Brush Creek Temperature Total Maximum Daily Load: Addendum to the Blackfoot River Subbasin Assessment and TMDL

Department of Environmental Quality

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Brush Creek Temperature TMDL

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Thank you all for contributing to the Brush Creek temperature TMDL.

Cover photo provided by Idaho Department of Environmental Quality.

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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

AU assessment unit

BMP best management practice

BURP Beneficial Use Reconnaissance Program

C Celsius

CWA Clean Water Act

CWE cumulative watershed effects

DEQ Department of Environmental Quality

EPA United States Environmental Protection Agency

FPA Idaho Forest Practices Act

FWS U.S. Fish and Wildlife Service

GIS Geographical Information Systems

HUC Hydrologic Unit Code

I.C. Idaho Code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDL Idaho Department of Lands

IDWR Idaho Department of Water Resources

LA load allocation

LC load capacity

m meter

mi mile

mi^2 square miles

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)

NPDES National Pollutant Discharge Elimination System

PNV potential natural vegetation

SBA subbasin assessment

STATSGO State Soil Geographic Database

TMDL total maximum daily load

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USDI United States Department of the Interior

USFS United States Forest Service

USGS United States Geological Survey

WAG Watershed Advisory Group

WLA wasteload allocation

WQLS water quality limited segment

WQMP water quality management plan

WQRP water quality restoration plan

WQS water quality standard

Executive Summary

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

This document addresses Brush Creek in the Blackfoot River Subbasin that has been placed on Idaho's current §303(d) list. This document only addresses the temperature TMDL for this stream. For more information about this watershed and the subbasin as a whole see the *Blackfoot River TMDL- Waterbody Assessment and Total Maximum Daily Load*.

This TMDL analysis has been developed to comply with Idaho's TMDL schedule. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

Subbasin at a Glance

The Blackfoot River Subbasin is located in the Upper Snake River Basin in southeastern Idaho (Figure A). Brush Creek was placed on the Idaho 1998 303(d) list for temperature pollution.

The Environmental Protection Agency (EPA) added streams to Idaho's 1998 303(d) list of impaired waters that exceeded Idaho's temperature criteria. In the Blackfoot River Subbasin, Brush Creek was among those EPA additions (Figure A).

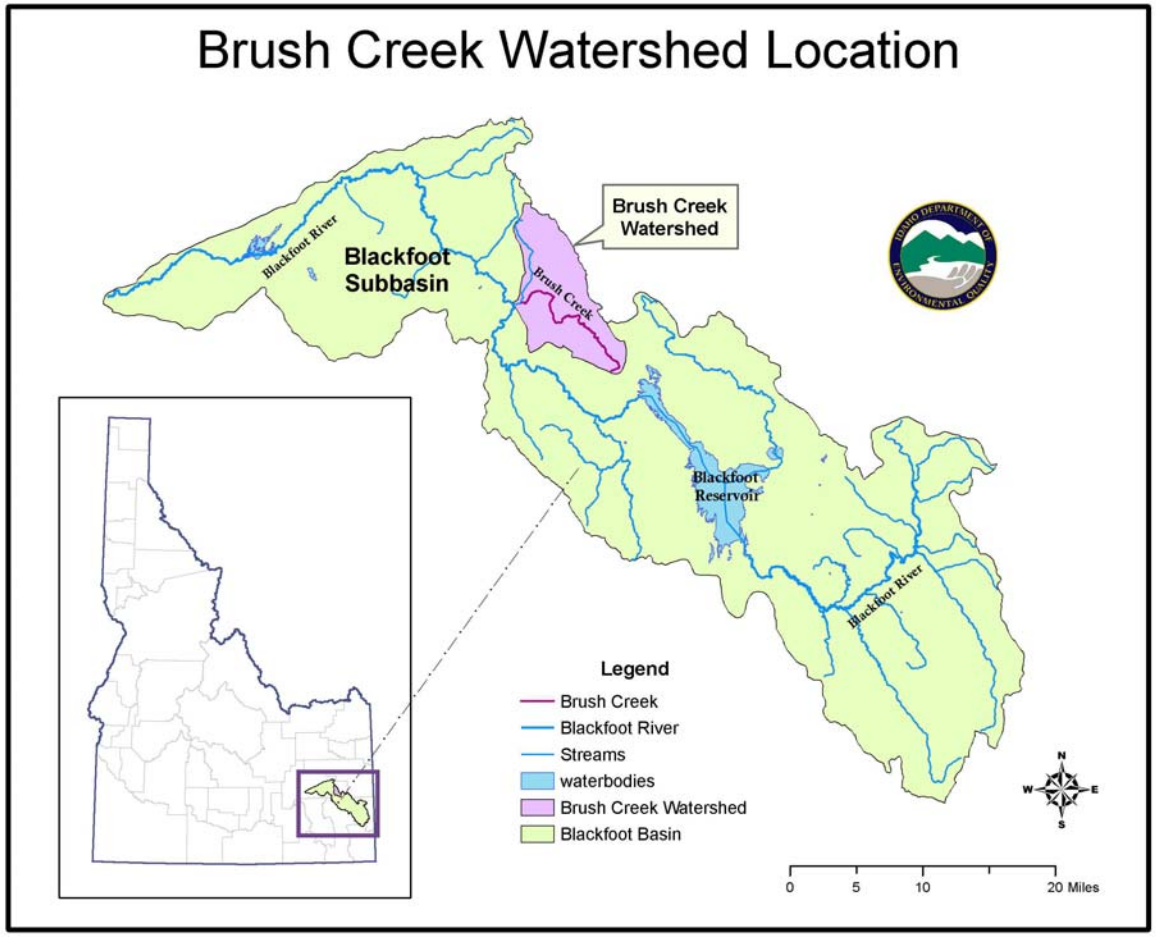

Figure A. Subbasin at a glance, Brush Creek watershed location.

Water Quality Assessments

DEQ collected aquatic data through their Beneficial Use Reconnaissance Program (BURP) to determine support of beneficial uses (CWAL and SS) in Brush Creek (Table A). Evaluations of BURP data are based primarily on three facets of wadeable streams: macroinvertebrate community, stream habitat, and fish community. Individual metrics within each category are combined to create a multimetric index score for macroinvertebrate community, fish community, and stream habitat. The multimetric index scores are called stream macroinvertebrate index (SMI), stream habitat index (SHI), and stream fish index (SFI). From those scores, a condition ranking of 1, 2, or 3 is assigned to the site based on percentile categories of reference conditions. At least two scores are needed to evaluate a streams support status; and those scores must average 2 or greater (on a scale of 0 to 3) for beneficial uses to be considered supported. DEQ's Water Body Assessment Guidance (WBAG) II (Grafe et al. 2002) further outlines the methodology behind SMI, SFI, and SHI development and calculations.

Table A. BURP condition ranking and support status in Brush Creek.

BURP Site ID #	Date Sampled	Site Desc.	Score			Ave Score
			SMI	SFI*	SHI	
2004POCA018	7/19/04	Lower	3		2	2.5
2002SPOCA039	7/29/02	Middle	1		1	1
2002SPOCA040	7/29/02	Upper	0		1	0
1996SPOCA23	7/1/96	Lower	1		1	1
1996SPOCA24	7/1/96	Upper	0		1	0

*No SFI evaluated in the watershed.

Fish Data

Fish distribution and age classes are important for documentation of the existence and status of fish in the watershed. DEQ collected fish data in 2005 in lower Brush Creek, approximately 0.8 miles above the Brush Creek Road crossing. Seven salmonids (brook trout) and 72 non-salmonids were collected (1 sculpin and 71 dace). Of the seven brook trout, all of them, with the exception of one (2-3 year age class), were yearlings.

Temperature Data

In 2006 the Department of Environmental Quality (DEQ) collected stream temperature data in the Brush Creek watershed. Temperature data were collected at four locations in Brush Creek (Figure B); 1) just above the mouth, below the Rawlins Creek confluence, 2) above the Rawlins Creek confluence, 3) middle Brush Creek in a location referred to locally as "the hole", and 4) near headwaters, just above the Blackfoot River Road crossing.

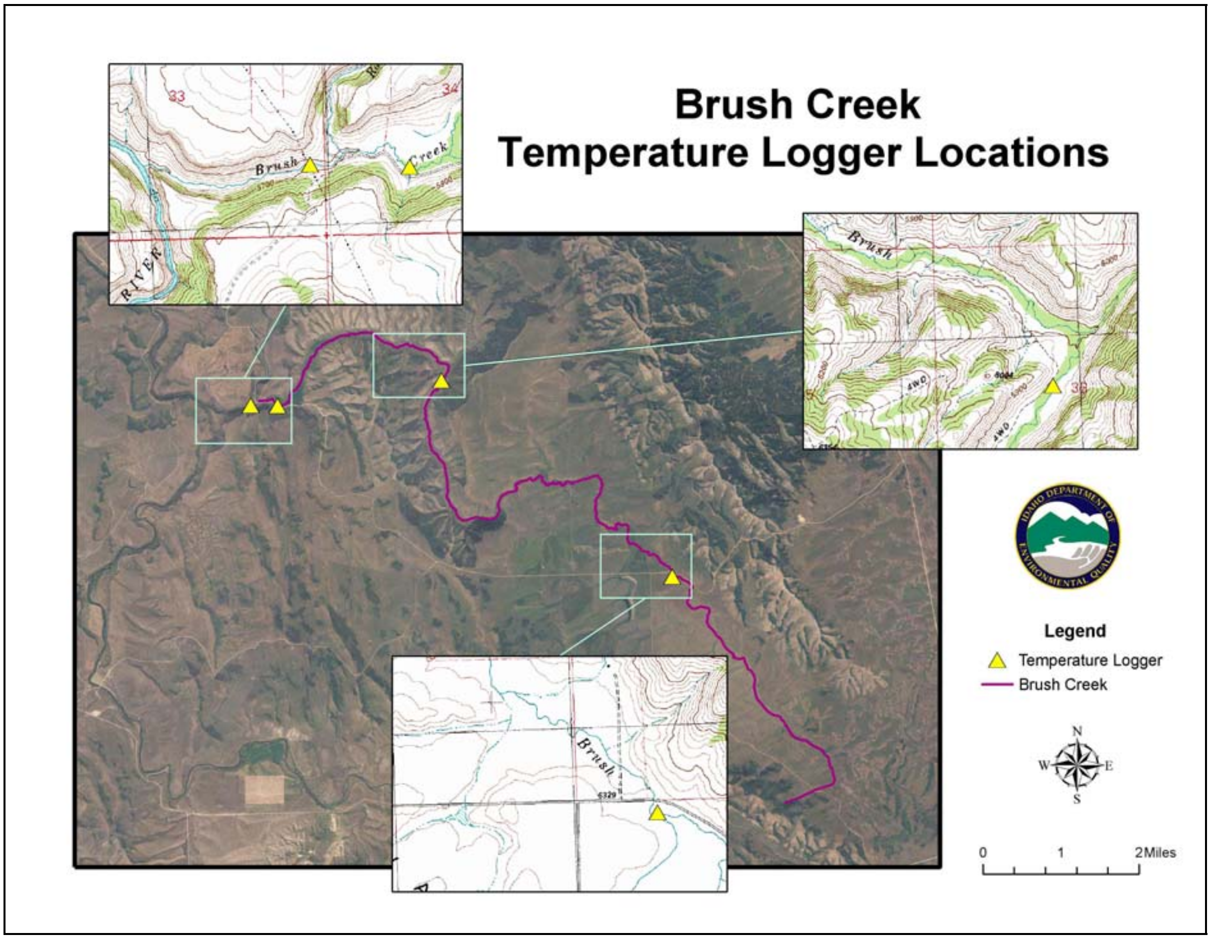

Figure B. Temperature logger locations in the Brush Creek watershed.

Raw stream temperature data were evaluated for State of Idaho water temperature criteria for all four locations. These criteria are in two categories: cold water aquatic life (CWAL) and salmonid spawning (SS). The temperature criteria for CWAL is an instantaneous temperature of 22°C (66.2°F) or less, with a maximum daily average of no greater than 19°C (71.6°C). Cold Water Aquatic Life criterion is evaluated for the summer season (June 22 through September 21). The criterion for SS is an instantaneous temperature of 13°C (55.4°F) or less, with a maximum daily average no greater than 9°C (48.2°F) (IDAPA 58.01.02.2250.02). According to Idaho Department of Fish and Game (IDFG), spring SS in Brush Creek generally occurs between April 1st and mid June. Fall spawning is known to occur in October (Teuscher 2006).

A major exceedance of temperature criteria occurs when the criteria are exceeded 10% of the time. A minimum of two measurements must be evaluated before the determination of a violation can be made. Major temperature exceedances, for CWAL and SS were documented at each temperature logger location in Brush Creek (Tables B and C).

Table B. Brush Creek 2006 temperature data and number of days where water temperatures exceeded the CWAL criteria.

			Cold Water Aquatic Life					
				22˚C Inst		19˚ C Daily Ave.		
Stream Name	Date Period	# Days Evaluated	# Days Over	Max Temp	Max Date	# Days Over	Max Temp	Max Date
Brush Creek, near mouth, below Rawlins Creek	6/21/06-9/22/06	94	28	25.48	7/22/06	4	19.89	7/20/06
Brush Creek, above Rawlins Creek	6/21/06-9/22/06	94	49	28.22	7/22/06	31	22.31	7/22/06
Brush Creek, middle (“the hole”)	6/21/06-9/22-06	94	48	29.16	7/21/06	21	21.96	7/21/06
Brush Creek, upper, River Rd x-ing	6/21/06-9/22/06	94	46	29.85	7/21/06	29	22.73	7/21/06

Gray shading denotes a major exceedance (>10%) of temperature criteria

Table C. Brush Creek 2006 temperature data and number of days where water temperatures exceeded the SS criteria.

			Salmonid Spawning					
				13˚C Inst		9˚ C Daily Ave.		
Stream Name	Date Period	# Days Evaluated	# Days Over	Max Temp	Max Date	# Days Over	Max Temp	Max Date
Brush Creek, near mouth, below Rawlins Creek	6/7/06-6/15/06	9	9	21.91	6/12/06	9	16.74	6/6/06
Brush Creek, above Rawlins Creek	6/7/06-6/15/06	9	9	16.78	6/8/06	9	19.52	6/7/06
Brush Creek, middle (“the hole”)	6/7/06-6/15/06	9	9	23.34	6/12/06	9	18.39	6/7/06
Brush Creek, upper, River Rd x-ing	6/7/06-6/15/06	9	9	25.89	6/7/06	9	13.94	6/8/06

Gray shading denotes a major exceedance (>10%) of temperature criteria

Key Findings

Reduced riparian vegetation contributes to accelerated streambank erosion, which results in increased thermal loading, which, combined with associated changes in channel morphology are the primary causes of increased temperature loading in the watershed.

Brush Creek was placed on the 1998 303(d) list of impaired waters by EPA for reasons associated with temperature criteria violations (Table D). Idaho DEQ water quality data (2006) document major exceedances of state water quality standards for CWAL and SS.

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

Stream	Pollutant(s)
Brush Creek	Temperature

Effective shade targets were established for Brush Creek based on the concept of maximum shading under potential natural vegetation equals natural background temperature levels (Table E). Shade targets were actually derived from effective shade curves developed for similar vegetation types in the Northwest. Existing shade was determined from aerial photo interpretation that was field verified with solar pathfinder data.

Table E. Summary of assessment outcomes.

Water Body	AU of ID17040207	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Brush Creek	SK026_02	Temperature	Temperature	Move to § 4a of Integrated Report	Temperature exceedances documented and PNV analysis completed
Brush Creek	SK026_03	Temperature	Temperature	Move to § 4a of Integrated Report	Temperature exceedances documented and PNV analysis completed

5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the 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 load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear 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 for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 In-stream Water Quality Targets

For the Brush Creek temperature TMDL we utilize a potential natural vegetation (PNV) approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) which establishes that if natural conditions exceed numeric water quality criteria, an exceedance of the criteria is not considered to be a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and the natural level of shade and channel width become the target of the TMDL. The instream temperature which results from attainment of these conditions is consistent with the water quality standards, even though it may exceed numeric temperature criteria. See Appendix B for further discussion of water quality standards and background provisions. The PNV approach is described below. Additionally, the procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in this section. For a more complete discussion of shade and its affects on stream water temperature, the reader is referred to the South Fork Clearwater Subbasin Assessment and TMDL (IDEQ 2004).

Potential Natural Vegetation for Temperature TMDLs

There are several important contributors of heat to a stream including ground water temperature, air temperature and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most likely to be controlled or manipulated. The parameters that affect or control the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology affects how closely riparian vegetation grows as well as water storage in the alluvial aquifer. Streamside vegetation and channel morphology are factors influencing shade. These factors are those most likely to have been influenced by anthropogenic activities and those most readily 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 on a stream by virtue of its proximity. We can measure the amount of shade that a stream enjoys in a number of ways. Effective shade, that shade provided by all objects that intercept the sun as it makes its way across the sky, can be measured in a given spot with a solar pathfinder or with optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and the stream's aspect. In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream, and can be measured using a densiometer, or estimated visually either on site or on aerial photography. All of these methods tell us information about how much the stream is covered and how much of it is exposed to direct solar radiation.

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

Existing shade or cover was estimated for Brush 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 (see below for methodology). PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width. Existing and PNV shade was converted to solar load from data collected on flat plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations collecting these data. In this case, the Pocatello, Idaho station was used. The difference between existing and potential solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are assumed to be natural (so long as there are no point sources or any other anthropogenic sources of heat in the watershed), and are thus considered to be consistent with the Idaho water quality standards, even though they may exceed numeric criteria.

<u>Pathfinder Methodology</u>

A solar pathfinder was utilized to determine the extent of effective riparian shading along Brush Creek. The solar pathfinder is a device that allows one to trace the outline of shade producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the spot that the tracing is made. In order to adequately characterize the effective shade on a reach of stream, in Brush Creek, ten traces were taken at systematic or random intervals along the length of the stream.

At each sampling location the solar pathfinder was be placed in the middle of the stream about the bankfull water level. Traces were taken in accordance with the manufacturer's instructions were followed, orienting to true south and leveling the pathfinder. Systematic sampling was utilized to reduce bias in sample locations. In Brush Creek we started at a unique location, such as 100 m from a bridge or fence line and then proceeded 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.).

Bankfull widths and notes were taken at each pathfinder trace location. Photographs were taken of the stream at several unique locations to document type and extent of vegetation. Special attention was paid to changes in riparian plant communities and the kinds of plant species (the large, dominant, shade producing ones) that were present.

Aerial Photo Interpretation

In Brush Creek canopy coverage estimates or expectations of shade based on plant type and density were determined for natural breaks in vegetation density and marked out on a 1:100K or 1:250K hydrography. Each interval was assigned a single value representing the bottom of a 0%-canopy coverage or shade class as described below (*adapted from the CWE process, IDL 2000)*.

For example, if we estimate that canopy cover for a particular stretch of stream is somewhere between 50% and 59%, we assign the value of 50% to that section of stream. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and the width of the stream. The typical vegetation type (below) shows the kind of landscape a particular cover class usually falls into for a stream 5m wide or less. For example, if a section of a 5m wide stream is identified as 20% cover class, it is usually because it is in agricultural land, meadows, open areas, or clearcuts. However, that does not mean that the 20% cover class cannot occur in shrublands and forests, because it does on wider streams.

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

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

Stream Morphology

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

The only factor not developed from the aerial photo work presented above is channel width (i.e., NSDZ or Bankfull Width). Accordingly, this parameter must be estimated from available information. Regional curves for the major basins in Idaho were used to determine channel widths in the Brush Creek watershed. Regional curve data was compiled by Diane Hopster of Idaho Department of Lands (Figure 1).

For each stream evaluated in the loading analysis, bankfull width was estimated based on drainage area of the Upper Snake curve from Figure 1. Additionally, existing width was evaluated from available data. If the stream’s existing width was wider than that predicted by the Upper Snake curve in Figure 1, then the Figure estimate of bankfull width was used in the loading analysis. If existing width was smaller, then existing width was used in the loading analysis. In all cases, existing bankfull widths were slightly smaller than those predicted by the Upper Snake regional curve (see Table 1). Thus, existing widths were used in this analysis.

Table 1. Estimates of bankfull width (in meters) from the Upper Snake (US) regional curve and existing field measurements.

Location	Area (mi^2)	Upper Snake (m)	Existing (m)
Brush Cr @ Mouth	56.4	9	7.8
Brush Cr above Rawlins Cr	35.8	8	4.6
Middle Brush Creek @ “the hole”	20.3	6	4.1
Brush Cr @ Blackfoot River Rd	9.58	4	2.4

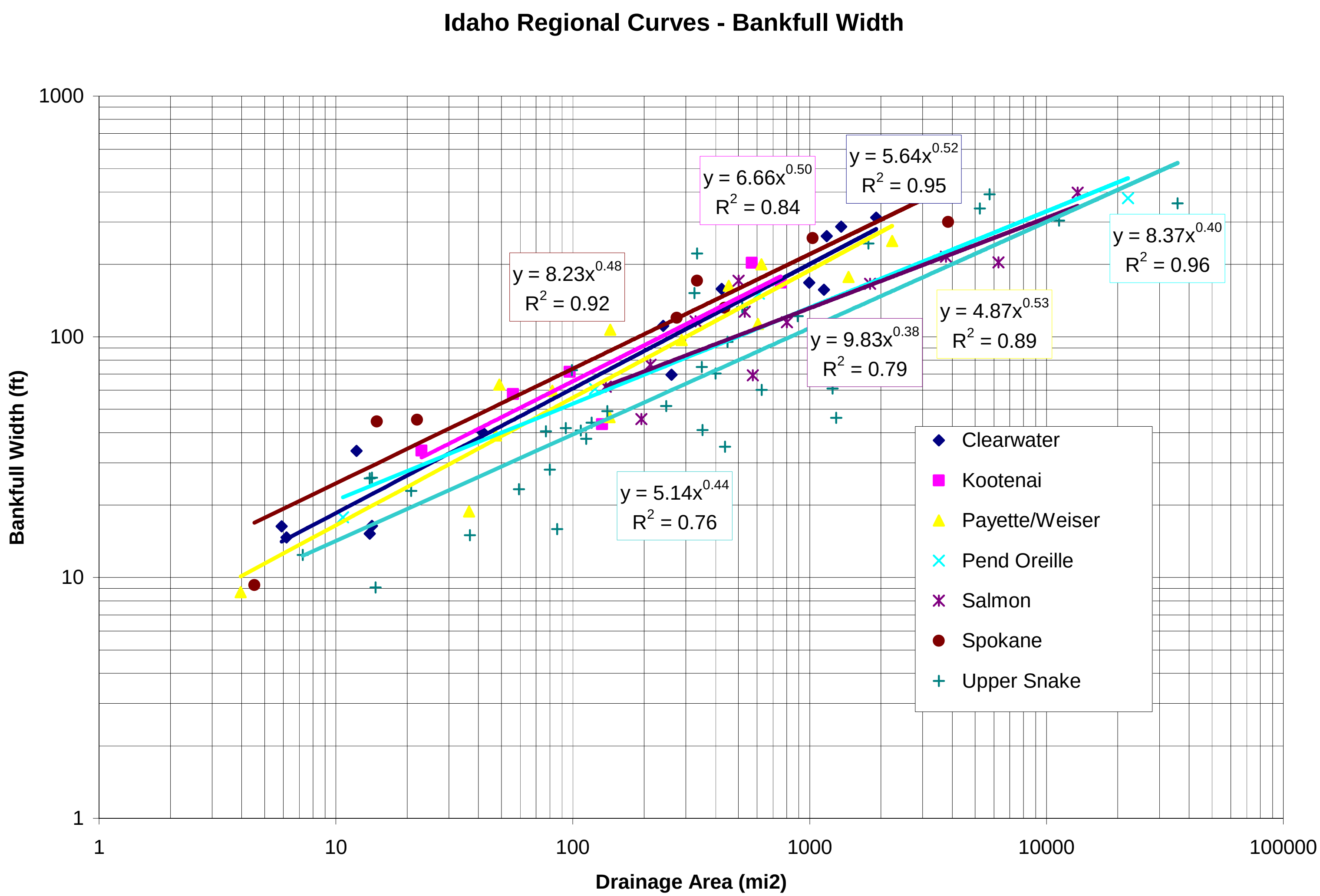

Figure 1. Bankfull width as a function of drainage area.

Design Conditions

The landscape surrounding Brush Creek is primarily sagebrush/bunchgrass communities. The riparian area along Brush Creek is willow and grass dominated. In the headwaters area and in a lower section near Rawlins Creek, grass meadows tend to dominate with shrubs making up a small proportion of the community. Near the mouth, an aspen/alder/willow community dominates. Elsewhere along the creek, willow shrubs are the predominant shade producing vegetation. Thus, shade targets were developed for these three vegetation types.

Target Selection

To determine potential natural vegetation shade targets for Brush Creek, effective shade curves from several existing temperature TMDLs were examined. These TMDLs had previously used vegetation community modeling to produce these shade curves. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. As a stream becomes wider, a given vegetation type loses its ability to shade wider and wider streams. Although these TMDLs reflect a wide variety of geomorphologies and topographies, effective shades at the same stream width were remarkably similar. For Brush Creek curves for the most similar vegetation type were selected for shade target determinations. Because no two landscapes are exactly the same, shade targets were derived by taking an average of the various shade curves available. Thus, the selected shade curves represent a range of shade conditions that presumably the riparian community of interest in this TMDL falls into.

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

Shade Curves

For the willow/grass vegetation type (Figure 2) found primarily in the headwaters of Brush Creek, three shade curves were used to develop targets (Table 2). The co-dominant mesic graminoid-willow community from the Trout Creek province of the Alvord Lake TMDL has an average height = 8.5 ft and an average canopy density = 10%. The tufted hairgrass meadow community from the Salmon-Chamberlain (Crooked Creek) TMDL has an average height of 2 ft and a canopy cover of 42%. Also selected was the OW province from the Willamette TMDL, a vegetation comprised of 5% savanna and 95% prairie (average height = 6.2 ft, density = 74%).

Table 2. Shade targets for the willow/grass vegetation type at various stream widths.

Willow/Grass Mix	1m	2m	3m	4m	5m	6m	7m	8m
graminoid/willow – Trout (ODEQ 2003)	39	25	18	14	10	8	7	5
tufted hairgrass – (IDEQ 2002)	53	31	17	13	11	9	8	6
OW province (ODEQ 2004a)	60	50	40	24	22	20	17	15
Average	50.7	35.3	25.0	17.0	14.3	12.3	10.7	8.7
Target (%)	**51**	**35**	**25**	**17**	**14**	**12**	**11**	**9**

Figure 2. Willow/Grass vegetation in upper Brush Creek.

For the willow shrub vegetation type (Figure 3) three shade curves showed promise (Table 3). They are the willow mix communities from the Pueblo (average height = 14 ft, average density = 50%) and Trout Creek (average height = 18 ft, average density = 60%) provinces of the Alvord Lake TMDL. Also included was the sagebrush/bunchgrass vegetation response unit 12/16 from the SF Clearwater TMDL (average height = 8.4 ft, 80% shrub and 20% grass with 90% bank cover).

Table 3. Shade targets for the willow shrub vegetation type at various stream widths.

Willow Shrub Mix	1m	2m	3m	4m	5m	6m	7m	8m
Willow mix – Pueblo (ODEQ 2003)	79	66	57	50	41	33	29	25
Willow mix – Trout (ODEQ 2003)	85	75	68	61	53	44	40	35
VRU12/16 (IDEQ 2004)	87	71	45	38	32	26	23	21
Average	83.7	70.7	56.7	49.7	42.0	34.3	30.7	27.0
Target (%)	84	71	57	50	42	34	31	27

Figure 3. Willow shrub vegetation in Brush Creek.

The tall willow vegetation type (Figure 4), located in lower Brush Creek, utilizes three shade curves from the Alvord Lake TMDL that have a small tree component (Table 4). The aspen/alder/willow community from the Pueblo ecological province has an average height of 33 ft and an average canopy density of 85%. The aspen/willow community from the Trout Creek mountains has an average height of 29 ft and an average canopy density of 90%. The willow/cottonwood/aspen community from East Steens has an average height of 25 ft and an average canopy density of 65%.

Table 4. Shade Targets for the Tall Willow Vegetation Type at Various Stream Widths

Tall Shrub	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m
Aspen/alder/willow – Pueblo (ODEQ 2003)	85	82	76	71	65	58	54	50	44	41
Aspen/willow – Trout (ODEQ 2003)	92	89	84	79	74	65	61	57	51	48
Willow/cottonwood/aspen-ES (ODEQ 2004a)	82	77	70	62	57	53	49	44	39	34
Average	86.33	82.67	76.67	70.67	65.33	58.67	54.67	50.33	44.67	41
Target (%)	86	83	77	71	65	59	55	50	45	41

Figure 4. Tall willow community in lower Brush Creek.

Monitoring Points

The accuracy of the aerial photo interpretations were field verified with a solar pathfinder in three locations along Brush Creek (Figure 5). Effective shade monitoring can take place on any reach throughout Brush Creek and compared to estimates of existing shade seen on Figure 7 and described in Table 5. Those areas with the largest disparity between existing shade estimates and shade targets, as shown in figure 8, should be monitored with solar pathfinders to verify the existing shade levels and to determine progress towards meeting shade targets. It is important to note that many existing shade estimates have not been field verified, and may require adjustment during the implementation process. Stream segments for each change in existing shade vary in length depending on land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade towards target levels. Ten equally spaced solar pathfinder measurements within that segment averaged together may suffice to determine new shade levels in the future.

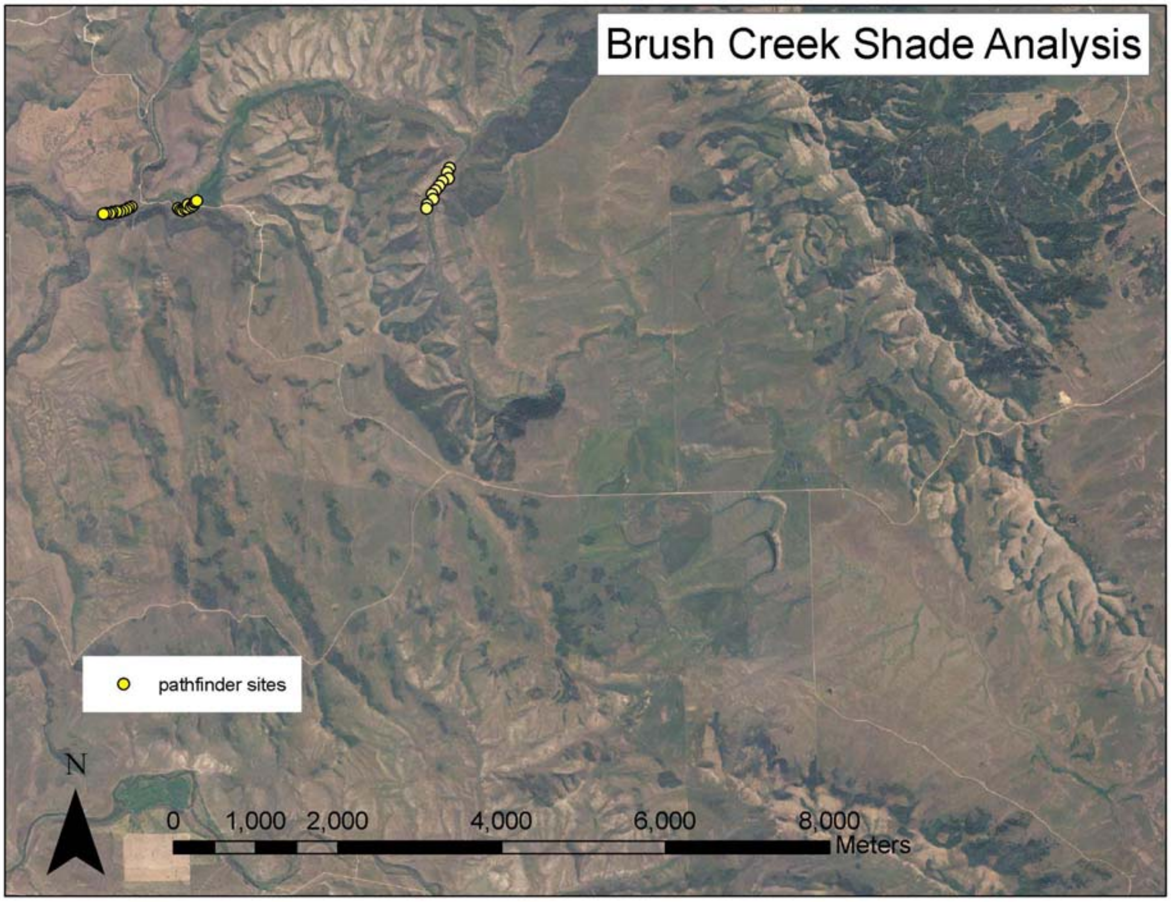

Figure 5. Solar pathfinder field verification locations.

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 (Table 5 and Figure 6). These loads are determined by multiplying the solar load to 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. the percent open or 1-percent shade). In other words, if a shade target is 60% (or 0.6), then the solar load hitting the stream under that target is 40% of the load hitting the flat plate collector under full sun.

We obtained solar load data for flat plate collectors from National Renewable Energy Laboratory (NREL) weather stations near by. In this case, data from the Pocatello, Idaho station were used. The solar loads used in this TMDL are spring/summer averages, thus, we use an average load for the six month period from April through September. These months coincide with time of year that stream temperatures are increasing and when deciduous vegetation is in leaf. Table 5 show the PNV shade targets (identified as target or potential shade) and their corresponding potential summer load (in kWh/m^2/day and kWh/day) that serve as the loading capacities for the streams.

The loading capacity for Brush Creek is 399,308 kWh/day (Table 5).

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 and field verification with a solar pathfinder. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat plate collector at the NREL weather stations. Existing shade data are presented in Table 5. Like loading capacities (potential loads), existing loads in Table 5 are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day).

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

Existing load for Brush Creek is 479,153 kWh/day (Table 5).

Table 5. Existing and potential solar loads for Brush Creek.

Associated Figure	**% Lack of Shade** (target shade minus existing shade)	Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Existing Stream Width (m)	Natural Stream Width (m)	Existing Segment Area (m²)	**Existing Load** Existing Summer Load (kWh/day)	Natural Segment Area (m²)	**Load Capacity** Potential Summer Load (kWh/day)	**Load Allocation** Potential Load minus Existing Load (kWh/day)	**% load Reduction** Reach Specific	Vegetation Type
C-1	-41%	1410	0.1	5.535	0.51	3.0135	-2.52	1	1	1410	7804.35	1410	4249.035	-3555.315	46	willow/grass
C-2	-51%	2330	0	6.15	0.51	3.0135	-3.14	1	1	2330	14329.5	2330	7021.455	-7308.045	51	
C-1, C-2	-35%	1920	0	6.15	0.35	3.9975	-2.15	2	2	3840	23616	3840	15350.4	-8265.6	35	
C-2	-35%	588	0	6.15	0.35	3.9975	-2.15	2	2	1176	7232.4	1176	4701.06	-2531.34	35	
C-2	-15%	560	0.1	5.535	0.25	4.6125	-0.92	3	3	1680	9298.8	1680	7749	-1549.8	17	
C-2	-17%	1450	0	6.15	0.17	5.1045	-1.05	4	4	5800	35670	5800	29606.1	-6063.9	17	
C-3	-22%	320	0.2	4.92	0.42	3.567	-1.35	5	5	1600	7872	1600	5707.2	-2164.8	28	willow shrub
C-3	-2%	330	0.4	3.69	0.42	3.567	-0.12	5	5	1650	6088.5	1650	5885.55	-202.95	3	
C-3	-12%	310	0.3	4.305	0.42	3.567	-0.74	5	5	1550	6672.75	1550	5528.85	-1143.9	17	
C-3	-14%	1040	0.2	4.92	0.34	4.059	-0.86	6	6	6240	30700.8	6240	25328.16	-5372.64	18	
C-3	-24%	400	0.1	5.535	0.34	4.059	-1.48	6	6	2400	13284	2400	9741.6	-3542.4	27	
C-3	-34%	530	0	6.15	0.34	4.059	-2.09	6	6	3180	19557	3180	12907.62	-6649.38	34	
C-3	-24%	220	0.1	5.535	0.34	4.059	-1.48	6	6	1320	7306.2	1320	5357.88	-1948.32	27	
C-3	-14%	170	0.2	4.92	0.34	4.059	-0.86	6	6	1020	5018.4	1020	4140.18	-878.22	18	
C-3	-4%	290	0.3	4.305	0.34	4.059	-0.25	6	6	1740	7490.7	1740	7062.66	-428.04	6	
C-3	-21%	1890	0.1	5.535	0.31	4.2435	-1.29	7	7	13230	73228.05	13230	56141.505	-17086.545	23	
C-3	-31%	910	0	6.15	0.31	4.2435	-1.91	7	7	6370	39175.5	6370	27031.095	-12144.405	31	
C-3	-21%	170	0.1	5.535	0.31	4.2435	-1.29	7	7	1190	6586.65	1190	5049.765	-1536.885	23	
C-3	-1%	870	0.3	4.305	0.31	4.2435	-0.06	7	7	6090	26217.45	6090	25842.915	-374.535	1	
C-3, C-4	-7%	380	0.2	4.92	0.27	4.4895	-0.43	8	8	3040	14956.8	3040	13648.08	-1308.72	9	
C-3, C-4	1%	650	0.1	5.535	0.09	5.5965	0.00	8	8	5200	28782	5200	29101.8	0	0	willow/grass
C-3, C-4	11%	150	0.2	4.92	0.09	5.5965	0.00	8	8	1200	5904	1200	6715.8	0	0	
C-3, C-4	1%	530	0.1	5.535	0.09	5.5965	0.00	8	8	4240	23468.4	4240	23729.16	0	0	
C-3, C-4	11%	260	0.2	4.92	0.09	5.5965	0.00	8	8	2080	10233.6	2080	11640.72	0	0	
C-3, C-4	-9%	470	0	6.15	0.09	5.5965	-0.55	8	8	3760	23124	3760	21042.84	-2081.16	9	
C-3, C-4	-20%	310	0.3	4.305	0.5	3.075	-1.23	8	8	2480	10676.4	2480	7626	-3050.4	29	willow shrub
C-4	10%	410	0.6	2.46	0.5	3.075	0.00	8	8	3280	8068.8	3280	10086	0	0	
C-4	20%	460	0.7	1.845	0.5	3.075	0.00	8	8	3680	6789.6	3680	11316	0	0	
									Total	**92,776**	**479,153**	**92,776**	**399,308**	**-89,187**	**19**	

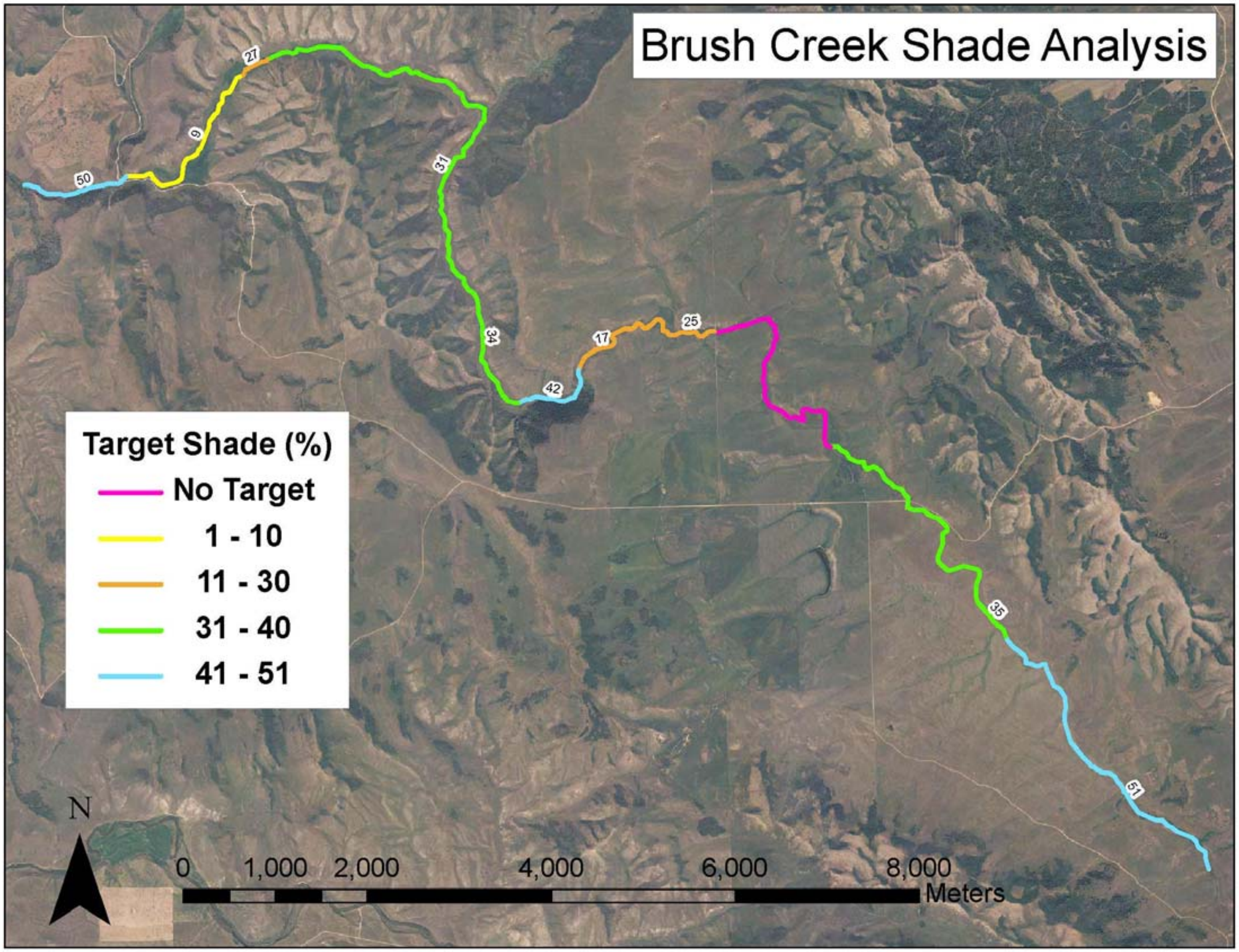

Figure 6. Target shade for Brush Creek.

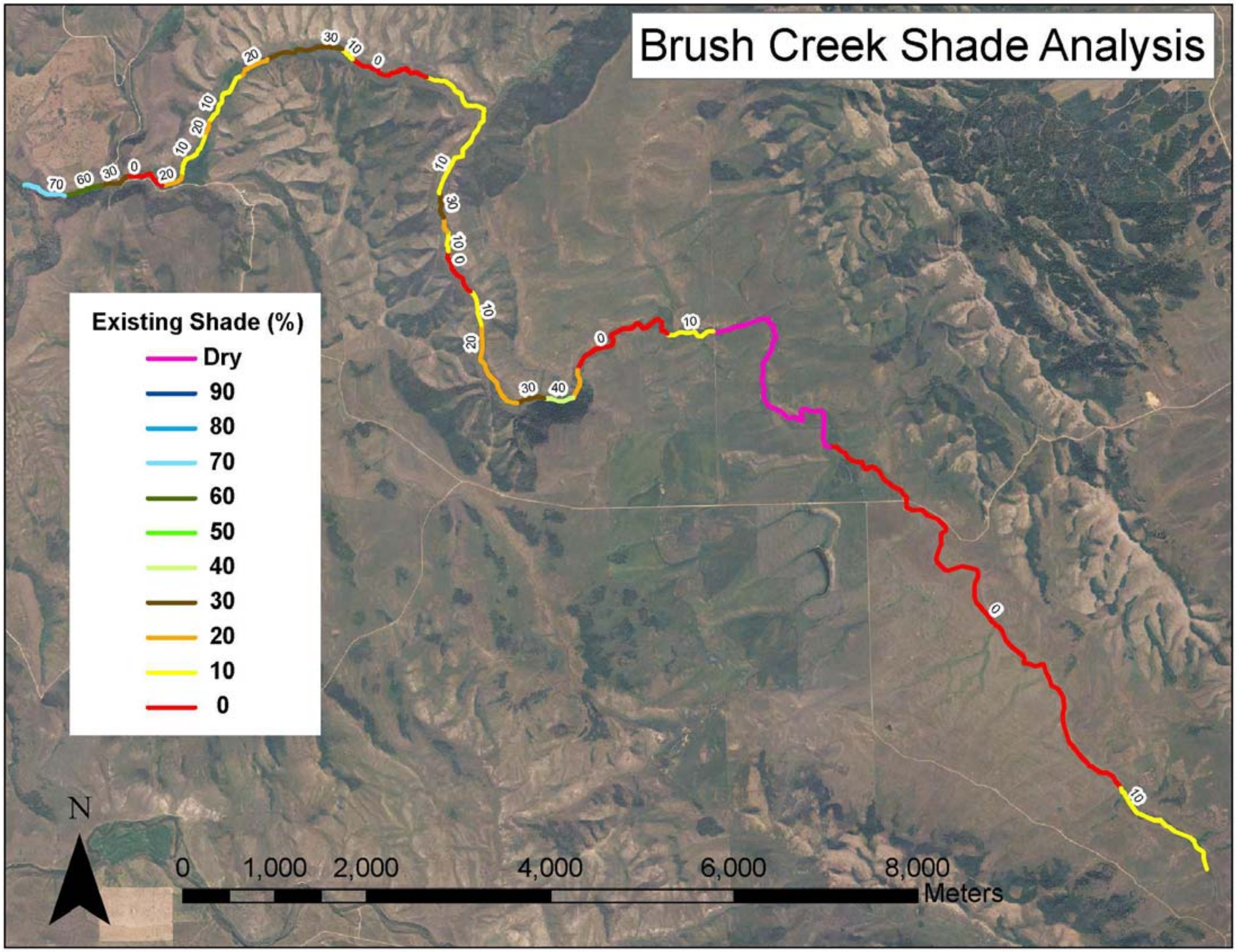

Figure 7. Existing shade estimated for Brush Creek by aerial photo interpretation.

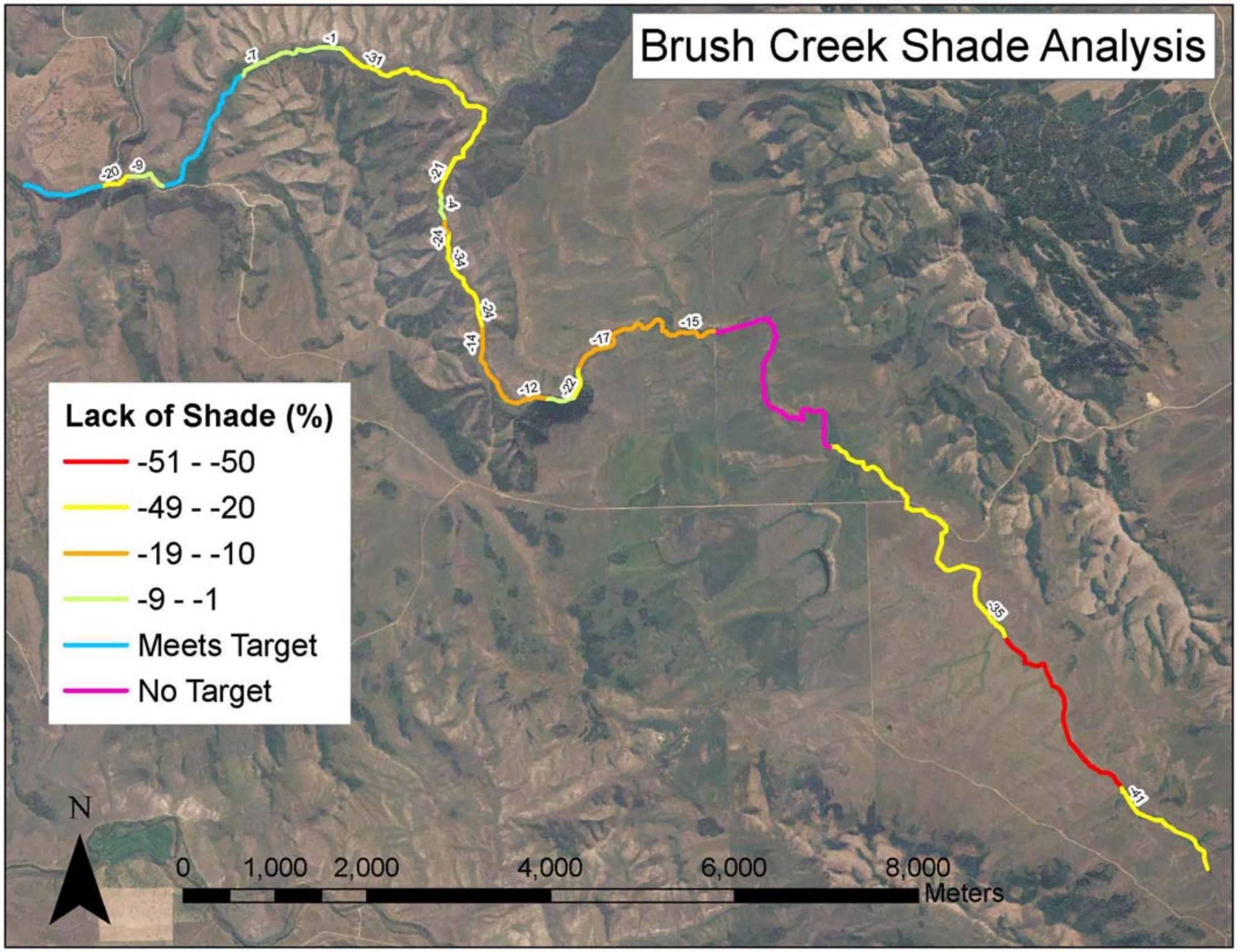

Figure 8. Lack of shade (difference between existing and target shade) for Brush Creek.

5.4 Load Allocation

Because this TMDL is based on potential natural vegetation, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to non point source activities that have or may affect riparian vegetation and shade as a whole. Load allocations are therefore stream reach specific and are dependent upon the target load for a given reach. Table 5 shows the target or potential shade which is converted to a potential summer load by multiplying the inverse fraction (1-shade fraction) by the average loading to a flat plate collector for the months of April through September. That is the loading capacity of the stream and it is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its loading capacity. Additionally, because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the water examined here need to be in natural conditions in order to prevent excess heat loads to the system.

In this TMDL there is a reach of Brush Creek that has been identified as dry and no specific target has been placed on this section of the stream. There is insufficient hydrologic data to identify whether this section of the stream is intermittent or ephemeral, as defined in Idaho WQS (IDAPA 58.01.02.010.31 and 58.01.02.010.45). It is difficult to develop a target for a section of the stream where there is insufficient water to support a riparian community. Because of this, no specific target or load has been placed on this section of the stream however, like all tributaries to Brush Creek, this section of the stream needs to be in its natural condition to prevent excess heat loads to the system.

The excess heat load experienced by Brush creek is 89,187 kWh/day and the percent reduction necessary to bring Brush Creek to target load levels is 19%.

Although the loading analysis dwells on the total heat load for Brush Creek, it is important to note that differences between existing shade and target shade, as depicted in Figure 8, are the key to successfully restoring these waters to achieving WQS. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should key in on the largest differences between existing and target shade as locations to prioritize implementation efforts.

There are no point sources in the Brush Creek Watershed. Thus, there are no wasteload allocations. Should a point source be proposed that would have thermal consequence on these waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 & IDAPA 58.01.02.401.03) should be involved (see Appendix B).

Margin of Safety

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

Seasonal Variation

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

5.5 Implementation Strategies

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

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

Several designated land management agencies are involved where watershed implementation is concerned. The largest portion of the watershed, with perennial water, consists of private and state land. The Idaho Soil Conservation Commission (SCC) and Idaho Department of Lands (IDL) will provide implementation strategies for riparian management for the areas that fall under their realm of jurisdiction.

Time Frame

The expected time frame for attaining the water quality standard and restoring beneficial use is a function of management intensity, climate, ecological potential, and natural variability of environmental conditions. If implementation of best management practices is embraced enthusiastically, some improvements may be seen in as little as several years. Even with aggressive implementation, however, some natural processes required for satisfying the requirements of this TMDL may not be seen for many years. The deleterious effects of historic land management practices have accrued over many years and recovery of natural systems may take longer than administrative needs allow for.

As stated above, the expected time frame for restoring Brush Creek so as to restore natural stream temperatures is highly dependent on several variables, principally the effort taken by those responsible for implementing such measures. In a completely ideal situation, where implementation occurs within five years of TMDL approval, vegetative recovery to natural conditions could occur within 20 years of planting and near exclusion of livestock.

Approach

It is anticipated that by improving riparian management practices, overall riparian zone recovery will precipitate streambank stabilization, reduce sedimentation, increase canopy cover, and lower stream temperatures, all of which will precipitate overall stream habitat improvements. Such improvements will contribute to an overall improvement in stream morphology and habitat, shifting stream health towards beneficial use attainment.

Responsible Parties

The SCC and IDL are the identified state entities that will be involved in or responsible for implementing the TMDL.

Monitoring Strategy

It is presumed that in stream temperatures will continue to be monitored with temperature loggers to evaluate improvements or declines in temperature regimes. Implementation effectiveness monitoring should also include using solar pathfinders to determine stream shading and progress towards meeting target shade levels. Additionally, Beneficial Use Reconnaissance Program monitoring will continue to be conducted by DEQ and should also provide insight regarding steam conditions.

5.6 Conclusions

The primary water quality concern in the Brush Creek watershed is elevated stream temperatures. To address this concern, a temperature TMDL has been written to address this non-point source pollutant. Elevated temperatures in the watershed are attributed to riparian vegetation disturbance.

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GIS Coverages

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Glossary

305(b)

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

§303(d)

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

Acre-foot

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

Adsorption

The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules

Aeration

A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.

Aerobic

Describes life, processes, or conditions that require the presence of oxygen.

Adfluvial

Describes fish whose life history involves seasonal migration from lakes to streams for spawning.

Adjunct

In the context of water quality, adjunct refers to areas directly adjacent to focal or refuge habitats that have been degraded by human or natural disturbances and do not presently support high diversity or abundance of native species.

Alevin	A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.
Algae	Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.
Alluvium	Unconsolidated recent stream deposition.
Ambient	General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).
Anadromous	Fish, such as salmon and sea-run trout, that live part or the majority of their lives in the saltwater but return to fresh water to spawn.
Anaerobic	Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.
Anoxia	The condition of oxygen absence or deficiency.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Anti-Degradation	Refers to the U.S. Environmental Protection Agency's interpretation of the Clean Water Act goal that states and tribes maintain, as well as restore, water quality. This applies to waters that meet or are of higher water quality than required by state standards. State rules provide that the quality of those high quality waters may be lowered only to allow important social or economic development and only after adequate public participation (IDAPA 58.01.02.051). In all cases, the existing beneficial uses must be maintained. State rules further define lowered water quality to be 1) a measurable change, 2) a change adverse to a use, and 3) a change in a pollutant relevant to the water's uses (IDAPA 58.01.02.003.61).

Aquatic

Occurring, growing, or living in water.

Aquifer

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

Assemblage (aquatic)

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

Assessment Database (ADB)

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

Assessment Unit (AU)

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

Assimilative Capacity

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

Autotrophic

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

Batholith

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

Bedload

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

Beneficial Use

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

Beneficial Use Reconnaissance Program (BURP)

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

Benthic

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

Benthic Organic Matter.

The organic matter on the bottom of a water body.

Benthos

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

Best Management Practices (BMPs)

Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Best Professional Judgment

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

Biochemical Oxygen Demand (BOD)

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

Biological Integrity

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

Biomass	The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.
Biota	The animal and plant life of a given region.
Biotic	A term applied to the living components of an area.
Clean Water Act (CWA)	The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.
Coliform Bacteria	A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).
Colluvium	Material transported to a site by gravity.
Community	A group of interacting organisms living together in a given place.
Conductivity	The ability of an aqueous solution to carry electric current, expressed in micro (µ) mhos/centimeter at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.
Cretaceous	The final period of the Mesozoic era (after the Jurassic and before the Tertiary period of the Cenozoic era), thought to have covered the span of time between 135 and 65 million years ago.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.

Cubic Feet per Second

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

Cultural Eutrophication

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

Culturally Induced Erosion

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

Debris Torrent

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

Decomposition

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

Depth Fines

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

Designated Uses

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

Discharge

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

Dissolved Oxygen (DO)

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

Disturbance	Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.
E. coli	Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.
Ecology	The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.
Ecological Indicator	A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework.
Ecological Integrity	The condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes (EPA 1996).
Ecosystem	The interacting system of a biological community and its non-living (abiotic) environmental surroundings.
Effluent	A discharge of untreated, partially treated, or treated wastewater into a receiving water body.
Endangered Species	Animals, birds, fish, plants, or other living organisms threatened with imminent extinction. Requirements for declaring a species as endangered are contained in the Endangered Species Act.
Environment	The complete range of external conditions, physical and biological, that affect a particular organism or community.

Eocene

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

Eolian

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

Ephemeral Stream

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

Erosion

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

Eutrophic

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

Eutrophication

1) Natural process of maturing (aging) in a body of water. 2) The natural and human-influenced process of enrichment with nutrients, especially nitrogen and phosphorus, leading to an increased production of organic matter.

Exceedance

A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

Existing Beneficial Use or Existing Use

A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

Exotic Species

A species that is not native (indigenous) to a region.

Extrapolation

Estimation of unknown values by extending or projecting from known values.

Fauna

Animal life, especially the animals characteristic of a region, period, or special environment.

Fecal Coliform Bacteria
Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

Fecal Streptococci
A species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.

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

Fixed-Location Monitoring
Sampling or measuring environmental conditions continuously or repeatedly at the same location.

Flow
See *Discharge*.

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

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

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

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

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

Geographical Information Systems (GIS)
A georeferenced database.

Geometric Mean	A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.
Grab Sample	A single sample collected at a particular time and place. It may represent the composition of the water in that water column.
Gradient	The slope of the land, water, or streambed surface.
Ground Water	Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.
Growth Rate	A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.
Habitat	The living place of an organism or community.
Headwater	The origin or beginning of a stream.
Hydrologic Basin	The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).
Hydrologic Cycle	The cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Atmospheric moisture, clouds, rainfall, runoff, surface water, ground water, and water infiltrated in soils are all part of the hydrologic cycle.
Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more

commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

Hydrologic Unit Code (HUC)

The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

Hydrology

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

Impervious

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

Influent

A tributary stream.

Inorganic

Materials not derived from biological sources.

Instantaneous

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

Intergravel Dissolved Oxygen

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

Intermittent Stream

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

Interstate Waters

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

Irrigation Return Flow

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

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

Knickpoint
Any interruption or break of slope.

Land Application
A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge.

Limiting Factor
A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.

Limnology
The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.

Load Allocation (LA)
A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).

Load(ing)
The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.

Load(ing) Capacity (LC)
A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.

Loam
Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.

Loess
A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.

Lotic	An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth.
Luxury Consumption	A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants' current needs.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Macrophytes	Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp.*), are free-floating forms not rooted in sediment.
Margin of Safety (MOS)	An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.
Mass Wasting	A general term for the down slope movement of soil and rock material under the direct influence of gravity.
Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Median	The middle number in a sequence of numbers. If there is an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11.

Metric
1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)
A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm).

Million Gallons per Day (MGD)
A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Miocene
Of, relating to, or being an epoch of, the Tertiary between the Pliocene and the Oligocene periods, or the corresponding system of rocks.

Monitoring
A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

Mouth
The location where flowing water enters into a larger water body.

National Pollution Discharge Elimination System (NPDES)
A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition
The condition that exists with little or no anthropogenic influence.

Nitrogen
An element essential to plant growth, and thus is considered a nutrient.

Nodal
Areas that are separated from focal and adjunct habitats, but serve critical life history functions for individual native fish.

Nonpoint Source
A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for

grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Not Assessed (NA)

A concept and an assessment category describing water bodies that have been studied, but are missing critical information needed to complete an assessment.

Not Attainable

A concept and an assessment category describing water bodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

Not Fully Supporting

Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Not Fully Supporting Cold Water

At least one biological assemblage has been significantly modified beyond the natural range of its reference condition.

Nuisance

Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient

Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Nutrient Cycling

The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic

The Greek term for "poorly nourished." This describes a body of water in which productivity is low and nutrients are limiting to algal growth, as typified by low algal density and high clarity.

Organic Matter
Compounds manufactured by plants and animals that contain principally carbon.

Orthophosphate
A form of soluble inorganic phosphorus most readily used for algal growth.

Oxygen-Demanding Materials
Those materials, mainly organic matter, in a water body that consume oxygen during decomposition.

Parameter
A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.

Partitioning
The sharing of limited resources by different races or species; use of different parts of the habitat, or the same habitat at different times. Also the separation of a chemical into two or more phases, such as partitioning of phosphorus between the water column and sediment.

Pathogens
A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Perennial Stream
A stream that flows year-around in most years.

Periphyton
Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants.

Pesticide
Substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

pH

The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Phased TMDL

A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a water body. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.

Phosphorus

An element essential to plant growth, often in limited supply, and thus considered a nutrient.

Physiochemical

In the context of bioassessment, the term is commonly used to mean the physical and chemical factors of the water column that relate to aquatic biota. Examples in bioassessment usage include saturation of dissolved gases, temperature, pH, conductivity, dissolved or suspended solids, forms of nitrogen, and phosphorus. This term is used interchangeable with the term “physical/chemical.”

Plankton

Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.

Point Source

A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.

Pollutant

Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution
A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

Population
A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.

Pretreatment
The reduction in the amount of pollutants, elimination of certain pollutants, or alteration of the nature of pollutant properties in wastewater prior to, or in lieu of, discharging or otherwise introducing such wastewater into a publicly owned wastewater treatment plant.

Primary Productivity
The rate at which algae and macrophytes fix carbon dioxide using light energy. Commonly measured as milligrams of carbon per square meter per hour.

Protocol
A series of formal steps for conducting a test or survey.

Qualitative
Descriptive of kind, type, or direction.

Quality Assurance (QA)
A program organized and designed to provide accurate and precise results. Included are the selection of proper technical methods, tests, or laboratory procedures; sample collection and preservation; the selection of limits; data evaluation; quality control; and personnel qualifications and training (Rand 1995). The goal of QA is to assure the data provided are of the quality needed and claimed (EPA 1996).

Quality Control (QC)
Routine application of specific actions required to provide information for the quality assurance program. Included are standardization, calibration, and replicate samples (Rand 1995). QC is implemented at the field or bench level (EPA 1996).

Quantitative	Descriptive of size, magnitude, or degree.
Reach	A stream section with fairly homogenous physical characteristics.
Reconnaissance	An exploratory or preliminary survey of an area.
Reference	A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.
Reference Condition	1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).
Reference Site	A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.
Representative Sample	A portion of material or water that is as similar in content and consistency as possible to that in the larger body of material or water being sampled.
Resident	A term that describes fish that do not migrate.
Respiration	A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.
Riffle	A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.

Riparian

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

Riparian Habitat Conservation Area (RHCA)

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

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

River

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

Runoff

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

Sediments

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

Settleable Solids

The volume of material that settles out of one liter of water in one hour.

Species

1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.

Spring

Ground water seeping out of the earth where the water table intersects the ground surface.

Stagnation

The absence of mixing in a water body.

Stenothermal

Unable to tolerate a wide temperature range.

Stratification

A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).

Stream

A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.

Stream Order

Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.

Storm Water Runoff

Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the stream. The water often carries pollutants picked up from these surfaces.

Stressors

Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Subbasin

A large watershed of several hundred thousand acres. This is the name commonly given to 4^{th} field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)

A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed

A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6^{th} field hydrologic units.

Surface Fines

Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 millimeters depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.

Surface Runoff

Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.

Surface Water

All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Suspended Sediments

Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Taxon

Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).

Tertiary

An interval of geologic time lasting from 66.4 to 1.6 million years ago. It constitutes the first of two periods of the Cenozoic Era, the second being the Quaternary. The Tertiary has five subdivisions, which from oldest to youngest are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs.

Thalweg

The center of a stream's current, where most of the water flows.

Threatened Species

Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Total Maximum Daily Load (TMDL)

A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Dissolved Solids

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Toxic Pollutants

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Tributary

A stream feeding into a larger stream or lake.

Trophic State

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

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Turbidity

A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Vadose Zone

The unsaturated region from the soil surface to the ground water table.

Wasteload Allocation (WLA)

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

Water Body

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

Water Column

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

Water Pollution

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

Water Quality

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

Water Quality Criteria

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

Water Quality Limited

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

Water Quality Limited Segment (WQLS)

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

Water Quality Management Plan

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

Water Quality Modeling

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

Water Quality Standards

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

Water Table

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

Watershed

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

Water Body Identification Number (WBID)

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

Wetland

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

Young of the Year

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

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
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

Flow Rate	Cubic Feet per Second (cfs)[a]	Cubic Meters per Second (m^3/sec)	1 cfs = 0.03 m^3/sec 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 °C = 37.4 °F

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

Appendix B. State and Site-Specific Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring spawning salmonids, the default spawning and incubation period recognized by DEQ is generally from March 15th to July 1st each year (Grafe et al., 2002). Fall spawning can occur as early as August 15th and continue with incubation on into the following spring up to June 1st. As per IDAPA 58.01.02.250.02.e.ii., the water quality criteria that need to be met during that time period are:

> 13^{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.).

Appendix C. Percent Lack of Shading in Brush Creek

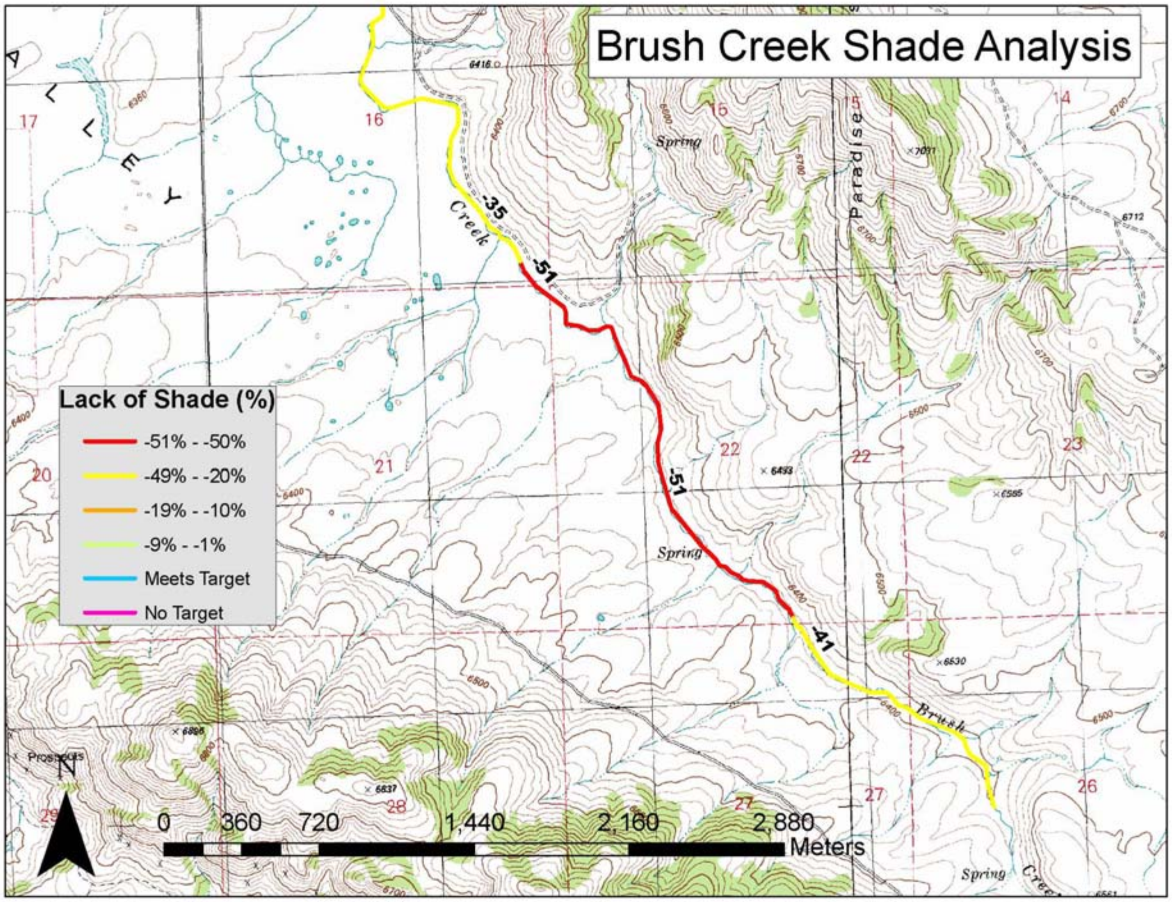

Figure C-1. Percent lack of shade for upper Brush Creek.

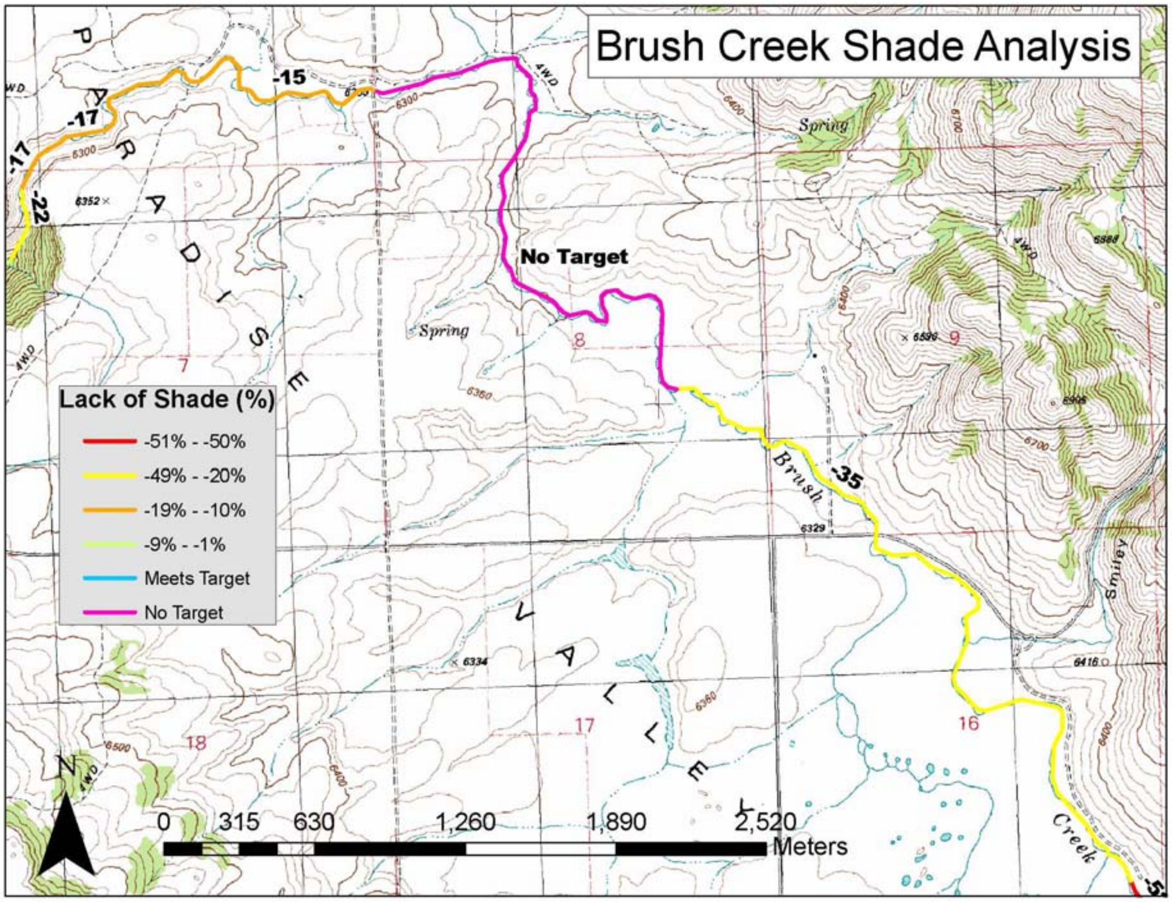

Figure C-2. Percent lack of shading for upper-middle Brush Creek.

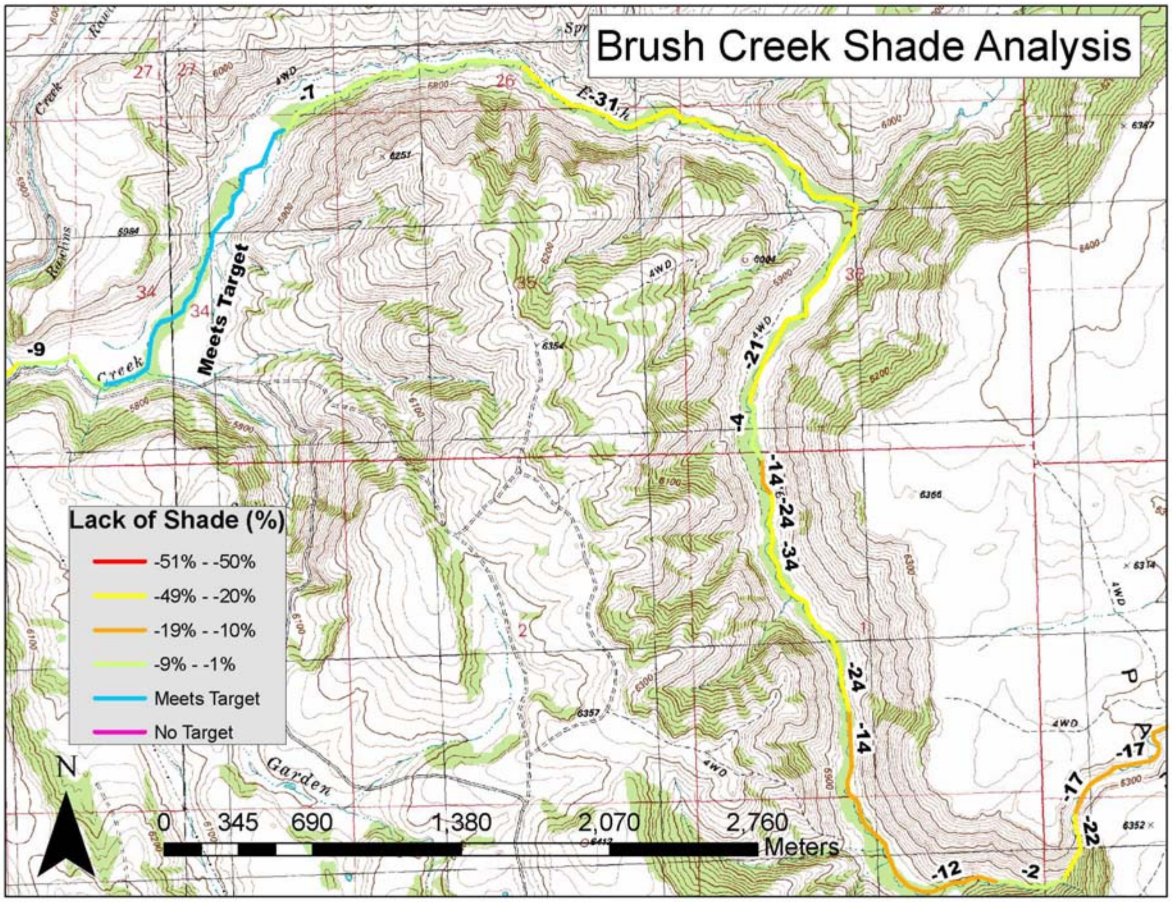

Figure C-3. Percent lack of shading for middle Brush Creek.

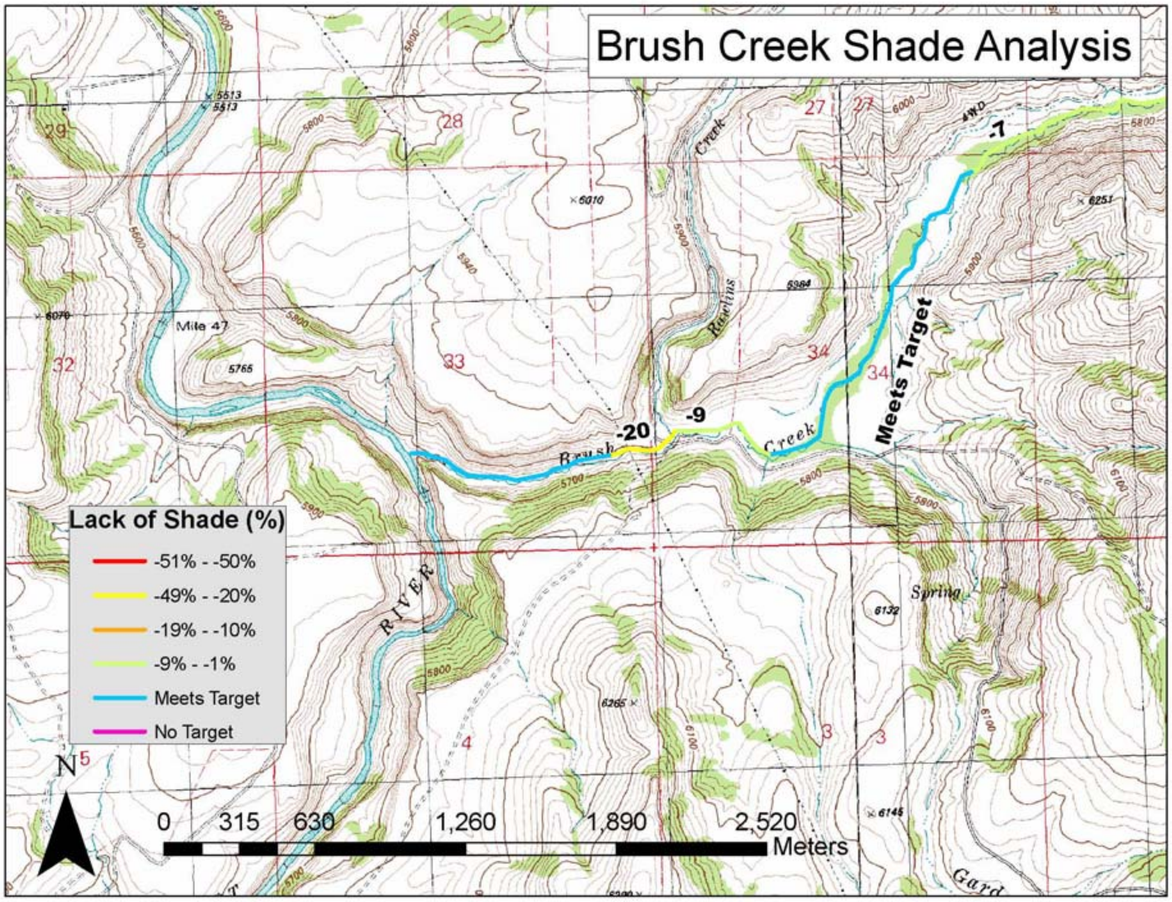

Figure C-4. Percent lack of shading for lower Brush Creek.

Appendix D. Data Sources and Temperature Data

Table D-1. Data sources for Brush Creek temperature TMDL.

Water Body	Data Source	Type of Data	When Collected
Brush Creek	DEQ Pocatello Regional Office	Pathfinder effective shade and stream width	September 2006
Brush Creek	DEQ Pocatello Regional Office	Aerial Photo Interpretation of existing shade and stream width estimation	September 2006
Brush Creek	DEQ Pocatello Regional Office	Temperature	June through September 2006
Brush Creek	DEQ Pocatello Regional Office	Fish Data	Summer 2005
Brush Creek	DEQ Pocatello Regional Office	BURP Data	July 1996, 2002 and 2004

Appendix E. Distribution List

Charlotte Reid - Chairwoman Blackfoot Watershed Advisory Group Lower Presto Blackfoot, ID 83221	William Stewart Idaho Operations Office Environmental Protection Agency 1435 N. Orchard St. Boise, ID 83706
Justin Krajewski, Riparian Specialist Idaho Association of Soil Conservation Districts 1551 Baldy Ave., Ste. #2 Pocatello, ID 83201 Justin.krajewski@agri.idaho.gov	Pat Brown Area Supervisor Idaho Department of Lands 3563 Ririe Hwy Idaho Falls, ID 83401
Richard Scully Idaho Department of Fish and Game Southeast Region 1345 Barton Road Pocatello, ID 83204	Amy Jenkins, Water Quality Analyst Idaho Association of Soil Conservation Districts 1551 Baldy Ave., Ste. #2 Pocatello, ID 83201
Martha Turvey, US EPA – Region 10 Region 10 (OW-134) 1200 Sixth Ave. Seattle, WA 98101 Turvey.martha@epa.gov	Dean Smith, District Conservationist Natural Resources Conservation Service Blackfoot Service Center 725 Jensen Grove Dr Blackfoot, ID 83221-1636
Leigh Woodruff, Watershed Unit US Environmental Protection Agency 1435 N Orchard Boise, Idaho 83716 Woodruff.leigh@epa.gov	Matt Woodard, Chairman Upper Snake River Basin Advisory Group mwoodard@tu.org

Appendix F. Public Comments

The DEQ contacted the Blackfoot Watershed Advisory Group multiple times through the development of this TMDL and provided several opportunities for them to participate in the process and to hold a public meeting to discuss components of the TMDL. The WAG president offered suggestions and comments with regard to the development of the TMDL however, the WAG chose to forego the public meeting process. A copy of the document was sent to the Upper Snake River Basin Advisory Group (BAG) and they provided preliminary comments regarding the TMDL.

The public comment period for the Brush Creek Temperature TMDL was held for 30 days from August 15, 2007 through September 15, 2007. Comments received from the US Environmental Protection Agency (USEPA), Idaho Soli Conservation Commission (ISCC), and Upper Snake River BAG are included with responses in bold print.

Comments by the USEPA

Comments on Brush Creek Temperature draft TMDL: Addendum to the Blackfoot River Subbasin Assessment and TMDL

September 10, 2007

Dear Melissa,

Thank you for providing a draft of the Brush Creek Temperature TMDL for our review. As you are probably aware EPA and IDEQ recently met to discuss PNV issues that have been cropping up in a number of draft and final TMDLs around the state. The comments I have listed below address issues in the Brush Cr TMDL which were discussed in these meetings, and reflect understandings that were reached as a result of those meetings.

1. *Tributary Load Allocations:* Loads from tributaries to Brush Cr. are not addressed in this TMDL. We are not clear if there are any tributaries, but we are concerned that if there are, there could be cumulative impacts to Brush Creek from temperatures in these tributaries. As a result, PNV shade targets should be set for tributaries, or the tributaries should be shown to be in a natural state to ensure natural stream temperatures will be achieved in Brush Creek. We would like you to consider the idea of a gross allocation to tributaries in this TMDL, to send the message that riparian vegetation should be in a natural state along all the streams. Specific shade targets for specific reaches on tributaries could be identified at a later implementation phase.

The following statement has been added to section 5.4, Load Allocation (heading): "Because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the waters examined here need to be in natural conditions in order to prevent excess heat loads to the system."

2. *Shade Curve Selection,* EPA will generally accept IDEQ's shade curve selection. However, we found it difficult to evaluate the appropriateness of the shade curves currently chosen, since there was limited description of the potential vegetation in the Brush Creek watershed. We recognize the difficulty in establishing regional or site specific curves for non-forested areas in southern Idaho, and because of this, we have offered to assist in the development of such curves. We understand that such curves will be incorporated into Idaho temperature TMDLs at the 5-year review stage if they are available.

Comment noted.

3. *Beneficial uses and criteria.* The document should specifically identify the designated and existing beneficial uses for Brush Creek, and the relevant temperature criteria. Some of this is discussed under the Temperature assessment section, but it would help to consolidate this information in a short section specifically devoted to the beneficial uses and criteria. Appendix B provides geneneral criteria information, which is useful, but it does not include specific beneficial use information for Brush Creek.

Beneficial use information for Brush Creek is outlined in the Executive Summary. Existing water temperature data and an analysis of those data with reference to Idaho water quality criteria for salmonid spawning and cold water aquatic life are also located in the Executive Summary.

4. *Reach specific allocations.* Allocations for specific reaches in Table 5 are not easily located on the maps provided, nor at a scale which would be useful to implementation. While this relates primarily to implementation of the TMDL, we recommend both including a means to relate reach specific allocations to the map, e.g. using a common numbering system on the map(s) and table, and including maps with higher resolution. This would allow landowners and staff from land management agencies to more easily determine reach-specific allocations.

Since the TMDL relates directly to percent shading and the percent reduction for each reach is mathematically derived, figure 8 which depicts the percent lack of shade is the most useful tool for land stewards to evaluate reach-specific management activities. An additional appendix (C) has been added with four topographic maps that are of a higher resolution than figure 8. A column has been added to table 5 that shows which figure(s) the associated stream reaches are located in. To further assist implementers in reach identification, a column with the percent lack of shade has also been added to table 5. The addition of the higher resolution maps and a statement of their location in table 5 will allow implementers to better identify reach-specific allocations by cross referencing figures C-1 thought C-4 with the load allocation column in table 5.

5. *No target.* One reach is shown in Figure 8 for which there is no shade target. Is there some reason for this? If water flows through this reach, even intermittently, a shade target should be established, but there may be hydrologic or other factors we are not aware of.

It is difficult to determine whether or not this section of the stream is intermittent or ephemeral so background conditions are the desired condition. To address this issue, the following paragraph has been added to section 5.5, Load Allocation (heading):

In this TMDL there is a reach of Brush Creek that has been identified as dry and no specific target has been placed on this section of the stream. There is insufficient hydrologic data to identify whether this section of the stream is intermittent or ephemeral, as defined in Idaho WQS (IDAPA 58.01.02.010.31 and 58.01.02.010.45). It is difficult to develop a target for a section of the stream where there is insufficient water to support a riparian community. Because of this, no specific target or load has been placed on this section of the stream however, like all tributaries to Brush Creek, this section of the stream needs to be in its natural condition to prevent excess heat loads to the system.

6. *Areas where existing shade is greater than target shade.* The assessment methodology and target selection processes are not precise. Areas identified as having shade above target levels are described in Table 5. These areas should be considered as critical areas for protection to ensure natural temperature conditions. However, the current method of averaging the targets over the whole table results in these healthy shade areas averaging out impacted areas along other reaches of the stream. (See comment 6 below.)

Yes, there are areas of the stream that have shade above the target level, however, your statement that, "The current method of averaging the targets over the whole table results in these healthy shade areas averaging out impacted areas along other reaches of the stream.", is not accurate because no positive value (kWh/day) was given to those segments. Rather, those segments were given a zero value, so that the TMDL does not support the additional removal of vegetation. A zero value does not contribute to healthy shade areas averaging out impacted areas along reaches of the stream therefore they have no impact on the total load allocation or percent reduction. See table 5.

7. *Averaging needed shade improvements (p. 17).* Averaging the needed shade improvements for a water can mask areas of needed restoration. For example, some areas in the Brush Creek watershed are shown to have no shade currently, but should have 50% natural shade. These problematic areas might be ignored 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, and referencing reach specific targets in Table 5.

The following statement has been added to section 5.5, Load Allocation (heading):

> **Although the loading analysis dwells on the total heat load for Brush Creek, it is important to note that differences between existing shade and target shade, as depicted in Figure 8, are the key to successfully restoring these waters to achieving WQS. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should key in on the largest differences between existing and target shade as locations to prioritize implementation efforts.**

Providing a map showing reach specific values of lack of shade, as you do now, is good (see also suggestions in 4. above). It would also be helpful to show the percent solar load reductions <u>for each of the reaches</u> in Table 5, rather than the summed solar load reduction for the whole subwatershed and, as suggested above, to link the reaches on the table to maps of the watershed.

A column showing reach specific percent reductions has been added to table 5. As stated above, new figures (appendix C) which are cross referenced to reaches in table 5 have been added.

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 which show deviation from natural would need improvement.

As stated above, the following statement has been added to section 5.5, Load Allocation (heading):

> **Although the loading analysis dwells on the total heat load for Brush Creek, it is important to note that differences between existing shade and target shade, as depicted in Figure 8, are the key to successfully restoring these waters to achieving WQS. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should key in on the largest differences between existing and target shade as locations to prioritize implementation efforts.**

8. *Implementation strategies:*
   a. Timeframe – we think it would be valuable to discuss more explicitly what it will take to achieve natural stream temperatures, e.g. restoring riparian vegetation and channel width to a natural state, the timeframe it would take to restore natural vegetation, even if these are only rough estimates at this point.

The following statement has been added to section 5.5 Implementation Strategies, Time Frame (heading): "As stated above, the expected time frame for restoring Brush Creek so as to restore natural stream temperatures is highly dependent on several variables,

principally the effort taken by those responsible for implementing such measures. In a completely ideal situation, where implementation occurs within five years of TMDL approval, vegetative recovery to natural conditions could occur within 20 years of planting and near exclusion of livestock."

b. In addition to instream temperature monitoring, the monitoring strategy should also discuss field evaluation of existing and future shade levels, as you do on p. 10. This type of monitoring may be as important if not more so than temperature monitoring, as it provides a direct measure of implementation effectiveness, and may respond to changes in management more quickly than stream temperature.

The following language has been added to section 5.5, Implementation Strategies (heading), Monitoring (subheading): "Implementation monitoring should also include using solar pathfinders to determine stream shading and progress towards meeting target shade levels."

9. *Construction Storm Water and TMDL Waste Load Allocations:* While it is important to include this section in the TMDL, the discussion should include how this is related to the temperature TMDL. As stated in the document the typical main pollutant of concern is sediment which when in excess can impact temperature conditions. Post construction storm-water management that addresses sediment issues will benefit temperature which is a link that can be made in this section.

The section on construction storm water and TMDL waste load allocations has been removed from the document. This is boilerplate language that is out of context for this watershed and associated TMDL. This is a very rural watershed, dominated by agriculture and there is no foreseeable development that would be associated with construction storm water.

Thanks for the opportunity to review this draft TMDL, please give me a call if you have any questions regarding these comments at 206-553-1354.

Comments by the Idaho Soil Conservation Commission

We assessed most (about half) of Brush Creek in 2000 (prior to the solar pathfinder).

Also, we found the reaches in Poor, Fair, and Good condition with bankfull widths ranging from 2 m to 10 m. Numerous beaver dams and ponds on the lower section with very wide greenline widths (>40 m).

We didn't find any canopy cover on the middle section (below the county road to the dry section onto to the canyon) and 25% to 75% canopy cover on the lower sections.

Brush Creek is listed as a high priority segment in our TMDL ag plan, however the SWCD has chosen to implement individual projects and not a watershed scale project at this time.

Also, our implementation plan alternatives cover the temperature concerns along Brush Creek.

Certainly, the most difficult aspect of this TMDL are the sections and targets above the county road. The flat, meandering, fine sediment, herbaceous vegetated, meadow type stream doesn't allow for restoration of a willow community too easily. Additionally, the disappearance of the creek in the middle section (below the county road) and subsequent downcutting of the stream channel and valley across the black basalt geologic formations may probably add to the temperature loading as well.

Comments noted.

Comments by the Upper Snake River Basin Advisory Group

I have looked through your Brush Creek TMDL Subbasin Assessment Draft.

I would make the following observations:

- Clearly the problem on much of the upper section of Brush Creek is the severe lack of over head cover and little or no presence of woody vegetation resulting in poor bank conditions or unstable bank conditions resulting in increased sediment loading and elevated water temperatures.
- If you're going to recover this stream to usable condition a combination of things will need to be implemented, especially if you're looking at salmonids.
  - A severe cutback in live stock numbers and or rest rotation grazing plan based on at a minimum of two years rest with one year on with stubble height restrictions that will need to be carefully monitored.
  - Woody plant reintroduction to provide improved soil stability and increased overhead cover to meet your targeted shade cover index will require either fencing of the riparian area which would be best or a range rider that would push livestock off the stream daily. Development of offsite water if available would help in keeping livestock out of the riparian area.
  - Planners should also look at presences of wetland plant species like Nebraska Sedge, Beaked Sedge, Spikes Rush, and Baltic Rush. These could be reintroduced if they are not presence with plug cuttings to improve soil holding and bank stability improvement.
  - I think you have done a good job a accessing the relevant factors that are contributing to elevating temperature or the stream being impaired do to high temperature and the lack of shade for most of the stream except the lower portions where it appears to be in better shape. I would hope that Idaho Department of Lands and the Soil Conservation Commission along with NRCS would look at what really needs to happen here to get this stream back in healthy condition.

Comments noted.