertainty. Uncertainty arises in relation of water quality target to load capacity, and estimates of existing loads, and may be attributed to incomplete knowledge or understanding of the system, such as assimilation not well known, sparse data, or large variability in data. The margin of safety is effectively a reduction in loading capacity that "comes off the top" (i.e., before any allocation to sources). Second in line is the background load, a further reduction in loading capacity available for allocation. It is also prudent to allow for growth by reserving a portion of the remaining available load for future sources. Future growth allocations are determined by the input from local stakeholders and commented on by the watershed advisory group of the subbasin.

The remaining load capacity is then apportioned among existing and future pollutant sources. Allocations may take into account equitable cost, cost effectiveness, and credit for prior efforts, but all within the ceiling of remaining available load. These allocations may take the form of percent reductions rather than actual loads as is the case with mercury. The point sources of the subbasin are total containment source and as a result do not receive an allocation. Nonpoint sources are allocated by subwatershed, and landownership. It is not necessary to refine the nonpoint source allocation further so long as water quality targets can be met with the reductions that are specified. If a finer resolution of nonpoint sources is needed the load allocations can be made on a refined allocation scheme during the five year review of the progress towards meeting the TMDL goals.

Margin of Safety

In addition to estimating a load capacity a given water body can carry, the Clean Water Act includes statutory requirements for a MOS in a TMDL. The MOS is intended to account for uncertainties in available data or in the actual effect controls will have on load reductions and the receiving water body's water quality. The MOS may be implicit, such as conservative assumptions used in various calculations, specifically those of natural background, loading capacity, wasteload allocations, and load allocations. Otherwise, a MOS must be clearly defined. For the Salmon Falls Creek Subbasin TMDLs, an explicit 10 percent MOS will be used for most pollutant water body combinations and is presented in Tables 76-79.

Table 76. Total Phosphorus MOS Load and Load Duration Categories.

LOAD DURATION CATAGORIES (DURATION INTERVAL)		HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY		lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Reservoir						
	Salmon Falls Creek	17.21	4.55	1.69	1.14	0.49
	China Creek	0.17	0.04	0.01	0.01	0.01
	Whiskey	0.027	0.027	0.027	0.027	0.027

LOAD DURATION CATAGORIES (DURATION INTERVAL)		HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
	Slough					
	Corral Creek	0.01	0.00	0.00	0.00	0.00
Cedar Creek Reservoir						
	House Creek	0.84	0.35	0.24	0.22	0.20
	Cedar Creek	0.25	0.21	0.20	0.19	0.19
Cottonwood Creek		1.68	0.40	0.12	0.06	0.01
Big Creek		2.07	0.61	0.29	0.23	0.15
Hanna's Fork		0.28	0.07	0.02	0.01	0.00
Salmon Falls Creek Lower		16.54	10.30	8.22	5.90	2.45

Table 77. Total Nitrogen MOS Load and Load Duration Categories.

LOAD DURATION CATAGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek lower	248	155	123	88	37

Table 78. Bacteria MOS Load and Load Duration Categories.

LOAD DURATION CATAGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	org/day	org/day	org/day	org/day	org/day
Cottonwood Creek	4.391×10^{10}	1.056×10^{10}	3.029×10^{9}	1.580×10^{9}	7.189×10^{7}

Table 79. TSS MOS Load and Load Duration Categories.

LOAD DURATION CATAGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Upper	17,206	4,549	1,692	1,143	487
Salmon Falls Creek Lower	8,271	5,151	4,112	2,949	1,227

To address uncertainty issues with the mercury fish tissues based load capacity an explicit MOS of 20 percent was used reducing the tissue criteria from 0.3 mg/kg to 0.240 mg/kg. Furthermore, any conservative approaches used in the various calculations required by a TMDL will be included as an implicit component of the MOS. The implicit MOS; however, will not be clarified further. Rather, the conservative approaches and assumptions presented throughout the document have been sufficiently identified in appropriate sections.

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

Seasonal Variation

The Clean Water Act states that TMDLs …"*shall be established at a level necessary to implement the applicable water quality standards with seasonal variation*". Load duration curves have, as an integral part in their development, the seasonal variation in flow incorporated in them. As a result, seasonal variation is clearly shown in the existing loads as well as the load capacity of a given system. Load duration curves also allow for critical periods and watershed processes to be more clearly identified for a given water body pollutant combination. As most TMDLs proposed from the Salmon Falls Subbasin utilize load duration curves for the development of load capacity seasonal variation has been accounted for.

Approaches that differed from the load duration curve methodology, such as bank stability, PNV temperature, and mercury TMDLs seasonal variation is accounted for and described below.

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

The bank stability TMDL are based on annual loads. However, all loads have been calculated from estimations of bank recession rates. Consequently, the loads are typically delivered during peak spring time flow events when the banks actually recede. The critical time period is April-June when spring salmonids spawning is occurring. Sediment delivery is not likely to be a problem for beneficial uses outside of this time period because of lower flows, less bank scouring, and limited overland wash-off processes occurring. Consequently the conversion to daily load for the bank stability sediment TMDLs will simply the annual load divided by 91 days.

The fish tissues based mercury TMDL approach inherently takes into account for seasonality because fish tissue values integrate exposure to Hg over seasonal and annual periods. Furthermore, human health effects of excess methylmercury intake are based on a lifetime average, not variation in intake within a year. None-the-less, because data were collected during fall, when the lipid content is the highest, the data already provide a conservative estimate of year-round average mercury concentrations including low-lipid-content seasons such as spring. The critical period for mercury load delivery to the reservoir has been clearly shown to be during spring time flushing flows in the various rivers and tributaries. However, the critical period for mercury methylation in the reservoir has not been clearly documented, rather it is assumed to occur during oxygen depletion events in the hypolimnion of the reservoir which occur throughout the summer months and potentially while the reservoir refilling each year.

Background

Several recent Idaho TMDLs have discussed background levels for the various constituents. Much of that information is applicable to the Salmon Falls Creek Subbasin as well. Therefore the information was used in whole or in part from the Big Wood River TMDL, the Mid Snake Succor Creek TMDL, Snake River Hells Canyon TMDL or the Pahsimeroir River TMDL for the Salmon Falls Creek Subbasin TMDLs.

Nutrients

The following discussion comes from the Snake River Hells Canyon TMDL (SR-HC TMDL). The SR-HC TMDL assessed natural phosphorus conditions in the mainstem Snake River by looking at concentrations in the Blackfoot and Portneuf watersheds where there are high naturally occurring concentrations of phosphorus. Natural sources of nutrients include erosion of phosphorus-containing rock and soils through wind, precipitation, temperature extremes and other weathering events.

Natural deposits of phosphorus (Hovland and Moore, 1987) have been identified in the Snake River drainage near Pocatello, Idaho (RM 731.2). Geological deposits in the Blackfoot River watershed (inflow at RM 750.6) contain phosphorus in sufficient concentrations that they have been mined. The Snake River flows through this area some distance upstream of the SR-HC TMDL reach.

In an effort to assess the potential magnitude of natural phosphorus concentrations in the mainstem Snake River due to these geological deposits, total phosphorus concentrations occurring in the mainstem near the Blackfoot and Portneuf River inflows (RM 750.6 and 731.2 respectively) were evaluated. Data was available for the Snake River near Blackfoot, Idaho (USGS gage # 13069500, RM 750.1) and for the Blackfoot and Portneuf Rivers (USGS, 2001a). The mainstem Snake River and these tributary river systems, where they flow through the natural mineral deposits represent a worst-case scenario for evaluation of natural phosphorus loading and were identified as potential sources of naturally-occurring phosphorus to the SR-HC reach. USGS gauged flow data and water quality data from the 1970s to the late 1990s is available for the Blackfoot and Portneuf Rivers ((USGS gage # 13068500, and #13075500 respectively). Because both the mainstem and tributary watersheds have been settled for some time, and land and water management has occurred extensively, the data compiled represent both natural and anthropogenic loading.

Total phosphorus concentrations in the Snake River mainstem, measured near Blackfoot, Idaho (RM 750.1), from 1990 to 1998 averaged 0.035 mg/L (range = <0.01 to 0.11 mg/L, median = 0.03 mg/L, mode = 0.02 mg/L) (USGS, 2001a). Nearly 40 percent (23 samples) of the total data set showed total phosphorus concentrations less than or equal to 0.02 mg/L. Data represents year-round sampling. Winter sampling was slightly less frequent (approximately 19% of the total) than spring, summer or fall.

Natural phosphorus concentrations were not assessed as part of the Blackfoot River TMDL (DEQ, 2001b). Total phosphorus concentrations in the Blackfoot River, measured near the mouth, from 1990 to 1999 averaged 0.069 mg/L (range = <0.01 to 0.43 mg/L, median = 0.04 mg/L, mode = 0.03 mg/L) (USGS, 2001a). Nearly 23 percent (12 samples) of the total data set showed total phosphorus concentrations less than or equal to 0.02 mg/L. Data represents year-round sampling. Winter sampling was less frequent (approximately 13% of the total) than spring, summer or fall.

Natural phosphorus concentrations were not assessed for the Portneuf River TMDL (DEQ, 1999d). Total phosphorus concentrations in the Portneuf River, measured near the mouth, from 1990 to 1998 averaged 0.085 mg/L (range = <0.01 to 0.28 mg/L, median = 0.069 mg/L, mode = 0.03 mg/L) (USGS, 2001a). Nearly 21 percent (6 samples) of the total data set showed total phosphorus concentrations less than or equal to 0.02 mg/L. Data represents year-round sampling. Winter sampling represented approximately 22 percent of the total.

The fact that very low total phosphorus concentrations were observed routinely (more than 20% of the time) in the mainstem Snake River, the Blackfoot River and the Portneuf River, all watersheds with a high level of use and management show that the natural loading levels are likely below detection limit concentrations. The additional fact that these low concentrations were observed in watersheds in much closer proximity to the rich geological phosphorus deposits indicates that these deposits likely do not represent a significant source of high, natural loading to the Salmon Falls Creek TMDL reaches, located in close proximity to the watersheds identified.

Given the above discussion, the natural background concentration for total phosphorus in the mainstem Snake River has been estimated as at or below 0.02 mg/L for both the Mid Snake River/Succor Creek and SR-HC TMDL reaches. This value is based on the available data set. Data from the Snake River upstream of RM 409 was included in this data set to address the concern of enrichment of surface waters by the phosphoric deposits located in central and eastern Idaho (Hovland and Moore, 1987). Due to the fact that there are substantial anthropogenic influences in Snake River Basin, the lower 15th percentile value for total phosphorus concentration was selected as a conservative estimate of natural phosphorus concentration. In this manner, natural concentration levels for the mainstem Snake River were calculated conservatively. This initial estimate will be reviewed as additional data become available and revisions will be made as appropriate.

The estimated natural background loading concentration for the mainstem Snake River (0.02 mg/L) is most likely an overestimation of the natural loading but represents a conservative estimate for the purposes of load calculation. In addition, this concentration correlates well with other studies that have been completed and closely approximates the total phosphorus concentration identified for a reference system (relatively unimpacted) by the US EPA (US EPA, 2000d; Dunne and Leopold, 1978). Because phosphorus concentrations had dropped to below the detection limit in the Blackfoot watershed after implementation of BMPs, background was assessed at 0.02 mg/L based on the lowest 15th percentile value for phosphorus. This choice of percentile addressed bias introduced by using a lower percentile that contained values below the detection limit and lack of data located directly below the natural source of phosphorus.

Based on the above discussion the TP natural background estimates for the various systems requiring a nutrient TMDL are presented below in Table 80.

Natural background estimates of total nitrogen in free flowing stream are limited in Idaho. Other sources of this information may exist elsewhere. However, for the Salmon Falls Creek Subbasin, DEQ estimated natural background from the existing data collected in the upper portion of the subbasin not associated with a nitrate priority area. The methodology for this estimate was very straightforward. Assuming that the 0.02 mg/L TP is the natural background concentration of that particular nutrient as outlined above, and that if TP were at natural background levels that TN was also likely at natural background levels. To account for the mobility of nitrates in groundwater DEQ selected only those TN samples that were not collected in a groundwater impacted system. TN samples from this subset ranged from 0.0075 to 0.498 mg/L and had an average concentration of 0.26 mg/L and a standard deviation of 0.11 mg/L. Given the relatively low coefficient of variation (0.43) DEQ is confident that the range of data is small, and overall the average can be used as the natural background concentration until such time that a better estimate is made. The natural background estimate for the TN TMDL for lower Salmon Falls Creek is presented in Table 81.

Table 80. Total Phosphorus Background Load and Load Duration Categories.

LOAD DURATION CATAGORIES (DURATION INTERVAL)		HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY		lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Reservoir						
	Salmon Falls Creek	68.82	18.20	6.77	4.57	1.95
	China Creek	0.70	0.17	0.05	0.03	0.00
	Whiskey Slough	0.11	0.11	0.11	0.11	0.11
	Corral Creek	0.027	0.01	0.01	0.01	0.00
Cedar Creek Reservoir						
	House Creek	3.37	1.41	0.97	0.89	0.78
	Cedar Creek	1.01	0.82	0.78	0.78	0.77
Cottonwood Creek		3.36	0.81	0.23	0.12	0.01
Big Creek		4.13	1.22	0.58	0.45	0.31
Hanna's Fork		0.56	0.13	0.04	0.02	0.00
Salmon Falls Creek Lower		33.08	20.61	16.45	11.79	4.91

Table 81. Total Nitrogen Background Load and Load Duration Categories.

LOAD DURATION CATAGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek lower	430	268	214	153	64

Temperature

Background for temperature is considered to be the amount of heat in the water when the maximum riparian potential is met. Thus, the background temperature is the same as the loading capacity.

Bacteria

Background bacteria colonies enter the stream from many sources not controllable through the TMDL process. Generally, these sources are the wildlife that use the stream. In some cases, waterfowl have been shown to be a significant contributor of E coli (Campbell 2001). Other studies have indicated that skunks, ground squirrels, and other small mammals may be significant contributors. No work has been done in the Salmon Falls Creek subbasin to partition these sources from the overall counts. This would entail genetic differentiation of the E coli found within each watershed. Rather than a detailed genetic study of the E coli, DEQ opted to make some simple assumptions about the sources. The first of these is that the contributions from wildlife sources of E coli are similar throughout the year. The second is that anthropogenic sources are more heavily concentrated during the summer. These sources may include recreation as well as grazing. If these two assumptions are met then the uncontrollable portion, that from the wild life sources, could be identified as the average counts for the period when anthropogenic sources are minimized. Based on the above discussion the bacteria natural background estimates for the various systems requiring a bacteria TMDL are presented below in Table 82.

Table 82. Bacteria Background Load and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	org/day	org/day	org/day	org/day	org/day
Cottonwood Creek	1.830×10^{10}	4.399×10^{9}	1.262×10^{9}	6.585×10^{8}	2.996×10^{7}

Sediment

Background sediment production from stream banks equates to the load at 80% stream bank stability as described in Overton et al. (1995), where stable banks are expressed as a percentage of the total estimated bank length. Natural condition stream bank stability potential is generally at 80% or greater for A, B, and C channel types in plutonic, volcanic, metamorphic, and sedimentary geology types.

Table 83. TSS Background Load and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Upper	41,294	10,918	4,062	2,743	1,169
Salmon Falls Creek Lower	19,851	12,363	9,868	7,076	2,946

Mercury

Geologic Features Related to the Presence of Mercury

Geothermal areas throughout the region are known for their contribution of mercury into the environment. However, literature searches and visual observations did not reveal an over abundance of hot springs within the Salmon Falls Creek Subbasin study area. Examples include the Magic Hot Springs along the Idaho-Nevada border, springs along Hot Creek, and unnamed hot springs in the San Jacinto area. The once developed springs at Mineral Hot Springs appear to be dried up. Analytical results show that samples from Magic Hot Springs contain approximately 16 ng/L of mercury. Mercury analyses in Shoshone Creek approximately two miles downstream of Magic Hot Springs average approximately 0.7 ng/L (DEQ, 2006). Thus, the analytical data suggest that mercury from these sources may attenuate either through dilution, absorption into the sediments or both.

Sulfide polymetallic mineral deposits are documented at the Contact and Elk Mountain Mining Districts. Mercury is often associated with such sulfide deposits. The major sulfide ore minerals at these mining districts include chalcopyrite, sphalerite, and galena. Field observations indicate there are no apparent waste rock piles or tailings in, or close (within several hundred yards) to Salmon Falls Creek. Therefore, Salmon Falls Creek does not appear to come into direct contact with residual mining waste that may to contain high concentrations of mercury.

Shales are present to some degree within the Paleozoic sequence within the watershed. According to the literature, shale outcrops are not prevalent in the study area, and several within the Contact Mining District have been silicified (Schrader 1935). Due to the limited nature of these outcrops and relatively low concentrations of mercury in Salmon Falls Creek, which drains these areas, they are not considered a significant potential source of mercury in the watershed.

Volcanic rocks are often associated with hydrothermal activity and increased sulfide mineralization indicative of potential mercury deposition. The Jarbidge volcanics prevalent in the western portion of the study area are characterized by the younger, non-ore bearing rhyolites, which originally inundated the watershed. These younger flows appear to lack the dikes, veins and fissures so numerous in the older lavas which are common in the Jarbidge mining district to the west.

The Elk Mountain Mining District and west slope of the Jarbidge Mining District are drained by the north and south forks of Salmon Falls Creek. These creeks join to form the main Salmon Falls Creek approximately 11 miles upstream from the Contact Mining District. Therefore, potential impacts to these surface waters from all three mining districts enter into Salmon Falls Creek upstream of the inlet to Salmon Falls Creek Reservoir. The Contact Mining District is approximately 15 miles upstream from the DEQ's sampling point on Salmon Falls Creek near the inlet to the reservoir. Analytical results at this sample point show mercury levels at 1.3 ng/L, which are below the ambient mercury concentrations seen in the Salmon Falls Creek reservoir.

A suite of samples from northern Nevada were pulled from the NURE archives and analyzed for mercury in 1998. Within the Salmon Falls Creek watershed, this included soil, dry stream sediments, and wet stream sediments. Of the approximately 75 samples analyzed, all samples were below 1 mg/kg. As a result, no "significant clusters of high mercury values" were identified in the watershed. The majority of the high mercury clusters were identified southwest of the watershed in the Humboldt basin.

The geologic evaluation did not reveal any apparent sources(s) of mercury contamination to surface water from historic or current mining activities, or from naturally occurring geologic sources. Compared to other mining districts in northern Nevada, the geologic structure and stratigraphy in the Salmon Falls Creek watershed study area do not appear to be favorable for significant naturally occurring mercury deposition.

Natural geothermal activity in the Salmon Falls Creek watershed is not as prevalent as in the adjoining Humboldt River Basin to the south, or in the Snake River Plain north of the study area. Analytical results indicate attenuation of mercury concentrations in downstream surface waters considering the 16 ng/L of mercury adjacent to Magic Hot Springs compared to the 0.7 ng/L two miles downstream. The Mineral Hot Springs, downstream from Contact, Nevada, are dry at this time and apparently have been for some time.

Although sample data are sparse in the study area, current analytical results indicate there are no significant natural sources of mercury in the study area impacting Salmon Falls Creek near the Idaho-Nevada border as mercury concentrations average about 1.3 ng/L. Mercury concentrations in SFC and China Creek near where they enter the reservoir are approximately one-half of those concentrations found during the snow pack sampling project performed by DEQ during the spring of 2005.

Load Allocation

The following should be considered the tabular summarization of the SBA and TMDL processes. They also the meet the legal definition of a TMDL such that:

$$TMDL = LC = NB + MOS + LA + WLA$$

Where
LC = Load Capacity
NB = Natural Background
MOS = Margin of Safety
LA = Load Allocation (nonpoint sources)
WLA = Waste Load Allocation (point sources)

Rearranging the equation and solving of Load Allocation yields

$$LA = LC – MOS – NB – WLA$$

Individual components of the TMDL equation, LC, MOS, and NB, were presented in previous discussions. Additionally, as stated previously, there are no point sources within the watersheds. Therefore, no waste load allocations were made. Nonpoint sources were allocated by subwatershed. Therefore, it is incumbent upon the land management agencies and private individuals to develop the appropriate BMPs to meet the nonpoint source load allocations during the implementation plan development. A finer allocation based upon land ownership or other mechanism is not needed at this time so long as water quality targets can be met by the aggregate reductions of those sources that are prescribed a reduction in load through the implementation plan. Watershed and reach level load allocations based upon the load duration categories and stream bank erosion process are presented below in Tables 84-85 and 88-89.

Graphical presentation of the TMDLs (Figures 125 –137) provide the complete understanding of the seasonality of a system and the changes in loadings that occur as flow changes within the systems.

Nutrients

Table 84. Total Phosphorus Load Allocation and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)		HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY		lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Reservoir						
	Salmon Falls Creek	86.03	22.75	8.46	5.71	2.43

LOAD DURATION CATEGORIES (DURATION INTERVAL)		HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
	China Creek	0.87	0.21	0.07	0.04	0.007
	Whiskey Slough	0.13	0.13	0.13	0.13	0.13
	Corral Creek	0.03	0.02	0.01	0.01	0.009
Cedar Creek Reservoir						
	House Creek	4.21	1.76	1.21	1.11	0.98
	Cedar Creek	1.26	1.03	0.98	0.97	0.96
Cottonwood Creek		11.76	2.83	0.81	0.42	0.02
Big Creek		14.47	4.26	2.03	1.59	1.07
Hanna's Fork		1.96	0.47	0.14	0.08	0.005
Salmon Falls Creek Lower		115.79	72.12	57.56	41.28	17.18

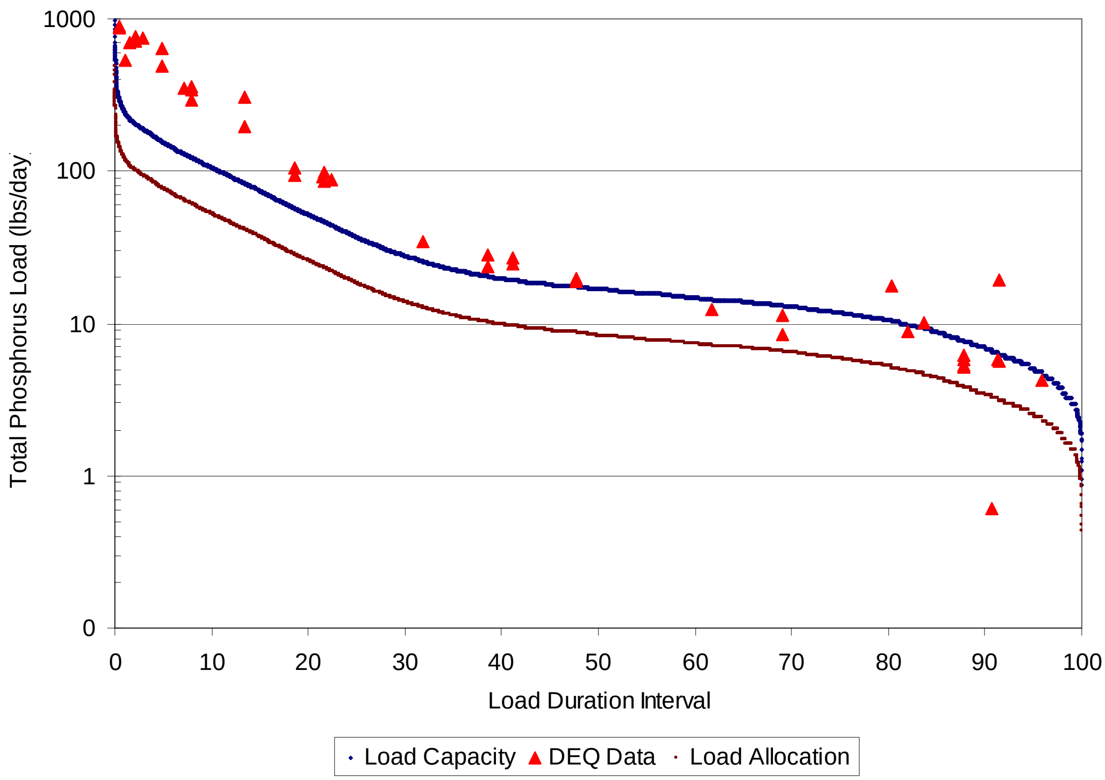


Figure 125. Salmon Falls Creek Upper TP TMDL.

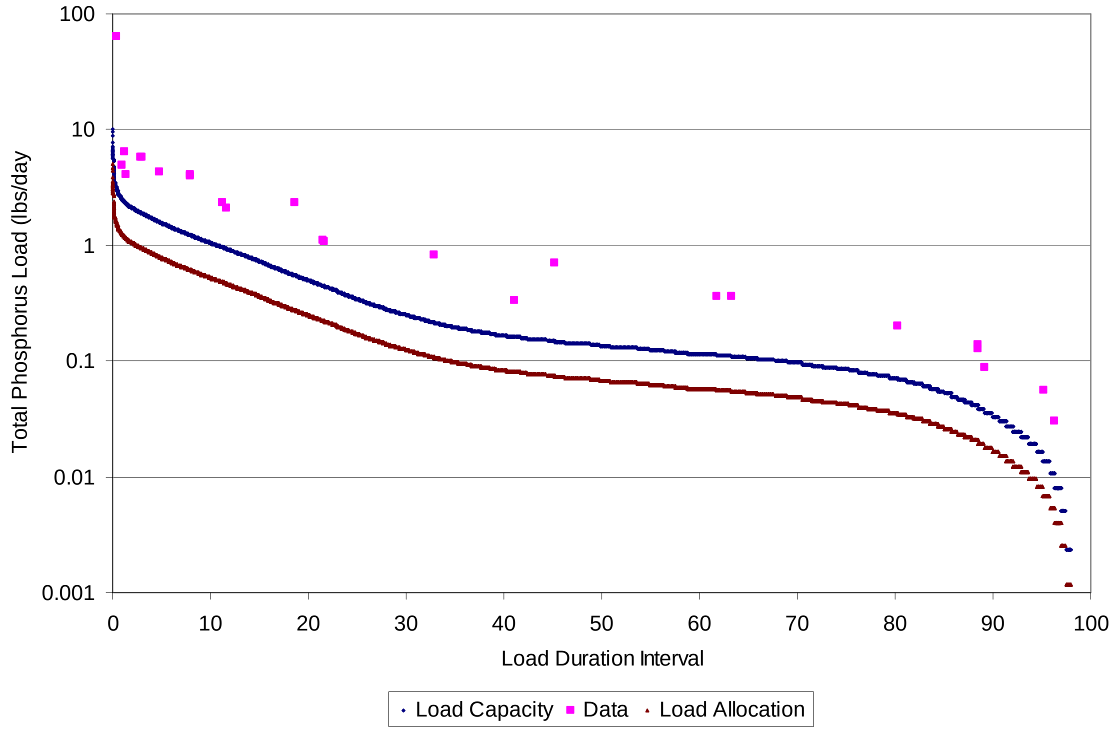


Figure 126. China Creek TP TMDL.

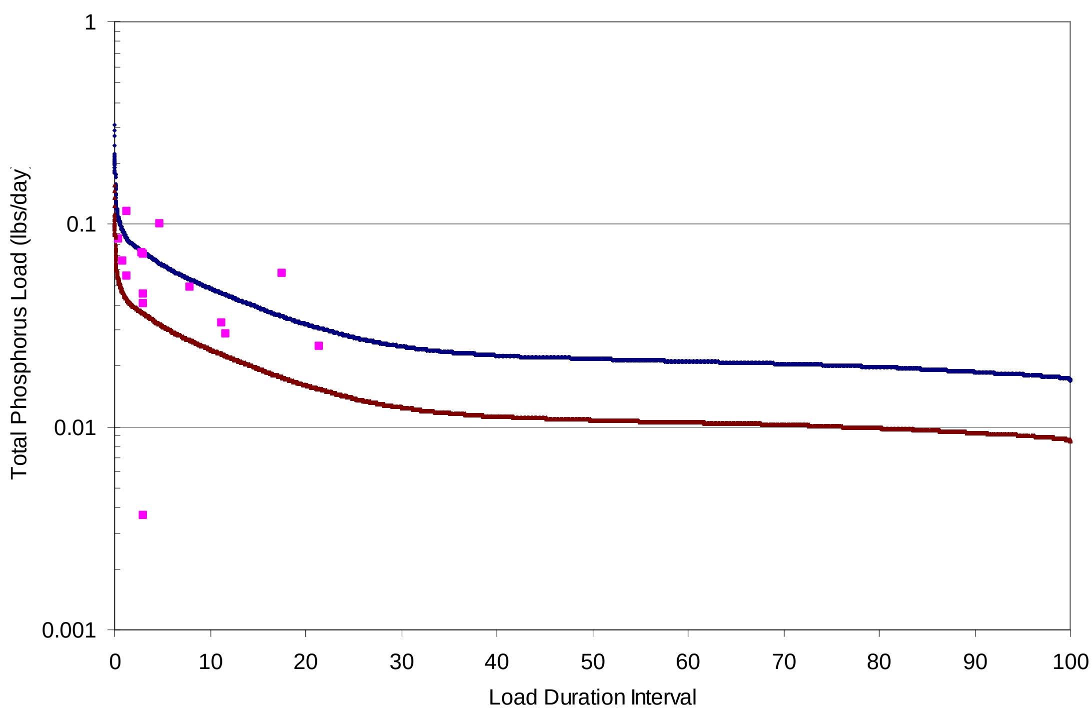


Figure 127. Corral Creek TP TMDL.

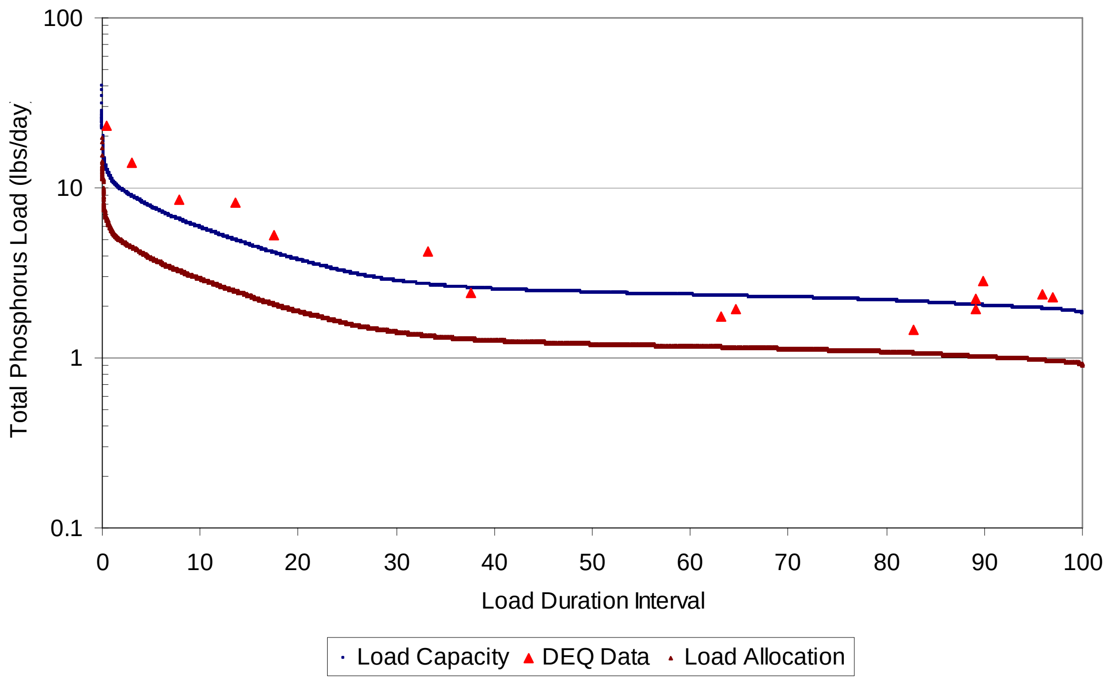


Figure 128. House Creek TP TMDL.

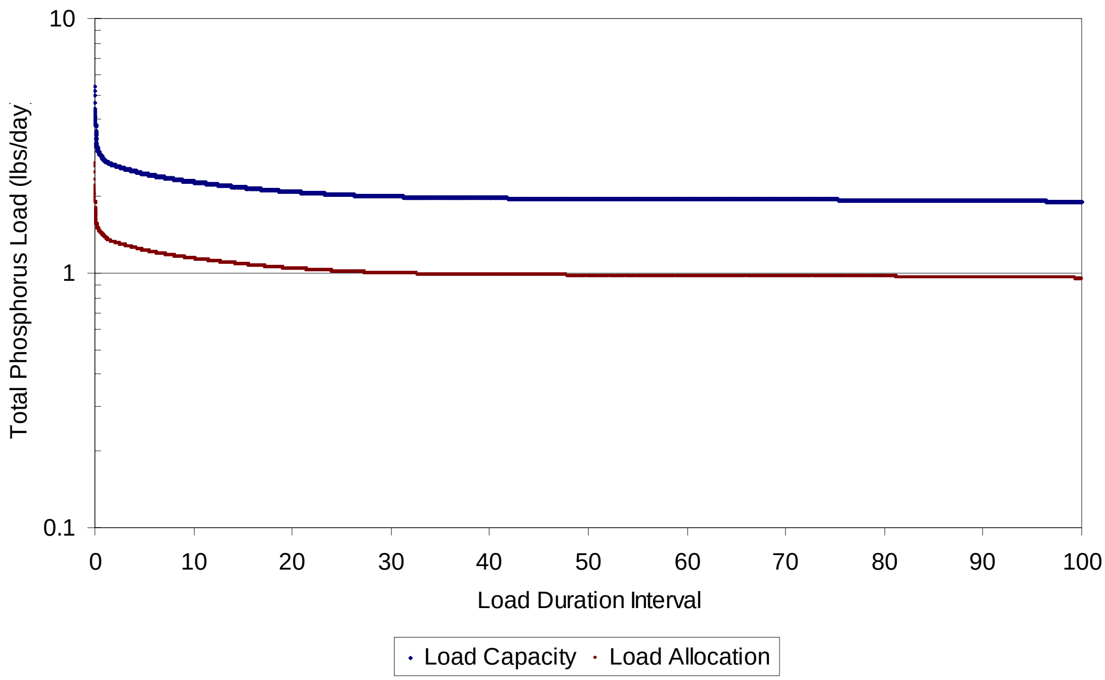


Figure 129. Cedar Creek Upper TP TMDL.

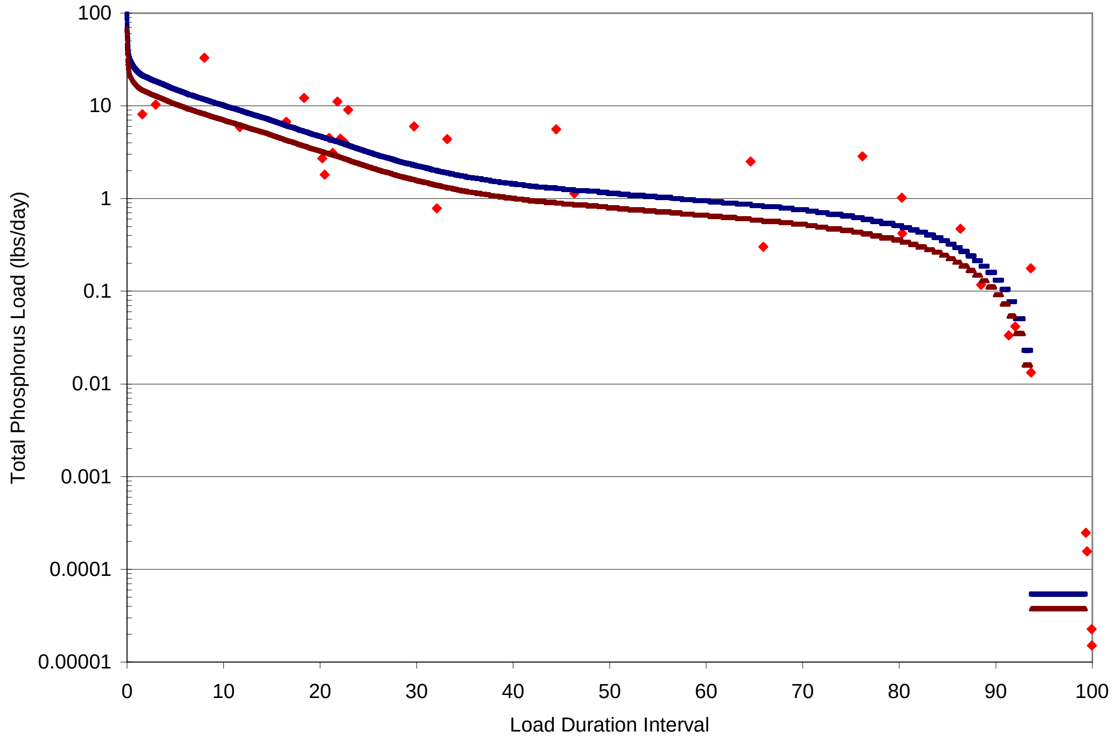


Figure 130. Cottonwood Creek TP TMDL.

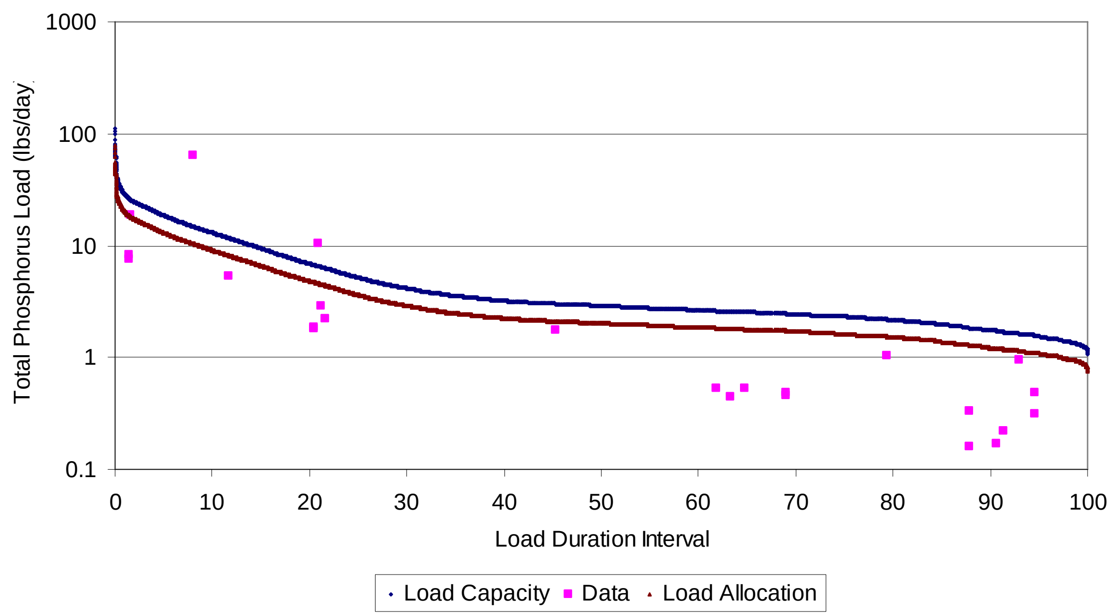


Figure 131. Big Creek TP TMDL.

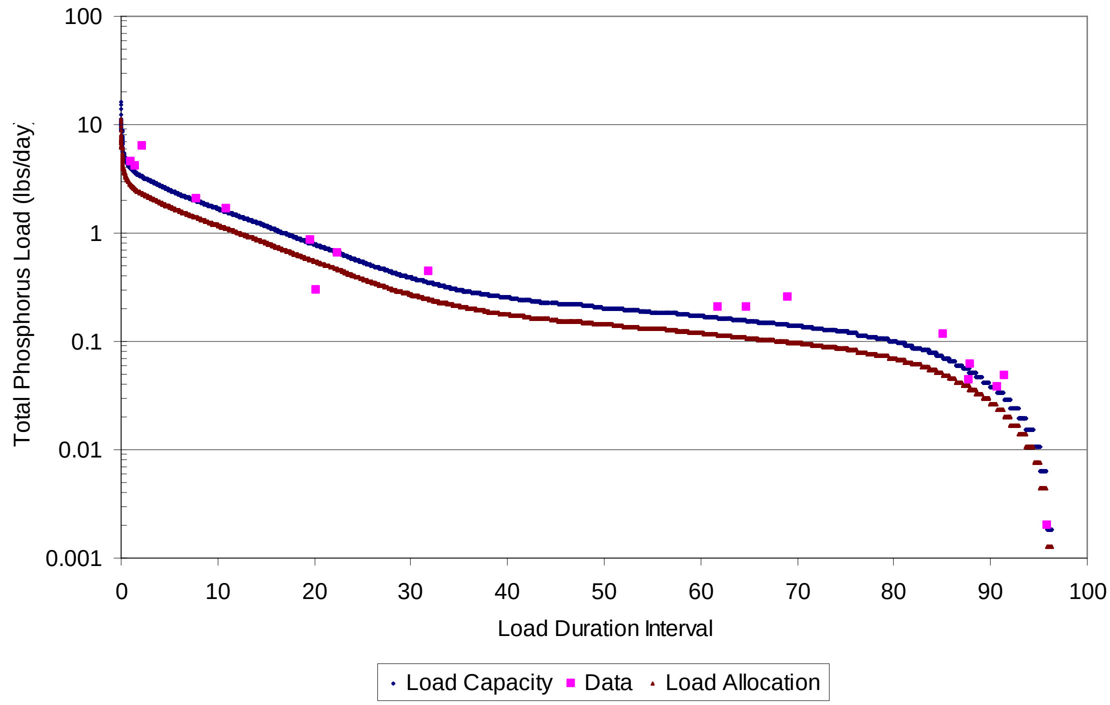


Figure 132. Hanna's Fork TP TMDL.

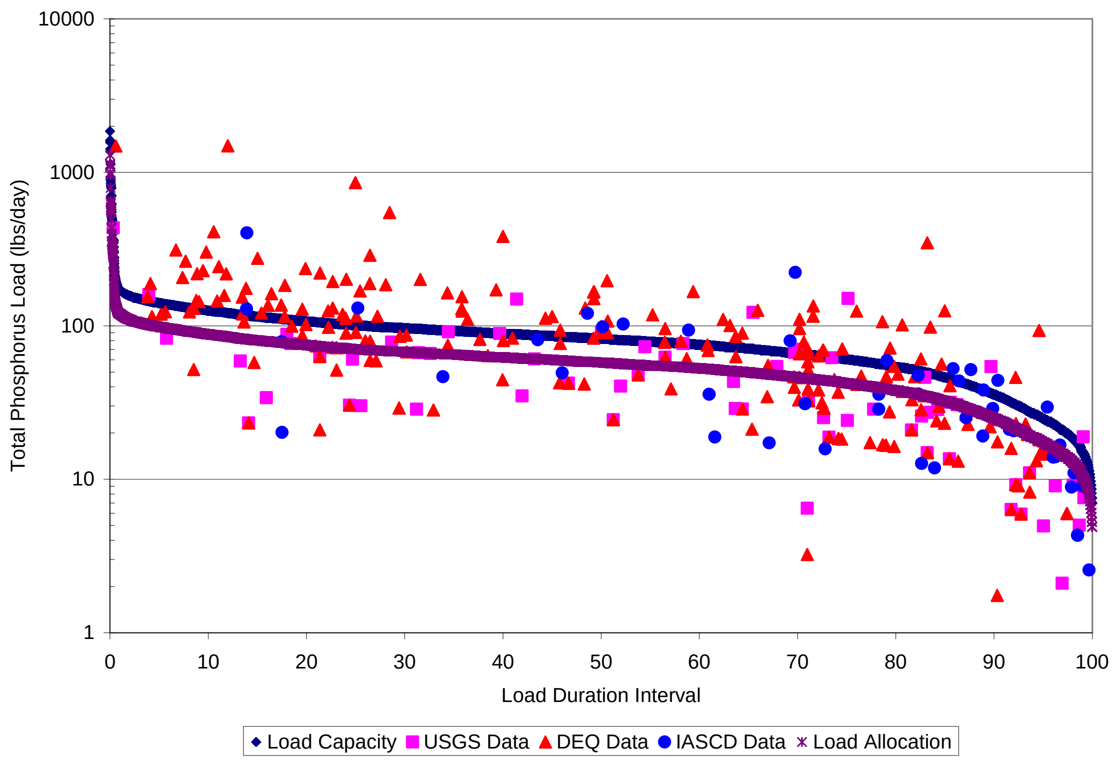


Figure 133. Salmon Falls Creek Lower TP TMDL.

Table 85. Total Nitrogen Load Allocation and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek lower	1,803	1,123	896	643	268

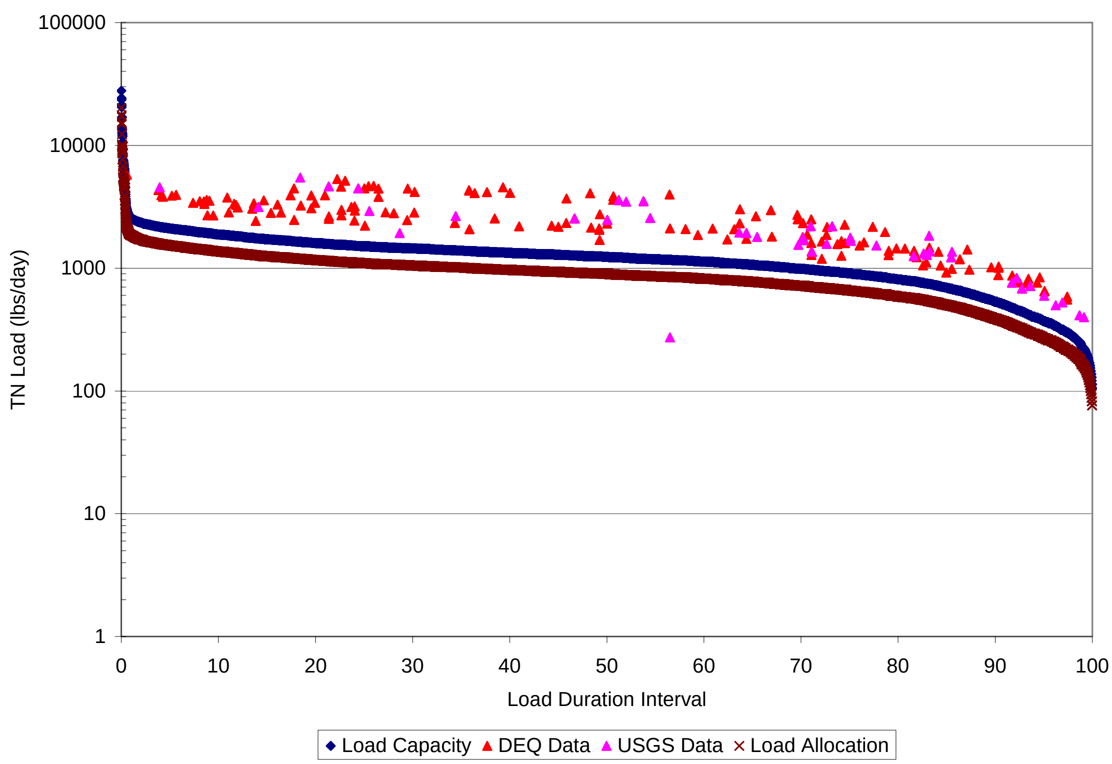


Figure 134. Salmon Falls Creek Lower TN TMDL.

Temperature

Because the temperature TMDLs are based on potential natural vegetation, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to non point source activities that have 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 41 through 61 and Figure 29 show the target or potential shade, which is converted to a potential summer load by multiplying the inverse fraction (1-shade fraction) by the average loading to a flat plate collector for the months of April through September. That is the loading capacity of the stream and it is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its loading capacity.

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. Tables 86 and 87 show the excess heat load (kWh/day) experienced by each water body examined and the percent reduction necessary to bring that water body back to target load levels. 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. Tables 86 and 87 list the tributaries in order of their excess loads highest to lowest. Therefore, large tributaries tend to be listed first and small tributaries are listed last. Percent reductions vary considerably (12 to 68%) with an average percent reduction for the whole group at 41%. Although the following analysis dwells on total heat loads for streams in this TMDL, it is important to note that differences between existing shade and target shade, as depicted in Figure 4, 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 the largest differences between existing and target shade as locations to prioritize implementation efforts.

Tributaries 303d listed for temperature pollution in this subbasin include Salmon Falls Creek, Shoshone Creek, and Hot Creek. The excess solar loading to these streams is listed in Tables 86 and 87. Salmon Falls Creek below the reservoir (Table 86) has the highest excess load (817,208 kWh/day) and a needed 20% reduction to achieve loading capacity. Salmon Falls Creek above Salmon Falls Reservoir has substantial amounts of excess loading (263,967 kWh/day). However, the percent reduction necessary to achieve loading capacity is relatively low for this stream (12-20%) due to its size. Larger tributaries to Salmon Falls Creek contributed higher excess heat than did smaller tributaries. Cedar Creek, House Creek and Devil Creek are larger tributaries with percent reductions greater than 30%.

Shoshone Creek has the second highest excess load at 783,328 kWh/day, and a 40% reduction to meet target levels (Table 87). Additionally, several tributaries to Shoshone Creek contribute significant amounts of heat loading including Cottonwood Creek (151,580 kWh/day) and Big Creek (136,638 kWh/day). Most tributaries in this drainage had percent reductions greater than 20%. Only Horse Creek had a relatively low percent reduction to meet target levels. Cottonwood Creek and Big Creek are large contributors of heat loading to Shoshone Creek due to their size and lack of shade. Only a small portion of Hot Creek (Table 87) was examined as the bulk of this stream is found in Nevada. The 5,190 meter section of Hot Creek in Idaho had an excess load of 25,756 kWh/day, which represents 40% over target levels.

There are no point sources in the affected watersheds. Thus, there are no wasteload allocations. Should a point source be proposed that would have thermal consequence on these waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 & IDAPA 58.01.02.401.03) should be involved (see Appendix B).

Table 86. Excess Solar Loads and Percent Reductions for Salmon Falls Creek and its Tributaries.

WATER BODY	EXCESS LOAD (KWH/DAY)	PERCENT REDUCTION
Salmon Falls Creek below reservoir	817,208	20%
Salmon Falls Creek above reservoir	263,967	12%
Cedar Creek, below reservoir	107,427	45%
House Creek	136,940	31%
Devil Creek	71,703	33%
Cedar Creek, above reservoir	50,907	41%
China Creek	42,775	47%
Browns Creek	18,717	64%
NF Salmon Falls Creek (Idaho portion)	16,405	55%
Whiskey Slough	14,988	36%
Little House Creek	15,252	21%
Player Creek	8,335	58%

Table 87. Excess Solar Loads and Percent Reductions for Shoshone Creek and its Tributaries.

WATER BODY	EXCESS LOAD (KWH/DAY)	PERCENT REDUCTION
Shoshone Creek	783,328	40%
Cottonwood Creek	151,580	46%
Big Creek	136,638	38%
Langford Flat Creek	58,566	49%
Pole Camp Creek	31,794	68%
Hot Creek (Idaho portion)	25,756	40%

WATER BODY	EXCESS LOAD (KWH/DAY)	PERCENT REDUCTION
Hannah's Fork	22,965	55%
Horse Creek	16,410	20%
SF Shoshone Creek	6,252	39%

Bacteria

Table 88. Bacteria Load Allocation and Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	org/day	org/day	org/day	org/day	org/day
Cottonwood Creek	3.770×10^{11}	9.063×10^{10}	2.600×10^{10}	1.357×10^{10}	6.171×10^{8}

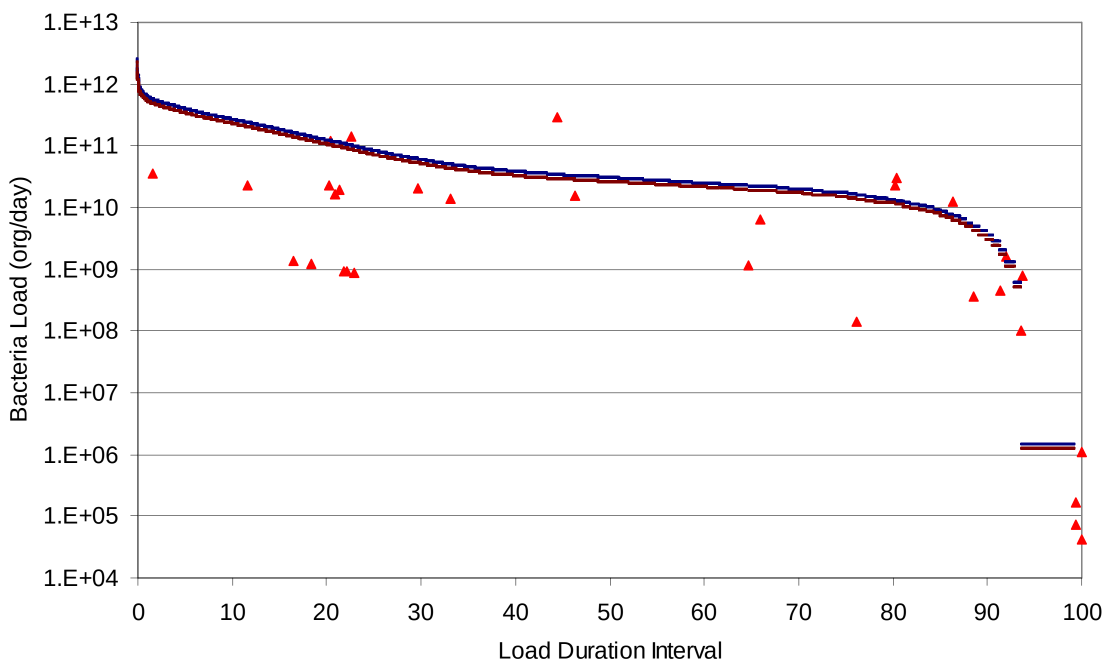


Figure 135. Cottonwood Creek Bacteria TMDL.

Sediment

Because the bank stability TMDLs are based on an equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to non point source activities that have or may affect bank stability. Load allocations are therefore stream reach specific. Table 72 show the target or load allocation.

Table 89. TSS Load Allocationand Load Duration Categories.

LOAD DURATION CATEGORIES (DURATION INTERVAL)	HIGH 0-10	MOIST 10-40	MIDRANGE 40-60	DRY 60-90	LOW FLOW 90-100
WATER BODY	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Salmon Falls Creek Upper	113,557	30,025	11,170	7,543	3,214
Salmon Falls Creek Lower	54,589	33,999	27,137	19,460	8,101

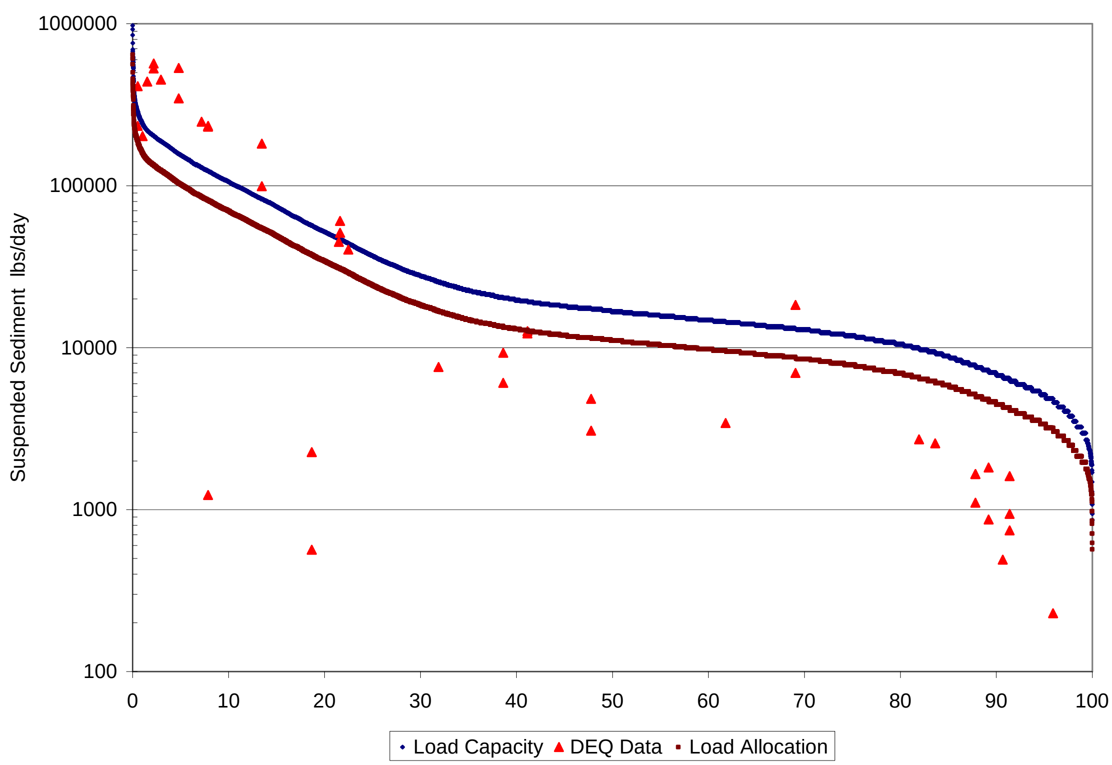


Figure 136. Salmon Falls Creek Upper Suspended Sediment TMDL.

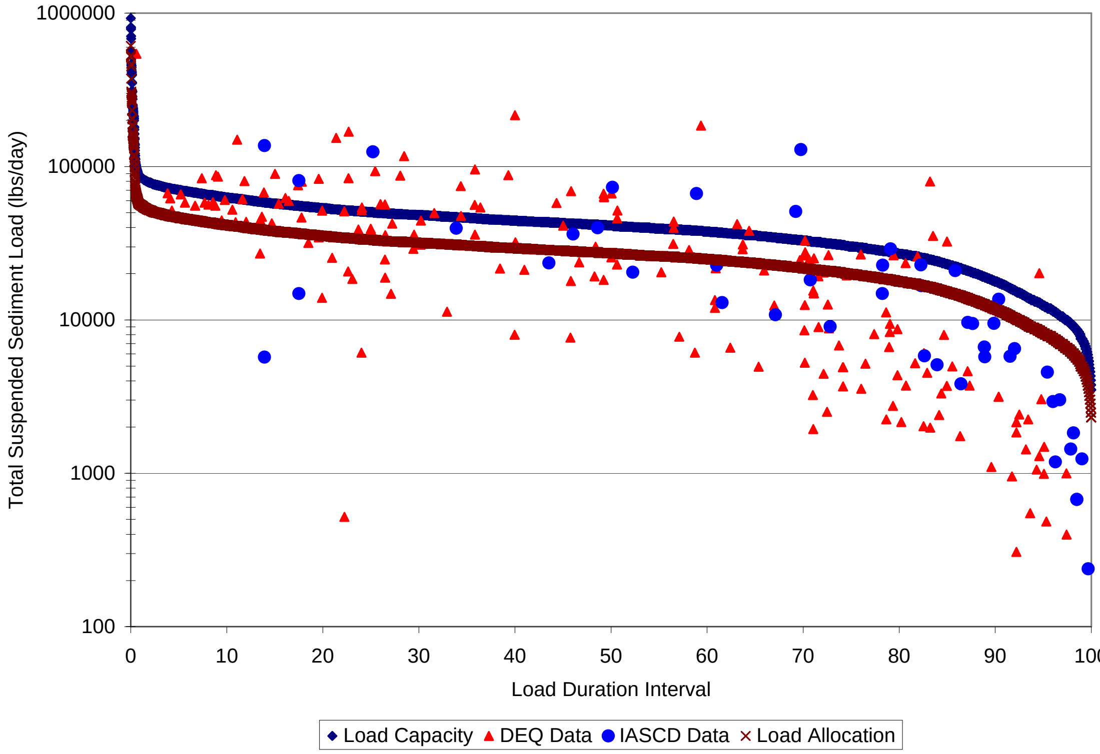


Figure 137. Salmon Falls Creek Lower Suspended Sediment TMDL.

Mercury

The predominant sources of mercury loading to the Salmon Falls Creek Subbasin are from atmospheric deposition, watershed nonpoint sources, and background loads. Reduction in mercury loading from these sources will require implementation of mercury emission regulations and erosion BMPs. Percent reductions required to reduce fish tissue concentrations to target levels was estimated to be 69 percent, or a reduction of 433.73 grams per year.

These reductions are expected to achieve the fish tissue mercury target levels. However, a complete understanding of the sources of mercury in the subbasin is limited, and DEQ is unable to allocate among specific sources.

Our understanding of the pathways into the reservoir is relatively complete. For example, the loads from the streams contribute 85 percent of the inputs to the reservoir while direct atmospheric contributions make up the remainder. However, the percentage of the mercury load in the stream that derives from atmospheric sources is not understood and may make up a significant portion of this load. Therefore, an allocation by pathways is potentially misleading.

Consequently a gross allocation to nonpoint sources, which includes local and regional atmospheric sources and watershed nonpoint sources is made, and presented in Table 90. The load allocation does not incorporate losses to the outlets nor from volatilization as those losses are dependant on the concentration of mercury in the reservoir and will decrease in relationship with the decrease in concentration of mercury. The actual percent reduction of mercury load to the watershed needed may be lower than 69 percent. On the other hand, the mass balance model indicates that the reservoir has stored mercury annually. This internal mercury load of the reservoir is also unaccounted for in the allocation, which could make the percent reduction needed much higher, especially if the behavior of the reservoir as a sink for Hg were to change.

Table 90. Mercury Load Allocation.

Month	Mercury Load to Reservoir	Percent Reduction	Load Allocation
	Grams Hg	%	Grams Hg
January	9.81	69.19	3.02
February	12.58	69.19	3.87
March	115.40	69.19	35.55
April	225.13	69.19	69.36
May	308.89	69.19	95.17
June	187.88	69.19	57.88
July	34.39	69.19	10.59
August	30.29	69.19	9.33
September	19.07	69.19	5.87
October	16.84	69.19	5.19
November	15.81	69.19	4.87
December	8.55	69.19	2.64
Annual	984.63	69.19	303.37

The mercury TMDL was developed using the best available information on mercury levels in the environment, and current water quality standards. This TMDL may need to be revised in the future as new information becomes available that has a bearing on the assumptions on which this TMDL is based.

Reserve

An allowance in the TMDL for a portion of the loading capacity to be set aside for future growth is permissible and encouraged. Careful documentation of the decision making process must accompany the TMDL. This allowance for future growth must be based on existing or readily available data at the time of the TMDL development if it is to be applicable to the assumptions and calculations used to develop the TMDL loads.

In the Salmon Falls Creek Subbasin, little discussion with the local stakeholders has occurred in regards to a reserve load. In fact, the history of the MidSnake Wag has been to forgo the use of a reserve. Further discussions with the Salmon Falls Creek Stakeholders are required. If it is deemed feasible, a reserve may be developed in a similar fashion as the Wood River WAG used. In that the reserve will be developed during the implementation of the TMDL. Nevertheless, it should be noted that developing a reserve post hoc will result in more stringent load reductions than presented in the various TMDLs.

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 non-point 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 if one can be quantified. TMDLs developed in the past and present that do not have a WLA for construction storm water activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate Best Management Practices.

Typically, there are specific requirements you must follow 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

The purpose of this implementation strategy is to outline the pathway by which a larger, more comprehensive, implementation plan will be developed 18 months after TMDL approval. The comprehensive implementation plan will provide details of the actions needed to achieve load reductions (set forth in a TMDL), a schedule of those actions, and specify monitoring needed to document actions and progress toward meeting state water quality standards. These details are typically set forth in the plan that follows approval of the TMDL. In the meantime, a cursory implementation strategy is developed to identify the general issues such as responsible parties, a time line, and a monitoring strategy for determining progress toward meeting the TMDL goals outlined in this document.

The objective of the Salmon Falls Creek Subbasin TMDLs is to allocate allowable loads among different pollutant sources, so that the appropriate control actions can be taken and water quality standards achieved. The total pollutant load on these water bodies is derived from nonpoint and background sources. The Salmon Falls Creek Subbasin TMDLs have attempted to consider the effect of all activities or processes that cause or contribute to the water quality limited conditions of not just the water bodies listed on the 1998 §303(d) list, but rather all potential sources.

Control measures to implement this TMDL do not contain NPDES authorities, but are based on the reasonable assurance that state and local authorities and actions to reduce nonpoint source pollution will also occur. “There must be assurances that nonpoint source control measures will achieve expected load reductions in order to allocate a wasteload to a point source with a TMDL that also allocates expected nonpoint source load reductions (EPA 1991).” The Salmon Falls Creek TMDLs have load allocations calculated with margins of safety to meet water quality standards. The allocations, however, are based on estimates that have used available data and information. Therefore, monitoring for the collection of new data is necessary and required.

For the Salmon Falls Creek TMDLs, the reasonable assurance that it will meet its goal of water quality standards is based on two components: 1) nonpoint source implementation of BMPs based on land management agencies’ assurance that reductions will occur; and 2) trend monitoring that will be used to document relative changes in various aquatic organism populations and in physical and chemical water quality parameters over a 10-year period in conjunction with data from various agencies, organizations, and water user industries that will assess overall progress towards attainment of water quality standards and related beneficial uses.

Implementation strategies for TMDLs produced using potential natural vegetation-based shade and solar loading should incorporate the loading tables presented in this TMDL.

These tables need to be updated, first to field verify the existing shade levels that have not yet been field verified, and secondly to monitor progress towards achieving reductions and the goals of the TMDL. Using the solar pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further field verification will find discrepancies with reported existing shade levels in the loading tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include solar pathfinder monitoring to simultaneously field verify the TMDL and mark progress towards achieving desired reductions in solar loads.

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.

Responsible Parties

Development of the final implementation plan for the Salmon Falls Creek Subbasin TMDLs will proceed under the existing practice established for the state of Idaho. The plan will be cooperatively developed by DEQ, the MidSnake WAG, the affected private landowners, and other "designated agencies" with input from the established public process. Of the four entities, the WAG will act as the integral part of the implementation planning process to identify appropriate implementation measures. Other individuals may also be identified to assist in the development of the site-specific implementation plans as their areas of expertise are identified as beneficial to the process.

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

- Idaho Department of Lands (IDL): timber harvest, oil and gas exploration and development, mining.
- Idaho Soil Conservation Commission (ISCC): grazing and agriculture.
- Idaho Department of Transportation (IDT): public roads.
- Idaho Department of Agriculture (IDA): aquaculture, animal feeding operations (AFOs), CAFOs.
- Department of Environmental Quality: all other activities.

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

All stakeholders in the Salmon Falls Creek Subbasin have a responsibility for implementing the TMDLs. DEQ and the "designated agencies" in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. Their general responsibilities are outlined below.

- DEQ will oversee and track overall progress on the specific implementation plan and monitor the watershed response. DEQ will also work with local governments on urban/suburban issues.
- IDL will maintain and update approved BMPs for forest practices and mining. IDL is responsible for ensuring use of appropriate BMPs on state and private lands.
- ISCC, working in cooperation with local Soil and Water Conservation Districts, IDA, and the NRCS, will provide technical assistance to agricultural landowners. These agencies will help landowners design BMP systems appropriate for their properties, and identify and seek appropriate cost-share funds. They also will provide periodic project reviews to ensure BMPs are working effectively.
- IDT will be responsible for ensuring appropriate BMPs are used for construction and maintenance of public roads.
- IDA will be responsible for working with aquaculture to install appropriate pollutant control measures. Under a memorandum of understanding with EPA and DEQ, IDA also inspects AFOs, CAFOs, and dairies to ensure compliance with NPDES requirements.
- EPA will be responsible for working with out of state interests in regards to pollutant reductions and monitoring of sources.

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

- Develop BMPs to achieve LAs.
- Give reasonable assurance that management measures will meet LAs through both quantitative and qualitative analyses of management measures.
- Adhere to measurable milestones for progress.
- Develop a timeline for implementation, with reference to costs and funding.
- Develop a monitoring plan to determine if BMPs are being implemented, individual BMPs are effective, LA and WLA are being met, and water quality standards are being met.

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

Feedback Loop and Adaptive Management

The feedback loop is a component of the Salmon Falls Creek Subbasin TMDL strategy that provides for accountability of plan goals for various pollutants. As part of the TMDL process, the Salmon Falls Creek TMDLs will use adaptive management as a style and process whereby management of the watershed is initiated by the state, federal agencies, and the water user industries, then, an evaluation process will ascertain the direction in which the reductions are progressing, and, based on monitoring information collected from various agencies, organizations, and water users refine the goals, targets, and BMPs based on short-term and long-term objectives for ecosystem management of the Salmon Falls Creek watershed. Past management experiences may be used to evaluate both success and failure and to explore new management options where necessary. By learning from both successes and failures, the Salmon Falls Creek TMDL will be iterative to allow implementation of those techniques which may be most useful and helpful, as well as gain insights into which practices best promote recovery for restoration of beneficial uses and state water quality standards (Williams et al. 1997).

For the Salmon Falls Creek Subbasin the main goal is to reach the preliminary in-stream water quality target of 576 col/100 ml *E. coli* for all tributaries and to maintain the low TSS annual mean value already existing in most of the other systems. Additionally, for the Salmon Falls Creek Subbasin an additional main goal is to reach the preliminary in-stream water quality target of 0.05 mg/L TP for the stream systems feeding Salmon Falls Creek and Cedar Creek Reservoirs. These preliminary targets are set up in this way to allow for modifications in the targets over the next 10-15 years to attain beneficial uses and meet state water quality standards.

In order for the feedback loop to be successful in the Salmon Falls Creek TMDLs, a concrete mechanism has to be designed with short-term and long-term goals for DEQ, other agencies, and the Salmon Falls Creek citizen groups. These entities must regularly review the implementation progress and monitoring results and evaluate plan effectiveness. Sufficient flexibility in management plans must be incorporated to allow for corrections in management strategies that may not be effective in achieving beneficial uses or state water quality standards. Nonpoint source industries will follow the feedback loop by: 1) identifying critical water quality parameter(s); 2) developing site-specific BMPs; 3) applying and monitoring BMPs; 4) evaluating effectiveness of BMPs by comparing established water quality standards; and 5) modifying the BMPs where needed to achieve water quality goals.

DEQ will review all monitoring results and will provide an opportunity for the Salmon Falls Creek residents and EPA to review and comment on them. Each industry should provide summary review/reports to DEQ on its monitoring efforts, strategies, and on-going reduction mechanisms. Each industry should provide its own data in its reports. Based on these reports and other data, the Salmon Falls Creek Subbasin TMDL will be revised accordingly as an iterative plan. All industry plans will also be iterative and further developed through adaptive management as new knowledge and technology are discovered for pollution reduction efforts.

Additionally, because of the diverse nature of the partnerships and commitments within the Salmon Falls Creek Subbasin citizen groups from various agencies, organizations, and water users, both restoration and education efforts will be guided by DEQ via the Soil Conservation Districts. The citizen groups will take advantage of partner technical knowledge, experience, existing management plans, and resources in determining which types of activities are appropriate for continued implementation of the Salmon Falls Creek Subbasin TMDL. The MidSanke WAG will continue to meet as needed. If needed, a technical advisory committee may be developed through the Soil Conservation District and DEQ. As a result, the citizen groups will have available to them the technical expertise of biologists, hydrologists, range conservationists, foresters, and other water quality and watershed specialists. Monitoring done by the various agencies, organizations, and water users will be evaluated by DEQ, the technical advisory committee, and citizen groups as a feedback mechanism. This will provide the citizens of the Salmon Falls Creek Subbasin an evaluation that is scientifically based with an understanding of local constraints. Through such adaptive management, scientific knowledge will be adapted to the task of watershed restoration by the residents of the subbasin almost immediately.

Monitoring and Evaluation

The objectives of a monitoring effort are to demonstrate long-term recovery, better understand natural variability, track implementation of projects and BMPs, and track effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the “reasonable assurance of implementation” for the TMDL implementation plan.

The implementation plan will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. The mechanism for tracking specific implementation efforts will be reports submitted to DEQ.

The “monitoring and evaluation” component has two basic categories:

- Tracking the implementation progress of specific implementation plans; and
- Tracking the progress of improving water quality through monitoring physical, chemical, and biological parameters.

Monitoring plans will provide information on progress being made toward achieving TMDL allocations and achieving water quality standards and will help in the interim evaluation of progress as described under the adaptive management approach.

Implementation plan monitoring has two major components:

- Watershed monitoring and

- BMP monitoring.

While DEQ has the primary responsibility for watershed monitoring, other agencies and entities have shown an interest in such monitoring. In these instances, data sharing is encouraged. The designated agencies have primary responsibility for BMP monitoring.

Watershed Monitoring

Watershed monitoring measures the success of the implementation measures in accomplishing the overall TMDL goals and includes both in-stream and in-river monitoring. Monitoring of BMPs measures the success of individual pollutant reduction projects. Implementation plan monitoring will also supplement the watershed information available during the development of associated TMDLs and will fill data gaps.

In the Salmon Falls Creek Subbasin TMDLs, watershed monitoring has the following objectives:

- Evaluate watershed pollutant sources,
- Refine baseline conditions and pollutant loading,
- Evaluate trends in water quality data,
- Evaluate the collective effectiveness of implementation actions in reducing pollutant loadings, and
- Gather information and fill data gaps to more accurately determine pollutant loading.

BMP/Project Effectiveness Monitoring

Site or BMP-specific monitoring may be included as part of specific treatment projects if determined appropriate and justified and will be the responsibility of the designated project manager or grant recipient. The objective of an individual project monitoring plan is to verify that BMPs are properly used and maintained and are working as designed. Monitoring for pollutant reductions at individual projects typically consists of spot checks, annual reviews, and evaluation of advancement toward reduction goals. The results of these reviews can be used to recommend or discourage similar projects in the future and to identify specific watersheds or reaches that are particularly ripe for improvement.

Evaluation of Efforts over Time

Reports on progress toward TMDL implementation will be prepared to provide the basis for the assessment and evaluation of progress. Documentation of TMDL implementation activities, actual pollutant reduction effectiveness, and projected load reductions for planned actions will be included. If water quality goals are being met, or if trend analyses show that implementation activities are resulting in benefits that indicate that water quality objectives will be met in a reasonable period of time, then implementation of the plan will continue. If monitoring or analyses show that water quality goals are not being met, the TMDL implementation plan will be revised to include modified objectives and a new strategy for implementation activities.

Implementation Time Frame

The implementation plan must demonstrate a strategy (Table 91) for implementing and maintaining the plan and the resulting water quality improvements over the long term. The timeline should be as specific as possible and should include a schedule for BMP use and/or evaluation, monitoring, reporting dates, and milestones for evaluating progress. There may be disparity in timelines for different subwatersheds or pollutants. This is acceptable as long as there is reasonable assurance that milestones will be achieved.

The implementation plan will be designed to reduce pollutant loads from sources to meet TMDLs and water quality standards. DEQ recognizes that where implementation involves significant restoration, water quality standards may not be met for quite some time. In addition, DEQ recognizes that technology for controlling nonpoint source pollution is, in some cases, in the development stages and will likely take one or more iterations to develop effective techniques.

A definitive timeline for implementing the TMDL and the associated allocations will be developed as part of the implementation plan. In the meantime a compliance timeframe (Table 91) will be developed in this document as part of the implementation strategy. The final implementation plan timeline will be developed in consultation with the WAG, the designated agencies, and other interested publics as the implementation plan is developed. In the interim, the timeframe outlined here will be used.

Table 91. Implementation strategy goals and time frame for nonpoint sources.

Industry	Year 1.5	Year 3	Year 10	Year 15	Year 25
Agriculture	Develop implementation plan for private lands	Begin BMP[a] implementation	Document BMP implementation progress for DEQ database	Reevaluate targets and reductions	Meet reviewed TMDL targets; beneficial uses fully supported
Grazing	Federal agencies review allotment management plans	Begin allotment management adjustments as necessary	Document BMP implementation progress for DEQ database	Reevaluate targets and reductions	Meet reviewed TMDL targets; beneficial uses fully supported

Industry	Year 1.5	Year 3	Year 10	Year 15	Year 25
DEQ	Maintain database; review nonpoint source efficacy data; seek funding	Collect data to determine water quality trends	Collect data to determine water quality trend, BMP effectiveness, and beneficial use support	Reevaluate targets and reductions, assess beneficial uses	Collect data to determine water quality trend, BMP effectiveness, and beneficial use support

[a] BMP = Best management practice.

5.6 Conclusions

All streams examined had excess heat loads due to a lack of shade. Shoshone Creek and Salmon Falls Creek had the largest excess loads due to their size, although percent reductions to achieve loading capacities were only 40% and 20%, respectively. In order to prioritize water bodies, individual waters should be examined to see the differences between existing shade and target shade on a reach by reach basis. Those streams and reaches with the largest difference between existing and target shade are candidates for priority implementation. Additionally, any coupling of sediment and temperature problems on specific reaches should also be priorities as remedies for both often result in the same BMP practices. Such candidates would include most tributaries examined in this analysis.

In addition to shade, all streams examined had excess sediment loads due to poor bank stability, which is not surprising considering that riparian vigor and bank stability are closely related. Salmon Falls Creek and Cottonwood Creek had the largest excess sediment loads. Priority water bodies, those streams with high excess loading and high percent reductions should be examined for possible bank stability improvements. Such candidates would include Salmon Falls Creek above the reservoir, Cottonwood Creek, and Big Creek both of which are major tributaries to Shoshone Creek.

In conjunction with poor bank stability, both sections of Salmon Falls Creek had excess loads of suspended sediment. In the upper watershed this is likely tied to poor bank stability; however, in the lower section of the river, below the reservoir the likely sources of the elevated suspended sediment is agricultural runoff. In this area of the subbasin priority should be given to sediment retention ponds and other agricultural based BMPs rather than prioritizing bank stability improvements.

The third most common pollutant of concern was excess nutrients in the form of total phosphorus. Salmon Falls Creek, both above and below the reservoir, had the largest excess loads 149.8 and 119.2 lbs/day respectively. Both reservoirs examined in the subbasin assessment were also highly impacted by nutrients. Priority water bodies for excess nutrients would include Salmon Falls Creek above the reservoir and both Cedar Creek and House Creek. These water bodies have very large impacts on themselves as well as being transmitted to the downstream receiving waters. Nutrient load reductions in the smaller water bodies such as Corral Creek and China Creek would ultimately have an imperceptible effect on the reservoir water quality.

Coupled with the excess TP the lower Salmon Falls Creek had very high excess loading of TN. Approximately 4,469 lbs/day of TN are transported through the reach at high flows, and similar to the suspended sediment issues within that reach of the river, the likely sources are agriculturally based via contamination of the local aquifer by nitrates. The lower reaches of Salmon Falls Creek flow through a nitrate priority area. Nitrate reductions should be carefully considered along with TP and TSS reductions in any final implementation plan for the lower reaches of Salmon Falls Creek.

In general grazing management in the subbasin appears to be managing the contribution of bacteria successfully. The only egregious exceedances of recreation water quality standards was found in Cottonwood Creek. This was in contrast with the outcome of other water quality studies conducted in Southern Idaho, where the most common water quality violations were seen in the recreation standards. Excess bacteria load in Cottonwood Creek was 2.262 x 10^{11} org/day and would require an 88 percent reduction. Again, this is likely tied to the very low bank stability and poor riparian vigor seen in this assessment unit.

Loading analyses for each water body include tables and figures that show when and where existing pollutant loads are greater than target loads and thus where excess loading is occurring. These tables and figures are important tools for prioritizing and directing implementation activities to those areas where BMP implementation is needed the most.

A summary of the assessment outcomes is presented in Table 92 for each assessment unit of the Salmon Falls Creek Subbasin

Table 92. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutants	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cedar Creek Lower ID17040213SK000_04	Flow Alteration Temperature Sediment	Yes	Retain for Flow Alt. TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability
Salmon Falls Creek Lower ID17040213SK001_06 ID17040213SK003_06	Temperature Nutrients Sediment	Yes	TMDLs completed move to Section 4A upon approval. Delist Bact and DO	Existing Shade Excess TP Excess TN Excess TSS

Water Body Segment/ AU	Pollutants	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cedar Creek Reservoir ID17040213SK004_L ID17040213SK004	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval.	Existing Shade Bank Stability Excess TP
House Creek ID17040213SK005	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval. Delist Bacteria	Existing Shade Bank Stability Excess TP
Cedar Creek Upper ID17040213SK006	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval.	Existing Shade Bank Stability Excess TP
China Creek, Corral Creek, Whiskey Slough ID17040213SK007_02	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TP
Salmon Falls Creek Reservoir ID17040213SK007_L	Mercury	Yes	TMDLs completed move to Section 4A upon approval	Fish Tissue
China Creek ID17040213SK008_03	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TP
Salmon Falls Creek ID17040213SK009_06	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TSS Excess TP
North Fork Salmon Falls Creek ID17040213SK010	Temperature	Yes	Add, TMDLs completed move to Section 4A upon approval	Existing Shade
Shoshone Creek ID17040213SK011_04 ID17040213SK013_04 ID17040213SK016_04	Temperature Sediment	Yes	TMDLs completed move to Section 4A upon approval. Delist Bacteria	Existing Shade Bank Stability
Hot Creek ID17040213SK012_03A ID17040213SK012_04	Temperature	Yes	TMDLs completed move to Section 4A upon approval. Delist sediment	Existing Shade
Big Creek/ ID17040213SK014	Temperature Sediment Nutrients	Yes	TMDLs completed move to Section 4A upon approval	Existing Shade Bank Stability Excess TP

Water Body Segment/ AU	Pollutants	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cottonwood Creek ID17040213SK015	Temperature Sediment Nutrients Bacteria	Yes	TMDLs completed move to Section 4A upon approval. Delist DO	Existing Shade Bank Stability Excess TP Excess *E. coli*.

The Salmon Falls Creek Subbasin assessment and TMDL analysis has been developed to comply with Idaho's TMDL schedule. The subbasin assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the Salmon Falls Creek Subbasin located in south central Idaho. The first part of this document, the subbasin assessment, is an important first step in leading to the actual development of TMDLs or pollution budgets for the water quality limited streams of the subbasin.

The starting point for this assessment was Idaho's current §303(d) list of water quality limited water bodies. Nine segments in the Salmon Falls Creek Subbasin were on this list. However, there were 22 water body pollutant combinations. In addition, three additional water bodies were assessed due to bacterial contamination data collected in the past. These water bodies were North Fork Salmon Falls Creek, Big Creek, and the Left Hand Fork House Creek. Bringing the total number of potential TMDLs to 25. The subbasin assessment portion of this document examined the current status of all of these waters, and defines the extent of impairment and causes of water quality limitation throughout the subbasin. Sediment, nutrients, temperature, and bacteria are the listed pollutants in the subbasin. These pollutants were listed on the 1996 §303(d) listed water bodies within the subbasin. Other listed pollutants and stressors include habitat, flow, and unknown. By far the most influential stressor, as noted by the SBA, was flow alteration. In general, the impacts to the beneficial uses were determined by assessing the biological communities and the limited water chemistry data available. When these two data sets were in agreement with one another, appropriate actions, such as completing a TMDL or delisting the stream, were undertaken.

To this end, it was determined that 16 different TMDLs will be completed. Of the original listed water bodies DEQ will delist four of the nine. These include Lower Salmon Falls Creek Reservoir, Mill Creek, Hopper Gulch Creek, and China Creek. Of the three additional streams assessed it was determined that North Fork Salmon Falls Creek was not impaired by bacterial contamination and that all other parameters studied were of exceptional quality during the assessment phase.

Often times the beneficial uses were impacted by flow alteration, which obscured the impacts, if any, of the other pollutants on the beneficial uses. Flow and habitat alteration issues were not discussed at great length in the assessment portion due to current DEQ policy. It is DEQ policy that flow and habitat alterations are pollution and therefore not "TMDLable" pollutants. These forms of pollution will remain on the §303(d) list;

however, TMDLs for these two parameters will not be completed on segments listed with altered flow or habitat as a pollutant at this time.

The next phase was the development of the loading analysis or pollution budgets for the 16 different water body pollutant combinations. The loading analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards. In addition, the pollution budgets must contain discussions of back ground levels, margin of safety, and seasonality.

The load capacity for each water body pollutant combination was developed using the information gathered during the assessment phase. The most important of this information was the hydrography of a stream and time of the year in which the various beneficial uses were likely to be impaired by specific pollutants. Only three streams in the subbasin have USGS gauge information available. For the remaining streams a relationship with this gauged data was developed to predict the hydrology. In all but one case, the relationship was significant and included much of the variability of the data.

Other components of load capacity include targets for the different pollutants. In general DEQ adopted targets developed in other TMDLs. For example, the Salmon Falls Creek Sediment targets include percent bank stability which was presented in TMDLs from the Idaho Falls DEQ Region, and suspended sediment targets of 50 mg/L TSS as presented in TMDLs developed from the Twin Falls Region. In addition to these sediment targets DEQ adopted nutrient targets from guidelines and recommendations from EPA. These targets are 0.100 mg/L TP for free flowing streams, 0.050 mg/L for streams entering into a lake or reservoir, and 0.025 mg/L for waters within a reservoir or lake. To many local stakeholders this may appear overly conservative. However, through the adaptive management loop the target will be reevaluated. It is likely that beneficial uses may be fully supported at concentrations differing from 0.100, 0.050, and 0.025 mg/L. In the meantime, as we reduce from current levels, with unsupported beneficial uses, towards fully supported beneficial uses the target will be reassessed. Once beneficial uses are restored the targets will be adjusted to that value which should be at some level greater than the natural background level documented in the Salmon Falls Creek Subbasin for free flowing streams and rivers.

Seasonality plays a strong role in the Salmon Falls Creek Subbasin. In most cases the beneficial uses are impacted during the summer months. The pollutants typically causing the impairments are sediment, nutrients, and bacteria. The change in pollutants has a strong correlation to grazing activities in the different watersheds. Although no statistical interpretation of this correlation was made. In general, the rise in pollutants also coincided with summer base flow conditions. Therefore the load capacity and other subsequent calculations were made using summer base flow or other appropriate design flows as indicated in the state water quality standards; such as, greater than 1 cfs for cold water aquatic life.

A MOS is required in the TMDL regulations of the Clean Water Act. This is to account for uncertainty in the TMDL and how that budget restores beneficial uses. In the Salmon

Falls Creek Subbasin TMDLs the required margin of safety was two-fold. The first of these was an explicit margin of 10 percent. The explicit MOS allows DEQ greater freedom in other aspects of the TMDL process in that the implicit MOS can be assumed rather than arduously explained at every turn. That being said, the Salmon Falls Creek Subbasin TMDLs include an implicit MOS as well. The best example of this may lie in the bacteria TMDLs determination of background. The background levels used in these TMDLs may be slightly higher than actual background levels, as determined from other watersheds. These elevated levels reduce the available load for waste load allocations and load allocations thereby providing an implicit MOS for each watershed. In future studies the actual background level may be determined in greater detail, which, in turn, would reduce the implicit MOS. Therefore, the explicit MOS is a required element of these TMDLs.

As we move forward with implementation of the Salmon Falls Creek Subbasin TMDLs, local stakeholders and concerned publics should see the value of adaptive management. As our understanding of the water quality issues grows so should our ability to change the current TMDLs. Especially as the current TMDLs were based upon a limited amount of data collected in a short amount of time.

Future iterations of the Salmon Falls Creek Subbasin Assessment and TMDLs will include newly listed §303(d) listed water bodies. These will be added as appropriate either as an addendum or in a separate document.

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GIS Coverages

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Other Related Documents

Twin Falls County population information: http://www.idoc.state.id.us

EPA Basins information: http://www.epa.gov/OST/BASINS/

Idaho Department of Fish and Game's species of special concern: www2.state.id.us/fishgame/info/nongame/ngconcern.htm

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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.
Flow Duration Interval	A FDI can also be referred to as a flow recurrence interval. Extremely high flows are rarely exceeded and have low FDI values; very low flows are often exceeded and have high FDI values.
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.

Load Duration Interval

A load duration or load capacity curve is created from a flow duration curve by multiplying the flow values by the applicable water quality criterion or target and a conversion factor. The independent x-axis is the load duration interval and the dependent y-axis is the load, at that point in the watershed, and represents the allowable load (or the load capacity) at each flow condition.

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.

River
A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.

Runoff
The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground

	zones (interflow), and through ground water to creates streams.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Settleable Solids	The volume of material that settles out of one liter of water in one hour.
Species	1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.
Spring	Ground water seeping out of the earth where the water table intersects the ground surface.
Stagnation	The absence of mixing in a water body.
Stenothermal	Unable to tolerate a wide temperature range.
Stratification	A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).
Stream	A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.
Storm Water Runoff	Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and

directly into the stream. The water often carries pollutants picked up from these surfaces.

Stressors

Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Subbasin

A large watershed of several hundred thousand acres. This is the name commonly given to 4th field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)

A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed

A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units.

Surface Fines

Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 millimeters depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.

Surface Runoff

Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.

Surface Water

All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Suspended Sediments

Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Taxon

Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).

Tertiary

An interval of geologic time lasting from 66.4 to 1.6 million years ago. It constitutes the first of two periods of the Cenozoic Era, the second being the Quaternary. The Tertiary has five subdivisions, which from oldest to youngest are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs.

Thalweg

The center of a stream's current, where most of the water flows.

Threatened Species

Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Total Maximum Daily Load (TMDL)

A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Dissolved Solids

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Toxic Pollutants

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Tributary

A stream feeding into a larger stream or lake.

Trophic State

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

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

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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 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.
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. State and Site-Specific Standards and Criteria.

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring spawning salmonids, the default spawning and incubation period recognized by DEQ is generally from March 15th to July 1st each year (Grafe et al., 2002). Fall spawning can occur as early as August 15th and continue with incubation on into the following spring up to June 1st. As per IDAPA 58.01.02.250.02.e.ii., the water quality criteria that need to be met during that time period are:

> 13°C as a daily maximum water temperature,
>
> 9°C as a daily average water temperature.

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of highest annual MWMT air temperatures) is compared to the daily maximum criterion of 13°C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during these time periods. If potential natural vegetation targets are achieved yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401.*

Section 401 relates to point source wastewater treatment requirements. In this case if temperature criteria for any aquatic life use is exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3°C (IDAPA 58.01.02.401.03.a.v.).

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Appendix C. Data Sources

Table C-1. Data sources for Salmon Falls Creek Subbasin Temperature TMDLs.

Water Body	Data Source	Type of Data	When Collected
Salmon Falls Creek Shoshone Creek and Associated tributaries	DEQ Regional Office	Pathfinder effective shade and stream width	July –September 2006
Salmon Falls Creek Shoshone Creek Associated tributaries	DEQ State Technical Services Office	Aerial Photo Interpretation of existing shade and stream width estimation	Based on 2004 NAIP imagery
Salmon Falls Creek Shoshone Creek Associated Tributaries	DEQ IDASA Database	Temperature	

Table C-2. Data sources for Salmon Falls Creek Sediment TMDLs.

Water Body	Data Source	Type of Data	When Collected
Salmon Falls Creek Shoshone Creek, Cedar Creek, and Associated Tributaries	DEQ Regional Office	Bank Height, Bank Stability, and Recession Rate Estimates.	July –September 2006

Table C-3. Data sources for Salmon Falls Creek Subbasin Load Duration Curve TMDLs.

Water Body	Data Source	Type of Data	When Collected
Salmon Falls Creek Shoshone Creek, Cedar Creek, and Associated tributaries Associated tributaries	DEQ Regional Office	Flow Data, Water Chemistry Grab Samples	2005-2006
Salmon Falls Creek Shoshone Creek, Cedar Creek, and Associated Tributaries	IASCD Twin Falls Regional Office	Flow Data, Water Chemistry Grab Samples	2000-2006
Salmon Falls Creek	USGS/EPA STORET	Flow Data, Water Chemistry	1970-1991
Salmon Falls Creek at San Jacinto Cedar Creek House Creek Salmon Falls Creek near Hagerman Salmon Falls Creek Reservoir Cedar Creek Reservoir	USGS web portal	Daily Average Discharge (cfs) or Reservoir storage (acre/feet)	Various (1910-date)

Table C-4. Data sources for Salmon Falls Creek Reservoir Mercury TMDLs.

Water Body	Data Source	Type of Data	When Collected
Salmon Falls Creek Shoshone Creek, China Creek, and Salmon Falls Creek Reservoir	DEQ Regional Office	Water Column Total Mercury Concentration.	2005-2006
Salmon Falls Creek Reservoir	DEQ Regional and State Office	Wet Deposition Total Mercury Concentration Weekly precipitation Daily Average Temperature Daily Average Wind Speed	2006-2007
Salmon Falls Creek, Shoshone Creek, Salmon Falls Creek Reservoir	DEQ Regional Office	Total Mercury Concentration Fish Tissues	August 2005 October 2007
Salmon Falls Creek Reservoir	DEQ State Office	Mercury Species Air Concentrations	2006-2007
Salmon Falls Creek Reservoir	DEQ State Office	Sediment Mercury Flux	April 2005

Appendix D. Distribution List

Idaho Department of Environmental Quality. Technical Editor.

Marti Bridges. Idaho Department of Environmental Quality. TMDL Program Manager.

Balthasar Buhidar. Idaho Department of Environmental Quality. Regional Manager.

Mike Etcheverry. Idaho Department of Environmental Quality. Implementation specialist.

Sue Switzer. Idaho Department of Environmental Quality. TMDL Writer.

Sean Woodhead. Idaho Department of Environmental Quality. BURP Coordinator. Idaho Department of Environmental Quality.

Don Essig. Idaho Department of Environmental Quality. Water Quality Standards Manager.

Martha Turvey. U.S. Environmental Protection Agency.

Leigh Woodruff. U.S. Environmental Protection Agency.

Randy Pahl. Nevada Department of Environmental Protection.

Steve Davis. U.S. BLM.

Mid-Snake Watershed Advisory Group Members.

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Appendix E. Public Comments

Comment 1

Name: Mike Abbott
Email Address: michael.abbott@inl.gov
Affiliation: INL
Comments:

1. Overall excellent and very thorough work.

Thank you for your review and comments.

2. p. 154 – Mercury hazards to wildlife. Saying "there are no known instances of mercury intoxication of wildlife in Idaho" implies that there is not a problem or threat. We basically don't know if there is a problem because nobody has looked into it. Additional work that could be done includes: (1) some inventory of wildlife that feed on fish in important wildlife/aquatic habitats in the State (e.g., loon, cormorant, osprey, mink), (2) a review of published work in this area (e.g., Lane and Evers recent work on Saltmarsh Sharp-tailed Sparrow), (3) incorporation into the State's mercury program plans for some reconnaisance sampling of critical species in sensitive wildlife areas. Although I realize there will be budget restraints on this, the wildlife issue is a critical data gap that will need some investigation before the DEQ can state their rules are protective of human health and the "environment."

Mercury hazards to wildlife have now been identified as a data gap. As per your suggestions the additional work was included in the text. Funding sources and work plans to fill this data gap will be sought after during the implementation phase of the TMDL.

3. p. 159 – Geologic sources. Does the DEQ have any soil sampling data from the SF watershed? This information is badly needed to really assess whether geologic sources in the watershed are contributing. The references in this section to "naturally enriched soils" and the Engle et al. (2001) paper apply to a known naturally enriched hot spot area in the Carlin Trend of NV, outside the SF watershed. There are several unfounded statements/implications in this section that the soils in the SF watershed would also be naturally enriched. Are there naturally enriched soils in the area where water is flowing into the reservoir (i.e., the Salmon Falls Sub-basin)? If unknown, this should also be a DEQ sampling priority. The inference that soils in the SF sub-basin could be similar to those in the Ivanhoe district (historical mercury mine well to the southwest of the SF sub-basin) and the flux estimates on the second to last paragraph (71 – 723 kg/y) are pure speculation and not based on any geological analysis/interpretation. There is an on-line USGS database that indicates soils in this area are relatively low in Hg content.

Two contrasting soil emission fluxes were presented in the paragraphs in question. The first was the very high levels associated with the Ivanhoe Mining District in the Carlin Trend . The second from an area with low mercury enriched soils. These two contrasting flux estimates were meant to show the range which could be occurring in the Salmon Falls Watershed and were not included in the loading estimates used for the reservoir. As stated in the section, the soil emission fluxes were assumed to be captured in the dry and wet deposition measures. Clearly soil samples are a data gap within the Salmon Falls Watershed, but DEQ felt that the dry deposition and wet deposition measures integrated the mercury flux from the soils sufficiently, so that soil samples were lower priorities. If funding sources are available during the implementation phase soil samples will be collected to augment our understanding of the sources of mercury.

4. p. 159 – Atmospheric sources. Please provide a reference for the statement, “In general, the global atmospheric “background” load is increasing as a result of industrialization.” The published research I have seen generally states that global levels are fairly constant now (offsetting decreases in industrialized countries and increases in some developing countries). And there are numerous EPA-published data showing U.S. emissions have significantly decreased.

The text in the paragraph in question was modified to reflect that mercury emissions in Europe and North America have decreased while those emission in Asia and other industrializing nations is increasing. The question remains if those reductions are off setting the increases from the emerging industrial nations. Several studies in the arctic, peat bogs in particular, indicate that global mercury levels are increasing, and a mercury model presented in the following publication indicates that global mercury levels may also be increasing.

Lamborg, C.H., W.F. Fitzgerald, J. O’Donnell and T. Torgersen. 2002. A non-steadystate compartmental model of global-scale mercury biogeochemistry with interhemispheric atmospheric gradients. Geochim. Cosmochim. Acta. 66(7):1105-1118.

5. p. 160 – 1st paragraph. There are published studies that indicate dry deposition is definitely greater than wet deposition in arid western locations. These include studies in New Mexico, Nevada, and in the Salmon Falls Creek area (in press) in addition to modeling studies (e.g., Lin et al., Atmos Env. 41, 6544), which found that dry deposition accounted for 2/3 of the total deposition.

This paragraph was intended to introduce both wet and dry deposition. The intent was not to indicate which was more prevalent. However, text was added to indicate that dry deposition is typically greater than wet deposition in arid environments.

6. p. 160 – 2nd paragraph. The amount of air monitoring data in the SF sub-basin (6 seasons of sampling) is actually fairly extensive (not

"very limited") compared to other published studies in the U.S. (and certainly western U.S.).

Thank you for this clarification. I am more familiar with water quality studies, and as a result the number of sampling events seemed small from that perspective. The text was modified to reflect your comment.

7. p. 163 – Table 29. The EPA TRI has had two annual updates since the 2003 numbers reported here. The latest 2005 TRI gives about 2100 kg/year for these mines. Also, there are more current 2006 values available from NDEP that I believe DEQ has access to. These indicate total mine Hg emissions of 4593 lb/yr (roughly the same as the 2005 TRI).

Table 29 was updated to include EPA TRI data from 1998 through 2005.

8. p. 160 – 163 – Atmospheric sources. There are numerous statements in here about source elemental Hg0 emissions having long transport distances and contributing only to the global pool of Hg. This suggests (to the uninformed reader) that high Hg0 emissions from these sources just blow away and have no impact in the SFCR area. The SF dry deposition study (which has been accepted for publication in Applied Geochemistry in Dec.) and other published studies in NV and NM have found that Hg0 deposition may be dominant in some areas even though there is uncertainty about the net exchange because of re-emission loss (which has not been well quantified). In addition, it is well known (and stated previously in this report) that some of the Hg0 is oxidized in transport to Hg+2, which can significantly increase its local deposition. Also, there are numerous published modeling studies that do show a deposition hot spot around the mines (e.g., Lin et al., Atmos Env. 41; and the EPA's Dwight Atkinson's study presented to DEQ). Finally, there are NDEP-reported stack gas speciation data (2006 Tier-1 Mercury Speciation Source Test Data) for at least four of the major mine sources that show some of these mines emit much more Hg+2 than originally thought. All of this has not been mentioned in the report. However, as it reads right now, DEQ is suggesting that these sources are not an issue for local deposition of Hg in the SF watershed, which the preponderance of evidence does not support. I recommend getting rid of these suggestive statements or give the complete story.

The statements made concerning transport distances were removed from the text. However DEQ determined that the paragraphs where transport was discussed in general would remain.

9. p. 169 – 2nd paragraph, 1st sentence. It's not clear whether you're referring to the Lake Champlain cores (that's what's referenced) or the SFCR cores.

The reference was for the Lake Champlain cores. These paragraphs were edited for more clarity.

Comment 2

Name: Leigh Woodruff, Watershed Unit, EPA
Martha Turvey, Watershed Unit, EPA
Affiliation: EPA
Comments:

1. Thank you for providing a draft of the Salmon Falls TMDL for our review. As discussed in our recent conversation Bruce Cleland, Watershed Unit, EPA, also reviewed the load duration curves in this document for accuracy and consistency. The following are our recommendations and comments.

2. In general we recommend IDEQ consider organizing Section 5 by pollutant. It would be much easier to read/review if all the critical elements (targets, loading, load capacity, allocations) were organized by pollutant and were located in the same area within this chapter. As it is you have to skip back and forth within the chapter to compare loading, targets, allocations, etc.

> Section 5 of the document was organized by critical element of a TMDL, as per the DEQ's TMDL template. This organization scheme allows the TMDL writer to address all elements of a TMDL in a step by step approach rather than repeating each critical element of the TMDL for each pollutant.

3. Temperature data. The document should include a description and analysis of existing temperature data (or the lack of temperature data). For example, where and when violations of water quality standards occur should be described. The patterns of the temperature data and how this information can be used in the implementation of the TMDL should be explained. If some of the unlisted tributaries have temperature data showing that they do not meet the standards, this should be described as well. If the waters are not meeting standards, and are covered by this TMDL, they would not need to be put on the 303(d) list, but would be included in Category 4a of the integrated report for waters with a TMDL.

> Temperature data is limited throughout the subbasin. In most cases single instantaneous measures are all that exist. DEQ conducted the existing shade evaluation of the streams of the subbasin and found that most if not all were in categories that would indicate temperature violation should be occurring. In those cases where continuous data were available the data confirmed the existing shade analysis. Therefore DEQ opted to completed shade TMDLs on all water bodies regardless of the presence or absence of continuous temperature records. If during implementation of a shade TMDL a Stakeholder or other interested party objects to this methodology a continuous temperature recorder can be placed within the system to determine the magnitude of the temperature violation.

4. Shade targets for tributaries. We applaud your inclusion of a number of tributaries to the four listed streams in your temperature analysis. However, we are concerned that there could be cumulative

impacts from the other smaller tributaries which occur basin-wide. Due to the cumulative effects of temperature increases and the potential impacts of these smaller tributaries on the temperature of listed segments, PNV shade targets should be set for the tributaries or the tributaries should be shown to be in a natural state to ensure natural stream temperatures will be achieved in the listed segments. We would like you to consider the idea of a gross allocation to smaller tributaries in this TMDL, to send the message that riparian vegetation should be in a natural state along all the streams. Specific shade targets for specific reaches on smaller streams could be identified at a later implementation phase.

Language added that indicates that all tributaries need to be at natural conditions.

5. Field verification of shade. The document indicates that solar pathfinder data were used to verify existing shade levels. We recommend including this information in the document (appendix) and explaining how it was used in the analysis. For example, if the field data varied from the aerial photo estimates of shade, were the estimates adjusted based on the field data, and if so, how was that done?

Language added describing how pathfinder data was used.

6. Areas where existing shade is greater than target shade. The assessment methodology and target selection processes are not precise. Areas identified as having shade above target levels are described as “Exceeds Target” (Figure 30). These areas should be considered as critical areas for protection to ensure natural temperature conditions. However, the current method of averaging the targets over the whole table utilizes these healthy shade areas to average out impacted areas along other reaches of the stream. (See comment below).

Areas exceeding target can result from both an artifact of the technique (slight excess) to actual dense vegetation exceeding expectations. These positive loads are added into the analysis and may offset other negative loads. We have added language that directs people to be concerned about specific differences in existing and targets rather than dwelling on these loading table results.

7. Averaging needed shade improvements. Averaging the needed shade improvements for a water can mask areas of needed restoration. For example, some areas in the Salmon Falls Creek watershed are shown to be lacking 50% - 90% of the expected natural shade. These problematic areas can be ignored if only the average conditions (shown in Table 85) are used as an evaluation criterion for attainment of the PNV approach. This is not an accurate application of the PNV methodology because it does not ensure potential natural stream temperatures. Instead of averaging, we recommend describing the range of improvements needed for the tributaries and referencing reach specific values in Tables 40 - 60. The map you provide showing reach specific values of lack of shade is useful. It would also be helpful to show the percent solar load reductions for each of the reaches in Tables 40 through 60, rather than the summed solar load reduction for the whole subwatershed and, if possible, to link the reaches on the tables to maps of the tributaries.

We have added language that directs people to be concerned about specific differences in existing and targets rather than dwelling on these loading table results.

8. Bankfull channel widths. The document indicates that the Upper Snake curve was used to represent the natural channel widths. What is the basis for the assumption that the Upper Snake curve represents natural channel widths for the Salmon Falls Creek watershed? Were curve values derived from known "natural" watersheds?

Language has been added that describes why Rosgen believes this is a useful tool for estimating bankfull dimensions at ungauged sites.

9. Prioritizing areas for improvement (p. 319). It is reasonable to suggest that land managers might want to initially target restoration on areas with the greatest departure from natural shade. The document indicates that
"… Those streams with high excess loading and percent reductions greater than 20% should be examined for possible shade recovery …" Without further discussion, this section suggests that only those areas with >20% shade reductions might need shade recovery, which is not consistent with achieving natural conditions throughout the watershed. One suggestion to address this issue is the following revision:
"… Those streams with high excess loading and percent shade reductions greater than 20% should be examined first for shade recovery, followed by streams in need of lesser shade reductions .…"

It should be made clear, that to meet water quality standards, all areas which show any deviation from natural would need improvement.

The offensive language has been removed.

10. Reservoir impacts. Salmon Falls Creek Reservoir and Cedar Creek Reservoir may have a significant effect on the temperature of these two creeks. Currently these effects are not assessed in the TMDL, and we recognize that doing so is not a quick or easy process. We would like to discuss with IDEQ options for evaluating these impacts and including them in the TMDL.

The design and operation of Salmon Falls Creek Reservoir was described in detail in the document. This reservoir completely eliminates water from the stream system below the reservoir. As a result the stream is "refilled" from groundwater systems if at all. The temperature impact of the reservoir to the downstream water body is nonexistent so long as the reservoir is operated as it has been for well over 100 years.

Cedar Creek Reservoir's design and operation were also discussed at length in the document. The water quality impacts to Cedar Creek were determined to be dominated by flow alteration. Water is transported, during the irrigation season, through only a small section of the stream. This area may have some temperature impacts from the reservoir, and are insignificant in comparison with the flow alteration of the system. The majority of the stream is dewatered year-round and refills from spring systems if at all. These conditions have also be discussed at length.

11. Page 208, Big Creek Assessment Unit Monitoring Locations: Please explain what is meant by describing in the first paragraph that land use practices in the general area are balanced.

This statement was clarified in the document.

12. Page 249, Shade and Stream Temperature Design: This comment refers to the 2nd and 3rd paragraphs. EPA does not have a problem with the selected shade curves or the selection of the critical time periods to input into the model. However, one of the purposes of the PNV model is to describe what the potential natural shade condition can be achieved at a given reach of stream. This potential is compared to the existing conditions and the difference is calculated. While it may be difficult to achieve this target due to long historic practices that have been consistently damaging to riparian conditions, it should not influence target selection. Target selection should not be biased in favor of historic practices which are preventing water quality standards from being reached. If a riparian community has the potential to reach a shadier willow dominated community and that this will achieve the water quality standard, than that should be what is factored into the model. If monitoring demonstrates that the target is not being reached during the implementation phase of the TMDL, than land management issues can be revisited to address problem areas. I recommend that these paragraphs be revised.

These paragraphs were revised.

13. Nutrients: Overall EPA supports the use of the Ecoregion criteria as expressed in the 2000 EPA Guidance as a more accurate means of developing a site specific target. Below is a comparison of the Ecoregion numbers and the Gold Book which is what is recommended in the TMDL We recommend that the TMDL include an explanation for why the Gold Book values were used as opposed to the Ecoregion Guidance.

	Ecoregion criteria:	SF Creek TMDL (Gold Book)
Total Phosphorus		
Annual Average	.055	0.100 (Cottonwood, SF Creek below Big Cr)
Fall	.035	
Spring	.0725	
Summer	.050	0.50 (Salmon Falls Cr, China Cr House Cr, Cedar Cr)
Winter	.060	
Total nitrogen		
Calculated	0.255	1.5
Reported	0.483	

EPA's ecoregional nutrient criteria guidance were derived to represent conditions of surface waters that are "minimally impacted by human activities" and as a starting point for states to develop their own nutrient criteria. The state of Idaho's water quality standard for nutrients is narrative and is set at such a level that nuisance aquatic vegetation does not occur. As a result this TMDL used values similar to the EPA guidance to determine natural background levels of nutrients. The average natural back ground level in the Salmon Falls Creek Subbasin was between 0.02 and 0.035 mg/L TP and represents minimally impacted by human activity levels. The Gold Book values were developed to address those levels that lead to nuisance aquatic vegetation. The TMDL was developed with the Ecoregion Criteria as a starting point of background and the Gold Book values to determine the level in which nuisance aquatic vegetation does not exist.

14. Editorial Revisions

Thank you for your review, editorial comments have been addressed.

Page 250 and 251: I suggest that you move the Nutrient section to follow the Temperature section so that the Target Selection section for temperature follows the Shade and Stream Temperature Design section.

Throughout the document pollutants were discussed in the following order: Nutrients, Temperature, Bacteria, Sediment, and Mercury. This section does so as well. For consistency within the document it will not be changed.

Table 91, page 321: Since this is a summary table, I recommend that in addition to putting the segment number in the 1st column you also include the name of the segment. For instance, House Creek which is in the Cedar Creek Reservoir water body was listed for bacteria but is recommended for delisting. The column, Recommended Changes to Section 303(d), does not specify which segment is being recommended for delisting. To avoid any confusion in the final document, it would be helpful to clarify these recommendations in the table.

This table was edited for clarity as suggested.

Index