Big Willow Creek Assessment and Temperature Total Maximum Daily Load: Addendum to the Lower Payette River Subbasin Assessment and TMDL

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June 2008

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Michael Ingham, the original author of this document passed away on January 31, 2008, after a long, courageous battle with cancer. Michael started work for DEQ in 1989 and was known as a very hard worker who took tremendous pride in his work in the surface water quality program.

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Cover photo: Big Willow Creek upstream of Fourmile Creek, by Mark Shumar, March 2006.

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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)

ADB assessment database

AFO animal feeding operation

ASL above sea level

AU assessment unit

BAG Basin Advisory Group

BLM United States Bureau of Land Management

BMP best management practice

BURP Beneficial Use Reconnaissance Program

C Celsius

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 unit

cm centimeters

CWA Clean Water Act

CWAL cold water aquatic life

CWE cumulative watershed effects

DEQ Idaho Department of Environmental Quality

DO dissolved oxygen

EPA United States Environmental Protection Agency

EPT Ephemeroptera, Plecoptera, and Tricoptera species

F Fahrenheit

FLIR forward looking infrared

GIS Geographical Information Systems

HUC Hydrologic Unit Code

IDAPA Refers to citations of Idaho administrative rules

IDL Idaho Department of Lands

IDWR Idaho Department of Water Resources

km kilometer

km^2 square kilometer

LiDAR light detection and ranging

LRR land resource region

LA load allocation

LC load capacity

m meter

m² square meter

m³ cubic meter

mi mile

mi² square miles

mg/L milligrams per liter

MCL maximum contaminant level

MLRA major land resource area

mm millimeter

MOS margin of safety

MWMT maximum weekly maximum temperature

n.a. not applicable

NA not assessed

NB natural background

nd no data (data not available)

NHD National Hydrography Dataset

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NREL National Renewable Energy Laboratory

NSDZ near-stream disturbance zone

NTU nephelometric turbidity unit

PCR primary contact recreation

ppm part(s) per million

PNV potential natural vegetation

QA quality assurance

QC quality control

SBA subbasin assessment

SFI DEQ's Stream Fish Index

SHI DEQ's Stream Habitat Index

SMI DEQ's Stream Macroinvertebrate Index

SS salmonid spawning

TIR thermal infrared

TMDL total maximum daily load

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USGS United States Geological Survey

WAG Watershed Advisory Group

WBAG *Water Body Assessment Guidance*

WLA wasteload allocation

WQRP water quality restoration plan

WQS water quality standards

YOY young of the year

Executive Summary

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

This document addresses one water body in the Lower Payette River Subbasin that has been placed on Idaho's current §303(d) list. For more information about this watershed and the subbasin see the *Lower Payette River Subbasin Assessment and Total Maximum Daily Loads.*

The first part of this document, the Subbasin Assessment (SBA), is an important first step in the TMDL. The starting point for this assessment was Idaho's 1998 §303(d) list of water quality limited water bodies. Big Willow Creek, from the headwaters to the mouth, is on this list. The SBA examines the current status of §303(d) listed waters and uses available data to define the extent of impairment and identify potential causes of water quality impairment throughout the subbasin. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition that meets Idaho water quality standards. This TMDL analysis has been developed to comply with Idaho's Total Maximum Daily Loads schedule.

During the development of this TMDL, Idaho published a new list of impaired waters (2002) by Assessment Units (AUs), designated by stream order (Strahler, 1957), and adopted revised water quality standards (2007). The 2002 list was approved by EPA in 2005 and lists Big Willow Creek 1st and 2nd order segments (ID17050122SW017_02), 4th order segments (ID17050122SW017_04), and 6th order segments (ID17050122SW017_06) as impaired for unknown pollutants. There are no identified fifth order stream segments in the Big Willow Creek subbasin, and no corresponding ID number with an 05 suffix. Big Willow Creek from headwaters to mouth was listed as impaired for temperature by EPA and included in Idaho's TMDL schedule.

This document addresses the AUs in the Big Willow Creek subbasin separately and develops a TMDL for temperature for listed AUs using Potential Natural Vegetation (PNV) targets developed for western regions. In order to make this document more readable the AUs will be identified by abbreviated labels as follows.

- ID17050122SW17_02 = AU02
- ID17050122SW17_03 = AU03
- ID17050122SW17_04 = AU04
- ID17050122SW017_06 = AU06

As there are no identified point sources of pollutants in the subbasin at the time this document was developed, all pollutants are presumed to be from nonpoint sources.

Subbasin at a Glance

The Lower Payette River Subbasin, Hydrologic Unit Code (HUC) 17050122, is located in southwestern Idaho, northwest of Boise (Figure A). The Environmental Protection Agency (EPA) added streams that exceeded Idaho's temperature criteria to Idaho's 1998 303(d) list of impaired waters. In the Lower Payette River subbasin, Big Willow Creek from the headwaters to the mouth was among those EPA additions. The Payette River from Black Canyon Dam to its mouth was listed on the Idaho 1998 303(d) list for temperature. A temperature TMDL for this segment of the Payette River has not been developed because, while DEQ acknowledges that reservoirs can affect thermal loads of rivers, methods to accurately and quantitatively define influences from these water bodies have not been developed.

Big Willow Creek is identified in Idaho's water quality standards as waterbody unit 17 (SW17) of 21 waterbodies in the Payette Subbasin (IDAPA 58.01.02). Big Willow Creek is a north side tributary with a total of 209.6 stream miles in the subbasin (DEQ database, 2002), draining an area of approximately 151 square miles (m^2) (USGS, 2008), and entering the Payette River between the cities of New Plymouth and Payette, Idaho (Figure A). Alterations made to Big Willow Creek now prevent the water body from discharging directly into the Payette River. The designated beneficial uses of Big Willow Creek described in Idaho water quality standards (IDAPA 58.01.02) are cold water aquatic life (CWAL), salmonid spawning (SS), and primary contact recreation (PCR) from the source to the mouth. The criteria for these standards is summarized in Section 2, Table 8, and Appendix B of this document.

There are three level IV ecoregions (Figure B) in the watershed which are all subregions of the Snake River Plain level III ecoregion: Treasure Valley, Semiarid Foothills, and Unwooded Alkaline Foothills (McGrath et al., 2002). Average annual precipitation in the watershed is 12.4 inches (USGS, 2008). The primary land ownership in the Big Willow Creek watershed is private landowners, and federal and state government, with land use being approximately 80% rangeland and 20% cultivated irrigated crops (Figure C). The cultivated lands are all located adjacent to Big Willow Creek or its tributaries.

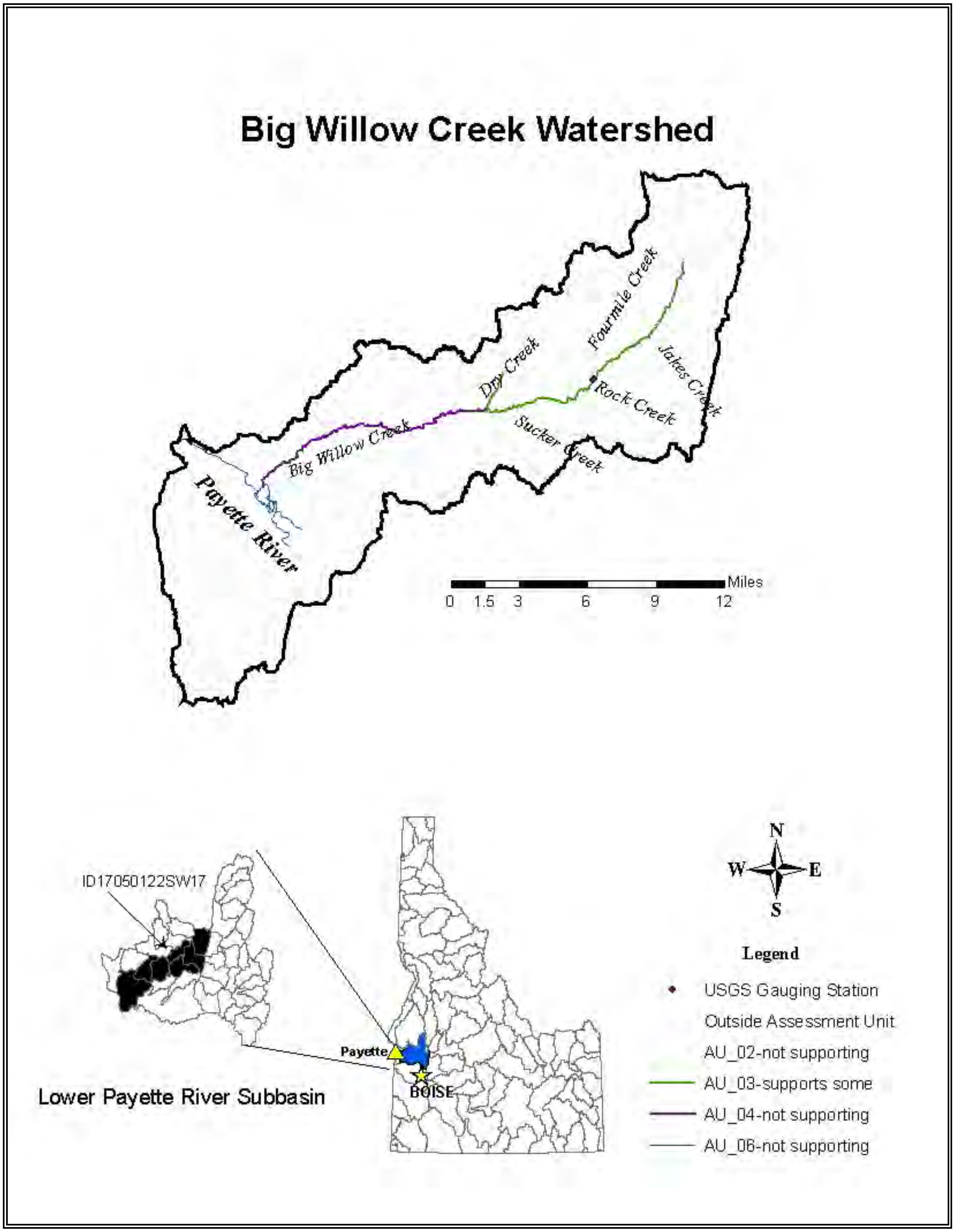

Figure A. Big Willow Creek Watershed. General Location, Surface Water Assessment Unit Designations, and Use Support Determinations

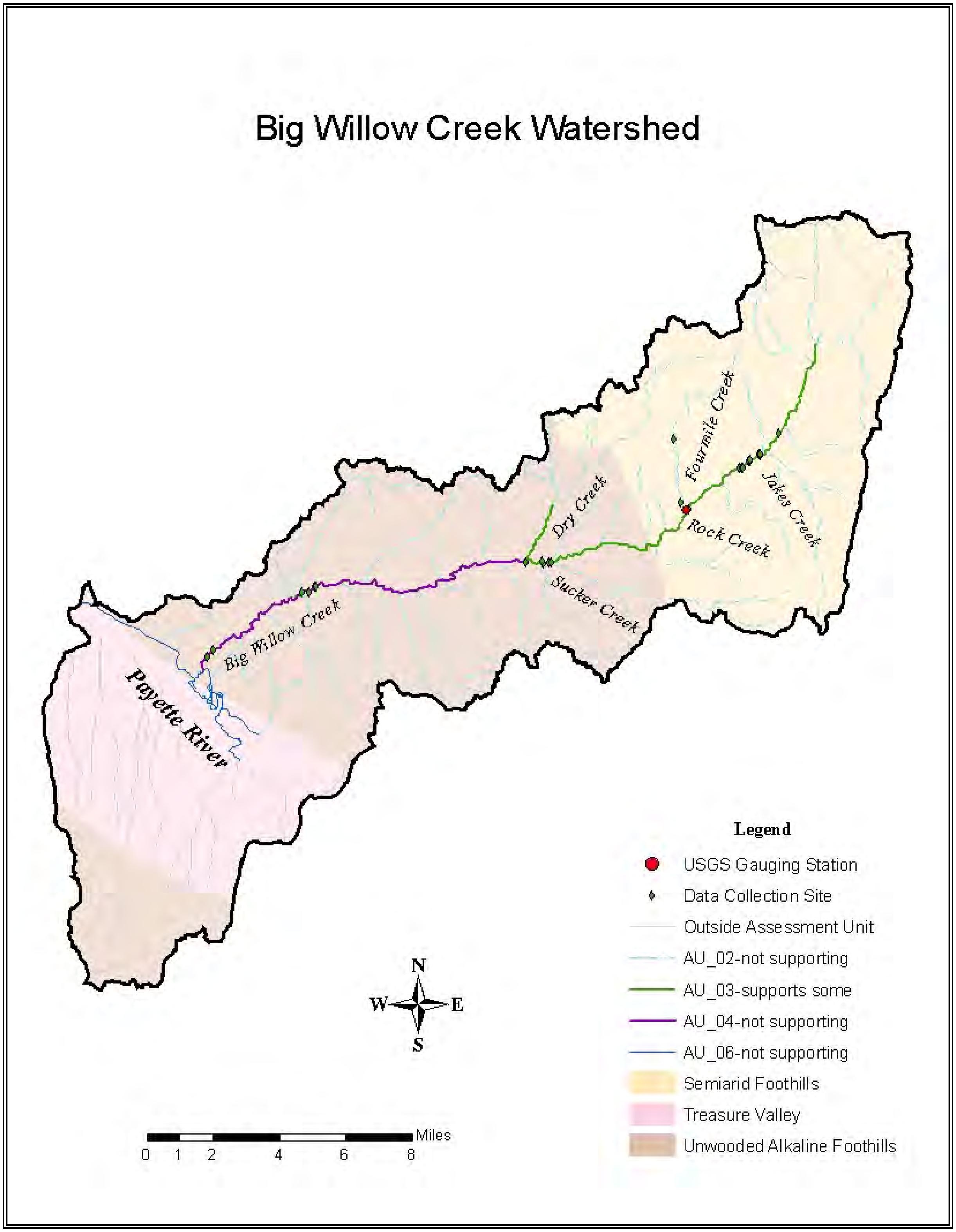

Figure B. Big Willow Creek Watershed Level IV Ecoregions, BURP Data Collection Locations, Surface Water Assessment Unit Designations

The hydrologic record for Big Willow Creek includes monthly measured discharge and water temperature data from 1973 through 1982 at the USGS gauging station near the confluence with Fourmile Creek near the center of AU03 (Figures A, B, C). This data indicate that flow in the watershed is very responsive to precipitation events, with most yearly peak flows occurring in late winter or early spring and low flows occurring in late summer and fall. The data also reflect that as stream flow decreases, water temperature increases (Figure D). The seasonal increase in water temperatures coincides with seasonal increases in air temperature (Figure 3, page 16). A survey of satellite imagery reveals at least 35 surface water controls in the watershed including eight dams regulated by the Idaho Department of Water Resources (IDWR). Idaho water quality standards regard discharges from dams as nonpoint sources, and EPA does not require a permit for any of the structures in the watershed[1]. The regulated dams have the capacity to impound 1,435 acre feet (af) of water and there is presently no method to estimate the unregulated impoundments.

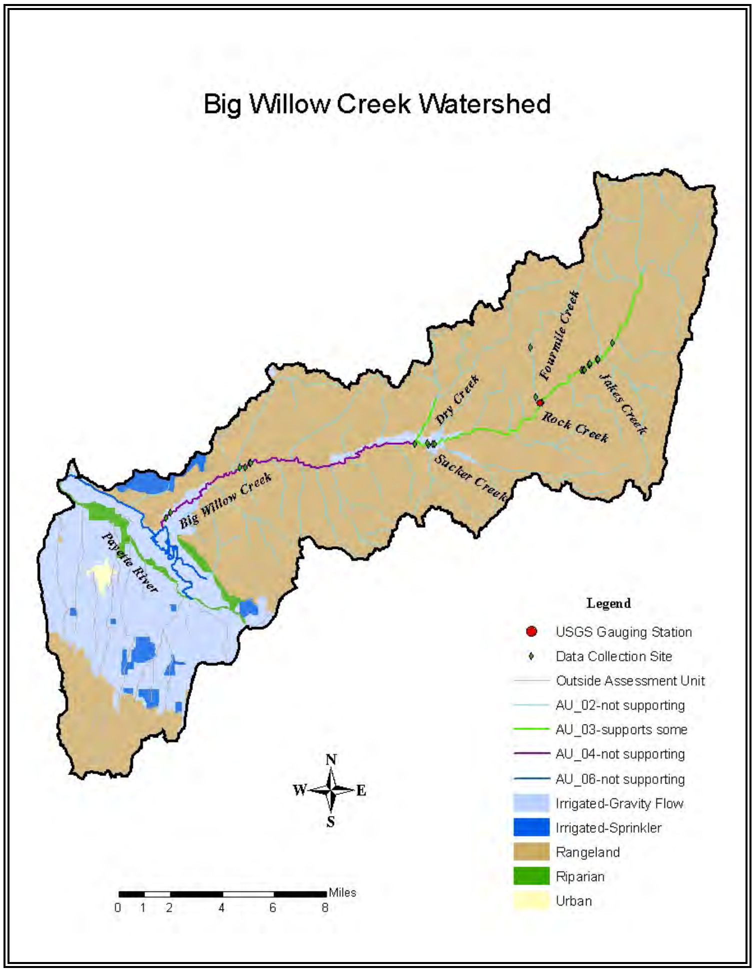

Figure C. Big Willow Creek Watershed Land Cover/Land Use, Surface Water Assessment Unit Designation,s and Related Information

[1] This does not affect Idaho's authority under § 401 of the CWA as determined by S.D. Warren *v.* Maine (2006).

There are two dams and two diversions on the mainstem of the creek and almost all cultivated agriculture is within the floodplain of the mainstem. While DEQ acknowledges that tributaries and flow control structures are likely contributors to temperature impairment, this document addresses the water body presently listed for temperature impairment (Big Willow Creek from headwaters to mouth). This TMDL develops a PNV for the mainstem Big Willow Creek.

Factors known to affect discharge and water temperature include anthropogenic sources such as stream channel alteration, impoundments, diversions, and vegetation removal as well as natural sources such as wildfires, mass wasting events, and floods. Anthropogenic sources are usually associated with land use and can intensify existing natural processes, resulting in increased pollutant delivery to streams. Evaluation of Beneficial Use Reconnaissance Program (BURP) data collected from Big Willow Creek indicate that AU02, AU03, AU04, and AU06 do not support all designated uses and observations made by DEQ assessment personnel confirm that impairments appear to be related to flow and habitat alteration as well as land uses that are known to contribute pollutants to streams through nonpoint sources. Habitat and flow alteration are not pollutants for which TMDLs are developed and nonpoint source pollutant reduction is accomplished through voluntary implementation of improved management practices.

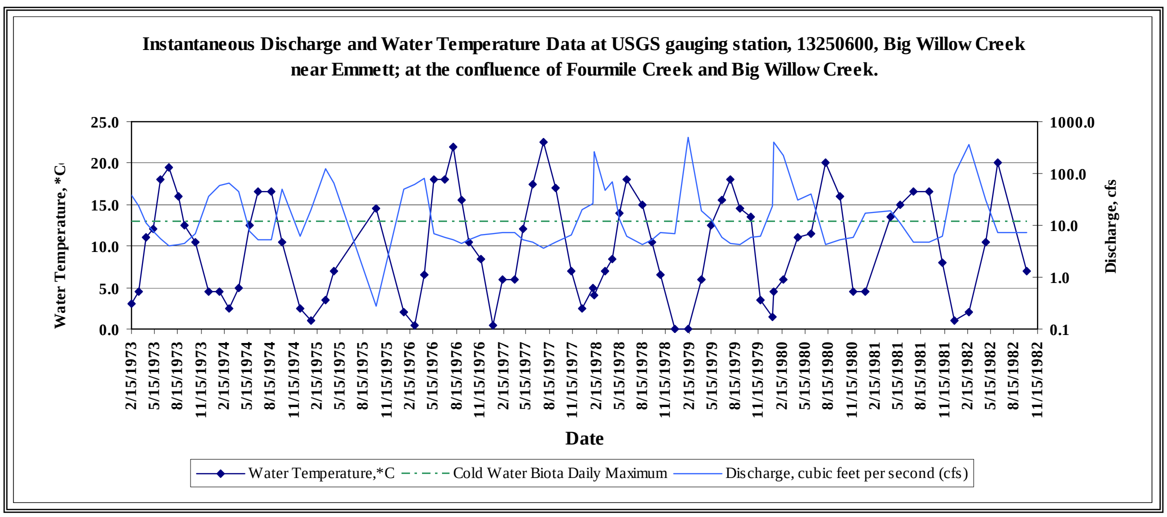

Figure D. Graph of Instantaneous Measured Discharge and Water Temperature from USGS Gauging Station 13250600, Big Willow Creek near Emmett, ID. The Gauging Station is Located near the Confluence with Fourmile Creek. (Figure A, B).

Public Involvement

The Lower Payette Watershed Advisory Group (WAG) began meeting in September 1995 to address water quality issues in the subbasin. After many meetings, the EPA approved a TMDL for bacteria in May 2000.

This draft temperature TMDL was sent to the WAG members and other interested parties in November 2006. A Lower Payette WAG meeting was held on January 11, 2007, and the WAG voted to send this document out for public comments. The public comment period was open from March 26 through May 4, 2007. Display copies of the document were sent to the Payette City Public Library, the WAG, Region 10 EPA, Emmett Public Library, Boise Public Library, IDEQ Boise Region Office, and on the DEQ internet site at www.deq.idaho.gov. News releases seeking public comment on the document were printed at least once between March 26 and April 2, 2007 in the Independent Enterprise (Payette) and Messenger-Index (Emmett) newspapers. Revisions to this document were resumed in January 2008 and the revised draft was sent to the WAG members in April 2008 for review.

Key Findings

Big Willow Creek was placed on the 1998 §303(d) list of impaired waters by EPA for reasons associated with temperature criteria violations (Table A). The original listing on the 1998 §303(d) list had the pollutant of concern listed as “unknown.” The 2002 Integrated §303(d)/305(b) Report has Big Willow Creek listed as a water body not supporting designated use(s) with the pollutant(s) of concern identified as “unknown.”

Table A. Streams and pollutants for which TMDLs were developed, Big Willow Creek.

Stream	Pollutant(s)
Big Willow Creek	Temperature

Since Big Willow Creek was an addition to the 1998 §303(d) list by EPA, it was assumed one of the pollutants of concern would be temperature. To evaluate whether any other pollutant(s) is/are impairing the designated uses in the water body, available biological data was examined to determine whether biological community composition and structure is linked with possible pollutants. An evaluation of land use was conducted to determine what, if any, pollutant associated with a given land use could be causing impairment.

Biological indicators offer mixed results. Benthic macroinvertebrates collected in AU02, AU03, and AU04 from 1994 through 2003 consistently resulted in a distribution of approximately 90% of the organisms tolerant to warm water and 10% tolerant to cold water. Fish data collected from AU03 from 2003 to 2005 included juvenile and adult salmonids, indicating that SS is an existing use in AU03, but not a supported use, based on water temperature data. Bacteria data was collected from AU03, but other AUs have not been assessed for PCR use attainment.

A channel-modifying flood event, estimated to exceed flow volumes expected of a 100-year flood, occurred in the region in late December 1996 and early January 1997. This flood resulted in extensive channel scouring, bank incision, devegetation of the riparian zone, and development of new terraces in AU03 and AU04. BURP data, including percent surface fines, had been collected from a few sites from 1994 through 1996 and data was collected from 1997 through 2005 at several other sites in the subbasin. While the BURP percent surface fines data is relevant for a qualitative habitat assessment, it is not sufficient to conclusively identify potential sources and quantification of sediment pollution in the subbasin. The wide range of percent surface fines and habitat scores collected at BURP locations between 1994 and 2005 indicate that sediment may be limiting attainment of beneficial uses in the subbasin. Idaho has adopted a method for determining sediment targets and quantifying sediment pollution in Idaho streams (Rowe et al., 2003). Further study in accordance with Idaho's guidance document is necessary to determine the degree of beneficial use impairment, by sediment, from natural events, flow and habitat alteration, anthropogenic activity, or some combination of these potential sources. Until a subbasin sediment and bacteria assessment is completed, Big Willow Creek should remain on the Section 5 list for "unknown" impairments.

Evaluation of primary habitat assessment data indicate adequate habitat in AU03 and degraded habitat in AU02 and AU04. AU06 is actively managed as an irrigation water conveyance structure and is not accessible for assessment through the BURP.

Land use in the subbasin is 80% grazing and 20% cultivated agriculture, with most of the streamside land privately held. A survey of satellite images of the subbasin revealed 35 flow control stuctures, most of them in AU03 and AU04. The flow control strucutures include dams, reservoirs, and channel diversions, with at least two dams in the mainstem of AU03. Stream segments downstream of diversions and impoundments are observably dry at various times of the year. Based on the results of information evaluated for this document, temperature is impairing the beneficial uses of Big Willow Creek and AU03, AU04, and AU06 should also be listed for flow and habitat alteration. Most stream segments in AU02 are ephemeral or intermittent in nature and AU06 is actively managed as an irrigation water conveyance structure.

Temperature

Effective shade targets were established for Big Willow Creek based on the concept that maximum shading under potential natural vegetation equals natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in the Northwest. Existing shade was estimated from aerial photo interpretation and field-verified with solar pathfinder data.

Big Willow Creek AU02 includes the headwaters of Big Willow Creek and all 1st and 2nd order tributaries in the subbasin. Most of these stream segments do not exhibit perennial flow and are not anticipated to benefit from active restoration projects. Based on the ecoregion and an analysis of the hydrology specific to the subbasion, ephemeral or intermittent flow in 1st and 2nd order streams is most likely a natural condition. The perennial segments were analyzed for solar load and were found to have excess solar loads from 10 to 70% when compared to proposed shade targets. Big Willow Creek AU03, AU04, and AU06 lack sufficient shade to meet targets and have an excess solar loads between 0 and 52% (approximately 767,000 kWh/day). A reduction in solar loading and an increase in shade between 0 and 35%, as outlined in Section 5 of this document, is necessary for these segments to meet load objectives

Much of the riparian community in AU03 and AU04 was severely disturbed by region-wide flood events in January 1997. The plant community is slowly returning to the newly established floodplain and shade characteristics in those segments are indicative of that recovery. It is anticipated that recovery will continue and that shade levels and solar load levels will meet PNV target reductions in the future.

Other Impairments

The data also indicate impairment in Big Willow Creek associated with flow and habitat alteration. Evaluation of the hydrology and stream morphology of AU03 and AU04 demonstrate a "flashy" hydrologic system with frequent high energy discharges usually associated with rain-on-snow events. Under recent and historic land use practices, Big Willow Creek responded to these events with degradation of stream morphology and near-stream riparian areas.

Implementation of some best management practices (BMPs) since the mid 1990s have resulted in reduced anthropogenic stress on the hydrologic system. Since the last major flood event in 1997, the stream is re-establishing a functional floodplain and bank-stabilizing vegetation is returning. Depending on hydrological events in the near future, and continued implementation of BMPs, stream morphology should continue to recover.

It appears that the CWAL and SS designated uses are impaired in Big Willow Creek and are strongly linked to flow modification and habitat alteration. Flow modification and stream habitat alteration for agriculture can be mitigated using a variety of appropriate BMPs to reduce the impact of no point source activities on water quality in the watershed. Based on the assessment of available data, AU02, AU03, AU04, and AU06 should be placed on Idaho's 4c list for flow and habitat alteration (Table B).

Table B. Summary of assessment outcomes, Big Willow Creek.

Water Body Segment/AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Big Willow Creek 02 03 04 06	Temperature	Yes	Place Big Willow Creek in Section 4a, TMDL Completed.	Potential Natural Vegetation (PNV) TMDL developed.
Big Willow Creek 02 03 04 06	Flow and Habitat Alteration	None required	Place Big Willow Creek in Section 4c of the Integrated Report	Stream habitat alteration and flow modification contribute to non-attainment of designated beneficial uses in the watershed.
Big Willow Creek 02 03 04 06	Unknown		Retain in Section 5	Qualitative habitat data and limited bacteria information indicate further study of potential pollutants is necessary.

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1. Subbasin Assessment - Watershed Characterization

Please refer to the *Lower Payette River Subbasin Assessment and Total Maximum Daily Load* (Ingham, 1999) for overall assessment of the subbasin characteristics.

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards (WQS) 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 WQS). 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 WQS. 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 Big Willow Creek watershed that have been placed on Idaho's current §303(d) list.

The overall purpose of the subbasin assessment (SBA) and TMDL is to characterize and document pollutant loads within the Big Willow Creek watershed. 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 develop a TMDL for each pollutant of concern for the Big Willow Creek watershed (Section 5).

1.1 Introduction

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

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

Background

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

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

These requirements result in a list of impaired waters, called the "§303(d) list." This list describes water bodies not meeting WQS. Waters identified on this list require further analysis. An SBA and TMDL provide a summary of the water quality status and allowable TMDL for water bodies on the §303(d) list. *The Big Willow Creek Subbasin Assessment and Temperature Total Maximum Daily Load: Addendum to the Lower Payette River Subbasin Assessment and TMDL* provides this summary for waters in the Big Willow Creek watershed currently included on the §303(d) list.

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

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

Idaho's Role

Idaho adopts WQS to protect public health and welfare, enhance the quality of water, and protect biological integrity. A WQS 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 anti-degradation provisions.

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

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

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

An SBA entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, spatial, 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 WQS).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identity and location of pollutant sources.
- Determine the causes and extent of the impairment when water bodies are not attaining WQS.

1.2 Physical and Biological Characteristics

Big Willow Creek is a 151-m^2 watershed situated in the northwestern portion of the Snake River Plain Level III ecoregion (McGrath et al., 2002) in the center of the Lower Payette River subbasin (Figure 1). The headwater elevation is 5,880 ft. above sea level (ASL) and the elevation at the confluence with the Payette Irrigation Canal is 2,210 feet ASL (USGS, 2008). Five 3rd order tributaries drain into the watershed through geologic strata identified as Miocene basalt and Pliocene-Pleistocene alluvium (Figure 4, page 17) (Strahler, 1957; Malde and Powers, 1962).

Big Willow Creek watershed is identified in the National Hydrography Dataset (NHD) as hydrologic unit code (HUC) ID17050122SW017. Two digits are added to this HUC number to distinguish assessment units (AUs) within the hydrologic unit. For example, AU ID17050122SW017_04 includes all the 4th order streams in the Big Willow Creek watershed. Because all the streams in this document have the same HUC, the AUs will generally be referred to using just the final two digits. In this way, ID17050122SW017_04 would just be called AU04. There are no identified fifth order stream segments in the Big Willow Creek subbasin, and no corresponding ID number with an 05 suffix. More information about assessment units is in the section About Assessment Units on page 35.

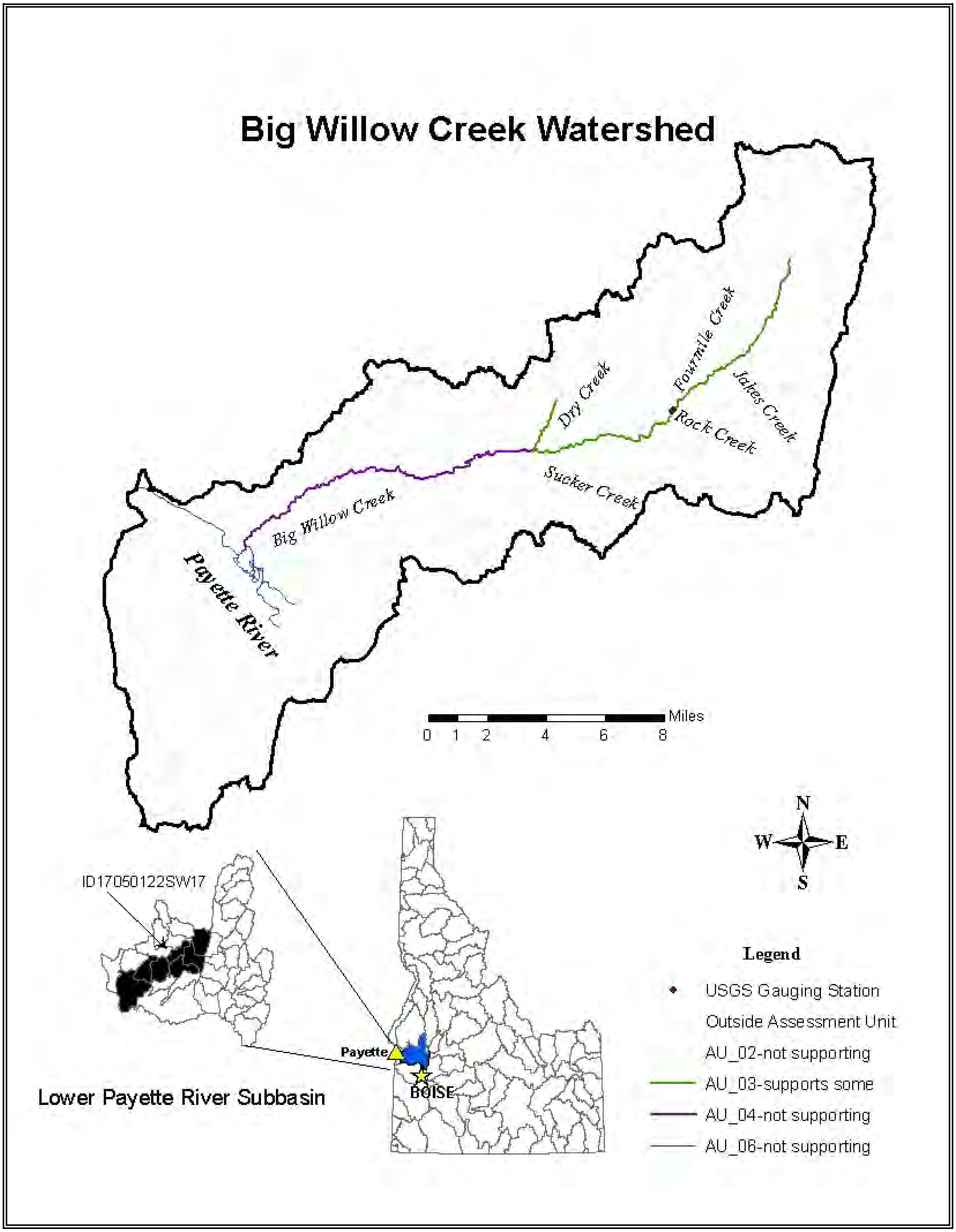


Figure 1. Subbasin at a Glance, Big Willow Creek.

Climate

Climate in the watershed is typical of semi-arid and unwooded alkaline foothills with most precipitation occurring November through February with occasional intense storms in the summer months. The National Weather Service records express the average annual pan evaporation rate for the Big Willow Creek watershed area as between 40 and 50 inches.

- Precipitation data has been collected from 1948 to the present at a climatology site in Payette, Idaho (Western Regional Climate Center [WRCC], 2008). During the period of record, annual precipitation has varied between 20.03 (1983) and 5.27 (1966) inches, with an annual mean of 10.75 inches. The daily maximum for the period of record is 2.30 inches, January 10, 1952 (Figure 2).

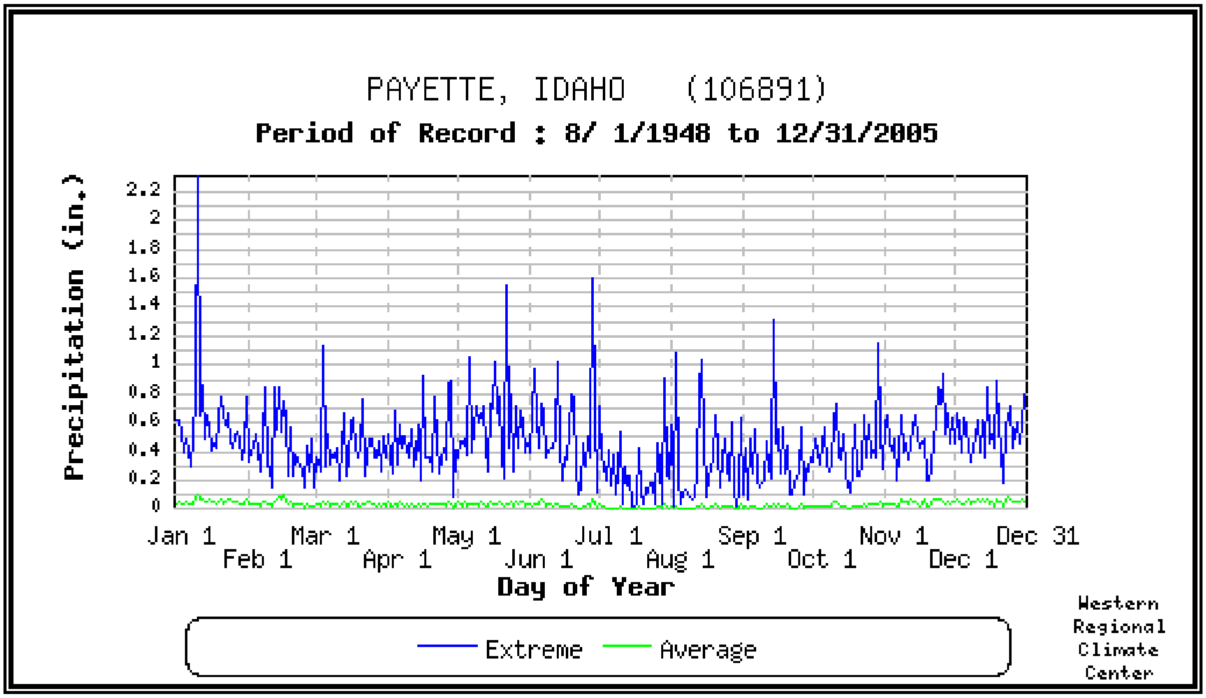


Figure 2. Summary Graph of Average and Extreme Daily Precipitation at Payette, ID Climatalogical Site. Data provided by the Western Regional Climate Center from http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?idpaye, 2/11/2008.

- Air Temperature data collected at a climatalogical site in Payette, Idaho from 1948 through 2005 indicate that air temperature in the watershed ranges from a summer maximum (July 12, 1967) of 109 degrees Fahrenheit (°F) to a winter minimum (February 26, 1995) of –26 °F. The air temperature data for the period of record is summarized in Figure 3 and is made available to the public through the WRCC.

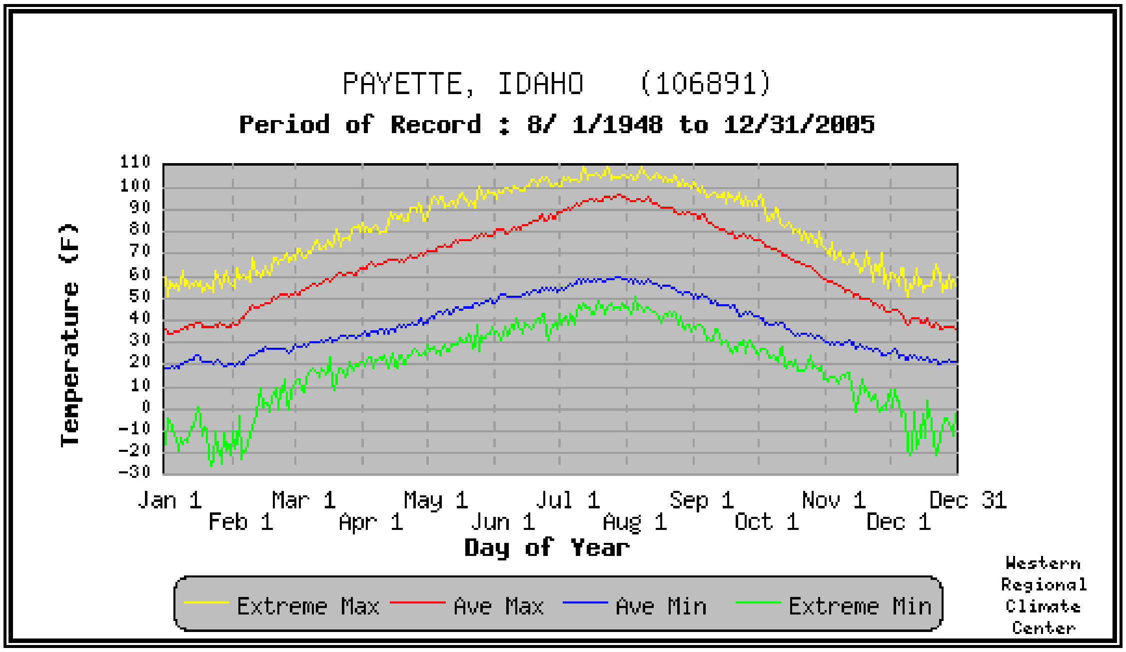


Figure 3. Summary Graph of Daily Maximum and Minimum, and Average Daily Maximum and Minimum Air Temperature at Payette, ID Climatalogical Site. Data provided by the Western Regional Climate Center from http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?idpaye, 2/11/2008.

Precipitation and air temperature data are key to understanding natural conditions that affect surface water flows and temperature conditions in the watershed so that natural forces that drive water temperature can be incorporated into management practices. This watershed receives most of its water during cold weather months in the form of fall and winter rain, and groundwater discharge from springs or shallow aquifers. During the summer months, when air temperature is highest, there is very little meteoric contribution to the watershed except for infrequent high-intensity storm events.

Big Willow Creek Characteristics

Hydrography

Big Willow Creek is a 6th order stream (Strahler, 1957) that drains into the Payette River system from the north between New Plymouth and Payette, Idaho. The creek drains semi-arid unwooded foothills at a moderate gradient (20%) through narrow canyons that open into confined valleys downstream of Rock Creek (Figure 1) with an approximate gradient of 3%. The stream exhibits a high degree of sinuosity with meander scars and abandoned channels evident from aerial and satellite imagery. Drainage patterns in the Big Willow Creek watershed are unique in that the headwaters and south-draining tributaries exhibit a trellis pattern while the north-draining tributaries exhibit a dendritic pattern.

Geology and Soils

The dominant rock types from oldest to youngest are extrusive volcanics, fluvial/lacustrine sediments, and terrace gravels (Figure 4). Soils derived from these parent materials in a semi-arid climate are described in the Natural Resources Conservation Service (USDA, 2002) publications and maps (Figure 5) as aridisols, mollisols, and entisols. These soil types are generally described as sandy, silty, or clayey well-drained soils, which are easily erodible by wind and water when vegetation is sparse.

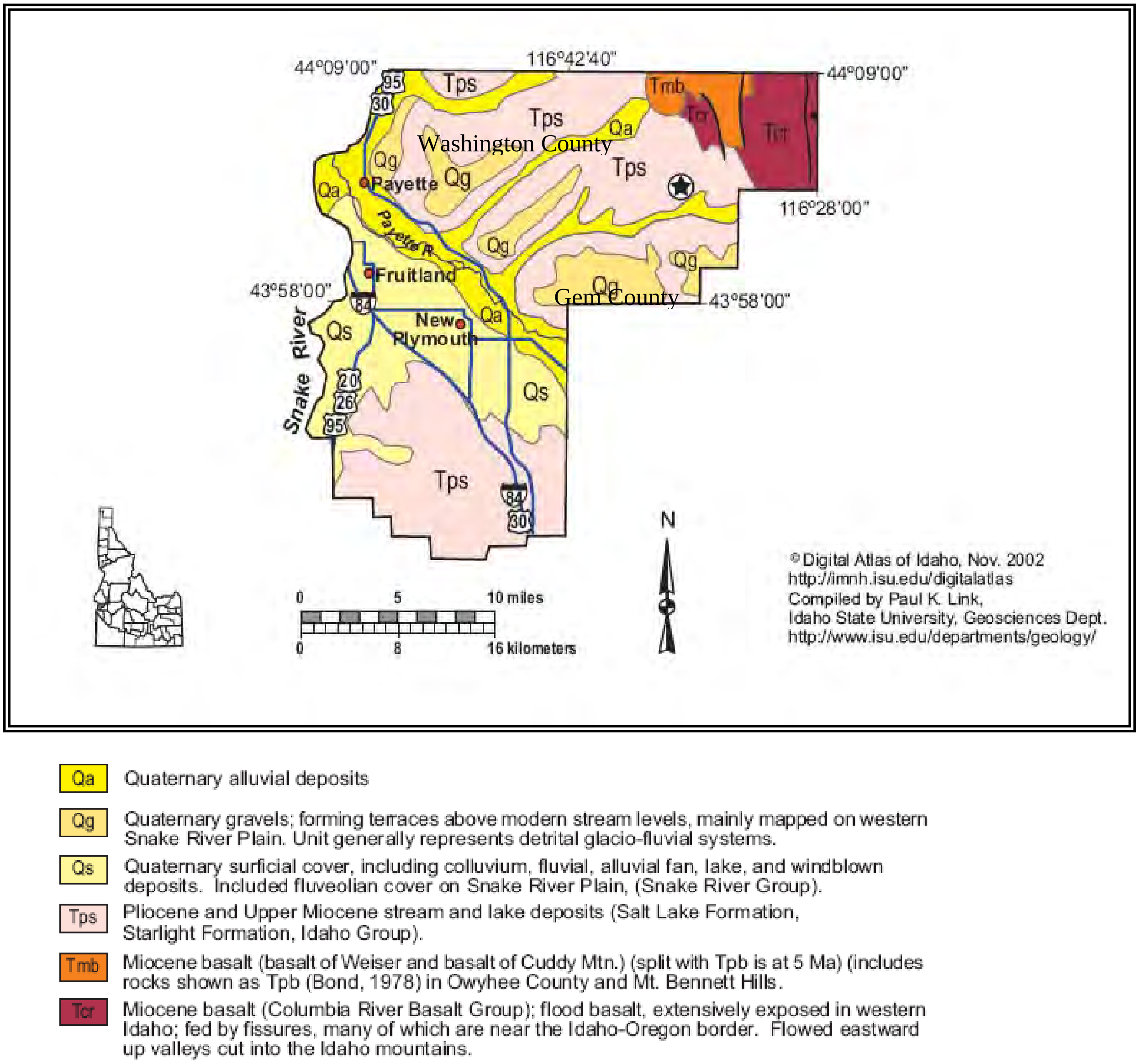


Figure 4. Geologic Map of Payette County. Retrieved on February 13, 2008, from http://imnh.isu.edu/digitalatlas/counties/gem/geomap.htm.

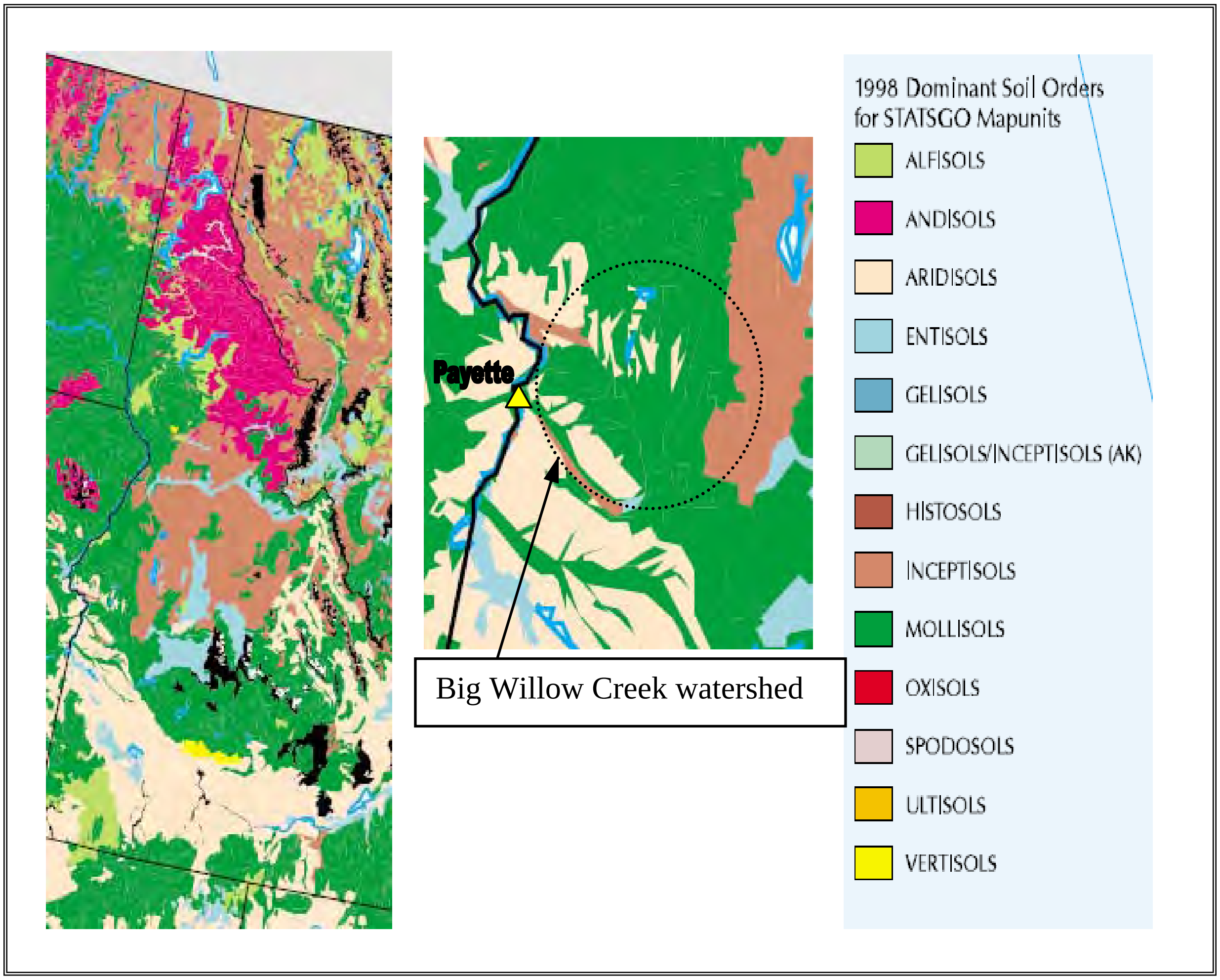


Figure 5. Idaho and Big Willow Creek Watershed Area map of the Distribution of Dominant Soil Types. Modified from data retrieved on February 13, 2008 from http://water.usgs.gov/lookup/getspatial?ussoils.

Vegetation

Recent literature was reviewed to determine the distribution of vegetation community types in the watershed and the percentage of land cover (percent cover) provided by each type. The types identified in the literature, in order from greatest to least percent cover, are shrub/steppe annual grass, perennial grassland, agriculture, sagebrush, bitterbrush, shrub-dominated riparian, and evergreen forest (< 1%) (Payette County, 2004). Native upland vegetation in the Big Willow Creek watershed consists mostly of sagebrush/steppe (grasses and shrub) community type. However, the increased occurrence of wildland fires in the area has created an exotic cheat grass (*Bromus tectorum*) community type, evident throughout the basin, but not mentioned in the literature (Shumar, 2005).

Deciduous woody species of the shrub-dominated riparian community consist of small willows (*Salix sp.*), dogwood (*Cornus sp.*), and birch (*Alder sp.* and *Birch sp.*) near springs and in the riparian zone. Cottonwoods (*Popular sp.*), although scarce, do exist along low-gradient stream segments. The riparian vegetation of Big Willow Creek is mainly a function of valley bottom type, depositional material, and recent scouring activity associated with the hydrology.

Alders and dogwood (Figure 6 and Figure 7) dominate riparian woody vegetation. Figure 8, Figure 9, and Figure 10 (Big Willow Creek, in the lower-gradient section, downstream of French Corner), illustrate an incised system lacking mature vegetation.

Figure 6. Big Willow Creek Upstream of French Corner. (M. Shumar, 2006)

Figure 7. Big Willow Creek Upstream of French Corner. (M. Shumar, 2006)

Figure 8. Big Willow Creek near Lower Road Crossing. (M. Ingham, 2005)

Figure 9. Big Willow Creek near Lower Road Crossing. (M. Ingham, 2005)

Figure 10. Big Willow Creek Four Miles Downstream of French Corner. (M. Ingham, 2005)

Aquatic Species

Since 1994, DEQ has conducted Beneficial Use Reconnaissance Program (BURP) monitoring on Big Willow Creek at various locations in AU02, AU03, and AU04. Table 1 shows the year of monitoring, BURP ID number, and AU number . The BURP monitoring locations are shown in Figures A, B, and C in the Executive Summary, and Figure 14 on page 27.

Table 2 summarizes the fish data collected through the BURP program from 2003 through 2005. All sites from which fish data were collected are located in AU03 and there is no information on listed species in the Big Willow Creek watershed through the US Fish and Wildlife Service.

Benthic macroinvertebrate data have also been collected through the BURP program from 1994 through 2005 (Table 3). Two sites in AU02 were sampled in 1997; Four sites in AU03 were sampled from 1994-1996 and in 2003; and six sites in AU04 were sampled from 1994 to 2003. Using a temperature-tolerance species index as an assessment tool (Grafe, et al., 2002), the benthic macroinvertebrate data indicate a species distribution of 90% warm water tolerant benthic macroinvertebrates and 10% cool or cold water tolerant organisms across all AUs.

Table 1. Beneficial Uses Reconnaissance Program (BURP) monitoring on Big Willow Creek, year of monitoring, BURP ID, and general location.

Date of Monitoring	*BURP ID*	*Location*	*AU*
05/31/1994	1994SBOIA001	Above Upper Road above USGS Gage	03
05/31/1994	1994SBOIA002	Above Upper Road above USGS Gage	03
06/01/1994	1994SBOIA004	Below Road Crossing at French Corner	03
06/01/1994	1994SBOIA003	Near Lower Road Crossing	04
05/18/1995	1995SBOIT009	Above Upper Road above USGS Gage	03
06/26/1995	1995SBOIA011	Below Road Crossing at French Corner	03
06/26/1995	1995SBOIA010	Near Lower Road Crossing	04
07/22/1996	1996SBOIA049	Above Upper Road above USGS Gage	02
07/22/1996	1996SBOIA050	Below Road Crossing at French Corner	03
07/22/1996	1996SBOIA051	Near Lower Road Crossing	04
06/19/1997	1997SBOIB013	Above Upper Road above USGS Gage	03
06/19/1997	1997SBOIB014	Below Road Crossing at French Corner	03
06/19/1997	1997SBOIB015	Near Lower Road Crossing	04
07/09/1998	1998SBOIB036	Near Lower Road Crossing	04
07/20/1998	1998SBOIA046	Above Upper Road above USGS Gage	03
07/20/1998	1998SBOIA045	Below Road Crossing at French Corner	03
09/22/1999	1999SBOIA055	Above Upper Road above USGS Gage	03
09/22/1999	1999SBOIA056	Below Road Crossing at French Corner	03
09/23/1999	1999SBOIA057	Lower Section, Payette Slough	04
07/26/2001	2001SBOIA033	Above Upper Road above USGS Gage	03
07/03/2002	2002SBOIA003	Above Upper Road above USGS Gage	03
07/31/2003	2003SBOIA023	Above Upper Road above USGS Gage	03
10/20/2003	2003SBOIA053	Lower Section, Payette Slough	04
07/08/2004	2004SBOIA040	Above Upper Road above USGS Gage	03
07/05/2005	2005SBOIA020	At Gem/Payette County Line	03

Table 2. Summary of fish data collected from Big Willow Creek through the Beneficial Use Reconnaissance Program (BURP) from 2003-2005.

Water Body Segment/ AU	Date Sampled	Salmonid Taxa	% Cold Water Preference (individuals)	Total Individuals	% Cool Water Preference (individuals)
AU03	7/31/2003	1	18.3	60	26.3
AU03	7/08/2004	1	2.4	41	97.6
AU03	7/05/2005	1	7.6	65	92.3

Table 3. Composite summary of benthic macroinvertebrate data collected from Big Willow Creek through the Beneficial Use Reconnaissance Program (BURP) from 1994 through 2003.

Water Body Segment/ AU	Dates Sampled	Warm Water Taxa	Cool Water Taxa	%Warm Water Taxa	% Cool Water Taxa
AU02	1996	98	10	91	9
AU03	1994-6, 2003	186	21	90	10
AU03	1994, 2001-2003	2072	177	92	8

Watershed Characteristics

Big Willow Creek is a 6th order perennial stream with headwaters originating just north of Squaw Butte, as located on the USGS Coonrod Quadrangle topographic map. The headwater stream segment is ephemeral in nature and flows northwest to the confluence of an unnamed tributary and then flows almost due south to the confluence with Rock Creek where the stream is redirected to a southwesterly flow aspect to its confluence with the Payette Irrigation Canal near the Payette River (Figure 11). The mean elevation of the watershed is 3,340 feet ASL with a hydrologic regime dominated by precipitation in the form of rain, rather than a system dominated by snowmelt runoff.

The hydrographic apex occurs at the confluence of a south side unnamed tributary immediately downstream of Rock Creek (Figure 11). Above the apex, 30% of the slopes have a slope angle greater than 30%; and below the apex, approximately 11% of the slopes have an angle greater than 30%.

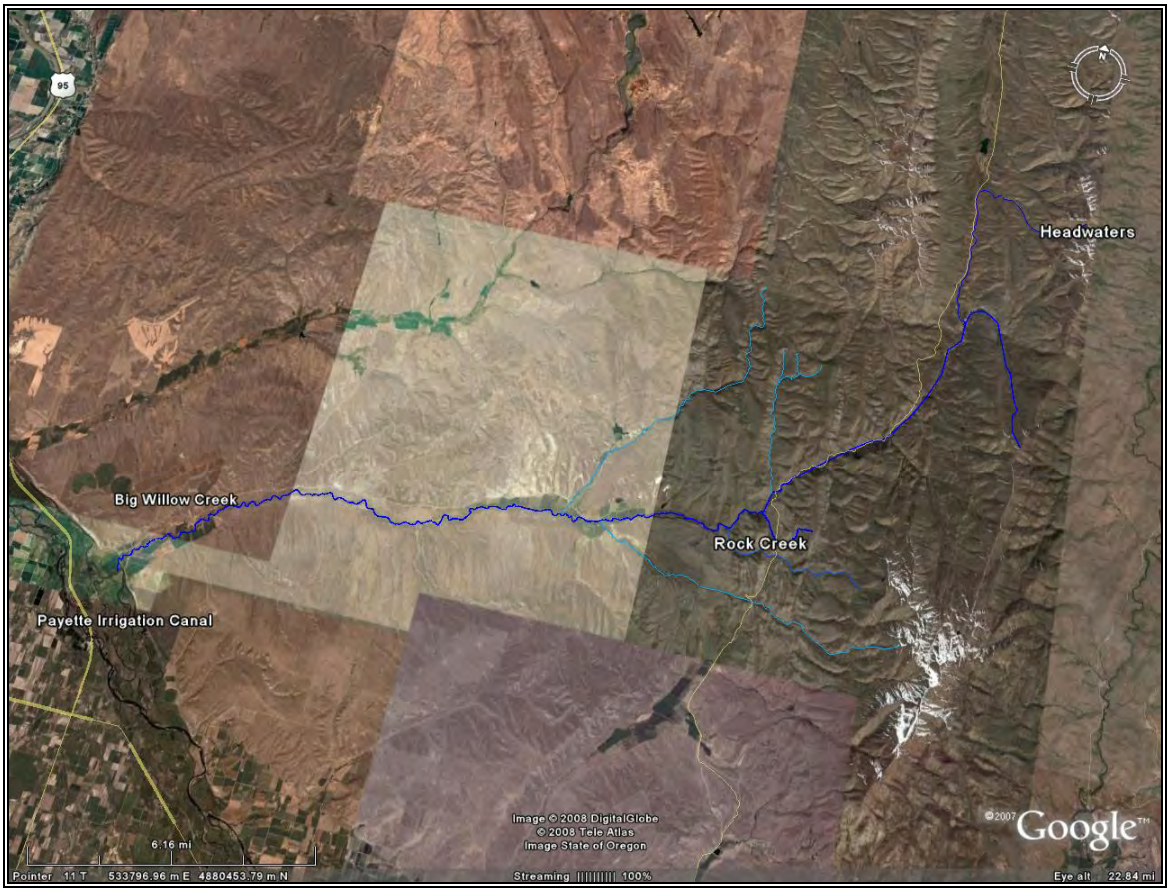


Figure 11. Main Channel of Big Willow Creek. Modified from GooglEarth on February 15, 2008.

The watershed characteristics and recommendations for future §303(d)-listing status of Big Willow Creek are summarized in Table 4.

Table 4. Summary of physical characteristics of Big Willow Creek watershed, Assessment Units, pollutants, sources, TMDLs and future listing recommendations.

Watershed	Big Willow Creek
5th Field HUCs	17050122SW017_02 17050122SW017_03 17050122SW017_04 17050122SW017_06
Miles of Impaired Water Bodies	209.6
Assessment Units	ID17050122SW017_02 ID01050122SW017_03 ID17050122SW017_04 ID17050122SW017_06
Total Acres	96,538
Listed Pollutants	Temperature and Unknown
Designated Uses	Cold Water Aquatic Life Salmonid Spawning Primary Contact Recreation
TMDL Allocation Goals	Potential Natural Vegetation TMDL Completed
Further Listing Recommendations	Place Big Willow Creek in Section 4a (temperature) and 4c of the Integrated Report for EPA approved temperature TMDL and flow and habitat alteration.
Pollutant Sources	Solar Radiation, Habitat and Flow Alteration, Unknown

The headwaters and most of the 1st and 2nd order tributaries upstream of the confluence with Rock Creek have intermittent flow and have carved v-shaped channels into basalt canyons which fit the criteria for Rosgen type A stream classification. The 3rd and 4th order stream segments (AU03, AU04) fit the classification for Rosgen type B and C channels and the 6th order segment cannot be classified with the data collected.

Big Willow Creek clearly demonstrates two main characteristics, divided by the hydrographic apex. Above the apex, the stream is dominated by a V-shaped type of valley bottom with a restricted flood plain confined to a small margin outside the wetted width, which amplifies stream energy during peak discharge. The stream segment below the apex is a natural wide valley type with a gradient of approximately 7 feet per stream mile. Anthropogenic channelization and other effects have confined the stream to an area almost 1/10th its normal range with little access to the natural flood plain. These types of modification to channel and riparian areas also serve to increase stream velocities during the frequent, naturally-occurring high-energy discharge events. Artificial constriction of streams is known to increase the potential for erosion and mass wasting events.

There are 35 flow alteration structures in the watershed designed to restrict, divert, or impound natural flow into reservoirs that range in surface area from 0.02 acres to more than 35 acres (Figure 12). Very little information is available on the amount of surface water impounded or diverted or the water quality of the outflow or seepage from those structures.

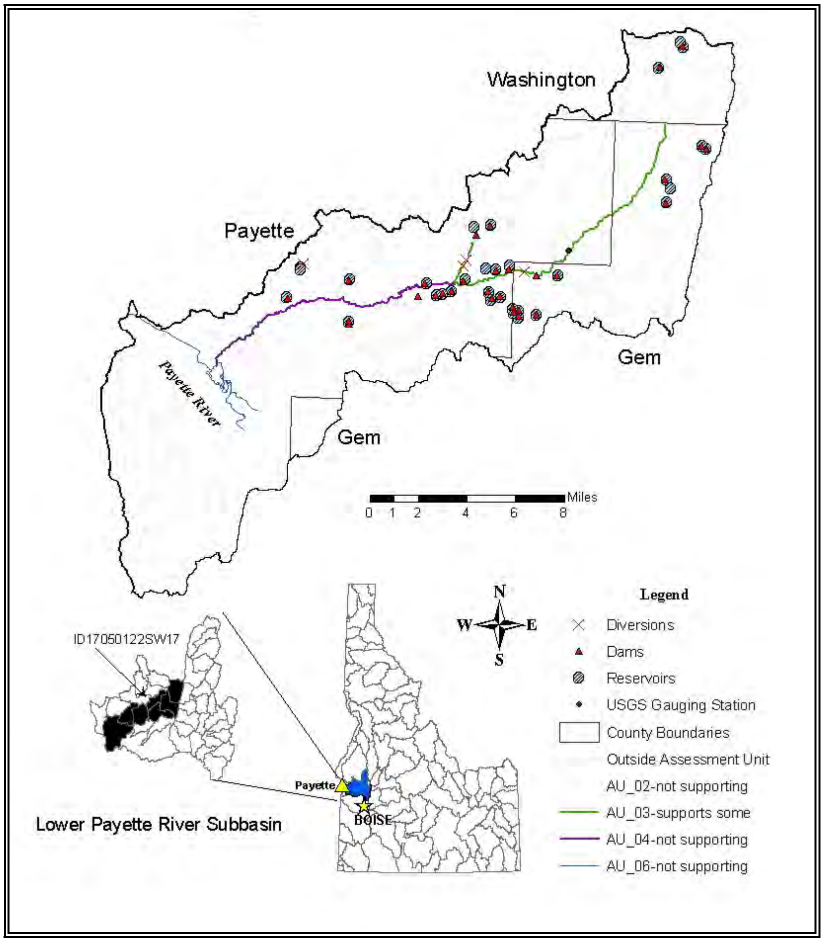


Figure 12. Flow Control Structures and AUs in Big Willow Creek Watershed.

Stream Characteristics

There is evidence that the Army Corp of Engineers channelized Big Willow Creek in the 1950s. Although not well documented, the current physical characteristics indicate the stream's morphology has been altered by straightening and confinement to the southeastern side of the valley and much of the stream in AU03 and AU04 is disconnected from the natural floodplain. Above the hydrographic apex, the stream has a moderately high gradient of approximately 26 feet per mile. More than half of the watershed is below the hydrographic apex with a moderate to low stream gradient of approximately 7 feet per mile. Normally, a stream with low gradient has high sinuosity and a wide floodplain. Numerous abandoned meanders are visible in satellite imagery, far removed from the incised low sinuosity channel now present. The stream experienced a channel-modifying flood event in 1997 and related scour and deposition created new terraces in segments of AU03 and AU04. Figure 13 is labeled with the location of observed historic flood deposits and flood deposits from the most significant flood event of record (USGS, 1997).

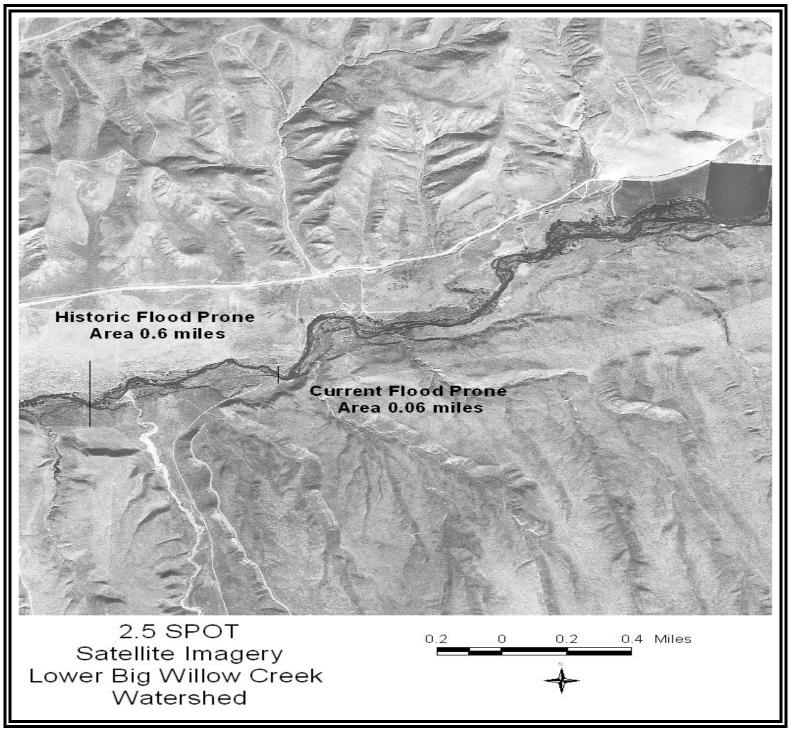


Figure 13. Satellite Image (2.5 SPOT) of Big Willow Creek between Dry Creek (right, out of frame) and Sheep Gulch (center top). Annotated with historic and present day flood zones.

At the hydrographic apex, the stream crosses a geologic boundary from basalt canyons into the younger fluvial/lacustrine and alluvial fan sediments. The historical stream meanders widen as the floodplain expands from 0.12 miles to approximately 0.6 miles near French Corner and then narrows to approximately 0.4 miles wide until the floodplain expands again, to 0.8 miles at the mouth.

Alteration and Modification

Dewatered channel segments have been observed by BURP data collection teams immediately downstream of water diversions. The first irrigation water diversion (Figure 12) is located upstream of an area known as French Corner. The diversion supplies water to irrigated row crops and ends about 7 miles downstream from the diversion.

The second diversion is further downstream, about three miles upstream of the confluence with the Payette Irrigation Canal. The Payette Irrigation Canal is an abandoned meander of the Payette River. The canal, along with Big Willow Creek, is channelized into a 10-foot wide manmade conveyance forming the upper segment of the Lower Payette Canal. The Lower Payette Canal provides irrigation water for cultivated agriculture to the north. Wastewater from the canal dumps into the Weiser River approximately 15 miles north of Big Willow Creek.

Of the 35 flow control structures (Figure 12) in the watershed, eight are regulated as dams by the Idaho Department of Water Resources (IDWR), two of which are on Big Willow Creek. Idaho WQS treat discharges from dams as nonpoint sources and EPA does not require NPDES permits for these structures.[2] Fourmile Creek is the only 3rd order tributary without flow control structures in place.

General Bed Sediment Character

Stream sediments correlate with the ecoregion (Figure 14) and geology and soils information (Figure 4 and Figure 5). General information on channel sediments is collected at BURP sites and can be used inferentially to determine the embeddedness of channel substrate. Generally speaking, low embeddedness can be correlated to habitat

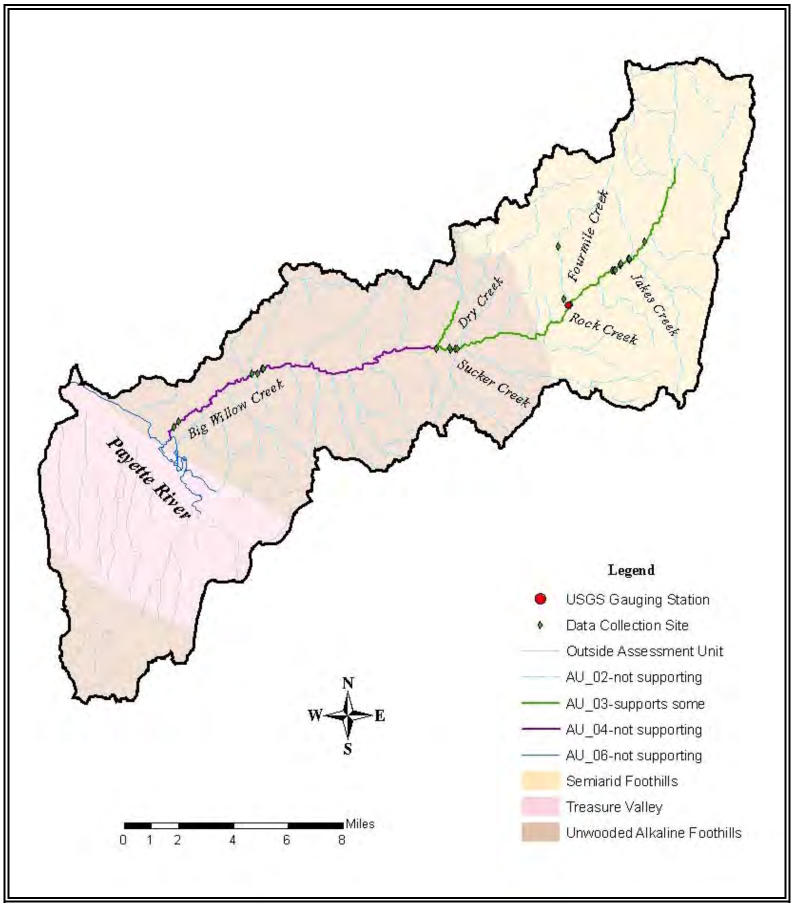


Figure 14. Big Willow Creek Watershed Level IV Ecoregions, BURP Data Collection Locations, Surface Water Assessment Unit Designations and Related Information.

more supportive of aquatic organismis, while high embeddedness correlates to reduced habitat quality for aquatic organisms. As the percent of surface fine sediment increases, so does channel substrate embeddedness. This is a qualitative approach to assessing

[2] This does not affect Idaho's authority under §401 of the CWA as determined by S.D. Warren *v*. Maine (2006).

aquatic habitat quality, not a quantitative measure of suspended sediment concentrations in streams. Based on the conditions observed and recorded by the BURP crews for sites on Big Willow Creek, the in-stream surface percent fines values indicate that the regional floods of 1997 have had a negative effect on in-stream habitat. Surface fines data collected within one year of massive flooding from AU02 and AU04 range from 41 to 69%; data collected in 1998 from AU03 and AU04 ranged from 12 to 61% (Appendix C). The only percent fines data that meets the Tier I criteria for use support determination was recorded from sites in AU03. These AU03 data indicate low embeddedness, with all Tier I (most recent 5 years) values below 30%, and observations between 1994 and 2005 ranging from 3 to 41%. There are more flow control structures in AU03 between Rock Creek and Dry Creek than in any other AU in this watershed; and most of the visible habitat alteration is from the Rock Creek confluence to the mouth of Big Willow Creek. The entire AU06 segment is a constructed channel used for irrigation and actively managed to maintain a width of 10 feet.

Riparian Characteristics

There is a sharp contrast in habitat conditions when comparing the stream segment above the hydrographical apex to the stream segment below the apex. However, when evaluating all physical influences, such as the differing ecoregions, parent geological material, stream alteration, and the hydrologic flow pattern, degraded habitat conditions in the lower segments would not be unexpected. Until an adequate flood plain is re-established to disperse the energy associated with the frequent peak discharge events, habitat will continue to be altered in AU03, AU04, and AU06.

1.2 Cultural Characteristics

In 2004, Payette County commissioned the development of a wildfire mitigation plan. This plan, *Payette County, Idaho Wildland-Urban Interface Wildfire Mitigation Plan: Main Document* (October 11, 2004), contains the most recent data on population demographics, political boundaries, local economy, and other topics pertinent to this section of the SBA. The summary information in this section is largely based on information from that document because the portions of the watershed that exist outside the boundaries of Payette County are largely unpopulated and are owned by the federal government.

Land Use

The US Department of Agriculture, Natural Resources Conservation Service (NRCS) published the *Agricultural Handbook 296, Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin* in 2006 and has made a map interface program available to the public through the Web site at http://www.cei.psu.edu/mlra/. This interface allows customized reports to be generated for specific land resource regions (LRRs) covered in the report. Using this map interface, custom reports were generated for the Northwestern Wheat and Range, Rocky Mountain Range, and Forest LRRs. The Snake River Plains, Central Rocky and Blue Mountain Foothills, and the Central Rocky Mountains are identified as major land resource areas

(MLRAs) that include portions of the Big Willow Creek watershed. In addition to a watershed-specific land use map (Figure 15), Figure 16 visually summarizes land use for the three MLRAs that include the Big Willow Creek watershed, showing primarily rangeland (80%), with irrigated agriculture (20%) close to surface water supplies.

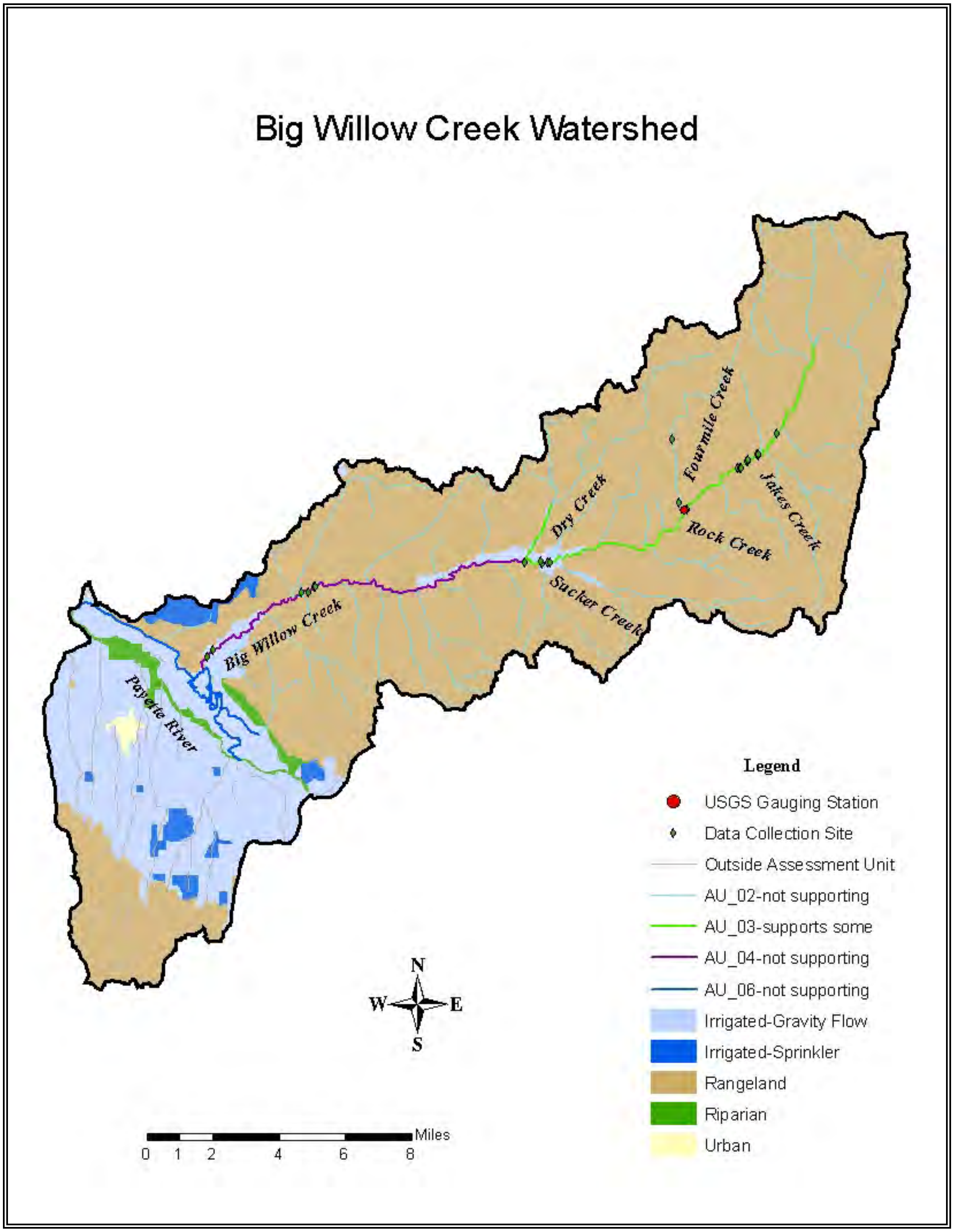
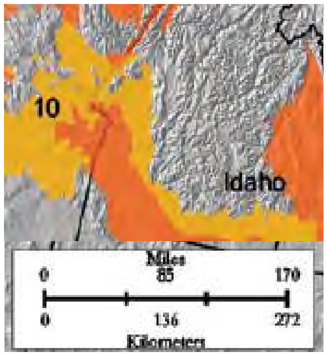
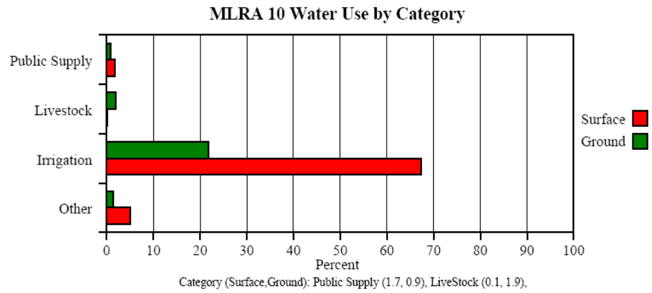


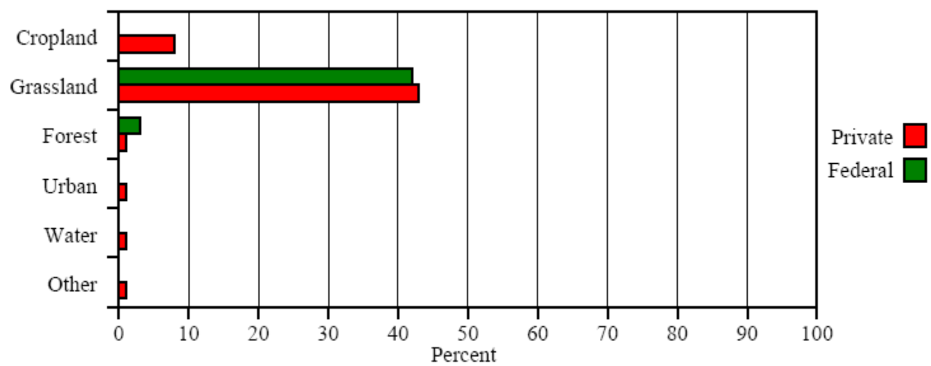
Figure 15. Big Willow Creek Watershed Land Cover/Use, Surface Water Assessment Unit Designations, and Related Information.

MLRA 10 - Central Rocky and Blue Mountain Foothills



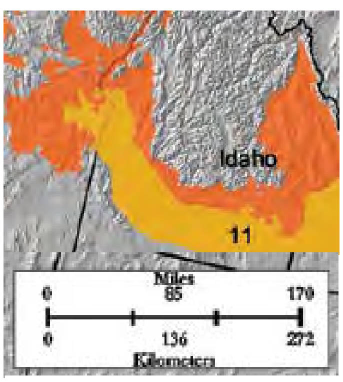


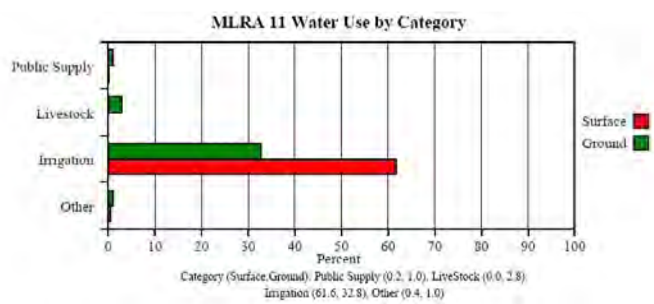
MLRA 10 Land Use by Category



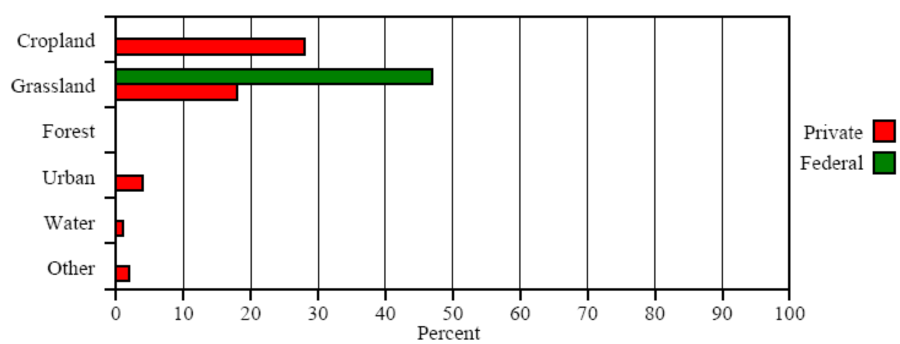
Category (Private,Federal): Cropland (8.0, 0.0), Grassland (43.0, 42.0), Forest (1.0, 3.0), Urban (1.0, 0.0), Water (1.0, 0.0), Other (1.0, 0.0)

MLRA 11 - Snake River Plains





MLRA 11 Land Use by Category



Category (Private,Federal): Cropland (28.0, 0.0), Grassland (18.0, 47.0), Forest (0.0, 0.0), Urban (4.0, 0.0), Water (1.0, 0.0), Other (2.0, 0.0)

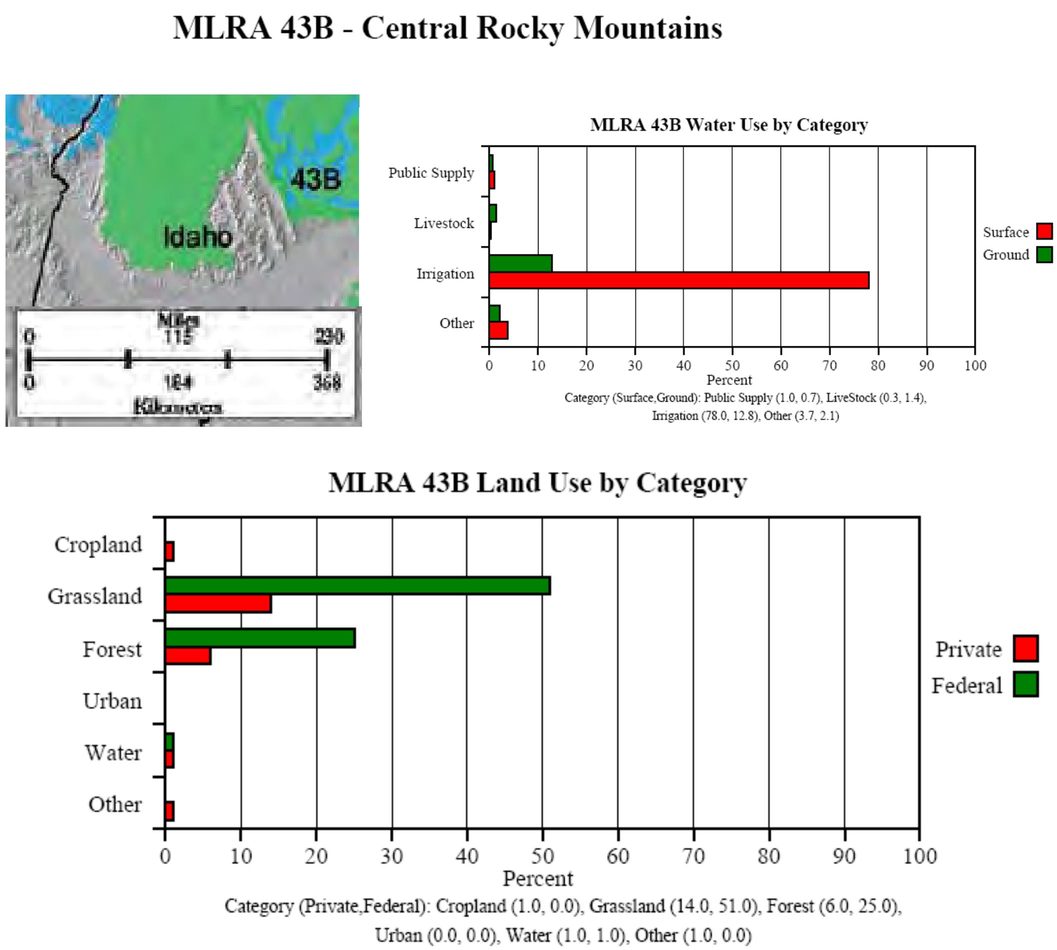


Figure 16. Land and Water Use in Big Willow Creek Watershed Area, by Major Land Resource Area. Modified from USDA NRCS, 2006.

Land Ownership, Cultural Features, and Population

Most of the land in the Big Willow Creek watershed is under the administration of private parties, with the Bureau of Land Management (BLM) being responsible for less than half of the watershed and the state of Idaho responsible for administering the smallest percentage (Figure 17, Table 5). This distribution of administrative responsibility is representative of each county that includes some portion of the watershed within its political boundaries. While the BLM is the sole administrator of public lands in the watershed and their lands are open to year-round use, there are no developed sites for public use or recreation. Almost all of the roads in the watershed are unimproved gravel or dirt roads maintained by BLM or private parties. AU02 is the only watershed segment in which the roads are within 150 feet of the stream channel and most stream crossings are bridges or unprotected crossings intended for use by off-road vehicles.

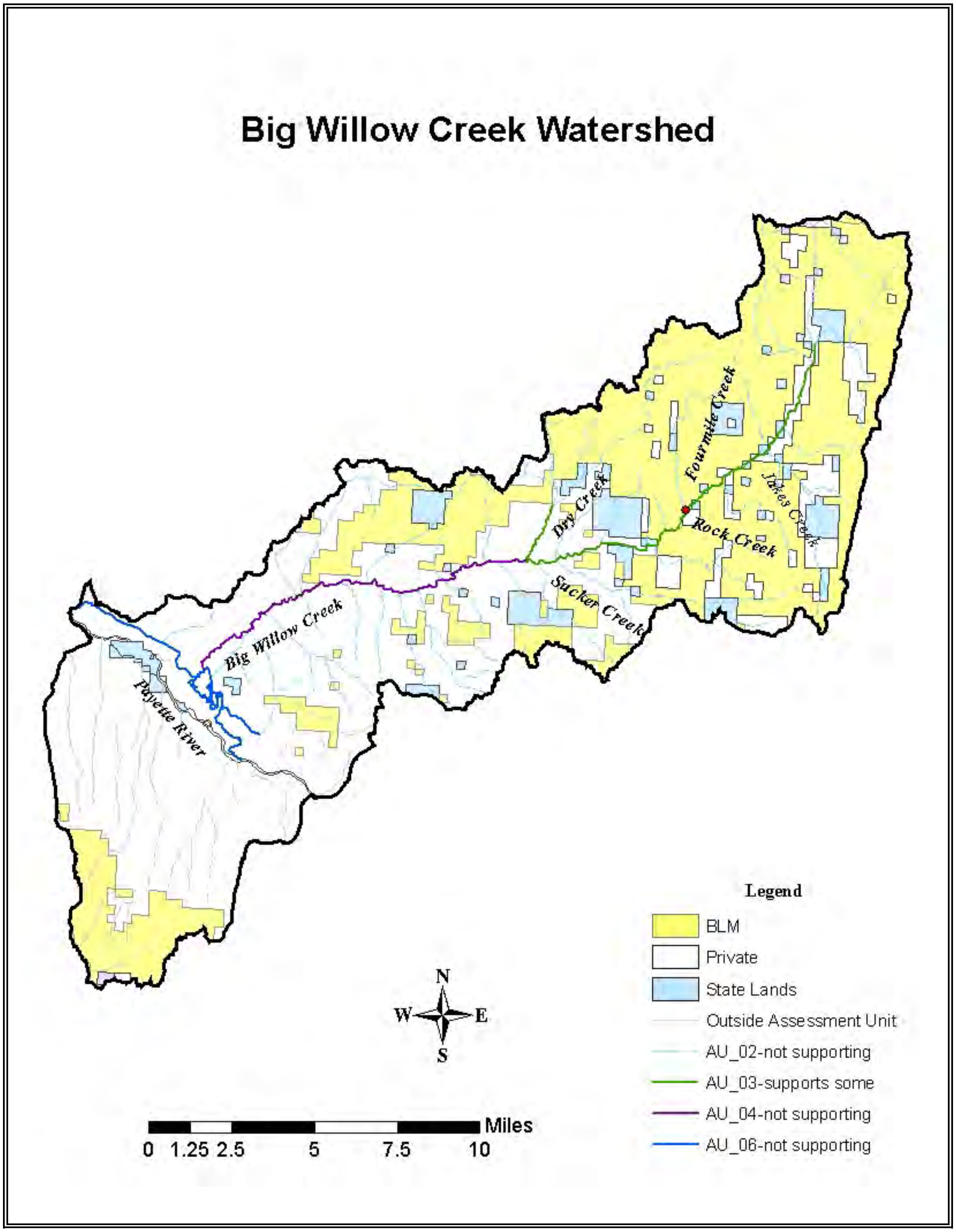


Figure 17. Land Stewardship in the Big Willow Creek Watershed. Created by DEQ using data available from the Idaho Department of Water Resources (IDWR) on February 13, 2008.

Table 5. Land stewardship of the Big Willow Creek watershed calculated from polygon areas displayed in Figure 17.

Stewardship Sector	% Watershed Land Area
Bureau of Land Management	42
State of Idaho	6
Private	52

Demographics

Payette County mailed surveys to 237 landowners in the county in the initial phases of drafting the 2004 Wildfire Mitigation Plan. Of the 107 landowners who responded to the survey, 99% stated that they consider their Payette County address to be their primary address. The population of Payette County as of the 2000 census is evenly proportioned between genders with 36% of the population between the ages of 25 and 54. Thirteen percent of the population is older than 65 and 20% younger than 19. Ninety percent of the population is Caucasian and 74% live in owner-occupied residences. Thirty-seven percent of households reported an annual income between $25,000 and $50,000 and 26% of the population lives below the poverty level. Population in the county increased 25% between 1990 and 2000 and the agriculture industry accounts for 10% of all industry and 6% of employment. In the Big Willow Creek subbasin, agriculture is the primary economy.

History and Economics

It is reported that cattle were introduced to the Payette Valley in 1818, almost 50 years before the first white settlers arrived in 1864, two years after a stage stop was established in 1862. With the addition of Oregon and Utah stage lines and trading posts, the region continued to attract settlers and Payette County was officially formed in 1917. The county seat, the city of Payette, began in 1883 as a work camp and storehouse for Union Pacific Railroad. Fertile river valley soils and plentiful surface water encouraged the growth of the agricultural industry and lands which are not suitable for cultivation continue to be grazed by livestock.

In the Big Willow Creek watershed, most of which is in Payette County, industry is tied to natural resources. Grazing, animal feeding operations, and cultivated crops account for all economic uses.

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2.0 Subbasin Assessment - Water Quality Concerns and Status

Please refer to the Lower Payette River SBA-TMDL (Ingham, 1999) for overall assessment of the water quality and assessment information for the entire lower Payette River Subbasin, including some important discussion of characteristics associated with Big Willow Creek in Section 2.1. This SBA and TMDL address the Big Willow Creek watershed, identified in Idaho WQS as water body unit 17 (SW17) of 21 water bodies in the Payette Subbasin (IDAPA 58.01.02).

2.1 Water Quality Limited Assessment Units Occurring in Big Willow Creek

Based on results of BURP assessment data, Big Willow Creek from Rock Creek to the Payette River was placed on Idaho's 303 (d) list for unknown pollutants in 1998. EPA subsequently added Big Willow Creek from the headwaters to the mouth to the Idaho's 1998 303(d) list for temperature. As a result of revisions to Idaho's water body assessment process and methods, subbasins were divided into assessment units for the 2002 303 (d) report and specific assessment units of Big Willow Creek were listed for unknown pollutants (Table 6). Water body assessment data collected through the BURP program from 1994 forward and data collected by the USGS from the 1960s to 1982 indicate that temperature, flow modification, and habitat alteration are primary factors contributing to the impaired status of the watershed.

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

About Assessment Units

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

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— even if ownership and land use change significantly, an AU remains the same.

Using AUs to describe water bodies offers many benefits, the primary benefit being that all the waters of the state are now defined consistently. In addition, using AUs fulfills the fundamental requirement of the 305(b) report required by the EPA, a component of the CWA 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 WQS for each AU, so that beneficial uses defined in the WQS are clearly tied to streams on the landscape.

However, the new framework (2002) 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 1998 303(d) list, all segments were added with boundaries from “headwaters to mouth.” 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 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 any listed segment were carried forward to the 2002 303(d) listings in Section 5 of the integrated report (DEQ, 2005). Any AU not wholly contained within a previously listed segment, but partially contained (even minimally), was also included on the 303(d) list. This was necessary to maintain the integrity of the 1998 303(d) list and continuity with the TMDL program. These new AUs will lead to better assessment of the needs for 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.).

Listed Waters

Table 6 shows the pollutants and the basis for listing for each §303(d)-listed AU in the subbasin. Not all of the water bodies will require a TMDL, as will be discussed later. However, a thorough investigation using the available data was performed before this conclusion was made. This investigation, along with a presentation of the evidence of non-compliance with standards for several other tributaries, is contained in the following sections.

Table 6. Assessment units, § 303(d) listed segments, and associated pollutants in the Big Willow Creek watershed.

Water Body Name	Assessment Unit ID Number	(year) §303(d) Boundaries	Pollutants	Listing Basis
Big Willow Creek	ID17050122SW017_02 through _06	(1998) Headwater to Mouth	Unknown (Temperature, EPA)	Excess Solar Radiation
Big Willow Creek	ID17050122SW017_03 through _06	(2002) Rock Ck to Payette River	Unknown	BURP data
Big Willow Creek	ID17050122SW017_02	(2002) 1st and 2nd order	Unknown	BURP data
Big Willow Creek	ID17050122SW017_04	(2002) 4th order	Unknown	BURP data
Big Willow Creek	ID17050122SW017_06	(2002) 6th order	Unknown	BURP data

2.2 Applicable Water Quality Standards

Idaho adopts both narrative and numeric WQS to protect public health and welfare, enhance the quality of water, and protect biological integrity. By designating beneficial use or uses for water bodies, Idaho has created a mechanism for setting criteria necessary to protect those uses and prevent degradation of water quality through anti-degradation provisions of state water quality standards. Beneficial use support is determined by DEQ through its water body assessment process. Table 7 shows designated beneficial uses for Big Willow Creek. The designated beneficial uses of Big Willow Creek, as identified in Idaho's WQS, are cold water aquatic life (CWAL), salmonid spawning (SS), and primary contact recreation (PCR) (IDAPA 58.01.02).

Table 7. Big Willow Creek watershed beneficial uses of §303(d) listed streams.

Water Body	Uses[a]	Type of Use
Payette Subbasin (ID17050122) Big Willow Creek (SW-17) source to mouth	CWAL, SS, PCR	Designated

[a] CWAL – cold water aquatic life, SS – salmonid spawning, PCR – primary contact recreation

Beneficial Uses

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

Existing Uses

Existing uses under the CWA are "those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the WQS." 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 WQS 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 support 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 the Idaho WQS (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 WQS do not yet have specific use designations. 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 presumed uses, DEQ will apply the numeric cold water aquatic life criteria and primary or secondary contact recreation criteria to undesignated waters. If, in addition to these presumed uses, an additional use (e.g., salmonid spawning) exists, because of the requirement to protect water quality for existing uses, the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen, temperature). However, if for example, cold water aquatic life is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

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).

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

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

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

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

Table 8 includes the numeric criteria most commonly used in TMDLs.

Figure 18 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 8. 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 Oxyge	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 1- day minimum and exceeds 6.0 mg/L for a 7- day average
Tempera-ture[d]			22 °C or less daily maximum; 19 °C or less daily average Seasonal Cold Water: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average. Spawning period for rainbow trout is March 15 through July 15. Bull trout: not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June – August; not to exceed 9 °C daily average in September and October
Turbidity			Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days.	
Ammonia			Ammonia not to exceed calculated concentration based on pH and temperature.	

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

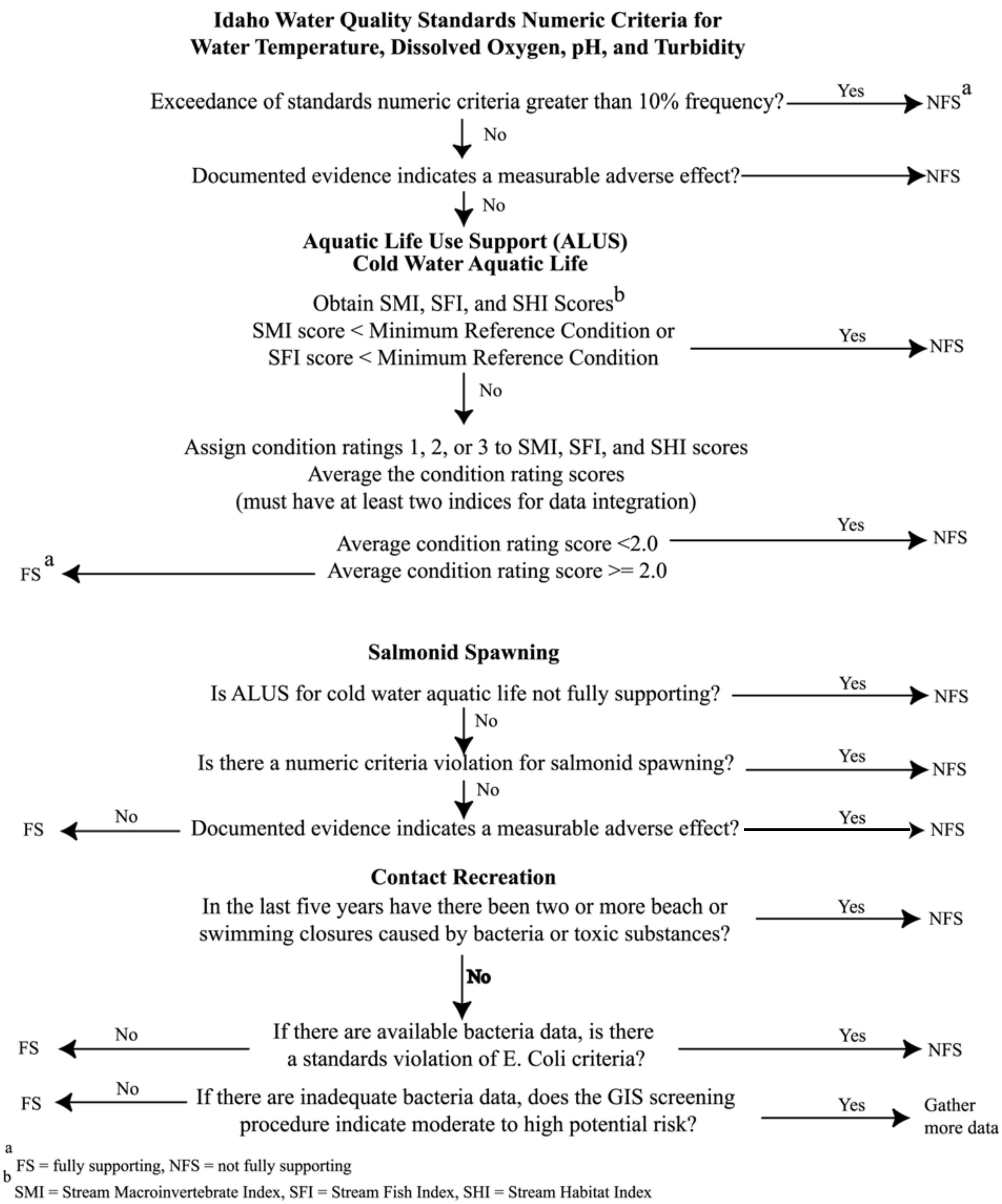

Figure 18. Stream Assessment Process for Use Determination

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.

Temperature

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

Elevated stream 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 is 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 period of time. Juvenile fish are 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 emerge from the substrate. Similar kinds of effects may occur to aquatic invertebrates, amphibians, and mollusks; although less is known about them.

2.4 Summary and Analysis of Existing Water Quality Data

This section describes the physical, chemical and biological data for Big Willow Creek as it pertains to determining beneficial use support status. The data used for this SBA and TMDL were collected by the USGS from 1973 through 1982 and DEQ through the BURP program. Figures A-C, 14, and 15 show the location of the monitoring sites and Figures D, 19-22 and Tables 1, 2, and 3 summarize the data.

Discharge (Flow) Characteristics

The USGS operated one discharge monitoring site on Big Willow Creek (USGS 13250600). Figure 19 shows the data described by the USGS as "Period of Approved Daily-Mean Data" from 1962 through 1982. The data presented in Figure 19 and Figure 20 show the "flashy" nature of Big Willow Creek's hydrology.

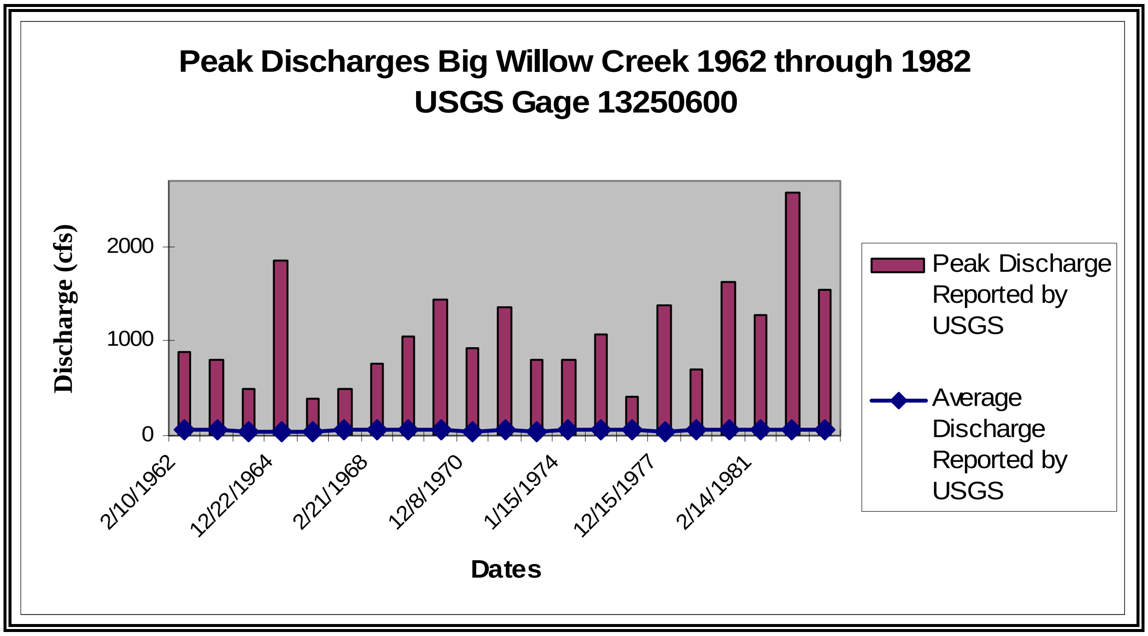

Figure 19. Average Daily and Peak Discharge Data from USGS Gauge 13250600, Big Willow Creek, October 1962 to October 1982.

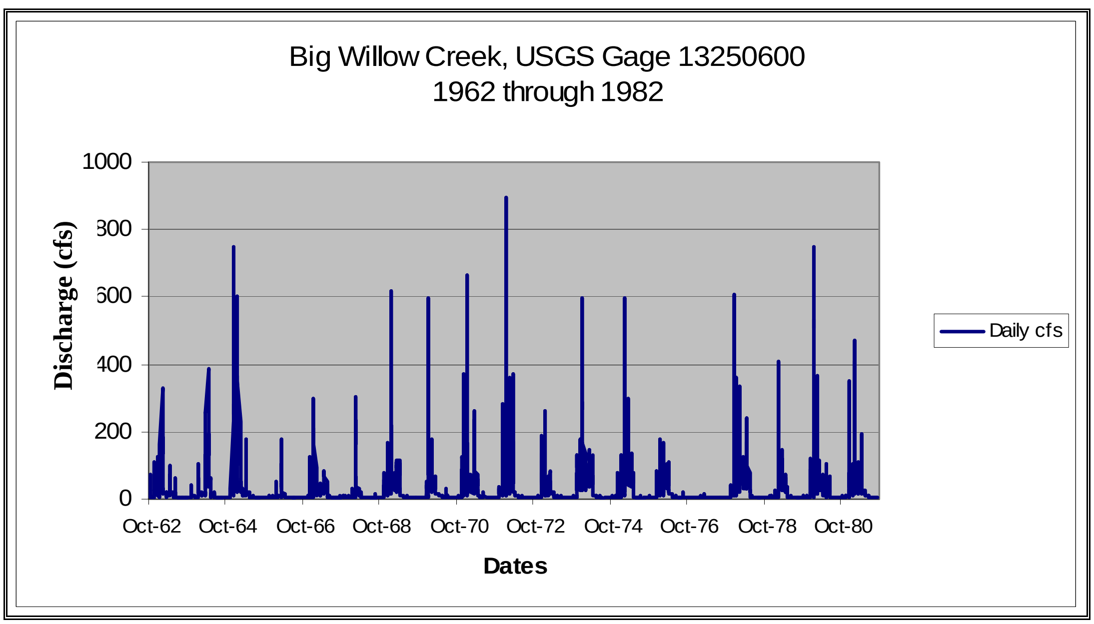

Figure 20. Daily mean Discharge, 1962 to 1982, USGS Gauge 13250600, Big Willow Creek.

Results from the estimated flow model compiled by Hortness and Berenbrock (2001) and the average monthly discharge were compared and are presented in Figure 21. Data is represented as an average of monthly measurements, and the estimated occurrence of monthly average peak flows at frequencies of 20 (Q20), 50 (Q50), or 80 (Q80) years over the period of record. It should be noted the data represent discharge associated with a little over

25% of the total drainage area of the watershed, or approximately 27,000 acres. Using the same model, the discharge for the entire watershed was estimated and is presented in Figure 22.

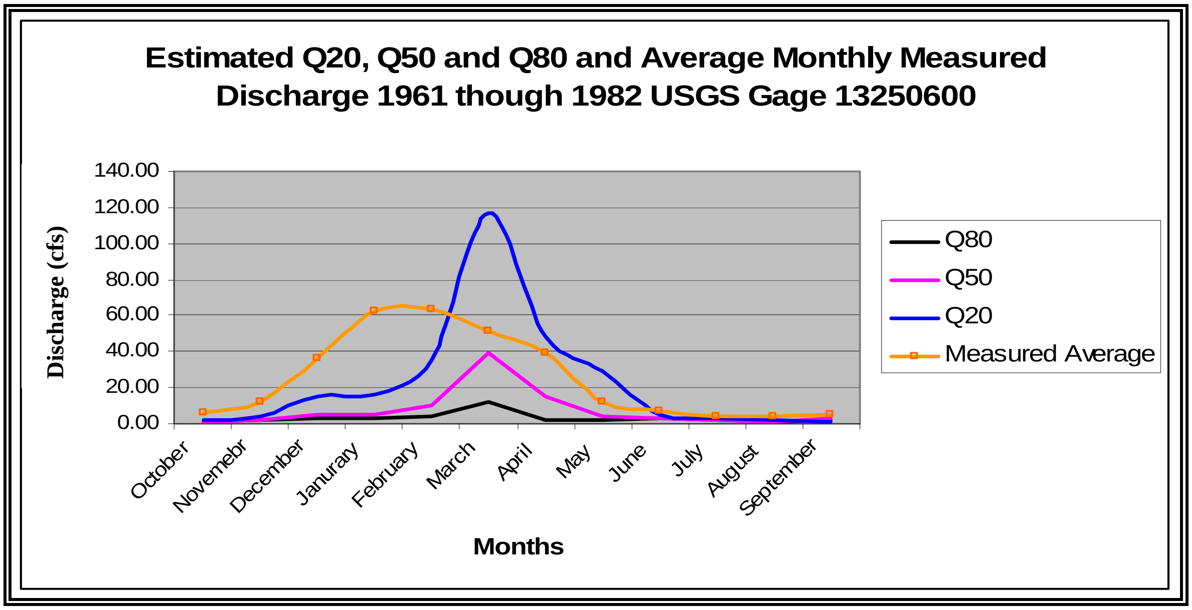

Figure 21. Estimated Q20, Q50, Q80 and Measured Average Monthly Discharge, USGS Gauge 13250600. Big Willow Creek.

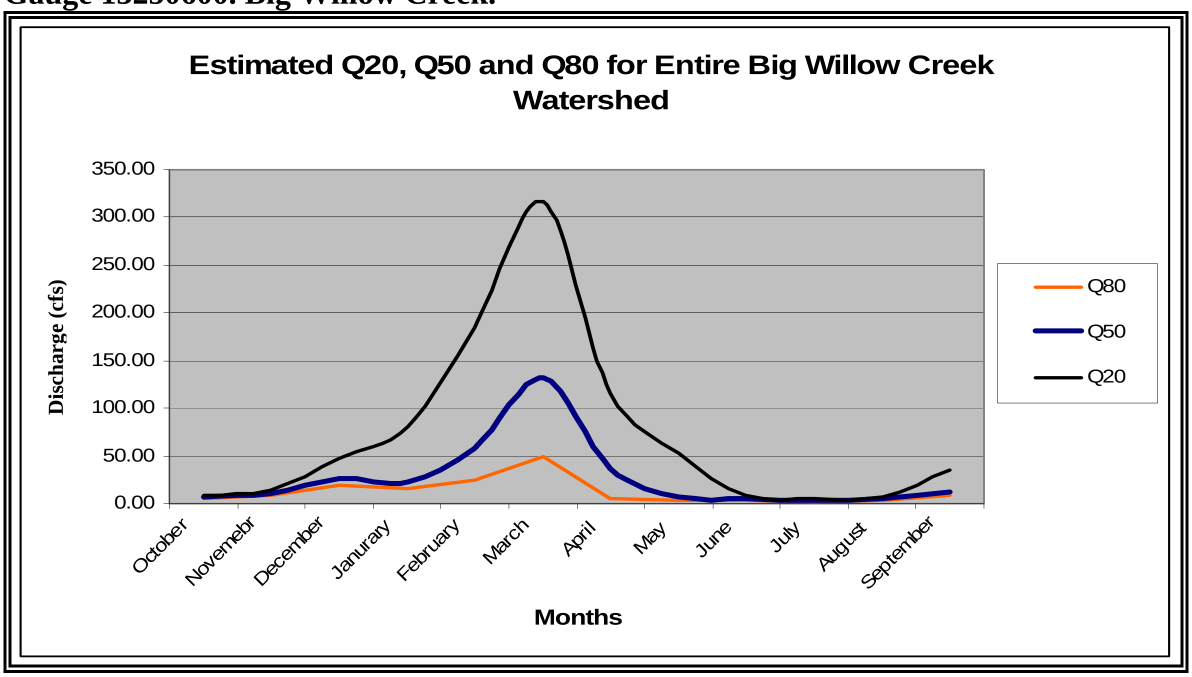

Figure 22. Estimated Q20, Q50, Q80 for Entire Big Willow Creek Watershed.

As expected, the model does not capture the extreme peak (Q100) discharges that occur in the watershed because continuous flow data must be collected for at least 25 years in order to estimate 100-year flood frequency statistics.

In 1997, the USGS gauge on the Payette River at Payette, Idaho (USGS 13251000) recorded a miximum peak discharge for the period of record of 32,000 cfs. At the same time, the USGS gage (13249500) at Emmett, Idaho, recorded a peak discharge for the same date at approximately 22,000 cfs, which indicates an increase of 9,000 to 10,000 cfs associated with the drainage area between those gauges. Local individuals living near the Big Willow Creek watershed stated their observation that, “a wall of water came shooting down the drainage taking out everything” during the period from January 1st through the 3rd (Pence, Personal Communication 1997). With the estimate of over 1,500 cfs made by USGS at the gauging station near the confluence of Fourmile Creek, it is conceivable the peak discharge associated with the entire watershed was near or possibly exceeded 3,000-4,000 cfs. Table 9 and Figure 21 and Figure 22 do not include the peak discharge estimated at 1,550 cfs reported by USGS on January 1, 1997.

Peak discharges, parent geological material, and stream morphology all play an important function in current biological indicators. These periodic high volume discharges into a confined channel create high energy scouring and eroding if an inadequate flood plain exists. This is the case for Big Willow Creek.

Table 9. Peak and average monthly discharge, USGS gauge site 13250600, Big Willow Creek.

Date	Peak Discharge Reported by USGS (cfs)	Average Monthly Discharge Reported by USGS (cfs)	Percent Increased above Average Monthly Discharge (%)
02/10/1962	882	63	1300%
01/31/1963	813	62	1211%
04/01/1964	499	39	1179%
12/22/1964	1860	36	5067%
03/09/1966	397	51	678%
01/21/1967	492	62	694%
02/21/1968	764	63	1113%
01/21/1969	1050	62	1594%
01/27/1970	1450	62	2239%
12/08/1970	921	36	2458%
01/20/1972	1360	62	2094%
12/24/1972	797	36	2114%
01/15/1974	809	62	1205%
02/13/1975	1080	63	1614%
02/26/1976	403	63	540%
12/15/1977	1390	36	3761%
02/13/1979	709	63	1025%
01/12/1980	1620	62	2513%
02/14/1981	1280	63	1932%
02/16/1982	2570	63	3979%

Water Column Data

The USGS collected baseline geochemical water quality data in June 1980 and temperature, discharge, and specific conductance data once each month from 1973 through 1982, from the gauging station (13250600). Because this gauging station is located in AU03, the data are only representative of that AU. Temperature data collected at the gauging station indicate that numeric temperature criteria for the CWAL designated use was exceeded from May through October in most years,

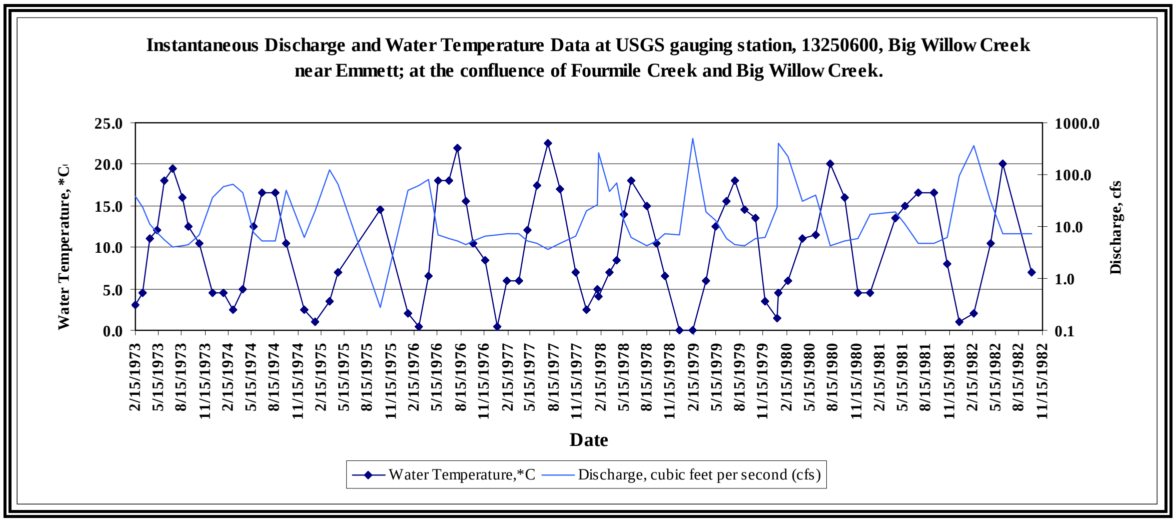

Figure 23. Graph of Instantaneous Measured Discharge and Water Temperature. Collected by the USGS at gauging station 13250600 near the confluence with Fourmile Creek.

The DEQ assessment of Big Willow Creek for temperature uses a potential natural vegetation (PNV) evaluation. The goal of the PNV TMDL is to improve water temperature conditions in the watershed by reaching potential natural vegetation conditions that should occur based on elevation, precipitation, and soil types.

Bacteria

In 2004, one sample for *E. coli* was collected at BURP site 2004SBOIA040, in AU03, to determine the support status of recreational uses. The sample result was 36 colony forming units per 100 milliliters of sample (cfu/100ml). Because this result was below the maximum contaminant level (MCL) of 406 cfu/100ml, which would require additional monitoring to determine if the numeric geometric mean of 126 cfu/100ml was exceeded, no further samples were collected and PCR is determined to be a supported use in AU03.

Temperature

Instantaneous water temperature data is collected from the water column when BURP data is collected. This data is included in Table C-4, Appendix C.

Biological and Other Data

This section includes an assessment of the biological and habitat data collected from locations in the Big Willow Creek subbasin.

Fish

Table 10 summarizes the fish data collected through the BURP program from 2001 through 2005, from the data collection sites shown on Figure 14. All sites from which fish data were collected are located in AU03. Rainbow trout collected ranged in size from 60 mm to 230 mm, which indicates diversity of age classes for salmonid species and recent spawning activity at or near the site (Grafe et al., 2002). In 2004 at site 2004SBOIA040, only one rainbow trout was captured. No other cold water indicator fish species, such as sculpin or mountain whitefish, were observed by BURP crews. The percentage of cold water species does not exceed 50% of the sample required to indicate use support for the CWAL designation in accordance with the WBAG II, (Grafe et al,. 2002) the condition ratings for the Stream Fish Index (SFI) are either a 1 or 0 for all sites (Table 16), but the data indicate that the designated use of salmonid spawning (SS) is an existing use in AU03.

Table 10. Summary of fish data collected from Big Willow Creek through the Beneficial Uses Reconnaissance Program (BURP) from 2001-2005.

AU	Date Sampled	Salmonid Taxa	% Cold Water Preference (individuals)	Total Individuals	% Cool Water Preference (individuals)
AU03	07/31/2003	1	18.3	60	26.3
AU03	07/08/2004	1	2.4	41	97.6
AU03	07/05/2005	1	7.6	65	92.3

Macroinvertebrates

Macroinvertebrate data was evaluated to determine the proportion of the benthic macroinvertebrate community tolerant to cold water conditions. Using the macroinvertebrate temperature tolerance index published in the WBAG, (Grafe et al., 2002), it was determined that BURP macroinvertebrate data from 1996 to 2004 indicate that cold water organisms are a small component (10%)of the biological community in Big Willow Creek and that cold water aquatic life is an unsupported beneficial use.

Table 11. Evaluation of cold water aquatic life as a supported use. Beneficial Use Reconnaissance Program (BURP) data, 1996 through 2004, Big Willow Creek.

Date Sampled	BURP ID	AU	Number of CW Taxa Present	Cold Water Aquatic Life Use
07/22/1996	1996SBOIA051	04	0	Not Supported
07/27/1997	1997SBOIA049	02	0	Not Supported
07/26/2001	2001SBOIA033	03	0	Not Supported
07/03/2002	2002SBOIA003	03	0	Not Supported
07/31/2003	2003SBOIA023	03	3	Not Supported
10/20/2003	2003SBOIA053	04	dry	Not Supported
07/08/2004	2004SBOIA040	03	1	Not Supported

All macroinvertebrate samples were analyzed using the Stream Macroinvertebrate Index (SMI) developed by Idaho DEQ. The final SMI score and the“condition rating” results are reported in Table 12. When the SMI score is combined with at least one other index score, such as the Stream Habitat Index (SHI) or the Stream Fish Index (SFI), resulting in an average "condition rating" score greater than 2, the water body is determined to be fully supporting beneficial uses. However, as with the case of Big Willow Creek, if one index score is less than the "minimal threshold value" for any index, the water body is not fully supporting the beneficial uses.

Table 12. Stream macroinvertebrate index scores and relative "condition rating" from Beneficial Use Reconnaissance Program (BURP) data, Big Willow Creek.

Date Sampled	*BURP ID*	*AU*	*Final SMI Score*	*Final Condition Rating*
07/22/1996	1996SBOIA049	02*	29.6	0
07/22/1996	1996SBOIA050	03*	24.0	0
07/26/2001	2001SBOIA033	03	76.49	3
07/03/2002	2002SBOIA003	03	67.37	3
07/31/2003	2003SBOIA023	03	60.05	3
07/08/2004	2004SBOIA040	03	66.90	3

*Non-Tier I data

The data displayed above indicate the expected biological communities are sometimes present in AU03, but the community structure appears to be degraded at sites in AU02. BURP data collected from AU04 in 1996 failed use support measures, and in 2003 water at the AU04 site was too deep to allow for collection above an irrigation diversion and the channel downstream of the diversion was completely dry. Appendix D contains additional macroinvertebrate data.

Habitat

As with macroinvertebrates and fish, DEQ has developed an index for scoring habitat condition. This Stream Habitat Index (SHI) evaluates multiple matrices such as canopy cover, substrate, bank stability, and pool complexity, to name a few (Grafe et al., 2002). Table 13 shows the overall SHI scores and "condition ratings" as determined with BURP data collected from 2001 through 2005. Additional habitat information is available in Appendix D.

Table 13. Stream habitat index scores and relative "condition rating" from Beneficial Use Reconnaissance Program (BURP) data, Big Willow Creek.

Date Sampled	BURP ID	AU	Final SHI Score	Final Condition Rating
07/22/1996	1996SBOIA049	02*	52	1
07/22/1996	1996SBOIA050	03*	45	1
07/26/2001	2001SBOIA033	03	72	3
07/03/2002	2002SBOIA003	03	60	3
07/31/2003	2003SBOIA023	03	67	3
10/20/2003	2003SBOIA053	04	10	1
07/08/2004	2004SBOIA040	03	70	3

*Non-Tier I data

As with the macroinvertebrate data, there appears to be a contrast in habitat conditions between AUs. However, when evaluating all physical influences such as the differing vegetation, parent geological material, stream alteration, and flashy discharge patterns; degraded habitat conditions in the lower segments would be expected. Restoration of natural flow structures and patterns along with restoration of riparian zone vegetation will help to protect the stream from pollutants and disperse the energy associated with the frequent peak discharge events.

Stream Substrate

Embedded stream conditions can impair benthic species and fisheries by limiting the interstitial space available for protection and suitable substrate for nest or redd construction. Certain primary food sources for fish (Ephemeroptera, Plecoptera, and Tricoptera species [EPT]) respond positively to a gravel to cobble substrate (Waters, 1995). Substrate embeddedness targets are difficult to establish. However, continued studies such as those described by Relyea, Minshall, and Danehy (2000) may eventually lead to the development of a macroinvertebrates index of sediment-tolerant organisms.

Salmonid species require clean, well-oxygenated gravels for spawning, incubation, and emergence. Intergravel space is required for fry to develop, find primary food sources, and take refuge. Pools are required for mature fish development and provide refuge during high water temperature and for prey protection (Burton, 1991). When fine sediment ("fines" -- particles less than 6.35 mm in diameter) exceed 27% of the total substrate, embryo survival and emergence of swim-up fry is reduced by 50% (Bjornn and Reiser 1991). Studies conducted on Rock Creek (Twin Falls County, Idaho) and Bear Valley Creek (Valley County, Idaho) found that when the percentage of fines ("percent fines") is greater than 30%, embryo survival is impaired (Idaho DEQ, 1990). Overton et al. (1995) found natural accumulation of percent fines to be about 34% in in Rosgen type C channels. Most Rosgen type C channels exhibit similar gradient (< 2.0%) as Rosgen type F channels (Rosgen, 1996).

In Big Willow Creek, BURP crews observed higher percent surface fines (particles less than 2mm in diameter) in low-gradient segments and nearer the mouth (Table C-3, Appendix C). As shown in Table 14, data collected from AU03 in the most recent 5 years (Tier I data) report percent surface fines ranging from 1.47% to 30.20%. Fine sediments are an important component for stream morphology and are usually the first material deposited during point bar development, creating the primary stage for energy dispersal. Once point bars are established, deep-rooted vegetation, such as sedges, can encroach into the wetted areas of a water body to assist in dispersing energy and stabilizing erodible areas. AU04 is a naturally low-gradient stream segment with percent surface fines observed between 41 and 63% from 1997 to 1999. While this observation exceeds the 27% threshold for salmonid spawning (Rowe, Essig, and Jessup, 2003), it may be within the normal range for a low-gradient stream segment recovering from an extreme flood event. Although a simplistic view of stream morphology and regeneration is described here, energy dispersal is the key component in streambank stability. Any activity that reduces or increases energy dispersal, such as point bar development or channel straightening, will have an impact on downstream locations; either by preventing or increasing erosion.

Table 14. Percent surface fines (< 2mm) for wetted area and wetted and bank full areas, Big Willow Creek (Tier I Data).

Date Sampled	BURP ID	AU	Percent Fines < 2.0 mm (wetted area)	Percent Fines < 2.0 mm (wetted and bank full areas)
07/26/2001	2001SBOIA033	03	21.6%	30.2%
07/03/2002	2002SBOIA003	03	4.6%	7.5%

07/31/2003	2003SBOIA023	03	11.1%	16.7%
07/08/2004	2004SBOIA040	03	1.47	1.64
07/05/2005	2005SBOIA020	03	7.81	10.78

Status of Beneficial Uses

To determine the support status based on biological and habitat indices using the process described in WBAG II (Grafe et al., 2002), any data older than five (5) years old, and any macroinvertebrate data collected prior to July 1 or after October 15 (non-Tier I) should not be used. For Big Willow Creek, this limits the amount of BURP data that can be used, and effectively restricts the process to only the sites in AU03. High flows and lack of access to the stream limit the data collection opportunities in the watershed. Table 15 shows the final index scores and the condition rating for the sites with viable data.

Table 15. Final index scores and condition rating based on Tier I Data, Big Willow Creek.

BURP ID	AU	SMI[a]	Condition Rating	SHI[b]	Condition Rating	SFI[c]	Condition Rating	Final Condition Rating
2001SBOIA033	03	76.5	3	72	3	ND		3.0
2002SBOIA003	03	67.4	3	60	3	ND		3.0
2003SBOIA023	03	60.1	3	67	3	64	2	2.7
2003SBOIA053	04	0	0	10	1	ND		1
2004SBOIA040	03	66.9	3	69	3	33	0	BMT

a. SMI – Stream Macroinvertebrate Index; b. SHI – Stream Habitat Index; c. SFI – Stream Fish Index; ND – No Data; BMT – Below Minimum Threshold

Using the support status guidance as described in the WBAG II (Grafe et al. 2002), AU03 of Big Willow Creek is supporting PCR, but not CWAL or SS, even though SS appears to exist at some sites in the AU. Applying the same evaluation to all years for which BURP data is available, the support status can be determined for AU02, AU03, and AU04. Table 16 shows the initial index scoring and condition ratings for all sites on the water body. AUs with a final condition rating of less than 2 are determined not to be supporting designated uses.

Table 16. Index scores and condition rating based on all available BURP data, Big Willow Creek.

BURP ID	AU	SMI[a]	Condition Rating	SHI[b]	Condition Rating	SFI[c]	Condition Rating	Final Condition Rating
1994SBOIA001	03	49.81	2	37	1			1.5
1994SBOIA002	03	48.00	2	27	1			1.5
1994SBOIA003	04	27.56	0	15	1			0
1994SBOIA004	03	31.25	0	19	1			0
1995SBOIA010	04	20.41	0	38	1			0
1995SBOIA011	03	28.99	0	33	1			0
1995SBOIT009	03	ND	ND	ND	ND			ND
1996SBOIA049	03	44.13	2	62	3			2.5
1996SBOIA050	03	27.20	0	36	1			0
1996SBOIA051	04	18.88	0	52	1			0
1997SBOIA049	02	29.67	0	52	1			0
1997SBOIA050	02	23.97	0	45	1			0
1997SBOIB013	03	59.28	3	62	3	33	0	0
1997SBOIB014	03	34.72	1	40	1			1.0
1997SBOIB015	04	30.10	0	21	1			0
1998SBOIA045	03	37.86	1	41	1			1
1998SBOIA046	03	60.46	3	59	3			3
1998SBOIB036	04	30.41	0	37	1			0
1999SBOIA055	03	62.01	3	78	3			3.0
1999SBOIA056	03	42.91	1	31	1			1.5
1999SBOIA057	04	46.95	2	31	1			1.5
2001SBOIA033	03	76.49	3	72	3			3.0
2002SBOIA003	03	67.37	3	60	3			3.0
2003SBOIA023	03	60.05	3	67	3	45.56	1	2.33
2003SBOIA053	04	ND	ND	10	1			1
2004SBOIA040	03	66.91	3	70	3	33.5	0	0
2005SBOIA020	03	57.83	3	72	3	37.31	0	0

a Stream Macroinvertebrate Index, b Stream Habitat Index, c Stream Fish Index, ND No Data

Conclusions

Based on final condition ratings, AU02, AU03 and AU04 are classified as not supporting CWAL designated uses based on the scoring of indices referenced in the WBAG II, (Grafe et al., 2002). Most of the streams in AU02 are ephemeral or intermittent streams and AU06 has been modified to serve as an irrigation water conveyance channel and is actively managed by the Payette Irrigation Company for that purpose. Based on the proportional dominance of organisms with a preference for warm water from sampled benthic macroinvertebrate organisms, it is reasonable to conclude that all listed segments in the Big Willow Creek watershed are impaired for temperature. In AU03, SS is an existing use, as documented by the presence of young of the year (YOY) salmonid species, and PCR is a supported use based on the results of *E. coli* analysis. Other AUs have not been assessed for PCR.

DEQ is assessing temperature impairment in Big Willow Creek through a potential natural vegetation (PNV) evaluation. The goal is to improve water temperature conditions in the watershed by reaching potential natural vegetation conditions that should occur based on elevation, precipitation and soil types.

Based on qualitative assessments of habitat and observations of flow control structures throughout the watershed, AU03, AU04, and AU06 appear to be impaired by flow alteration and habitat modification (Table 17). DEQ has determined that habitat modification from anthropogenic flow alteration and recent severe flooding are impairments to Big Willow Creek that can be addressed through reconnecting the channel with the natural floodplain and other appropriate BMPs.

Table 17. Assessment outcomes and recommendations, Big Willow Creek.

Designated Use	Support Status	Pollutant(s) Impairing Use(s)	Justification	Recommendations
Cold Water Aquatic Life (CWAL)	Not Supported	Temperature, Flow Alteration, Habitat Modification	Temperature data (USGS and BURP). Macroinvertebrate data (BURP). Constructed flow controls (IDWR, satellite imagery).	Place AU02, AU03, AU04, and AU06 on 4c list for flow and habitat alteration and remove from Section 5. A Potential Natural Vegetation (PNV) TMDL is developed.
Salmonid Spawning (SS)	Existing Use in AU03	Temperature, Flow Alteration, Habitat Modification and Unknown	Temperature data (USGS and BURP). Macroinvertebrate data (BURP). Constructed flow controls (IDWR, satellite imagery).	Place AU02, AU03, AU04, and AU06 on 4c list for flow and habitat alteration, and Retain in Section 5.for Unknown. A Potential Natural Vegetation (PNV) TMDL is developed.
Primary Contact Recreation (PCR)	Supported in AU03	Flow Alteration, Habitat Modification and Unknown	BURP data indicates compliance with numeric criteria in AU03	Future data collection from AU02, AU04, AU06. Remain in Section 5 for Unknown.

2.5 Data Gaps

Assessment technology and methods are constantly evolving, and while the best available technology and methods were used to collect the most representative samples possible, there are challenges that hinder the acquisition of what may be considered optimal data, analysis, or interpretation. It is the goal of DEQ to continue to develop and implement improved methods or to revise existing programs to incorporate new technology or information.

The data used to make use support determinations for this watershed include historical and recent water quality data, aquatic biota data, aerial photography interpretation, satellite imagery review, and stream habitat surveys. Water chemistry data has been collected only once in the watershed, by the USGS at the gauging station in 1980, as part of a nationwide assessment project. Numeric temperature data collected at the gauging station from 1973 to 1982 is not recent enough to qualify for Tier I data as described in the WBAG II, (Grafe, et al., 2002) and does not represent conditions outside of AU03. Temperature data collected by the BURP teams is not comprehensive enough to make a use support determination, but does support the results of benthic macroinvertebrate analysis, which indicate temperature impairment of all sampled AUs. Benthic macroinvertebrate assemblage data can be compared to an index of temperature tolerance for macroinvertebrates from which temperature pollution can be inferred and quantified. The macroinvertebrate data from BURP sites qualifies as Tier I data for AU02, AU03, and AU04. Samples collected through the BURP are representative of the AU from which data was collected and cannot be extrapolated to represent all AUs in the subbasin. The bacteria sample used to determine PCR use support applies directly to AU 03. At the present time, DEQ uses surrogate measures to quantify sediment loading to streams; subsurface percent fines of less than 27% and bank stability surveys of greater than 80% meet the criteria for SS use support (Rowe, Essig, and Jessup, 2003). There is no information for either surrogate measure from Big Willow Creek, but Tier I (most recent 5 years) percent surface fines values (Table 14) range between 2.94 and 30.2 at BURP sites in AU03.

In order to determine BMP effectiveness and monitor trends in the subbasin, it would be helpful to collect basic nutrient and bacteria data, in addition to measured discharge, from at least 5 sites in the watershed at least twice each year, once before crops are planted and again in late summer, to determine the use support status of AUs yet to be monitored. McNeil core samples and bank stability inventories from each perennial AU to assess percent depth fines and bank stability would also be useful in determining whether AU02, AU04, and AU06 are impaired by sediment.

Given the nature of land use in the basin and the difficulty and expense of collecting field data, remote sensing technology may offer benefits in determining whether the philosophy and methods used in the development of this TMDL provided the information necessary to restore the Big Willow Creek watershed to a condition that supports all designated uses. Periodic data collection from all third order or larger tributaries and the mainstem, using Forward Looking Infrared (FLIR) or Thermal Infrared (TIR), and Light Detection and Ranging (LiDAR), may be a cost-effective method for determining the source and degree of impairment in the watershed. This data could be collected through a collaborative effort with other stakeholders in the basin and accomplish several purposes simultaneously, at a savings to watershed stakeholders and taxpayers.

3.0 Subbasin Assessment–Pollutant Source Inventory

3.1 Sources of Pollutants of Concern

This section addresses the sources, identified and potential, in the watershed that may contribute to water quality impairments that prevent Big Willow Creek from attaining designated beneficial uses.

Point Sources

There are no point sources presently identified in the Big Willow Creek watershed.

Nonpoint Sources

Some conditions that impair water quality do not receive TMDLs. The EPA considers anthropogenic impacts that prevent the attainment of beneficial uses, such as flow alteration, or habitat alteration, as "pollution" even though they are not "pollutants." However, TMDLs are only required when a pollutant can be identified and in some way quantified. Because there are no identified point source impairments in the watershed, all impairments are presumed to be from nonpoint sources related to land use. Using data from the USDA (2006) and IDWR (current), land use is determined to be dominated by grazed rangeland (80%) with some cultivated agriculture (20%) which is almost entirely situated within the natural floodways and floodplains of the surface water bodies.

Temperature

Modifications to the riparian zone of Big Willow Creek have increased the solar load to the surface water system, resulting in increased water temperatures. DEQ acknowledges that tributaries are likely contributors to temperature impairment and while none of the tributaries to Big Willow Creek have been assessed for temperature, future assessments may include temperature loads for tributaries which may require TMDLs. In order for this temperature TMDL to be effective in restoring support of beneficial uses to the subbasin, tributary streams must also be at natural background conditions. The most critical timeframe for water temperature is in the summer months when stream flows are naturally at the lowest levels. Dewatered streams and un-shaded impoundments increase the solar load to the surface water system. Without adequate riparian vegetation, surface waters are unprotected from excess solar radiation.

Flow and Habitat Alteration

Numerous flow controls have been constructed in the watershed, some of which serve to augment the periodic high-energy flows, which occur naturally in the watershed as a function of ecoregion and terrain. The current stream morphology limits the natural function of the stream and the floodplains by increasing flow velocity and redirecting flow away from the floodplain. Channel embeddedness and riparian habitat degradation have adversely affected the aquatic communities. Irrigation diversions result in dewatered channels, which also contribute to loss of riparian vegetation. Without year-round channel flow and an adequate functional flood plain, vegetation that would serve to mitigate high-energy discharge events cannot be re-established.

3.2 Data Gaps

Point Sources

There are no identified point sources in the Big Willow Creek watershed.

Nonpoint Sources

The greatest area of uncertainty in developing this TMDL is the absence of temperature loads for the tributaries in the watershed and the contribution each tributary makes to Big Willow Creek. As remote sensing technology becomes more economical, new data may be available to quantify the temperature load of tributaries or contributions to temperature impairment from sources not yet identified.

Flow and habitat alteration are observably widespread in all AUs. Water chemistry data in addition to remotely sensed data would assist in identifying and quantifying specific sources of impairment in each AU. A more precise data set would be beneficial to develop and prioritize implementation projects or improved BMPs. Improving the dataset used to model the PNV or other impairment reduction models could hasten restoration of Big Willow Creek and delisting through more rapid attainment of designated beneficial uses.

Because the watershed recently experienced a severe flood event exceeding the magnitude of any recorded event, and estimated to have been more severe than a 100-year event, it is not possible to determine the source or impact of potential sediment pollution in the subbasin with the data presently available. Possible sources include seasonal or intense periodic precipitation events; flow and habitat alteration; erosion from land use related to grazing, agriculture, or wild fires; and near-stream roads. The State of Idaho has developed a guide for selecting sediment targets for use in TMDLs (Rowe, Essig, and Jessup, 2003) and the Big Willow Creek subbasin would benefit from collection of depth percent fines data and bank stability inventories in the perennial AUs (03, 04, 06) in conjunction with a geomorphology assessment (LiDAR) of AU06 to determine target sediment levels for the deltaic flow regime in AU06.

Bacteria and nutrient data necessary to determine use support status are also lacking for most of the subbasin. Data collection from the water column, stream bed, and stream banks in each AU would enable a determination to be made regarding the attainment of criteria-specific beneficial uses, such as PCR and SS.

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

Personal observations in 1992 (Ingham, 1992) indicated that the land near the stream corridor was used as a winter feeding area for cattle, creating a high density use during seasons in which plants are the most sensitive to destruction. This resulted in little to no vegetation cover to protect the stream, which increases stream temperature and flow velocity during precipitation events, and may have increased stream embeddedness.

In the mid 1990s the winter streamside use was discontinued and animals were fenced away from the riparian zone or moved to a different location. Woody vegetation began returning to the riparian area and a flood plain was reforming. In late December 1996 and early January 1997, a rain on snow event occurred in southwest Idaho resulting in record discharges recorded at nearby continuous discharge recording sites. This event caused numerous 2nd, 3rd, and 4th order water bodies to "blow out." Big Willow Creek was one of these.

Current management practices favor a "hands off" approach and no structural in-stream BMPs are being implemented. A slow progression toward a mature riparian corridor is occurring. Improvement to habitat and stream morphology is a slow process, but Big Willow Creek appears to be re-establishing woody vegetation and a flood plain. There is evidence of increased stream meandering, increased near-stream ground water recharge (hyporheic zone) and increased functionality as an aquatic ecosystem.

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5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources to assure WQS 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 receive a waste load allocation (WLA); and nonpoint sources, each of which receive a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of WQS, 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 margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human-made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a 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. The LC must be based on critical conditions – the conditions when WQS 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 it may appear on the surface.

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“other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable and relate to WQS, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows seasonal or annual loads.

5.1 In-stream Water Quality Targets

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

Design Conditions

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

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

The effective shade calculations are based on a 6-month period from April through September. Because solar gains can begin early in the spring, before deciduous vegetation has developed a leaf canopy over the stream, it affects the highest temperatures later on in the summer and salmonid spawning in spring and fall. The April through September period coincides with the critical time when temperatures affect SS beneficial uses and when CWAL criteria may be exceeded. Late July and early August typically represent the period of highest stream temperatures.

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

Upstream of the hydrographical apex, Big Willow Creek exists in a V-shaped valley surrounded by steep foothills that were once sagebrush/bunchgrass rangelands and have since been converted to exotic annual grasslands. Most of AU02 and some of AU03 exists in this topography. The headwater segment that extends out of the foothills ridge west of Ola Valley is often dry most of the year, and perennial flow in Big Willow Creek begins downstream of a series of springs near the Coonrod Gulch area. Riparian vegetation below the springs is dominated by willows and is limited in extent by basalt rock adjacent to the stream. However, as the valley narrows near Jakes Creek, the riparian vegetation changes to an alder tree-dominated plant community (presumably white alder, *Alnus rhombifolia*) with an occasional cottonwood.

Below Rock Creek, Big Willow Creek emerges from the narrowest portion of the canyon onto a broad plain. This is the hydrographical apex. Water is diverted from the stream for irrigation at this point and flows in the channel are highly variable, with portions of the stream observably dry during the summer months. The riparian plant community tends to be dominated by deciduous trees and shrubs like cottonwoods (*Populus sp.*) and willows (*Salix sp.*). This area experienced considerable flooding following a rain on snow event in 1997. Immediately downstream of the hydrographical apex, the streambed has been covered by a hardpan-like clay washed out of the upper watershed. The creek is incised in places and new terraces are forming along much of the creek in AU03 below Rock Creek and in AU04. The riparian community appears to be recovering on the gravel wash of the new terrace. In some locations, cottonwoods are fully developed on the older floodplain.

Stream Morphology

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

In this analysis, the only factor not developed from aerial photo interpretation is channel width (i.e., NSDZ or Bankfull Width). Accordingly, this parameter is 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 24).

For each stream segment evaluated in the loading analysis, bankfull width is estimated based on drainage area using the Payette/Weiser curve from the Idaho Regional Curves for Bankfull Width (Figure 24). Additionally, existing width is evaluated from available data. If the stream's existing width is greater than the estimated width based on the Payette/Weiser curve, then the curve-based estimate of bankfull width is used in the loading analysis. If existing width is smaller, then existing width is used in the loading analysis. Existing bankfull widths for Big Willow Creek upstream of Rock Creek are consistent with estimated widths from the Payette/Weiser regional curve. Downstream of Rock Creek, existing widths are not as consistent with the Payette/Weiser curve, due to agricultural diversion and return flows. However, existing widths do not appear to exceed regional curve predictions. Therefore, we have adhered to the regional curve estimate of bankfull width in the loading analysis. Widths measured at field verification sites are indicated on the loading analysis tables (Table 21 and Table 22) in red typeface.

Pathfinder Methodology

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

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

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

Aerial Photo Interpretation

To estimate canopy coverage or shade expectations based on plant type and density, natural breaks in vegetation density are marked out on a 1:100K or 1:250K hydrography. Each resulting stream segment (interval) is then assigned a single value representing the bottom of the respective 10% cover (canopy coverage) or shade class from the list of classes below (adapted from the CWE process, IDL 2000*)*. For example, if estimated canopy cover for a particular stretch of stream is 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 specified in the list below shows the kind of landscape a particular shade 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 clearcut areas. However, that does not mean that the 20% cover class cannot occur in shrublands and forests, because it does on wider streams.

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

It is important to note that the visual estimates made from 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 (OWEB, 2001). The visual estimates of shade in this TMDL were field-verified with a solar pathfinder. The pathfinder measures effective shade and accounts for other physical features that block the sun from hitting the stream surface (e.g. hillsides, canyon walls, terraces, man-made structures). The estimate of shade made visually from an aerial photo does not always take into account topography or 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.

Target Selection

Existing shade is estimated for Big Willow Creek 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. PNV targets were determined from an analysis of probable vegetation at the stream compared to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between stream width and effective shade. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of the stream. As the vegetation gets taller, the plant community is able to provide more shade at any given channel width. To convert existing shade values and PNV shade values to solar loads, data collected on flat plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather station were used (of the NREL stations that collect this type of data). In this case, data from the Boise, Idaho station was used. The difference between existing and potential solar load, assuming existing load is greater, is the load reduction necessary to bring the stream into compliance with WQS (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 (if there are no point sources or anthropogenic sources of heat in the watershed), and are thus considered to be consistent with the Idaho WQS, even though they may exceed numeric criteria.

To determine PNV shade targets for Big Willow Creek, effective shade curves, for similar ecoregions, from several existing temperature TMDLs were examined. For these TMDLs, vegetation community modeling was used to produce the curves. Although these TMDLs reflect a wide variety of geomorphologies and topographies, effective shade at the same stream widths were remarkably similar. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. Because no two landscapes are exactly the same, shade targets were derived by taking an average of the various shade curves available. The selected shade curves presumably represent a range of shade conditions that include the riparian community of interest in this TMDL.

PNV for Big Willow Creek AU02 segments with perennial flow are presumed to be a mixed deciduous tree and shrub plant community dominated by alders and willows (Table 18). In AU03, PNV is presumed to be a mix of mixed deciduous tree and shrub plant community and a basalt rock willow plant community (Table 19). In AU04, and AU06, the lower outwash plain, PNV is presumed to be a mixed deciduous tree and shrub community, dominated by cottonwoods (Table 20). For Big Willow Creek, effective shade curves for the most similar vegetation type were selected for shade target determinations.

Shade Curves

The mixed deciduous tree/shrub vegetation in the upper portion of the watershed was characterized using three shade curves from two different TMDLs. Used in the target development were the mountain alder and the willow/alder communities described in the Alvord Lake TMDL (ODEQ, 2003), and the deciduous zone curve from the Walla Walla TMDL (ODEQ, 2004b). The mountain alder shade curve is from the Willow-Whitehorse ecological province with system potential conditions of 25-foot average height, 30% average canopy density, and a 30-foot riparian buffer width. The willow/alder shade curve comes from the Trout Creek Mountains ecological province with system potential conditions of 24-foot average canopy height and 75% average canopy density. The deciduous zone curve includes mixed willows and alders with interspersed black cottonwoods with an average height of 22 meters (72 feet) and a canopy density of 80%. Average shade values for these three curves at specific stream widths were used as targets (Table 18). Targets range from 91% shade for stream width of 1 meter to 41% shade at 16 meters wide.

A portion of Big Willow Creek AU02 and AU03 upstream of Rock Creek, where these targets are applied, is also influenced by topographic shade. In this area (identified in Table 21 as beginning at “topo+10” and ending before “topo+0”), we have increased the targets by 10% to account for additional topographic shade.

Table 18. Shade targets for the upper mixed deciduous tree/shrub vegetation type at various stream widths, Big Willow Creek.

Upper Mxd Decidous Tree/Shrub	1m	2m	4m	6m	8m	9m	10m	12m	14m	16m
mountain alder (ODEQ, 2003)	90	88	80	68	60	53	50	43	40	35
willow/alder (ODEQ, 2003)	90	82	68	58	45	43	40	30	29	25
deciduous zone (ODEQ, 2004b)	94	93	90	88	82	80	78	75	68	64
Average	91.333	87.67	79.33	71.33	62.333	58.67	56	49.333	45.67	41.333
Target (%)	**91**	**88**	**79**	**71**	**62**	**58**	**56**	**49**	**46**	**41**

A portion of Big Willow Creek AU03 has basalt rock outcrops that limit the extent of riparian plant development. In this area, willow shrubs are mixed in with the surrounding upland sagebrush/grass vegetation. To develop targets for this portion (Table 19), we selected a willow mix curve from the Alvord Lake TMDL and the coyote willow shade curve from the Salmon-Chamberlain (Crooked Creek) TMDL and blended them with the bunchgrass and shrubland vegetation response unit (VRU12/16) of the South Fork Clearwater TMDL. The willow mix community from the Pueblo Mountains ecological province of Alvord Lake has an average canopy height of 14 feet and an average density of 50% (ODEQ, 2003). The coyote willow community from Crooked Creek (Idaho DEQ, 2002) has an average height of 8 feet and an average canopy cover of 82%. The VRU 12/16 shade curve represents an average shrub height of 8.4 feet and a grass height of 1 foot with an 80% shrub/20% grass distribution (Idaho DEQ, 2004).

Table 19. Shade targets for the basalt rock-limiting willow vegetation type at various stream widths, Big Willow Creek.

Basalt/Willow Mix	1m	2m	3m	4m	5m
willow mix 2-36 (ODEQ, 2003)	80	70	54	45	40
coyote willow (IDEQ, 2002)	90	72	47	41	34
VRU12/16 (IDEQ, 2004)	85	70	45	38	32
Average	85	70.667	48.667	41.33	35.3333
Target (%)	**85**	**71**	**49**	**41**	**35**

Shade curves used to describe the mixed deciduous tree/shrub plant community of the Big Willow Creek AU03 and AU04, reflect the more open, cottonwood-dominated nature of this lower elevation plant community. Again, three shade curves were averaged for target development. Two curves, the willow/cottonwood/aspen community and the alder/cottonwood/willow community, are from the Alvord Lake TMDL (ODEQ, 2003). The willow/cottonwood/aspen community is from the East Steens ecological province with a system potential of 25-foot average height and 65% average canopy density. The alder/cottonwood/willow community is from the Pueblo Mountains ecological province with a system potential of 28-foot average height and 75% average canopy density. The third shade curve used in the analysis was from the Willamette Basin TMDL (ODEQ, 2004a). Here the Qalf geologic province is used with a system potential plant community that is 52% forest (predominantly ash, alder, willow, and cottonwood), 28% savanna (predominantly white oak savanna), and 20% prairie (seasonally wet and dry prairies), resulting in an average height of 57.5 feet and a 68% stand density. Average shade values for these three curves at specific stream widths are used as targets (Table 20). Targets range from 84% at 1m stream width to 25% at 21m wide.

Table 20. Shade targets for the lower mixed deciduous tree/shrub vegetation type at various stream widths, Big Willow Creek.

Lower Mxd Deciduous Tree/Shrub	1m	2m	3m	4m	5m	6m	7m	8m	9m	
willow/cottonwood/aspen (ODEQ, 2003)	82	77	70	62	59	53	48	44	39	
Qalf (ODEQ, 2004a)	85	82	80	76	74	69	66	65	62	
alder/cottonwood/willow (ODEQ, 2003)	85	81	76	71	67	60	55	50	45	
Average	84	80	75.33	69.67	66.667	60.67	56.33	53	48.67	
Target (%)	**84**	**80**	**75**	**70**	**67**	**61**	**56**	**53**	**49**	
Lower Mxd Deciduous Tree/Shrub	10m	11m	12m	14m	15m	16m	17m	19m	20m	21m
willow/cottonwood/aspen (ODEQ, 2003)	34	32	31	27	24	23	22	20	19	18
Qalf (ODEQ, 2004a)	59	55	49	46	44	43	41	40	38	36
alder/cottonwood/willow (ODEQ, 2003)	42	40	35	30	27	25	23	22	21	20
Average	45.00	42.33	38.33	34.33	31.667	30.33	28.67	27.333	26	24.667
Target (%)	**45**	**42**	**38**	**34**	**32**	**30**	**29**	**27**	**26**	**25**

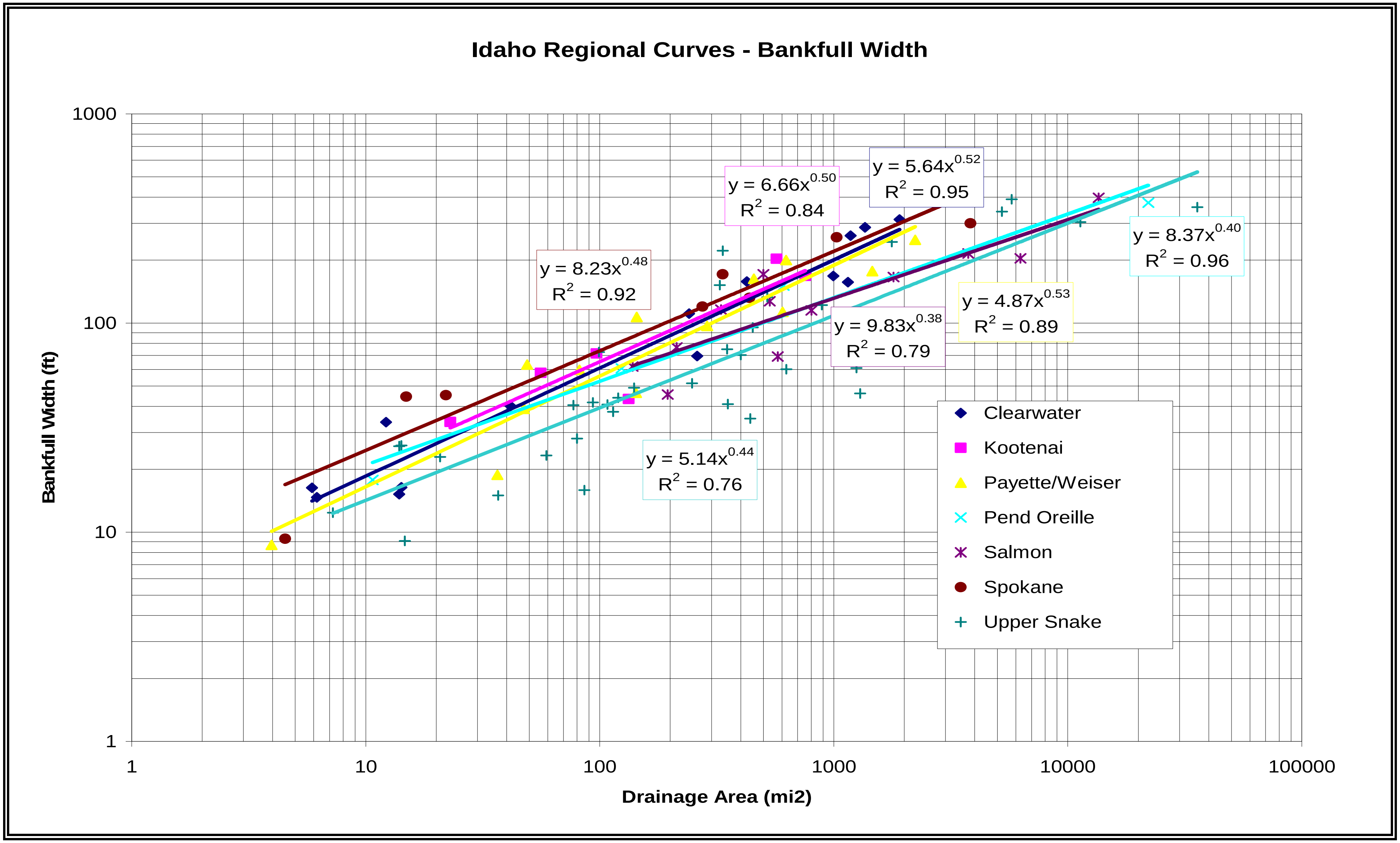

Figure 24. Bankfull width as a function of drainage area, as taken from IDL (2000).Monitoring Points

The accuracy of the aerial photo interpretations were field-verified with a solar pathfinder at 50 locations within five different shade class intervals. In general, those areas where aerial photo interpretation had classified shade as being at or below 40% were accurate interpretations. Areas where original aerial photo interpretations had classified shade as 50% or greater tended to be low by about 20%. As a result, these areas were reclassified with shade levels 20% higher. The new existing shade levels based on field verification are incorporated into the loading tables (columns 2 and 4, Table 21 and Table 22 and Figure 25, Figure 26, and Figure 27).

Future effective shade monitoring can take place on any reach throughout Big Willow Creek and compared to estimates of existing shade seen on Figure 26 and described in Table 22 and Table 23 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. The lengths of the stream segments assigned to existing shade classes vary, depending on land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade towards target levels. Ten equally-spaced solar pathfinder measurements within a given segment averaged together should suffice to determine new shade levels in the future.

5.2 Load Capacity

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

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

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

We obtained solar load data for flat plate collectors from a National Renewable Energy Laboratory (NREL) weather station. In this case, data from the Boise, Idaho station was used. The solar loads used in this TMDL are spring/summer averages, thus, we use an average load for the 6-month period from April through September. These months coincide with the time of year that stream temperatures are increasing and deciduous vegetation is in leaf. Table 22 and Table 23 show the PNV shade targets (identified as Target or Potential Shade) and the corresponding potential summer load (in kilowatt hours per square meter per day [kWh/m^2/day] and kilowatt hours per day [kWh/day]) that serve as the loading capacities for the streams.

The loading capacity ranges for measured segments of Big Willow Creek, in kWh/day, are as follows: AU02, 700.524 to 155.034; AU03, 86,068.752 to 618.22; AU04, 727,626.24 to

17,940.56; and AU06, 257,241.6 to 16,077.6 (Table 21 and Table 22). The corresponding percent lack of shade (Table 21, Table 22 and Figure 27) is calculated for each measured segment by subtracting the existing shade fraction (column 2, Table 22 and Table 23) from the potential shade fraction (column 4, Table 21 and Table 22) and multiplying the result by 100.

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.

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 an NREL weather station. Existing shade data are presented in Table 21, Table 22 and Figure 26. Like loading capacities (potential loads), existing loads are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day), with a final column in Table 21 and Table 22 representing the lack of shade (in percent), in each measured stream segment.

Existing and potential loads in kWh/day can be summed for the entire stream or by 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. Existing loads range from 304,830 kWh/day (Table 21) to 3,872,864 kWh/day (Table 22) in Big Willow Creek. Existing loads that presently meet target loads are indicated by a zero (0) in the final column of Table 21 and Table 22. The percent lack of shade ranges from 1 to 21 in AU02, 0 to 35 in AU03, 0 to 30 in AU04, and 5 to 25 in AU06.

Table 21. Existing and potential solar loads for Big Willow Creek, AU02 and AU03.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Lack of Shade (%)	**Big Willow Creek, headwaters to canyon mouth**
AU# 17050122SW017_02														
1220	0.9	0.638	0.91	0.5742	-0.06	1	1	1220	778.36	1220	700.524	-77.836	-1	upper mxd tree/shrub
270	0.7	1.914	0.91	0.5742	-1.3398	1	1	270	516.78	270	155.034	-361.746	-21	
120	0.8	1.276	0.88	0.7656	-0.5104	2	2	240	306.24	240	183.744	-122.496	-8	
430	0.7	1.914	0.88	0.7656	-1.1484	2	2	860	1646.04	860	658.416	-987.624	-18	
							Subtotal	**2,590**	**3,247**	**2,590**	**1,698**	**-1,550**		
AU# 17050122SW017_03														
220	0.7	1.914	0.88	0.7656	-1.1484	2	2	440	842.16	440	336.864	-505.296	-18	upper mxd tree/shrub
480	0.5	3.19	0.71	1.8502	-1.3398	2	2	960	3062.4	960	1776.192	-1286.208	-21	basalt/willow
370	0.7	1.914	0.83	1.0846	-0.8294	3	3	1110	2124.54	1110	1203.906	-920.634	-13	upper mxd tree/shrub
190	0.8	1.276	0.83	1.0846	-0.1914	3	3	570	727.32	570	618.222	-109.098	-3	
220	0.7	1.914	0.83	1.0846	-0.8294	3	3	660	1263.24	660	715.836	-547.404	-13	
1200	0.3	4.466	0.41	3.7642	-0.7018	4	4	4800	21436.8	4800	18068.16	-3368.64	-11	basalt/willow
180	0.2	5.104	0.41	3.7642	-1.3398	4	4	720	3674.88	720	2710.224	-964.656	-21	
390	0.3	4.466	0.35	4.147	-0.319	5	5	1950	8708.7	1950	8086.65	-622.05	-5	
220	0.4	3.828	0.35	4.147	0.319	5	5	1100	4210.8	1100	4561.7	350.9	0	
70	0	6.38	0.35	4.147	-2.233	5	5	350	2233	350	1451.45	-781.55	-35	
100	0.8	1.276	0.75	1.595	0.319	5	5	500	638	500	797.5	159.5	0	upper mxd tree/shrub
190	0.5	3.19	0.75	1.595	-1.595	5	5	950	3030.5	950	1515.25	-1515.25	-25	
150	0.8	1.276	0.75	1.595	0.319	5	5	750	957	750	1196.25	239.25	0	
180	0.5	3.19	0.75	1.595	-1.595	5	5	900	2871	900	1435.5	-1435.5	-25	
110	0.8	1.276	0.75	1.595	0.319	5	5	550	701.8	550	877.25	175.45	0	
390	0.6	2.552	0.71	1.8502	-0.7018	6	6	2340	5971.68	2340	4329.468	-1642.212	-11	
120	0.8	1.276	0.71	1.8502	0.5742	6	6	720	918.72	720	1332.144	413.424	0	
200	0.7	1.914	0.71	1.8502	-0.0638	6	6	1200	2296.8	1200	2220.24	-76.56	-1	
170	0.4	3.828	0.71	1.8502	-1.9778	6	6	1020	3904.56	1020	1887.204	-2017.356	-31	
400	0.7	1.914	0.71	1.8502	-0.0638	6	6	2400	4593.6	2400	4440.48	-153.12	-1	
240	0.5	3.19	0.71	1.8502	-1.3398	6	6	1440	4593.6	1440	2664.288	-1929.312	-21	
630	0.8	1.276	0.77	1.4674	0.1914	7	7	4410	5627.16	4410	6471.234	844.074	0	topo+10
140	0.7	1.914	0.77	1.4674	-0.4466	7	7	980	1875.72	980	1438.052	-437.668	-7	
850	0.8	1.276	0.77	1.4674	0.1914	7	7	5950	7592.2	5950	8731.03	1138.83	0	
240	0.6	2.552	0.72	1.7864	-0.7656	8	8	1920	4899.84	1920	3429.888	-1469.952	-12	
790	0.7	1.914	0.72	1.7864	-0.1276	8	8	6320	12096.48	6320	11290.048	-806.432	-2	
800	0.8	1.276	0.72	1.7864	0.5104	8	8	6400	8166.4	6400	11432.96	3266.56	0	
1590	0.7	1.914	0.68	2.0416	0.1276	9	9	14310	27389.34	14310	29215.296	1825.956	0	
200	0.4	3.828	0.68	2.0416	-1.7864	10	10	2000	7656	2000	4083.2	-3572.8	-28	
500	0.7	1.914	0.66	2.1692	0.2552	10	10	5000	9570	5000	10846	1276	0	
210	0.8	1.276	0.66	2.1692	0.8932	10	10	2100	2679.6	2100	4555.32	1875.72	0	
490	0.7	1.914	0.66	2.1692	0.2552	10	10	4900	9378.6	4900	10629.08	1250.48	0	
100	0.4	3.828	0.63	2.3606	-1.4674	11	11	1100	4210.8	1100	2596.66	-1614.14	-23	
280	0.7	1.914	0.63	2.3606	0.4466	11	11	3080	5895.12	3080	7270.648	1375.528	0	
440	0.4	3.828	0.63	2.3606	-1.4674	11	11	4840	18527.52	4840	11425.304	-7102.216	-23	
340	0.5	3.19	0.63	2.3606	-0.8294	11	11	3740	11930.6	3740	8828.644	-3101.956	-13	
310	0.4	3.828	0.63	2.3606	-1.4674	11	11	3410	13053.48	3410	8049.646	-5003.834	-23	
820	0.6	2.552	0.59	2.6158	0.0638	12	12	9840	25111.68	9840	25739.472	627.792	0	
140	0.4	3.828	0.59	2.6158	-1.2122	12	12	1680	6431.04	1680	4394.544	-2036.496	-19	
180	0.7	1.914	0.59	2.6158	0.7018	12	12	2160	4134.24	2160	5650.128	1515.888	0	
320	0.5	3.19	0.59	2.6158	-0.5742	12	12	3840	12249.6	3840	10044.672	-2204.928	-9	
430	0.4	3.828	0.59	2.6158	-1.2122	12	12	5160	19752.48	5160	13497.528	-6254.952	-19	
120	0.5	3.19	0.49	3.2538	0.0638	12	12	1440	4593.6	1440	4685.472	91.872	0	topo+0
660	0.5	3.19	0.38	3.9556	0.77	12	12	7920	25264.8	7920	31328.352	6063.552	0	lower mxd tree/shrub
80	0.3	4.466	0.38	3.9556	-0.5104	12	12	960	4287.36	960	3797.376	-489.984	-8	
610	0.4	3.828	0.38	3.9556	0.1276	12	12	7320	28020.96	7320	28954.992	934.032	0	
130	0.5	3.19	0.38	3.9556	0.7656	12	12	1560	4976.4	1560	6170.736	1194.336	0	
1390	0.3	4.466	0.34	4.2108	-0.2552	14	14	19460	86908.36	19460	81942.168	-4966.192	-4	
160	0.1	5.742	0.34	4.2108	-1.5312	14	14	2240	12862.08	2240	9432.192	-3429.888	-24	
1460	0.3	4.466	0.34	4.2108	-0.2552	15	14	21900	97805.4	20440	86068.752	-11736.648	-4	
690	0.2	5.104	0.34	4.2108	-0.8932	12	14	8280	42261.12	9660	40676.328	-1584.792	-14	
190	0.3	4.466	0.34	4.2108	-0.2552	10	14	1900	8485.4	2660	11200.728	2715.328	0	
1050	0.1	5.742	0.3	4.466	-1.276	13	16	13650	78378.3	16800	75028.8	-3349.5	-20	
							Subtotal	**205,200**	**690,833**	**209,030**	**641,130**	**-49,703**		
							Total	**207,790**	**694,080**	**211,620**	**642,828**	**-51,252**		

Table 22. Existing and potential solar loads for Big Willow Creek, AU04 and AU06, Big Willow Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Segment Area (m^2)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	Lack of Shade (%)	**Big Willow Creek, canyon mouth to Payette River**
AU# 17050122SW017_04														
480	0.1	5.742	0.3	4.466	-1.276	16	16	7680	44098.56	7680	34298.88	-9799.68	-20	lower mxd tree/shrub
860	0	6.38	0.3	4.466	-1.914	16	16	13760	87788.8	13760	61452.16	-26336.64	-30	
360	0.1	5.742	0.3	4.466	-1.276	16	16	5760	33073.92	5760	25724.16	-7349.76	-20	
790	0	6.38	0.3	4.466	-1.914	16	16	12640	80643.2	12640	56450.24	-24192.96	-30	
8800	0.1	5.742	0.28	4.5936	-1.1484	18	18	158400	909532.8	158400	727626.24	-181906.56	-18	
940	0	6.38	0.26	4.7212	-1.6588	20	20	18800	119944	18800	88758.56	-31185.44	-26	
1730	0.1	5.742	0.26	4.7212	-1.0208	18	20	31140	178805.88	34600	163353.52	-15452.36	-16	
820	0	6.38	0.26	4.7212	-1.6588	20	20	16400	104632	16400	77427.68	-27204.32	-26	
190	0.1	5.742	0.26	4.7212	-1.0208	20	20	3800	21819.6	3800	17940.56	-3879.04	-16	
460	0	6.38	0.26	4.7212	-1.6588	20	20	9200	58696	9200	43435.04	-15260.96	-26	
370	0.1	5.742	0.26	4.7212	-1.0208	20	20	7400	42490.8	7400	34936.88	-7553.92	-16	
1080	0	6.38	0.26	4.7212	-1.6588	20	20	21600	137808	21600	101977.92	-35830.08	-26	
1170	0.1	5.742	0.26	4.7212	-1.0208	20	20	23400	134362.8	23400	110476.08	-23886.72	-16	
1880	0	6.38	0.26	4.7212	-1.6588	20	20	37600	239888	37600	177517.12	-62370.88	-26	
560	0.1	5.742	0.26	4.7212	-1.0208	10	20	5600	32155.2	11200	52877.44	20722.24	-16	
480	0.3	4.466	0.25	4.785	0.319	11	21	5280	23580.48	10080	48232.8	24652.32	5	
450	0	6.38	0.25	4.785	-1.595	21	21	9450	60291	9450	45218.25	-15072.75	-25	
							Subtotal	**387,910**	**2,309,611**	**401,770**	**1,867,704**	**-441,908**		
AU#17050122SW017_06														
2560	0	6.38	0.25	4.785	-1.595	21	21	53760	342988.8	53760	257241.6	-85747.2	-25	lower mxd tree/shrub
1940	0.1	5.742	0.25	4.785	-0.957	21	21	40740	233929.08	40740	194940.9	-38988.18	-15	
1770	0	6.38	0.25	4.785	-1.595	21	21	37170	237144.6	37170	177858.45	-59286.15	-25	
880	0.2	5.104	0.25	4.785	-0.319	21	21	18480	94321.92	18480	88426.8	-5895.12	-5	
430	0	6.38	0.25	4.785	-1.595	21	21	9030	57611.4	9030	43208.55	-14402.85	-25	
250	0.2	5.104	0.25	4.785	-0.319	21	21	5250	26796	5250	25121.25	-1674.75	-5	
160	0	6.38	0.25	4.785	-1.595	21	21	3360	21436.8	3360	16077.6	-5359.2	-25	
600	0.2	5.104	0.25	4.785	-0.319	21	21	12600	64310.4	12600	60291	-4019.4	-5	
							Subtotal	**180,390**	**1,078,539**	**180,390**	**863,166**	**-215,373**		
							Total	**568,300**	**3,388,150**	**582,160**	**2,730,870**	**-657,280**		

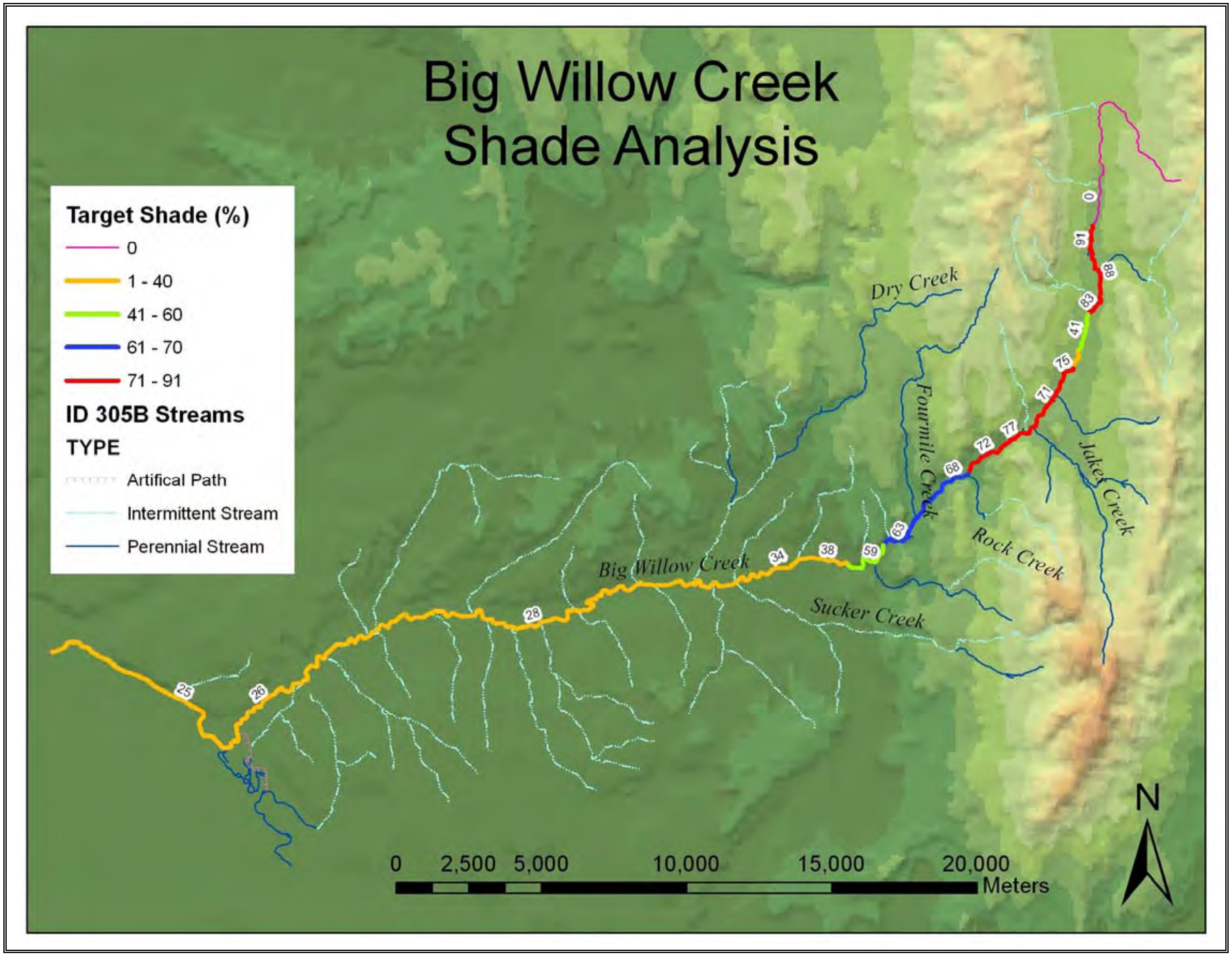

Figure 25. Target Shade for Big Willow Creek.

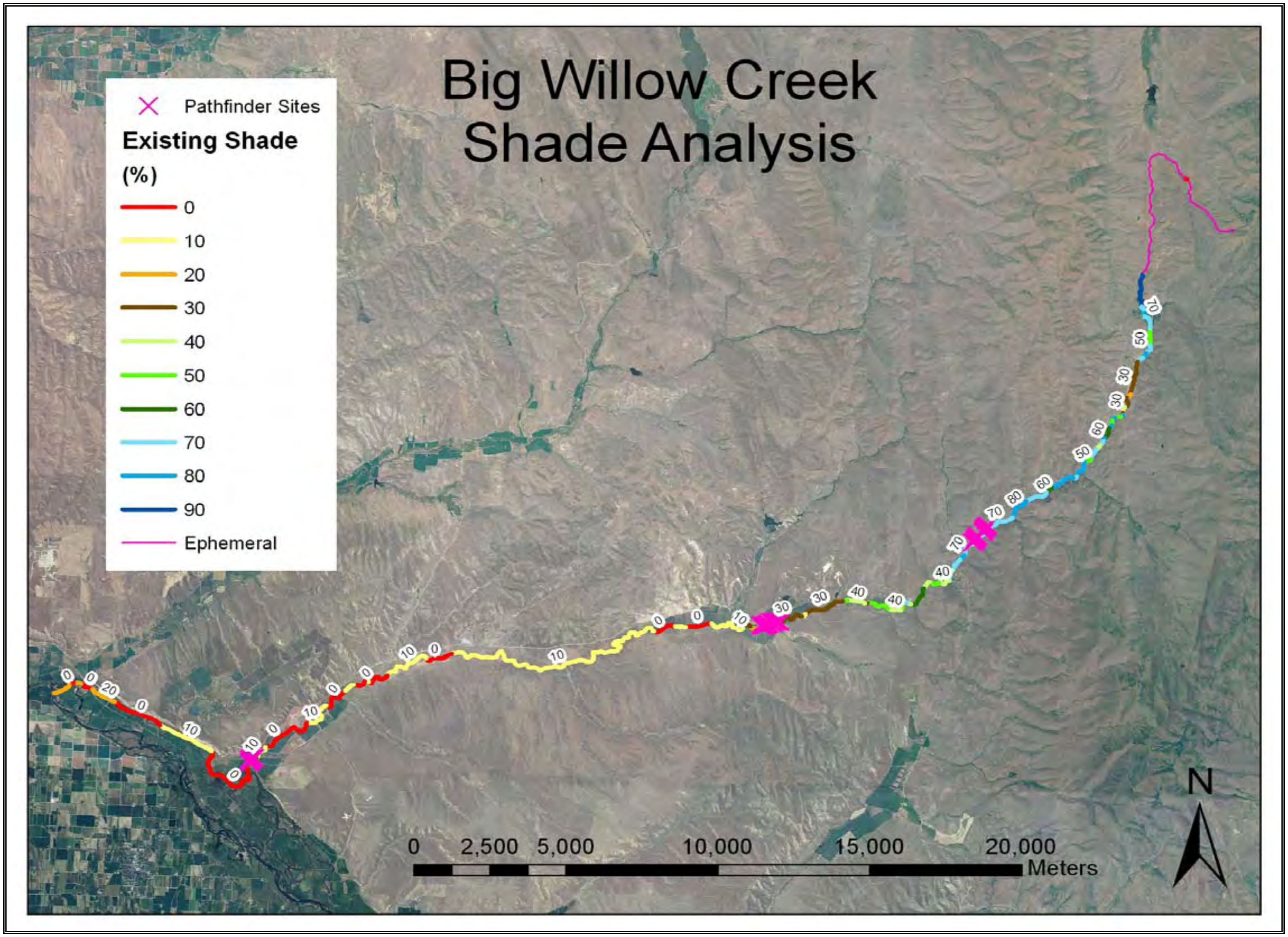

Figure 26. Existing Shade Estimated for Big Willow Creek by Aerial Photo Interpretation.

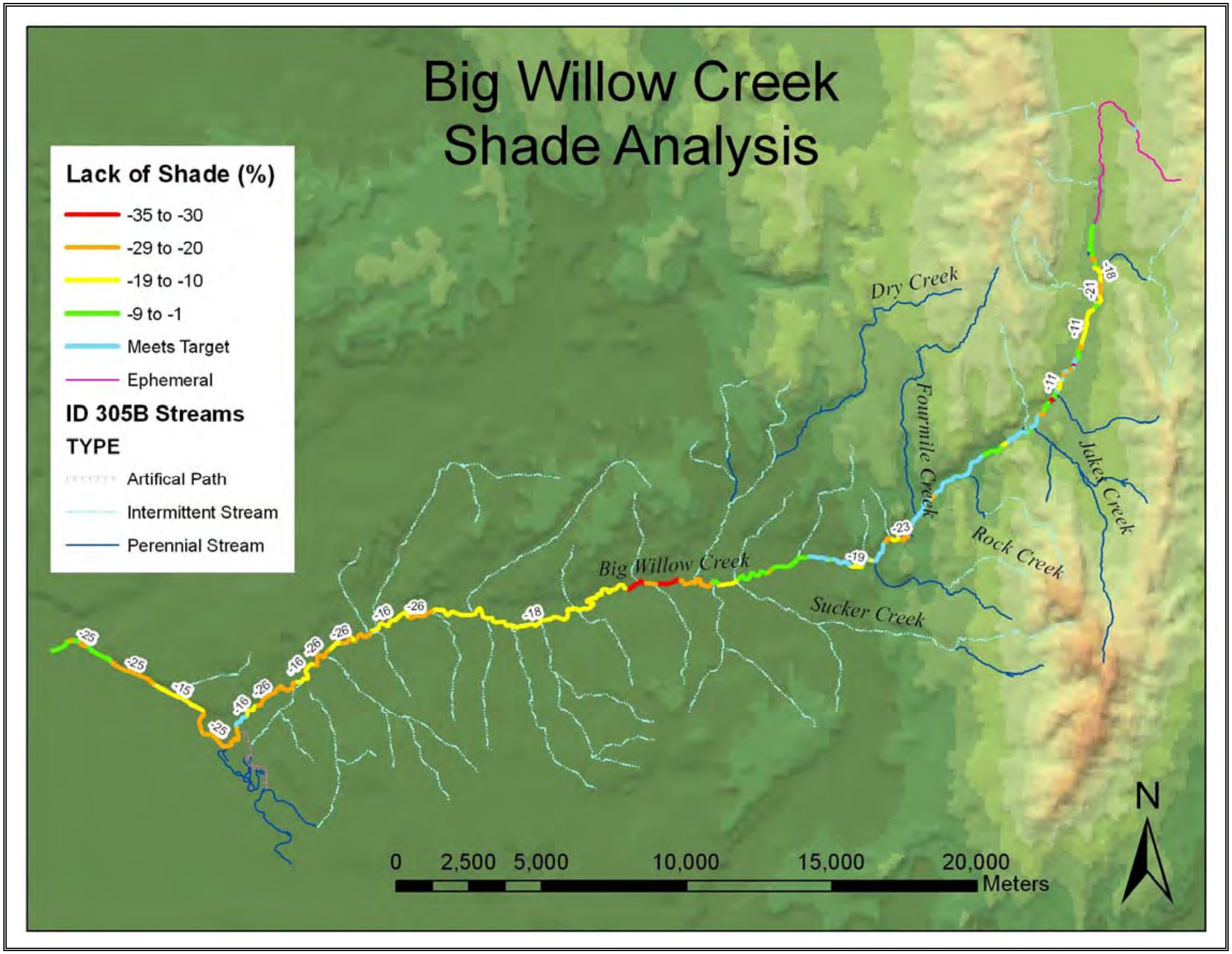

Figure 27. Lack of Shade (difference between existing and target) for Big Willow Creek.

5.4 Load Allocation

Because this TMDL is based on loading that does or would occur under PNV, which is equivalent to background load, the load allocation is essentially the target to achieve background conditions. However, in order to reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Load allocations are therefore stream reach-specific and are dependent upon the target load for a given reach. Table 21, Table 22 and Figure 25 show the target or potential shade converted to potential summer load by multiplying the average of total loads recorded on a flat plate collector for the months of April through September by the "percent open, " which is calculated as described above. That is the load capacity of the stream and it is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream, by any activity, without exceeding its load capacity. Additionally, because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the waters examined here need to be at natural background condition in order to prevent excess heat loads to the system.

Table 23 shows the total existing load, total target load, range (in percent) of excess heat load, and the range of percent lack of shade for Big Willow Creek (by AU). The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths as compared to smaller streams. Table 23 lists the sections in order of their excess loads highest to lowest. Therefore, large water bodies tend to be listed first and small tributaries last.

Although the following analysis dwells on total heat loads for streams in this TMDL, it is important to note that differences between existing shade and target shade, as depicted in Lack of Shade (Figure 27), are the key to successfully restoring these waters to meet WQS. Target shade levels for individual reaches should be the goals that managers strive for with future implementation plans. Managers should key in on the areas with the largest differences between existing and target shade as locations to prioritize implementation efforts. Each loading table contains a final column that lists the excess load (kWh/day) per linear meter of stream. It is derived from dividing the excess load for each segment by the length of each segment. Thus, stream segments with the largest excess load per meter are in the worst shape regarding shade.

Table 23. Total existing, target, and excess solar loads for Big Willow Creek.

Assessment Unit	Total Existing Load (kWh/day)	Total Target Load (kWh/day)	Excess Load (kWh/day)	Range in Percent Excess Load	Range in Percent Lack of Shade
AU02	3,247	1,698	1,550	10 to 70	1 to 21
AU03	694,080	642,828	51,252	0 to 60	0 to 35
AU04	2,309,611	1,867,704	441,908	0 to 30	0 to 30
AU06	1,078,539	863,166	215,373	6 to 25	5 to 25

Table 23 shows that AU04 Big Willow Creek has the highest excess load as well as higher excess loads per linear meter. The total excess load to AU02 is reasonably small, although there is a small segment where the excess load is 70%.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the loading analysis. Because existing shade is reported as a 10% class level and target shade is a unique integer, there is always a difference between them. For example, say a particular stretch of stream has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that stretch of stream were at target level, it would be recorded as 80% existing shade in the loading analysis because it falls into that existing shade class. Additionally, sometimes the existing shade is slightly greater than the target (e.g., a 90% existing shade reach with an 86% shade target), resulting in a positive load excess which should be ignored. These areas represent undefined errors in the calculations, which result in the appearance of "excess" shade. This result reflects the level of uncertainty in the model, which can mask problem areas where the shade curve and the model do not fit well, when the shade table is summarized to the percent value. Stream segments that yield results with positive differences between existing and potential shade are essentially at target and have zero excess load per linear meter.

Wasteload Allocation

There are no identified point sources in the watershed, and no waste load allocations (WLA). Should a point source be proposed that would have thermal consequence on these waters, background provisions addressing such discharges in Idaho WQS (IDAPA 58.01.02.200.09 and IDAPA 58.01.02.401.03) would be involved (see Appendix B).

Margin of Safety

The MOS in this TMDL is considered implicit in the design. Because the target is natural background conditions, loads (shade levels) are allocated to lands adjacent to the stream at natural background levels. Because shade levels are established at natural background or system potential levels, it is unrealistic to set shade targets at higher, or more conservative, levels. Although the loading analysis used in this TMDL involves estimations that are likely to have some variance, there are no load allocations that have been determined to benefit or suffer from that variance.

Seasonal Variation

This TMDL is based on average summer loads. All loads have been calculated to be inclusive of the 6-month period from April through September. This period was selected because it represents the time when the combination of increasing air and water temperatures coincide with increasing solar inputs and increasing vegetative shade. The critical periods are June, when spring salmonid spawning is occurring, July and August, when maximum temperatures exceed cold water aquatic life criteria, and September, during fall salmonid spawning. Water temperature is not likely to be a problem for beneficial uses outside of these times because of cooler weather and lower sun angle.

Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

The CWA requires operators of construction sites to obtain permits to discharge storm water to a water body or to a municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites. In the past, storm water was treated as a nonpoint source of pollutants. However, because storm water can be managed on site through BMPs or 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

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

In order to obtain the Construction General Permit (CGP), operators must develop a site-specific Storm Water Pollution Prevention Plan (SWPPP). The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically, and maintain the 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 attempts to incorporate a gross WLA for anticipated construction storm water activities where practical. TMDLs developed currently or in the past that did not have a WLA for construction storm water activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate BMPs.

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

5.5 Implementation Strategies

Implementation strategies for TMDLs produced using PNV-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 second to monitor progress toward 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.

Time Frame

Recovering streamside vegetation to levels near–PNV conditions is going to take time. Depending on the quality of the existing riparian vegetation, new growth may take years to develop. In the case of shrubs and herbaceous material where some remnants of the community exist, recovery after disturbance may only take a few years. Conversely, recovery of streamside forest that has been lost may take a century to reach its full potential. Big Willow Creek, for example, in the absence of any catastrophic floods, may take 50 years for cottonwood trees to reach mature heights.

Approach

Much of the riparian vegetation in Big Willow Creek AU03 and AU04 was removed in heavy flooding in the early winter of 1997. Riparian communities are recovering in this area and will likely provide substantial shading in the next 40 years. It is important that the plant community be allowed to recover by minimizing disturbance and rehabilitating any areas where bank erosion is evident. Areas with repeated bank erosion should be investigated for possible rehabilitation through bioengineering (plant-based structures). DEQ will continue to participate with the WAG on implementation and evaluation of existing and future projects in the watershed. Those projects are anticipated to focus on protection and restoration of the riparian zone and continued water quality, habitat, and biotic community monitoring and assessment.

Responsible Parties

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

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

- Idaho Department of Lands (IDL): timber harvest, oil and gas exploration and development, mining
- Idaho Soil Conservation Commission (ISCC): grazing and agriculture
- Idaho Department of Transportation (ITD): public roads
- Idaho Department of Agriculture (IDA): agriculture, aquaculture, animal feeding operations (AFOs), confined animal feeding operations (CAFOs)
- Idaho Department of Environmental Quality: all other activities

To the maximum extent possible, the implementation plan will be developed with the participation of federal partners and land management agencies (i.e., BLM, NRCS). 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 Big Willow Creek subbasin have responsibility for implementing the TMDL. DEQ and the “designated agencies” in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. Their general responsibilities are outlined below.

- **DEQ** will oversee and track overall progress on the specific implementation plan and monitor the watershed response. DEQ will also work with local governments on urban/suburban issues.
- **IDL** 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.
- **Idaho Soil Conservation Commission**, working in cooperation with local Soil and Water Conservation Districts and ISDA, 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.
- **ITD** will be responsible for ensuring appropriate BMPs are used for construction and maintenance of public roads.
- **IDA** will be responsible for working with agriculture and aquaculture to install appropriate pollutant control measures. Under a memorandum of understanding with EPA and DEQ, IDA also inspects AFOs, CAFOs, and dairies to ensure compliance with NPDES requirements.

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 analysis 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 WQS 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 significantly affects public acceptance of the document and the proposed control actions. Stakeholders (landowners, local governing authorities, taxpayers, industries, and land managers) are the most educated regarding the pollutant sources and will be called upon to help identify the most appropriate control actions for each area. Experience has shown that the best and most effective implementation plans are those that are developed with substantial public cooperation and involvement.

Monitoring Strategy

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. 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. 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.

In addition to data collection discussed above and in Section 2.5, bank stability inventory and habitat assessment monitoring should take place every 5 years. After a period of 10 years or more, aerial photo interpretation can be done to analyze the loading to the entire stream as it was done for this TMDL. It is anticipated that as the riparian community develops, shade will increase and solar load will decrease toward PNV levels.

5.6 Conclusions

Big Willow Creek from the headwaters to the mouth was placed on the 1998 303(d) list for temperature by EPA. It was subsequently carried forward to the 2002 303(d) list. The shade analysis in this TMDL reveals that AU02 and AU06 require the smallest percent increase in shade and AU03 requires the largest percent increase in shade. Excess solar load is evident in AU02, AU03, AU04, and AU06. AU02 has the least excess load, at less than 37,000 kWh/day. The segments of Big Willow Creek in the agriculturally-dominated outwash plain (AU03, AU04, and AU06) have excess solar loading (~676,000 kWh/day) due to a loss of riparian vegetation.

AU03, AU04, and AU06 have also experienced significant land use changes, water diversion, dewatered stream channels, habitat alteration, and reduced floodplain connectivity, which can exacerbate solar loading and increase water temperature. Some recent BMP implementations that removed livestock from riparian zones have improved flow patterns and habitat in some impaired segments. With continued BMP implementation to restore and protect natural hydrology and riparian vegetation, there is reason to believe shade levels will return to natural background conditions and stream habitat will become more supportive of aquatic organisms. These BMPs may also reduce the degree of impairment caused by flow and habitat alteration in all AUs. Recommendations for future listing status of Big Willow Creek are summarized in Table 24.

Table 24. Summary of assessment outcomes, Big Willow Creek.

Water Body Segment/AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Big Willow Creek AU02 AU03 AU04 AU 06	Temperature	PNV	Move to Section 4a of integrated report.[1]	Temperature TMDL completed.
Big Willow Creek AU02 AU03 AU04 AU06	Flow and Habitat Alteration	None required	Place Big Willow Creek in Section 4c of the integrated report	Stream habitat alteration and flow modification contribute to non-attainment of designated beneficial uses in the watershed.

[1] Section 4a of Integrated Report, Rivers with EPA approved TMDLs

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GIS Coverages

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Glossary

305(b)

Refers to section 305 subsection “b” of the Clean Water Act. The term “305(b)” generally describes a report of each state’s water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

§303(d)

Refers to section 303 subsection “d” of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Acre-foot

A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers.

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.

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).

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.

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.
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.

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).

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).

Feedback Loop

In the context of watershed management planning, a feedback loop is a process that provides for tracking progress toward goals and revising actions according to that progress.

Fixed-Location Monitoring

Sampling or measuring environmental conditions continuously or repeatedly at the same location.

Flow

See *Discharge*.

Fluvial

In fisheries, this describes fish whose life history takes place entirely in streams but migrate to smaller streams for spawning.

Focal

Critical areas supporting a mosaic of high quality habitats that sustain a diverse or unusually productive complement of native species.

Fully Supporting

In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Fully Supporting Cold Water

Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

Fully Supporting but Threatened

An intermediate assessment category describing water bodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a "not fully supporting" status.

Geographical Information Systems (GIS)

A georeferenced database.

Geometric Mean

A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.

Grab Sample

A single sample collected at a particular time and place. It may represent the composition of the water in that water column.

Gradient

The slope of the land, water, or streambed surface.

Ground Water

Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.

Growth Rate
A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.

Habitat
The living place of an organism or community.

Headwater
The origin or beginning of a stream.

Hydrologic Basin
The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).

Hydrologic Cycle
The cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Atmospheric moisture, clouds, rainfall, runoff, surface water, ground water, and water infiltrated in soils are all part of the hydrologic cycle.

Hydrologic Unit
One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

Hydrologic Unit Code (HUC)
The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

Hydrology
The science dealing with the properties, distribution, and circulation of water.

Impervious
Describes a surface, such as pavement, that water cannot penetrate.

Influent
A tributary stream.

Inorganic

Materials not derived from biological sources.

Instantaneous

A condition or measurement at a moment (instant) in time.

Intergravel Dissolved Oxygen

The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.

Intermittent Stream

1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. 2) A stream that has a period of zero flow for at least one week during most years.

Interstate Waters

Waters that flow across or form part of state or international boundaries, including boundaries with Native American nations.

Irrigation Return Flow

Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams.

Key Watershed

A watershed that has been designated in Idaho Governor Batt's *State of Idaho Bull Trout Conservation Plan* (1996) as critical to the long-term persistence of regionally important trout populations.

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.

Load Allocation (LA)	A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Load(ing) Capacity (LC)	A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.
Loess	A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.
Lotic	An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth.
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.

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.

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.
Protocol	A series of formal steps for conducting a test or survey.
Qualitative	Descriptive of kind, type, or direction.
Quality Assurance (QA)	A program organized and designed to provide accurate and precise results. Included are the selection of proper technical methods, tests, or laboratory procedures; sample collection and preservation; the selection of limits; data evaluation; quality control; and personnel qualifications and training (Rand 1995). The goal of QA is to assure the data provided are of the quality needed and claimed (EPA 1996).
Quality Control (QC)	Routine application of specific actions required to provide information for the quality assurance program. Included are standardization, calibration, and replicate samples (Rand 1995). QC is implemented at the field or bench level (EPA 1996).
Quantitative	Descriptive of size, magnitude, or degree.
Reach	A stream section with fairly homogenous physical characteristics.
Reconnaissance	An exploratory or preliminary survey of an area.
Reference	A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.
Reference Condition	1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be

determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).

Reference Site

A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.

Representative Sample

A portion of material or water that is as similar in content and consistency as possible to that in the larger body of material or water being sampled.

Resident

A term that describes fish that do not migrate.

Respiration

A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riffle

A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.

Riparian

Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.

Riparian Habitat Conservation Area (RHCA)

A U.S. Forest Service description of land within the following number of feet up-slope of each of the banks of streams:

- 300 feet from perennial fish-bearing streams
- 150 feet from perennial non-fish-bearing streams
- 100 feet from intermittent streams, wetlands, and ponds in priority watersheds.

River

A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.

Runoff

The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.

Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
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.

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.

Wasteload Allocation (WLA)

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

Water Quality Limited

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Limited Segment (WQLS)

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."

Water Quality Management Plan

A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

Water Quality Modeling

The prediction of the response of some characteristics of lake or stream water based on mathematical relations of input variables such as climate, stream flow, and inflow water quality.

Water Quality Standards

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Table

The upper surface of ground water; below this point, the soil is saturated with water.

Watershed

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a water body.

Water Body Identification Number (WBID)

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

Wetland

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

Young of the Year

Young fish born the year captured, evidence of spawning activity.

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Appendix A. Unit Conversion Chart Table

A-1. Metric - English Unit Conversions.

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Volume	Gallons (gal) Cubic Feet (ft^3)	Liters (L) Cubic Meters (m^3)	1 gal = 3.78 L 1 L= 0.26 gal 1 ft^3 = 0.03 m^3 1 m^3 = 35.32 ft^3	3 gal = 11.35 L 3 L = 0.79 gal 3 ft^3 = 0.09 m^3 3 m^3 = 105.94 ft^3
Flow Rate	Cubic Feet per Second (cfs)[a]	Cubic Meters per Second (m^3/sec)	1 cfs = 0.03 m^3/sec 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 °C = 37.4 °F

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.
[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water

Appendix B. State and Site-Specific Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring spawning salmonids, the default spawning and incubation period recognized by DEQ is generally from March 15th to July 15 th each year (Grafe et al., 2002). Fall spawning can occur as early as August 15th and continue with incubation on into the following spring up to June 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 ^{o}C as a daily maximum water temperature,
>
> 9 ^{o}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 ^{o}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 ^{o}C (IDAPA 58.01.02.401.03.a.v.).

Water Quality Standards Applicable to Cold Water Aquatic Life Temperature

As per IDAPA 58.01.02.250.02.b., Waters designated for cold water aquatic life are not to vary from the following characteristics due to human activities:

Water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C.

<u>Water Quality Standards Applicable to Primary Contact Recreation</u>

As per IDAPA 58.01.02.251.01, Waters designated for recreation are not to contain *E.coli* bacteria, used as indicators of human pathogens, in concentrations exceeding:

A geometric mean of one hundred twenty-six (126) E. coli organisms per one hundred (100) ml based on a minimum of five (5) samples taken every three (3) to seven (7) days over a thirty (30) day period.

> *A water sample exceeding the E. coli single sample maximums below indicates likely exceedance of the geometric mean criterion, but is not alone a violation of water quality standards. If a single sample exceeds the maximums set forth in Subsections 251.01.b.i., 251.01.b.ii., and 251.01.b.iii., then additional samples must be taken as specified in Subsection 251.01.c.*

For waters designated as primary contact recreation, a single sample maximum of four hundred six (406) E. coli organisms per one hundred (100) ml.

Appendix C. Data Sources and Assessment Data

Table C-1. Data sources for Big Willow Creek TMDL.

Water Body	Data Source	Type of Data	When Collected
Big Willow Creek	DEQ State Technical Services Office	Pathfinder effective shade and stream width	June 2006
Big Willow Creek	DEQ State Technical Services Office	Aerial Photo Interpretation of existing shade and stream width estimation	March 2006
Big Willow Creek	DEQ IDASA Database	BURP data	1994-2005; See Ingham, 1999
Big Willow Creek AU03 above Fourmile Creek	USGS Gauging Station 13250600, Big Willow Creek near Emmett, ID	Measured discharge, water temperature, peak discharge (water chemistry)	1973-1982, (1980)
Payette River Subbasin	Western Region Climate Center; Payette, ID; 106891	Air Temperature and Precipitation	1948-2006
Payette River Subbasin/ Big Willow Creek watershed	USDA, NRCS; Major Land Resource Regions Custom Report, USDA Agriculture Handbook 296 (2006)	Regional soil type, climate, geology, land ownership, land use, water use	2006
Big Willow Creek watershed	US EPA	Level III and IV ecoregion	2002
Big Willow Creek watershed	USGS-StreamStats	Watershed delineation and basin statistics	2008

Table C-2. BURP summary fish data collected from Big Willow Creek, 2003-2005.

BURPID	Date Measured	AU	Percent Cold Water	SFI
2003SBOIA023	07/31/2003	03	18.33	45.56
2004SBOIA040	07/08/2004	03	2.44	33.50
2005SBOIA020	07/05/2005	03	7.69	37.31

SFI Stream Fish Index

Table C-3. BURP summary habitat data collected from Big Willow Creek, 1994-2005.

BURPID	Date Meas	STREAM	AU	Wolman Score	Bank Cover Score	Canopy Score	Embedded-ness Score	Surface Percent Fines	Percent Fines Score	SHI
1994SBOIA001	5/31/1994	BIG WILLOW 001	03	10	10	10	0	15.89	7	37
1994SBOIA002	5/31/1994	BIG WILLOW CREEK 002	03	10	10	4	0	41.41	3	27
1994SBOIA003	6/1/1994	BIG WILLOW 003	04	5	10	0	0	73.24	0	15
1994SBOIA004	6/1/1994	BIG WILLOW CR 004	03	10	3	0	0	17.14	6	19
1995SBOIA010	6/26/1995	BIG WILLOW CREEK (LOWER)	04	0	8	0	0	ND	10	38
1995SBOIA011	6/26/1995	BIG WILLOW CREEK (UPPER)	03	0	1	0	0	ND	10	33
1995SBOIT009	5/18/1995	BIG WILLOW CREEK	03	ND	ND	ND	ND	ND	ND	ND
1996SBOIA049	7/22/1996	BIG WILLOW CREEK (UPPER)	03	0	10	9	9	ND	10	66
1996SBOIA050	7/22/1996	BIG WILLOW CREEK (MIDDLE)	03	0	10	0	0	ND	10	36
1996SBOIA051	7/22/1996	BIG WILLOW CREEK (LOWER)	04	0	10	5	8	ND	10	52
1997SBOIB013	6/19/1997	BIG WILLOW CREEK(UPPER)	03	9	2	9	4	5.77	10	623
1997SBOIB014	6/19/1997	BIG WILLOW CREEK(MIDDLE)	03	7	10	0	0	30.99	10	401
1997SBOIB015	6/19/1997	BIG WILLOW CREEK(LOWER)	04	5	2	0	0	40.57	6	211
1998SBOIA045	7/20/1998	BIG WILLOW CREEK (MIDDLE)	03	9	4	0	0	8.27	10	411
1997SBOIA049	07/27/1997	FOURMILE CREEK	02	8	10	10	0	69.32	0	521
1997SBOIA050	07/29/1997	FOURMILE CREEK	02	8	10	10	0	61.54	2	451
1998SBOIA046	7/20/1998	BIG WILLOW CREEK (UPPER)	03	10	6	10	0	12.34	9	593
1998SBOIB036	7/9/1998	BIG WILLOW CREEK (LOWER)	04	6	8	0	0	60.91	3	371
1999SBOIA055	9/22/1999	BIG WILLOW CREEK (UPPER)	03	10	9	9	8	9.73	9	783
1999SBOIA056	9/22/1999	BIG WILLOW CREEK (MIDDLE)	03	8	10	0	0	7.92	10	311
1999SBOIA057	9/23/1999	BIG WILLOW CREEK (LOWER)	04	7	5	5	0	62.89	1	301
2001SBOIA033	7/26/2001	BIG WILLOW CREEK	03	9	5	9	7	30.2	5	723
2002SBOIA003	7/3/2002	BIG WILLOW CREEK	03	9	0	7	7	14.91	10	603
2003SBOIA023	7/31/2003	BIG WILLOW CREEK	03	10	10	9	5	22.58	7	673
2003SBOIA053	10/20/2003	BIG WILLOW CREEK-dry channel	04	0	0	0	0	Dry	ND	1011
2004SBOIA040	7/8/2004	BIG WILLOW CREEK	03	10	10	9	7	3.28	10	703
2005SBOIA020	7/5/2005	BIG WILLOW CREEK	03	10	10	8	5	10.78	10	723

SHI Stream Habitat Index, ND No Data

Table C-4. BURP summary temperature and macroinvertebrate data collected from Big Willow Creek, 1994-2005.

BURPID	Date Measured	AU	Total Abundance	Sum Obligate CWB	SMI	Water Temperature °C
1994SBOIA001	5/31/1994	03	238	0.00	49.81	
1994SBOIA002	5/31/1994	03	551	0.00	48.00	
1994SBOIA003	6/1/1994	04	120	0.00	27.56	
1994SBOIA004	6/1/1994	03	652	0.00	31.25	
1995SBOIT009	5/18/1995	04	ND	ND	ND	
1995SBOIA010	6/26/1995	03	491	0.00	20.41	
1995SBOIA011	6/26/1995	03	508	0.00	28.99	
1996SBOIA049	7/22/1996	03	71	0.00	44.13	17
1996SBOIA050	7/22/1996	03	83	0.00	27.20	26.5
1996SBOIA051	7/22/1996	04	19	0.00	18.88	31
1997SBOIB013	6/19/1997	03	645	0.00	59.28	17
1997SBOIB014	6/19/1997	03	608	0.00	34.72	23
1997SBOIB015	6/19/1997	04	501	0.00	30.10	28
1997SBOIA049	07/27/1997	02	511	0.00	29.67	17
1997SBOIA050	07/29/1997	02	495	0.00	23.97	19
1998SBOIB036	7/9/1998	04	483	0.00	30.41	26.7
1998SBOIA045	7/20/1998	03	558	0.00	37.86	24
1998SBOIA046	7/20/1998	03	476	0.00	60.46	23.1
1999SBOIA055	9/22/1999	03	517	1.00	62.01	15
1999SBOIA056	9/22/1999	03	613	0.00	42.91	20
1999SBOIA057	9/23/1999	04	607	3.00	46.95	13.9
2001SBOIA033	7/26/2001	03	549	0.00	76.49	18.6
2002SBOIA003	7/3/2002	03	511	0.00	67.37	17.7
2003SBOIA023	7/31/2003	03	531	3.00	60.05	22.3
2003SBOIA053	10/20/2003	04	Diversion/dry channel	Diversion/dry channel	Diversion/dry channel	Diversion/dry channel
2004SBOIA040	7/8/2004	03	527	1.00	66.91	19
2005SBOIA020	7/5/2005	03	519	0.00	57.83	17.3

SMI Stream Macroinvertebrate Index

Table C-5. Stream Bankfull Width as collected for the Beneficial Use Reconnaissance Program and Solar Pathfinder data collection.

Stream Segment Length (meters)	Source	Date Measured	AU	Stream Width (ft)	Average Stream Width (ft)
1460	Pathfinder		03	14.7	15
690	Pathfinder		03	12.7	12
	BURP-1994SBOIA004	6/1/1994	03	17.8	10
	BURP-1995SBOIA011		03	10.7	10
	BURP-1998SBOIA045	7/20/1998	03	8.1	10
	BURP-1999SBOIA056	9/22/1999	03	6.2	10
190	Pathfinder		03		
	BURP-1996SBOIA050	7/22/1996	03	10.3	10
1530	BURP-1997SBOIB014	6/19/1997	03	13.3	13
1730	BURP-1996SBOIA051	7/22/1996	03	10.7	18
	BURP-1998SBOIB036	7/9/1998	03	5.5	18
	BURP-1997SBOIB015	6/19/1997	03	13.1	18
	BURP-1994SBOIA003	6/1/1994	03	43.9	18
560	BURP-1999SBOIA057	9/23/1999	04	10.3	10
	BURP-2003SBOIAO53	10/20/2003	04	10.3	10
480	Pathfinder		04	11.4	11

Appendix D. Distribution List

Lower Payette River WAG Members

Tom Hoppell
501 E. Main Street
Emmett, ID 83617

Karl Siller
Emmett Irrigation District
1945 Jackson Ave.
Emmett, ID 83617

Kirk Vickery
Gem SWCD
2397 Mesa Ave.
Emmett, ID 83617

Sharon Pratt
Gem County Commissioner
415 E. Main Street
Emmett, ID 83617

Dar Olberding
5454 W. Central Road
Emmett, ID 83617

John Kientz
3512 Sunset
Emmett, ID 83617

Ron Shurtleff
District 65
102 North Main Street
Payette, ID 83661

George McClelland
1905 NW 1st Ave.
Fruitland, ID 83619

Others

Tom Pence
5433 Big Willow Road
Payette, Idaho 83661

J.G. Schwarz
6000 Big Willow Road
Payette, Idaho 83661

Russ Manwaring
West Central Highlands RC&D
1805 Hwy. 16
Emmett, Idaho 83617

Appendix E. Public Comments

The draft of the *Big Willow Creek Assessment and Temperature Total Maximum Daily Load: Addendum to the Lower Payette River Subbasin Assessment and TMDL* went out for public review and comment on March 26, 2007. The document was sent to the Payette City Public Library, Emmett Public Library, Boise Public Library, the Lower Payette River WAG, and was available at the DEQ Boise Region Office and through DEQ's web site at www.deq.idaho.gov/public/comment.cfm. The official public comment period ended at 5:00 p.m. MDT, Friday, May 4, 2007. This appendix records the public comments received and DEQ-BRO's response to comments.

Source and Comments

Donna Walsh, USEPA Region 10, Seattle, WA 98101--April 30, 2007

EPA 1: Water quality standards. The document should include a section on the water quality standards that apply to Big Willow Creek specifically. Appendix B shows the state water quality criteria for salmonid spawning, but does not show any information specific to Big Willow Creek. For example, it is not clear if the salmonid spawning criteria apply to the entire watershed or only part of the watershed or when salmonid spawning occurs in this watershed. The applicable beneficial uses, the temperature criteria for those uses, and where and when those criteria apply for this watershed should be identified. We would suggest you include this information in the main body of the document, but if you choose to include it in the appendices, please include a reference to the information in section 2.0 Water Quality Limited and Supporting Information.

Response: A description of water quality standards and criteria that apply to Big Willow Creek have been added to the main body of the document in the "Subbasin At A Glance" and Section 2, Table 8, and Appendix B to clarify that salmonid spawning, cold water aquatic life and primary contact recreation uses do apply to Big Willow Creek from the source to the mouth. These additions include the water quality standard criteria for each beneficial use.

EPA 2. 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.

Response: Historical temperature data was retrieved from the USGS National Water Information Service (NWIS) internet site and from all available BURP field visits. The USGS collected instantaneous data from a gauging station above the confluence of Fourmile Creek (AU03) on a monthly basis from 1973 through 1982 and instantaneous data was collected annually for BURP assessments by DEQ from 1994 through 2005. This data was reviewed to determine attainment of water quality standards and has been added, in the form of graphs and tables to the document and the appendices.

EPA 3. Map. It would be helpful if the document included a map showing the different reaches of Big Willow Creek (Upper and Lower) as well as temperature monitoring locations, the names of the tributaries, and other locations referenced in the text. (Also, some of the maps and figures were difficult to read. For example, it was difficult to read the writing in Figure 5, the key of Figure 15, and the monitoring stations shown in Figure 16 because the print was so small.)

Response. DEQ has revised the figures, tables, and appendices to add clarity to the document. These additions include data collection locations, tributary names, important location identifiers, and revisions of text size to improve readability.

EPA 4. Sediment TMDL must be done. Sediment is shown to be a pollutant impairing the waterbody. Sediment tolerant biota are found in the lower reach of Big Willow Creek and the text states that the cold water aquatic life designated use is impaired and sediments are the causative pollutant. TMDLs must be developed for identified pollutants. A sediment TMDL must be developed for Big Willow Creek. Though the sediment impairment may be associated with flow modification and stream alteration, and TMDLs are not required for these forms of pollution, a TMDL is required for an identified pollutant impairing the water.

Response: Big Willow Creek was negatively impacted by severe regional flooding from a rain on snow event in 1996 and 1997. This event is estimated to be greater in magnitude than a 100- year event and is briefly described in Section 1 "Watershed Characteristics" and Section 4. Because this event caused mass wasting in AU02, AU03, and AU04 and altered the morphology of Big Willow Creek from the middle of AU03 to the Payette River, beneficial uses were negatively affected. Due in part to the semi-arid climate, channel re-stabilization is still in process. In conformance with IDAPA 58.01.02.053, DEQ has reviewed all data available from other agencies (USGS and USDA) in addition to Tier I BURP data and cannot reasonably conclude at this time that excess sediment delivery to the stream (beyond effects of natural events) is a greater contributing factor than flow alteration and habitat modification in limiting the beneficial uses of Big Willow Creek.

All measures (flow alteration, habitat modification, and embeddedness) were assessed using rapid or qualitative methods. Analysis of the available data indicate that habitat and flow alteration can be directly linked to non-attainment of beneficial uses in Big Willow Creek, whereas qualitative stream measure assessments could not be used to quantitatively identify or define excess sediment pollution in the stream.

DEQ used benthic macroinvertebrate indices for temperature tolerance, accepted and widely used by other scientists in the region, to verify temperature impairment in Big Willow Creek. The data analyzed for this TMDL reflect that 90% of the macroinvertebrate organisms are tolerant of warm temperatures and were collected from sites that exhibit altered flow and/or modified habitat, in conjunction with increased stream embeddedness.

DEQ realizes that significant improvements have been made in the research arena regarding aquatic community response to sediment pollution and that the results of these efforts may be useful in determining the source and degree of sediment impairments to natural streams, once indices similar to temperature tolerance indices have been developed. At this time, an index to quantify the proportion of the benthic community correlated to specific sediment regimes is not available. When sediment indices similar to macroinvertebrate temperature indices are developed for ecoregions similar to Idaho, those indices will be included in analysis of data to assist in determination of sediment pollution, which may result in additional sediment TMDLs for Idaho streams.

In order to develop a more comprehensive and deterministic data set for the five-year review, DEQ recommends semi-annual (high flow/low flow) water chemistry and physical property (including turbidity and suspended sediment concentrations) data collection from at least five sites throughout the watershed. McNeil core samples to assess each AU for proportional subsurface fines and bank stability inventories would also provide quantitative information to determine other possible sources of water quality limiting factors. This data is expected to provide enough quantitative information to facilitate a reasonable determination of parameter-specific impairments; which may lead to additional TMDLs in the Big Willow Creek subbasin for other pollutants (nutrients, DO, sediment, bacteria, etc.).

EPA 5. Sediment listing shown as Category 4C. EPA does not agree that Big Willow Creek can be placed in Category 4C of the integrated report for the pollutant sediment (as currently shown in Table B, page 2 and Table 17, page 52 of the TMDL.) A sediment TMDL should be developed and the sediment listing should subsequently be placed in Category 4a of the integrated report for waters with approved TMDLs.
Response: DEQ agrees with EPA that Section 4c is not the appropriate listing for a waterbody with quantified impairment by sediment pollution. For reasons explained in the previous response and based on a review of all available data, DEQ is recommending listing revisions summarized in Tables B and 24.

EPA 6. Shade targets established for Big Willow Creek only. Figure A shows several potentially significant tributaries to Big Willow Creek. Due to the cumulative effects of temperature increases and the potential impacts of these tributaries on the temperature of Big Willow Creek, 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 Big Willow Creek. Similar efforts have been developed for previous Idaho PNV TMDLs.

Response: DEQ acknowledges that tributary effects to water temperature in the Big Willow Creek is an unknown factor, and that in order to achieve PNV goals, tributaries must also be at natural background conditions. Because data, and access to collect data, in the subbasin is very limited, a PNV TMDL has been developed for the listed waterbody, which at this time is Big Willow Creek from source to mouth. Idaho has adopted a five-year review process and a schedule to facilitate attainment of designated beneficial uses of all state waters. As data become available for the 3rd and 4th order tributaries, additional waterbodies in the subbasin may be listed for specific impairments, including temperature. DEQ encourages TIR data collection from the Big Willow Creek subbasin to overcome data deficiency issues so that basin-wide assessments and tributary use attainment status can be determined. Data collection through the five-year review process may result in additional TMDLs in the subbasin.

EPA 7. Shade curves. It is difficult to connect the shade curves currently chosen to the vegetation in the Big Willow Creek watershed. Reviewing the local information and literature (BLM, USFS, NRCS, etc.) on the type, height and density of local natural vegetation could improve the selection of the shade curves. This local information could be used to select which existing shade curve(s) from regional TMDLs best represent local natural conditions. This method of choosing a shade curve, rather than the current method of averaging numerous shade curves which are often comprised of very different vegetation communities with very different underlying assumptions of PNV height and canopy density, should result in a more accurate estimate of natural shade for the specific watershed.

Response: DEQ has modified the shade curve to include a third vegetation type (basalt/ willow), and re-calculated excess solar load and lack of shade by linear meter for the entire creek. This calculation provides PNV targets for each linear meter of Big Willow Creek from AU03 to the mouth. DEQ has revised the document to more clearly describe this situation and process but acknowledges some error in aerial photograph interpretation may still exist and be reflected in the target shade calculations. DEQ is currently cooperating with Region 10 EPA to develop shade curves for Idaho and plans to use those curves in the next five-year review. These curves should reduce the percent error in PNV analysis.

EPA 8. 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 having "excess" shade. These areas should be considered as critical areas for protection to ensure natural temperature conditions. However, the current method of utilizing these “excess” shade areas is to average out impacted areas along the stream. This is not an accurate application of the PNV method and is well beyond the appropriate application of the modeling methodology used in this TMDL. The methodology is too imprecise to suggest areas have “excess” shade.

Response: The figures and text have been modified to remove language or other indicators that may imply that there is "excess" shade along any stream segment. Section 5.4 has been revised to clarify that there is no excess solar load capacity in the Big Willow Creek watershed. In order to achieve beneficial use support and natural background temperatures, additional removal of shade should be avoided as it would negatively impact achievement of that goal.

EPA 9. Averaging needed shade improvements. Averaging the needed shade improvements for a watershed can completely mask areas of needed restoration. For example, some areas in upper Big Willow Creek are shown to be lacking 30-35% of the expected natural shade. However, these problematic areas are ignored with the proposed averaging method if only the average conditions 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 example, 10 - 50% shade increases are needed, depending on the reach. Providing a map showing reach specific values of lack of shade (as you do now) is good. It would also be helpful to show the percent solar load reductions for each of the reaches in Tables 14 and 15, rather than the summed solar load reduction for the whole watershed. It is reasonable to suggest that land managers might want to initially target restoration on areas with the greatest departure from natural shade. However, it should be made clear, that to meet water quality standards, all areas that show any deviation from natural would need improvement.

Response: PNV calculations were also revised to quantify excess solar load and lack of shade by linear meter for each AU. Average values for large stream segments (upper and lower) were removed. Ranges, in percent, of excess solar load and lack of shade were calculated and included in the analysis tables and the corresponding maps for each AU.

EPA 10. Discussion of solar load reduction required. In the Key Findings, page 1, and in the Conclusions, page 52, you state that upper Big Willow Creek “may be sufficiently shaded to meet solar loads" and "is in relatively good shape" with respect to solar load reductions required. We find the first description to be unsubstantiated and both descriptions to be counterproductive, clearly sending the message that restoration is not needed in these reaches. These statements should be deleted. As an alternative, it would be reasonable to suggest that restoration be prioritized based on the percent departure from target conditions on a reach-by-reach basis as discussed in comment 9. However, as stated above, it should be clear that all reaches would need to meet PNV shade targets in order to meet water quality standards.

Response: DEQ is sensitive to EPA concerns that some language may imply that very little effort is necessary to reach attainment of beneficial uses. Summaries of analysis results and conditions under which PNV will be successful have been revised to add clarity to the document.

EPA 11. Discussion of Margin of Safety (MOS). Suggesting that areas which are within a calculated MOS don't need improvement is not consistent with the principle or intent of the MOS (Figure 20 - "Within MOS"). A MOS is incorporated to account for uncertainties in the analysis, to ensure the TMDL is protective. Accordingly, language and technical documentation must be removed from this TMDL, which suggests that areas where solar load reductions are within MOS are meeting water quality standards. The MOS described on page 47 of this document is not a MOS; it is a general description of uncertainty associated with the method used in this effort. For its intended application (Figure 20 – "Within MOS"), this method is too limited because it does not address the many uncertainties inherent in this application of the PNV method. For, example, in the shade curves section you state that you increased the target shade by 10% to account for topographical shade. In addition, in the Monitoring Points section the existing shade estimated by the aerial photos was determined to be approximately 20% lower than the field verified existing shade so 20% was added to the existing shade for areas with 50% or greater shade. These are two examples showing that this particular PNV application is imprecise and includes a high degree of uncertainty. To suggest that the margin of safety can be calculated as an exact percentage based on one assumption under these circumstances is inappropriate. The concept of a MOS, which is a required element of a TMDL, is rendered moot if targets, allocations and load capacities derived incorporating the MOS are not used.

Response: Based on the known and undefined errors in the PNV model, DEQ is willing to remove MOS as it was defined and discussed and will revise the document regarding the errors and uncertainties in the model, within which the MOS is inherent.

EPA 12. Field Verification of Current Effective Shade Estimates and MOS– A very spatially limited sampling of shade measurements were used to add 20% to estimated current shade values in areas that were greater than 50% shade (Described on page 40 and the measurement locations are illustrated on Figure 19.). This addition results in a much less conservative MOS when shade conditions are compared between current and PNV conditions. It is also problematic that such a spatially limited sampling was used to modify such a significant parameter over a very large area.

Response: DEQ acknowledges that data essential to this PNV has margins of error that may be substantial. DEQ is working with EPA to develop vegetation types specific to Idaho in an effort to diminish these errors in future work. The shade curves were re-analyzed in an effort to reduce the error in interpretation of the aerial photographs. Calculations were revised to quantify solar load and lack of shade by linear meter for each assessment unit. The tables generated from this review were then used to document the range of excess solar load and range of lack of shade by linear meter for each AU. Maps were modified to portray the results of the revised spatial analysis.

EPA 13. Bankfull channel widths. The TMDL states that the creek has been highly channelized and sinuosity greatly reduced in the lower floodplain. It also discusses excess sediment deposition. These things suggest that the current channel widths may be different from previous natural channel widths, yet the current channel widths are all assumed natural. Existing bankfull channel width data should be provided in the document and compared to the estimated natural bankfull channel widths.

Response: Available bankfull width data collected by DEQ has been added to Appendix D. Historical data collected by the USGS, satellite images, and BURP data were reviewed to identify paleo stream morphology, results of 1996/1997 flood events, and potential sources of stream channel alteration. With the data presently available, it appears that the most likely source of excess sediment delivery to Big Willow Creek is a result of severe flooding in 1996 and 1997. The channel widths measured at Solar Pathfinder data collection transects have been added to the TMDL tables in red bold typeface and used in the load analysis. The document has been revised to more fully describe the location and extent of flow alteration in the basin.

EPA 14. Incorrect % solar load reduction shown for Lower Big Willow Creek. In the Key Findings on page 1 and in the Conclusions on page 52, the solar load reduction needed for Lower Big Willow Creek is incorrectly stated as 13%, rather than 20%. Rather than using either of these summed % reductions, we recommend you show the range of solar load reductions needed for the different reaches as discussed in comment 5 above.

Response: The PVN TMDL was revised to include a third vegetation type and aerial photograph interpretations re-visited to calculate the excess load and lack of shade by linear meter and results include range (in percent) of excess load and corresponding lack of shade for each AU, by linear meter. The results of revisions have been added to the TMDL in text, maps, and tables.

EAP 15. Salmonid spawning not a fully supported use. Salmonid spawning is stated to be a fully supported use above Table 5 on page 21. Of the four final condition ratings found in Table 5, two of the condition rating scores are below “2” showing that salmonid spawning is not fully supported.

Response: DEQ agrees that salmonid spawning is an existing use in AU03 but, based on assessment data, is not a supported use. This modification and clarification has been added to the document.

DEQ, May 2008, TM57, 42106
Costs associated with this publication are available from the State of Idaho, Department of Environmental Quality in accordance with Section 60-202, Idaho Code.

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