Goose Creek Subbasin Temperature Total Maximum Daily Loads:

Addendum to the Goose Creek Subbasin Assessment and TMDLs

"Draft"

Department of Environmental Quality

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Goose Creek Subbasin Temperature TMDLs

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Prepared by:
State Technical Services office
Department of Environmental Quality
1410 N. Hilton St.
Boise, ID 83706

Acknowledgments

Cover photo: Goose Creek below Emery Creek (DEQ, 2008).

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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
PVG	potential vegetation group
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, set at a level to achieve water quality standards.

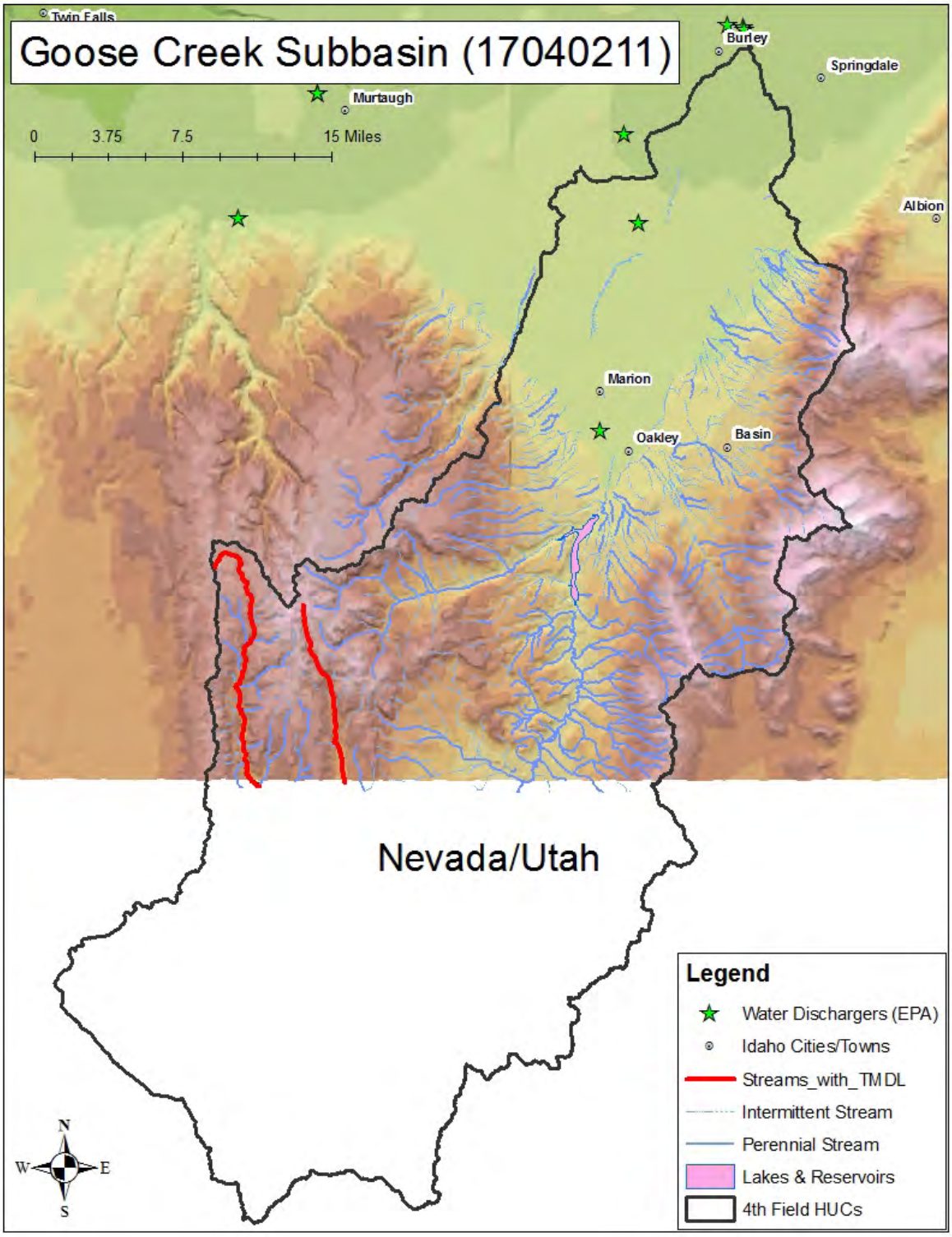
This document addresses two water bodies in the Goose Creek Subbasin that have temperature exceedances of water quality standards (see Appendix C). This document only addresses the temperature TMDLs for these streams. For more information about these watersheds and the subbasin as a whole see the *Goose Creek Subbasin Assessment and Total Maximum Daily Loads* (IDEQ, 2003).

This TMDL analysis has been developed to comply with Idaho's TMDL requirements. 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 Goose Creek Subbasin (17040211) is located south-central Idaho south of Burley, Idaho (see Figure A). Listed on the Idaho 1998 303d list for temperature pollution were Beaverdam Creek, Cold Creek and Goose Creek. A temperature TMDL for these streams was completed in 2003, however only the lower portion of Goose Creek from the Utah border to Goose Creek Reservoir was included (IDEQ, 2003). In the current 303d list (2008), upper Goose Creek (headwaters to Nevada border) and Trout Creek have been added to the list of streams with temperature impairment issues. Listing temperature data is presented in Appendix C. Both streams are located in the Sawtooth National Forest and drain south from the Monument Peak area to the Nevada border (see Figure A for streams in analysis). The following analysis includes the temperature TMDLs for upper Goose Creek and Trout Creek.

Figure A. Subbasin at a glance.



Key Findings

Two creeks (upper Goose Creek and Trout Creek) were placed on the 2008 303d list of impaired waters for reasons associated with temperature criteria violations (see Appendix C for listing temperature data). Effective shade targets were established for the two streams based on the concept of maximum shading under potential natural vegetation equals natural background temperature levels. Shade targets were actually derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation partially field verified with solar pathfinder data.

Both streams examined lacked shade in reference to targets. The lack of shade is likely the result of a combination of factors including natural and human-influenced dewatering of the stream channel and historic removal of riparian vegetation associated with livestock grazing and agricultural practices. Much of this was due to high target levels set for small width streams because of various tree-dominated vegetation types (aspen, lodgepole, etc.). Many of these streams lack these vegetation types now, or only have remnants of aspen or lodgepole stands. The reasons for this may be many and varied, from the lack of aspen regeneration due to grazing to a lack of water from diversion and drought throughout the subbasin. While not much can be done about the lack of water in channels, most streams would recover riparian vegetation if temporarily or permanently excluded from use.

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.

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

Stream	Pollutant(s)
(Upper) Goose Creek	Temperature
Trout Creek	Temperature

Table B. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Goose Creek/ ID17040211SK008_02 ID17040211SK008_03 ID17040211SK008_04	Temperature	Yes	Move to 4A	Excess solar load due to lack of shade
Trout Creek/ ID17040211SK007_02 ID17040211SK007_03	Temperature	Yes	Move to 4A	Excess solar load due to lack of shade

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

Potential Natural Vegetation for Temperature TMDLs

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

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

Potential natural vegetation (PNV) along a stream is that riparian plant community that has grown to an overall mature state, although some level of natural disturbance is usually included in our development and use of shade targets. The PNV can be removed

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

Existing shade was estimated for the two water bodies 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 Idaho (see Shumar and De Varona, 2009). 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 by more than 0.3°C.

Pathfinder Methodology

The solar pathfinder is a device that allows one to trace the outline of shade producing objects on 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, ten traces should be taken at systematic or random intervals along the length of the stream in question.

At each sampling location the solar pathfinder should be placed in the middle of the stream about the bankfull water level. Follow the manufacturer's instructions (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. Start at a unique location such as 50 to 100 m from a bridge or fence line and then proceed upstream or downstream stopping to take additional traces at fixed intervals (e.g. every 50m, every 50 paces, etc.). One can also

randomly locate points of measurement by generating random numbers to be used as interval distances.

It is a good idea to measure bankfull widths and take notes while taking solar pathfinder traces, and to photograph the stream at several unique locations. Pay special attention to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade producing ones) are present. Additionally or as a substitution, one can take densiometer readings at the same location as solar pathfinder traces. This provides the potential to develop relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

Expectations of shade based on plant type and density are provided for natural breaks in vegetation density, marked out on a 1:100K or 1:250K hydrography. Each interval is assigned a single value representing the bottom of a 10%-shade class as described below (*adapted from the CWE process, IDL, 2000)*. For example, if we estimate that shade for a particular stretch of stream is somewhere between 50% and 59%, we assign the value of 50% to that section of stream. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and the width of the stream. Streams where the banks and water are clearly visible usually are in low shade classes (10 to 30%). Streams with dense forest or heavy brush where no portion of the stream is visible usually are in high shade classes (70 to 90%). More open canopies where portions of the stream may be visible usually fall into moderate class intervals (40 to 60%).

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

Stream Morphology

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

This width factor (i.e., NSDZ or Bankfull Width) may not be discernable from the aerial photo work described previously. Accordingly, this parameter must be estimated from available information. We use regional curves for the major basins in Idaho, data

compiled by Diane Hopster of Idaho Department of Lands (Figure 1), to estimate natural bankfull width.

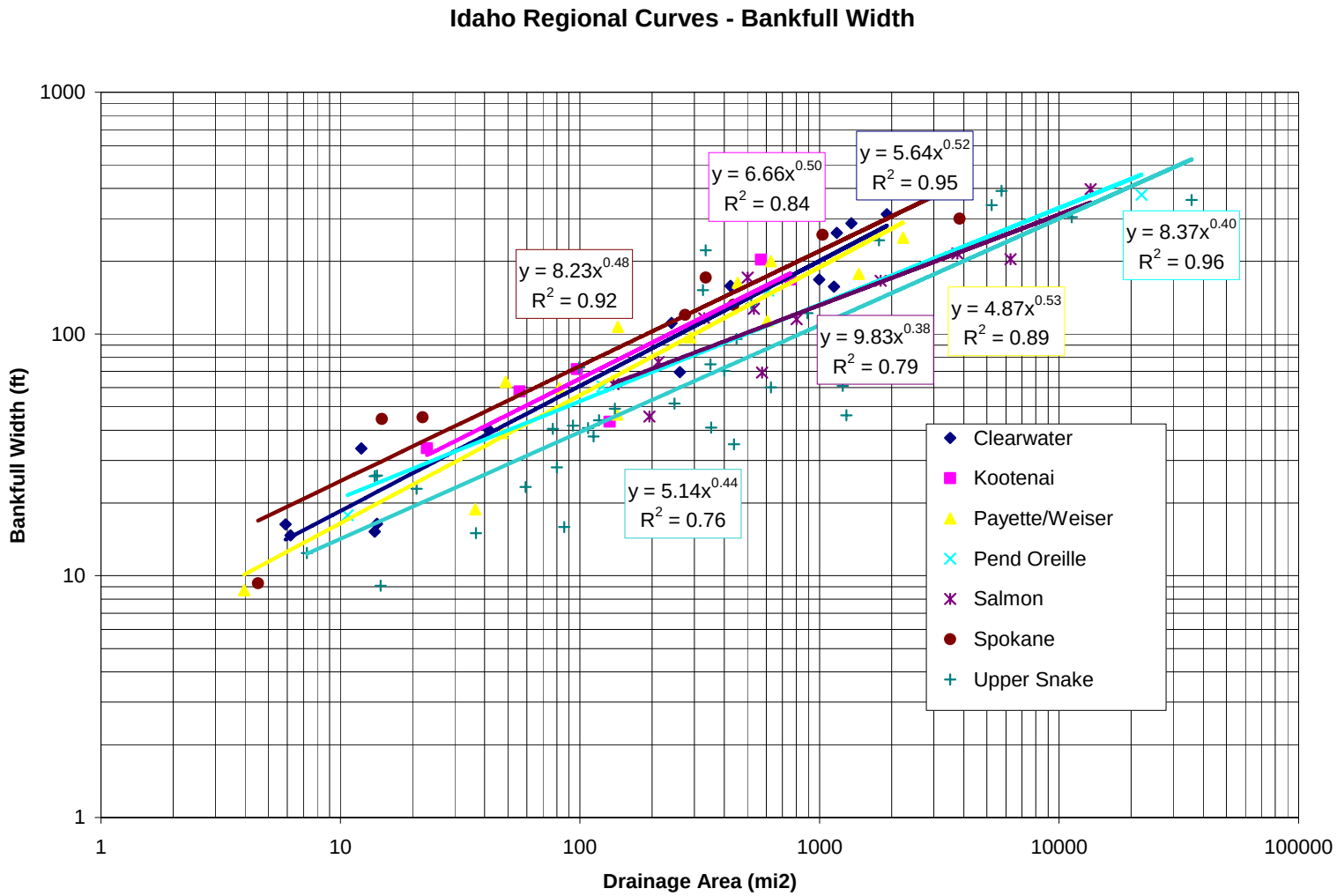
For each stream evaluated in the loading analysis, bankfull width is estimated based on drainage area of the Upper Snake curve from Figure 1. Additionally, existing width is evaluated from available data. If the stream's existing width is wider than that predicted by the Upper Snake curve in Figure 1, then the Figure estimate of bankfull width is used in the loading analysis for natural bankfull width. If existing width is smaller, then existing width is used in the loading analysis as natural bankfull width (i.e. existing = natural).

In general, the majority of existing bankfull width data showed that streams are typically smaller than or equal to what is predicted by regional curves. This is not surprising in an arid environment where a lack of precipitation results in a predominance of ephemeral and intermittent streams. Only a few locations had existing widths larger than predicted. Therefore, in most cases existing width is used for natural width in loading tables that follow in Section 5.3 (Estimates of Existing Loads). Only a few cases do existing widths show over-widening of stream channels.

Table 1. Regional Curve Estimates and Existing Measurements of Bankfull Width for Goose Creek Subbasin Streams (US = Upper Snake).

Location	area (sq mi)	US (m)	existing in meters (year measured)
Trout Cr @ stateline	18.8	6	3.1(98), 2.7(03)
Trout Cr @ 5800ft	14	5	3.8(97),2.8(02),3.4(05),4.2(06),1.9(07)
Trout Cr @ 6200ft	3.9	3	3.6(02), 7.3(08), 7.9(08)
Trout Cr @ 6800ft	1.9	2	
Upper Goose Cr ab Thoroughbred Cr	38	8	8.1(97),9.1(99), 6.3(01),7.1(06),4.9(07)
Upper Goose Cr @ 5800ft	32	7	5.3(97),5.4(04),4.3(06),4.2(07)
Upper Goose Cr @ 6000ft	25.7	7	5.4(99),4.6(02),3.9(03),4.7(04),4.9(06)
Upper Goose Cr @ 6400ft	8.9	4	3.4(97),2.5(05)
Upper Goose Cr @ 6800ft	1.69	2	8.8(08, near ponds)
green = low existing			
yellow = high existing			

Figure 1. Bankfull Width as a Function of Drainage Area



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Design Conditions

The majority of the Goose Creek Subbasin lies within the Northern Basin and Range Ecoregion (Level III) of McGrath et al. (2001). Although the outlet from Goose Creek Reservoir as well as several other drainages (e.g. Big Cottonwood Creek, Mill Creek) drain to the Magic Valley Province of the Snake River Plain Ecoregion. The high elevations of Magic Mountain and the Albion Mountains are within the High Elevation Forests & Shrublands Level IV Province and are characterized by a mix of conifers, mountain brush and sagebrush grasslands. North-facing slopes and flatter areas typically contain open Douglas fir, aspen and lodgepole pine. On lower slopes of these mountains and Middle Mountain (between Goose Creek and Birch Creek) the Semiarid Hills & Low Mountains Level IV Ecoregion predominates. Vegetation is characterized as mostly sagebrush steppe with juniper woodlands prevalent on rocky outcrops. In the valleys close to the town of Oakley, Idaho the Sagebrush Steppe Valleys Level IV Province is present. A small portion of lower Goose Creek at the border with the state of Utah lies within the Dissected High Lava Plateau Province, a sagebrush grassland that is slightly less wooded and more arid than other provinces in this ecoregion.

Riparian vegetation along streams varies greatly from higher elevation Douglas fir (*Psuedotsuga mentziesii*) or lodgepole pine (*Pinus contorta*) forests and quaking aspen (*Populus tremuloides*) stands to willow dominated areas at lower elevations. Generally the mid elevation (5000 – 6000ft) willow communities are lumped into a yellow willow (*Salix lutea*) type, and lower elevation (below 5000ft) willow communities are dominated by a coyote willow (*S. exigua*) type. Above 6000ft there are willow dominated riparian communities interspersed among lodgepole and aspen communities. The willow species were not identified, however, for the purposes of developing shade targets a Geyer willow/sedge community type was used to represent these areas. Geyer willow (*Salix geyeriana*) is a typical mid-elevation willow that could exist in these areas. West facing streams emanating from the Albion Mountains tend to have mountain alder (*Alnus incana*) riparian communities instead of aspen as in Magic Mountain streams. Occasionally stream flows are low enough that only a small ribbon of grass occurs at the interface between the stream and the upland vegetation. These community types are identified as grass-dominated or sagebrush/grass dominated depending on proximity of upland sagebrush plants to the stream edge. Grass dominated streams typically occur at high elevation meadows and sagebrush/grass dominated streams are usually lowland segments.

Target Selection

To determine potential natural vegetation shade targets for streams in the Goose Creek Subbasin, effective shade curves developed specifically for southern Idaho were examined (from Shumar and De Varona, 2009). In particular, we used shade curves from the southern Idaho Non-forest group developed from data by Hansen and Hall (2002), and the persistent lodgepole pine (PVG 10) shade curve developed for the Sawtooth National Forest (Southwest Idaho Ecogroup – Payette NF, Boise NF, and Sawtooth NF). Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. As a stream becomes wider, a given vegetation type loses its ability to shade wider and wider streams. For the streams in Goose Creek Subbasin curves for the most similar vegetation type were selected for shade target determinations. Targets are based on averaging the

individual curves for the three aspects (N/S, E/W, and NE/SW/NW/SE) for any given community type.

The locations where the various vegetation types were applied to streams in the loading tables (Tables 8 and 9) were dependent upon our best professional judgment based on field observations and experience to determine where vegetation types occur on streams. The lodgepole pine PVG and aspen locations were enhanced by the Sawtooth National Forest PVG overlay for those Forest lands.

Shade Curves

Table 2. Shade Targets for the Persistent Lodgepole Pine (PVG 10) Vegetation Type at Various Stream Widths

Persistent Lodgepole (PVG 10)	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	96	94	91	87	81	75	70	65	61	58	55	52	49
45/135/225/315 aspect	96	94	91	86	81	76	70	65	62	58	55	52	49
90/270 aspect	97	95	90	87	83	76	70	64	59	54	49	45	42
Target (%)	**96**	**94**	**91**	**87**	**82**	**76**	**70**	**65**	**61**	**57**	**53**	**50**	**47**

Table 3. Shade Targets for the Quaking Aspen Vegetation Type at Various Stream Widths

Aspen	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	99	99	99	96	93	90	86	82	78	75	71	68	65
45/135/225/315 aspect	100	99	99	96	93	89	85	81	77	73	69	65	62
90/270 aspect	100	99	99	97	95	91	84	76	67	61	56	52	48
Target (%)	**100**	**99**	**99**	**96**	**94**	**90**	**85**	**80**	**74**	**70**	**65**	**62**	**58**

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

Yellow willow	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	88	75	60	51	45	39	35	32	29	26	24	22	21
45/135/225/315 aspect	88	74	58	48	42	36	32	29	26	24	22	20	19
90/270 aspect	91	71	50	38	31	27	23	20	18	17	15	14	13
Target (%)	**89**	**73**	**56**	**46**	**39**	**34**	**30**	**27**	**24**	**22**	**20**	**19**	**18**

Table 5. Shade Targets for the Geyer Willow Vegetation Type at Various Stream Widths

Geyer Willow/sedge	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	92	83	68	59	51	45	41	37	33	31	28	26	24
45/135/225/315 aspect	92	82	66	56	48	42	38	34	31	28	26	24	22
90/270 aspect	94	82	58	45	37	31	27	24	21	19	18	16	15
Target (%)	**93**	**82**	**64**	**53**	**45**	**39**	**35**	**32**	**28**	**26**	**24**	**22**	**20**

Table 6. Shade Targets for the Sagebrush/Grass Vegetation Type at Various Stream Widths

Graminoid/Sagebrush	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	71	46	33	25	20	17	15	13	12	10	9	9	8
45/135/225/315 aspect	68	41	28	21	17	14	12	11	10	9	8	7	7
90/270 aspect	55	29	20	15	12	10	9	8	7	6	6	5	5
Target (%)	**65**	**39**	**27**	**20**	**16**	**14**	**12**	**11**	**10**	**8**	**8**	**7**	**7**

Table 7. Shade Targets for the Meadow Vegetation Type at Various Stream Widths

Graminoid	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	62	38	26	20	16	14	12	10	9	8	7	7	6
45/135/225/315 aspect	58	33	22	17	14	11	10	9	8	7	6	6	5
90/270 aspect	45	23	16	12	10	8	7	6	5	5	4	4	4
Target (%)	**55**	**31**	**21**	**16**	**13**	**11**	**10**	**8**	**7**	**7**	**6**	**6**	**5**

Monitoring Points

The accuracy of the aerial photo interpretations seen in Figure 3 were field verified with a solar pathfinder at three sites on Goose Creek and Trout Creek. The aerial photo estimate of shade was proved to be accurate at one of the three pathfinder sites (see Appendix C for pathfinder results). At the other two sites the aerial photo estimate was too high compared to field measured shade. The overall average difference between aerial estimates and field measured shade was 17% ± 17.3 (mean ± 95% C.I.). The original aerial photo estimates were corrected accordingly. Specific pathfinder sites were corrected to represent their field measured values and data were used to recalibrate our eyes to re-interpret all other shade interpretations.

Effective shade monitoring can take place on any reach throughout the Goose or Trout Creek watersheds and compared to estimates of existing shade seen on Figure 3 and described in Tables 8 and 9. Those areas with the largest disparity between existing shade estimates and shade targets should be monitored with solar pathfinders to verify the existing shade levels and to determine progress towards meeting shade targets. It is important to note that many existing shade estimates have not been field verified, and may require adjustment during the implementation process. Stream segments for each change in existing shade vary in length depending on land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade towards target levels. Ten equally spaced solar pathfinder measurements within that segment averaged together should suffice to determine new shade levels in the future.

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 (Figure 2). These loads are determined by multiplying the solar load to a flat plat collector (under full sun) for a given period of time by the fraction of the solar radiation that is not blocked by shade (i.e. the percent open or 1-percent shade). In other words, if a shade target is 60% (or 0.6), then the

solar load hitting the stream under that target is 40% of the load hitting the flat plate collector under full sun.

We obtained solar load data for flat plate collectors from National Renewable Energy Laboratory (NREL) weather stations near by. In this case, data from the Pocatello, Idaho station was 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. Tables 8 and 9 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 effective shade calculations are based on a six month period from April through September. This time period coincides with the critical time period when temperatures affect beneficial uses such as spring and fall salmonids spawning and when cold water aquatic life criteria may be exceeded during summer months. Late July and early August typically represent a period of highest stream temperatures. Solar gains can begin early in the spring and affect not only the highest temperatures reached later on in the summer, but solar loadings affect salmonids spawning temperatures in spring and fall. Thus, solar loading in these streams is evaluated from spring (April) to early fall (September).

5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR § 130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (land use) and area (such as a subwatershed), but may be aggregated by type of source or land area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat plate collector at the NREL weather stations. Existing shade data are presented in Tables 8 and 9. Like loading capacities (potential loads), existing loads in Tables 8 and 9 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.

Table 8. Existing and Potential Solar Loads for Trout Creek.

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
007_02	Trout Creek	1	1100	meadow	55%	2.77	1	1,000	3,000	50%	3.08	1	1,000	3,000	0	-5%
007_02	Trout Creek	2	2300	lodgepole	94%	0.37	2	5,000	2,000	80%	1.23	2	5,000	6,000	4,000	-14%
007_02	Trout Creek	3	210	Geyer willow	82%	1.11	2	400	400	70%	1.85	2	400	700	300	-12%
007_02	Trout Creek	4	350	Geyer willow	82%	1.11	2	700	800	40%	3.69	2	700	3,000	2,000	-42%
007_02	Trout Creek	5	520	lodgepole	94%	0.37	2	1,000	400	80%	1.23	2	1,000	1,000	600	-14%
007_02	Trout Creek	6	1500	aspen	99%	0.06	2	3,000	200	70%	1.85	2	3,000	6,000	6,000	-29%
007_02	Trout Creek	7	220	lodgepole	94%	0.37	2	400	100	80%	1.23	2	400	500	400	-14%
007_02	Trout Creek	8	570	aspen	99%	0.06	3	2,000	100	80%	1.23	3	2,000	2,000	2,000	-19%
007_02	Trout Creek	9	1800	Geyer willow	64%	2.21	3	5,000	10,000	20%	4.92	4	7,000	30,000	20,000	-44%
007_02	Trout Creek	10	220	aspen	99%	0.06	3	700	40	30%	4.31	6	1,000	4,000	4,000	-69%
007_02	Trout Creek	11	240		99%	0.06	3	700	40	60%	2.46	6	1,000	2,000	2,000	-39%
007_02	Trout Creek	12	300	yellow willow	56%	2.71	3	900	2,000	40%	3.69	6	2,000	7,000	5,000	-16%
007_02	Trout Creek	13	180		56%	2.71	3	500	1,000	30%	4.31	6	1,000	4,000	3,000	-26%
007_02	Trout Creek	14	530		56%	2.71	3	2,000	5,000	10%	5.54	5	3,000	20,000	20,000	-46%
007_02	Trout Creek	15	560		46%	3.32	4	2,000	7,000	20%	4.92	5	3,000	10,000	3,000	-26%
007_02	Trout Creek	16	2100		46%	3.32	4	8,000	30,000	30%	4.31	4	8,000	30,000	0	-16%
007_03	Trout Creek	17	800		46%	3.32	4	3,000	10,000	20%	4.92	4	3,000	10,000	0	-26%
007_03	Trout Creek	18	340		46%	3.32	4	1,000	3,000	30%	4.31	4	1,000	4,000	1,000	-16%
007_03	Trout Creek	19	250		46%	3.32	4	1,000	3,000	10%	5.54	4	1,000	6,000	3,000	-36%
007_03	Trout Creek	20	820		46%	3.32	4	3,000	10,000	0%	6.15	4	3,000	20,000	10,000	-46%
007_03	Trout Creek	21	1100		46%	3.32	4	4,000	10,000	10%	5.54	4	4,000	20,000	10,000	-36%
007_03	Trout Creek	22	420		46%	3.32	4	2,000	7,000	0%	6.15	4	2,000	10,000	3,000	-46%
007_03	Trout Creek	23	270		46%	3.32	4	1,000	3,000	10%	5.54	4	1,000	6,000	3,000	-36%
							Totals		110,000					210,000	100,000	

Table 9. Existing and Potential Solar Loads for upper Goose Creek.

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
008_02	Goose Creek	1	1270	lodgepole	96%	0.25	1	1,000	200	90%	0.62	1	1,000	600	400	-6%
008_02	Goose Creek	2	380	Geyer willow	93%	0.43	1	400	200	70%	1.85	1	400	700	500	-23%
008_02	Goose Creek	3	410	sage/grass	65%	2.15	1	400	900	60%	2.46	1	400	1,000	100	-5%
008_02	Goose Creek	4	740	Geyer willow	82%	1.11	2	1,000	1,000	80%	1.23	2	1,000	1,000	0	-2%
008_02	Goose Creek	5	1300		82%	1.11	2	3,000	3,000	60%	2.46	2	3,000	7,000	4,000	-22%
008_02	Goose Creek	6	470		82%	1.11	2	900	1,000	30%	4.31	2	900	4,000	3,000	-52%
008_02	Goose Creek	7	700		82%	1.11	2	1,000	1,000	60%	2.46	2	1,000	2,000	1,000	-22%
008_02	Goose Creek	8	1200		64%	2.21	3	4,000	9,000	60%	2.46	3	4,000	10,000	1,000	-4%
008_02	Goose Creek	9	580		64%	2.21	3	2,000	4,000	40%	3.69	3	2,000	7,000	3,000	-24%
008_02	Goose Creek	10	720		64%	2.21	3	2,000	4,000	50%	3.08	3	2,000	6,000	2,000	-14%
008_03	Goose Creek	11	990		53%	2.89	4	4,000	10,000	50%	3.08	4	4,000	10,000	0	-3%
008_03	Goose Creek	12	610		53%	2.89	4	2,000	6,000	40%	3.69	4	2,000	7,000	1,000	-13%
008_03	Goose Creek	12	1800		53%	2.89	4	7,000	20,000	50%	3.08	4	7,000	20,000	0	-3%
008_03	Goose Creek	13	3700		45%	3.38	5	20,000	70,000	40%	3.69	5	20,000	70,000	0	-5%
008_04	Goose Creek	14	970		45%	3.38	5	5,000	20,000	40%	3.69	5	5,000	20,000	0	-5%
008_04	Goose Creek	15	330		45%	3.38	5	2,000	7,000	30%	4.31	5	2,000	9,000	2,000	-15%
008_04	Goose Creek	16	900	aspen	94%	0.37	5	5,000	2,000	40%	3.69	5	5,000	20,000	20,000	-54%
008_04	Goose Creek	18	170		94%	0.37	5	900	300	10%	5.54	5	900	5,000	5,000	-84%
008_04	Goose Creek	19	1000	yellow willow	39%	3.75	5	5,000	20,000	20%	4.92	5	5,000	20,000	0	-19%
008_04	Goose Creek	20	1500		39%	3.75	5	8,000	30,000	30%	4.31	5	8,000	30,000	0	-9%
008_04	Goose Creek	22	1660		34%	4.06	6	10,000	40,000	20%	4.92	6	10,000	50,000	10,000	-14%
008_04	Goose Creek	23	660		34%	4.06	6	4,000	20,000	40%	3.69	6	4,000	10,000	(10,000)	0%
008_04	Goose Creek	24	410		34%	4.06	6	2,000	8,000	20%	4.92	6	2,000	10,000	2,000	-14%
008_04	Goose Creek	25	910		34%	4.06	6	5,000	20,000	30%	4.31	6	5,000	20,000	0	-4%
008_04	Goose Creek	26	1130		30%	4.31	7	8,000	30,000	20%	4.92	7	8,000	40,000	10,000	-10%
008_04	Goose Creek	27	420		30%	4.31	7	3,000	10,000	30%	4.31	7	3,000	10,000	0	0%
							Totals		340,000					390,000	55,000	

Figure 2. Target Shade for the Goose Creek Subbasin.

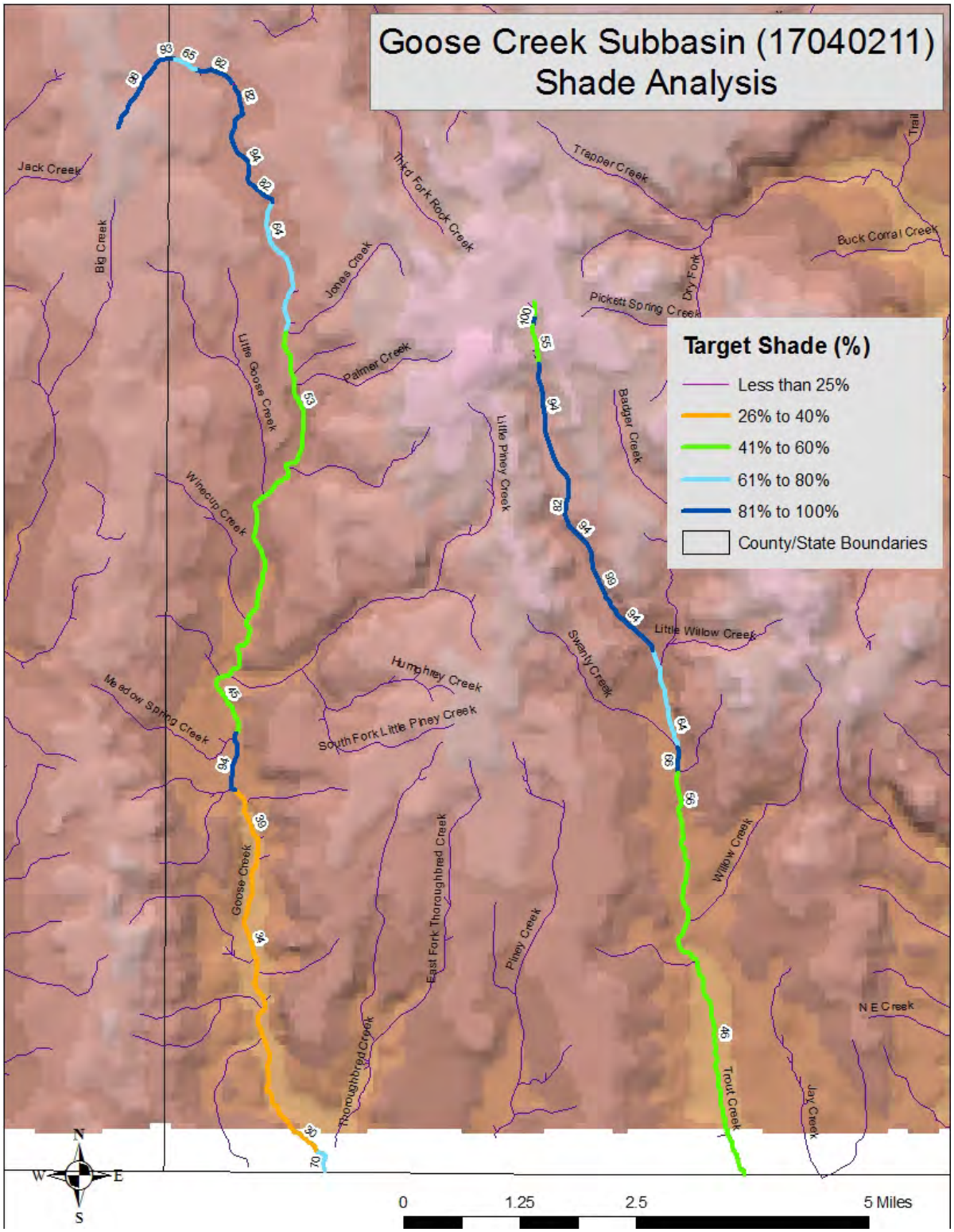


Figure 3. Existing Shade Estimated for the Goose Creek Subbasin by Aerial Photo Interpretation.

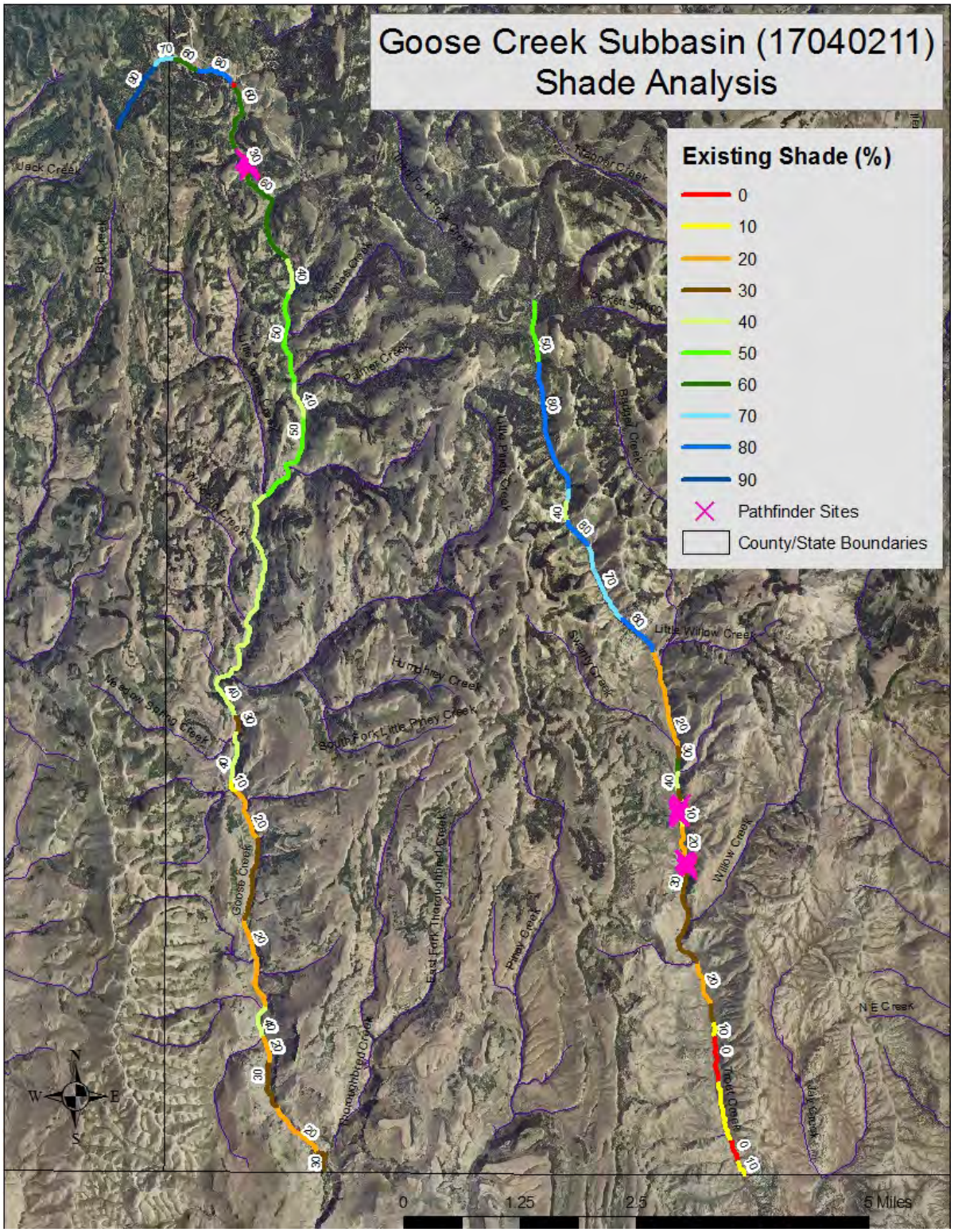
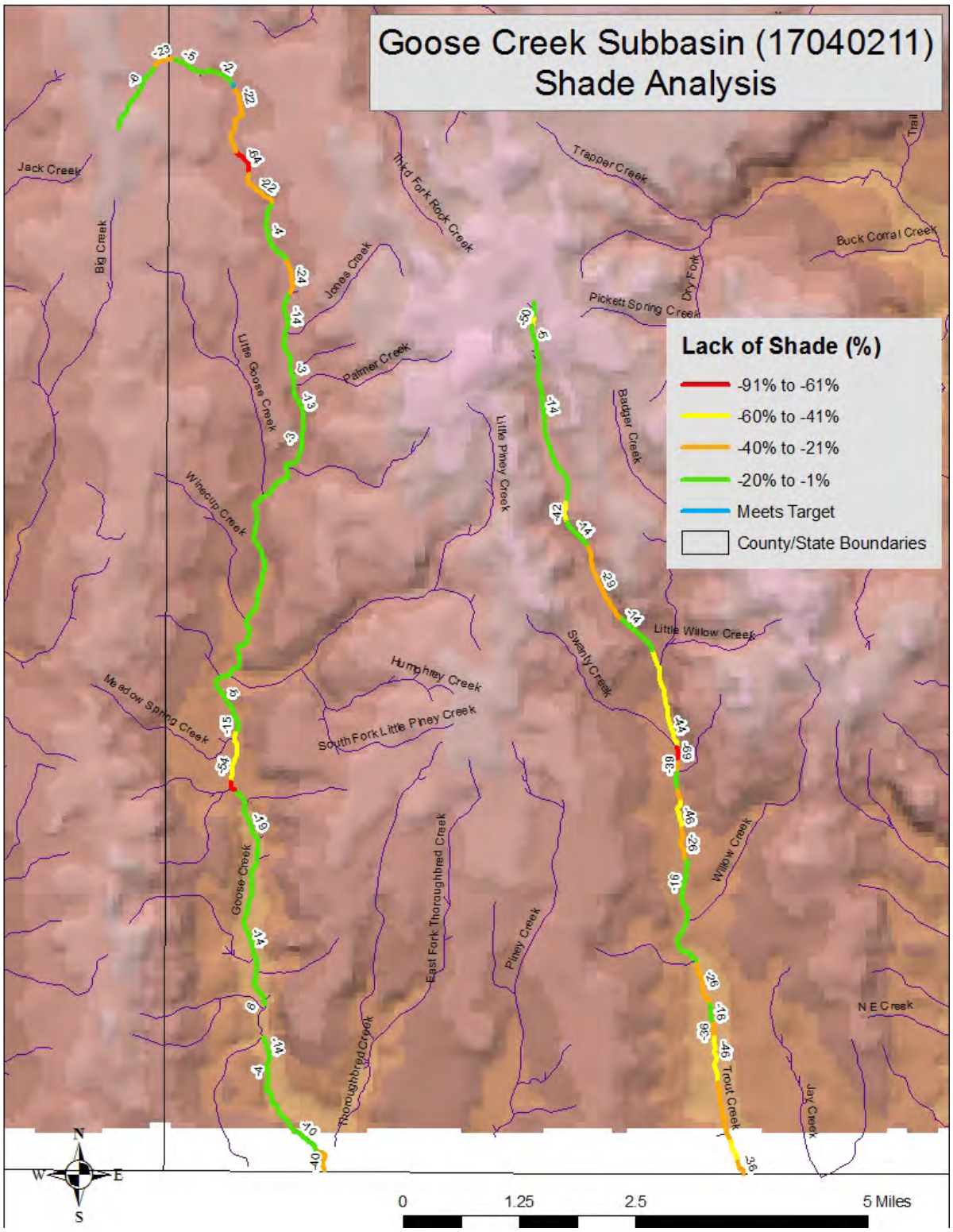


Figure 4. Lack of Shade (Difference Between Existing and Target) for the Goose Creek Subbasin.



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. Tables 8 and 9 show the target or potential shade which is converted to a potential summer load by multiplying the inverse fraction (1-shade fraction) by the average loading to a flat plate collector for the months of April through September. That is the loading capacity of the stream and it is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its loading capacity. Additionally, because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the waters examined here need to be in natural conditions in order to prevent excess heat loads to the system.

Table 10 shows the total existing, total target, and excess heat load (kWh/day) experienced by each water body examined, as well as the percent reduction needed to meet target loads. The table also presents the average lack of shade which is the result of averaging all the differences between existing shade and target shade. The last column of each load table (Tables 8 and 9) shows these differences between existing and target shade for each segment examined.

Table 10. Excess Solar Loads and Percent Reductions for All Tributaries (load data are rounded to two significant figures which may present rounding errors).

Water Body	Total Existing Load (kWh/day)	Total Target Load (kWh/day)	Excess Load (kWh/day)	Percent (%) Reduction	Average Lack of Shade (%)
Goose Creek	390,000	340,000	55,000	14	-16
Trout Creek	210,000	110,000	100,000	48	-29

Although Goose Creek is larger than Trout Creek as depicted by a larger target load, Goose Creek had a smaller excess load and reduction than did Trout Creek. The average lack of shade numbers reflect that Goose Creek was in general in better condition than Trout Creek. Trout Creek had more segments where lack of shade exceeded 40% and likely more segments that lacked between 20% and 40% shade (Figure 4).

Both streams lacked shade and had excess loads. Much of this was due to high target levels set for small width streams because of various tree-dominated vegetation types (aspen, lodgepole, etc.). Many of these streams lack these vegetation types now, or only have remnants of aspen or lodgepole stands. The reasons for this may be many and varied, from the lack of aspen regeneration due to grazing to a lack of water from diversion and drought throughout the subbasin.

Although the preceding analysis dwells on total heat loads for streams in this TMDL, it is important to note that differences between existing shade and target shade, as depicted in the Lack of Shade Figure (Figure 4), are the key to successfully restoring these waters to

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

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

Wasteload Allocation

There are no known NPDES permitted point sources in the affected watersheds. Thus, there are no wasteload allocations either. 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, load allocations are applied to the stream and its riparian vegetation rather than specific NPS activities, and can be adjusted as more information is gathered from the stream environment.

Seasonal Variation

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

Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

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

The Construction General Permit (CGP)

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

Storm Water Pollution Prevention Plan (SWPPP)

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

Construction Storm Water Requirements

When a stream is on Idaho's § 303(d) list and has a TMDL developed DEQ now incorporates a gross waste load allocation (WLA) for anticipated construction storm water activities. TMDLs developed in the past that did not have a WLA for construction storm water activities will also be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate Best Management Practices.

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

5.5 Implementation Strategies

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.

Time Frame

The timeframe for implementation will follow the goals as outlined in the Goose Creek Subbasin Assessment and TMDL (see page 205). This includes a time span from year one through year twenty-five.

Approach

The approach for implementation will be similar to that in the Goose Creek Subbasin Assessment and TMDL (see page 202). With the use of past management experiences to evaluate success and failures, insight into the practices that promote the best implementation techniques and restoration of beneficial uses can be utilized.

Responsible Parties

The responsible parties for implementation will be similar to those that are outlined in the Goose Creek Subbasin Assessment and TMDL (see page 201). These include state and federal agencies as well as private stakeholders.

Monitoring Strategy

The monitoring strategy for implementation will be similar to those listed in the Goose Creek Subbasin Assessment and TMDL (see page 204). These include tracking the implementation progress of specific plans and tracking the progress of improving water quality through the monitoring of physical, chemical and biological parameters.

5.6 Conclusions

Effective shade targets were established for upper Goose Creek and Trout Creek based on the concept of maximum shading under potential natural vegetation equals natural background temperature levels. Shade targets were actually derived from effective shade curves developed for vegetation types in southern Idaho. Existing shade was determined from aerial photo interpretation field verified with solar pathfinder data.

Both streams examined lacked shade in reference to targets. The lack of shade is likely the result of a combination of factors including natural and human-influenced dewatering of the stream channel and historic removal of riparian vegetation associated with livestock grazing and agricultural practices. Much of this was due to high target levels set for small width streams because of various tree-dominated vegetation types (aspen, lodgepole, etc.). Many of these streams lack these vegetation types now, or only have remnants of aspen or lodgepole stands. The reasons for this may be many and varied, from the lack of aspen regeneration due to grazing to a lack of water from diversion and drought throughout the

subbasin. While not much can be done about the lack of water in channels, most streams would recover riparian vegetation if temporarily or permanently excluded from use.

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.

Table 11. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Goose Creek/ ID17040211SK008_02 ID17040211SK008_03 ID17040211SK008_04	Temperature	Yes	Move to 4A	Excess solar load due to lack of shade
Trout Creek/ ID17040211SK007_02 ID17040211SK007_03	Temperature	Yes	Move to 4A	Excess solar load due to lack of shade

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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 4th field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)

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

Subwatershed

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

Surface Fines

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

Surface Runoff

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

Surface Water

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

Suspended Sediments

Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in

areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Taxon

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

Tertiary

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

Thalweg

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

Threatened Species

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

Total Maximum Daily Load (TMDL)

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

Total Dissolved Solids

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

Total Suspended Solids (TSS)

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

Toxic Pollutants	Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.
Tributary	A stream feeding into a larger stream or lake.
Trophic State	The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.
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Trophic State	The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.
Turbidity	A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.
Vadose Zone	The unsaturated region from the soil surface to the ground water table.

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

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

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

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

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

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

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

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

Water Quality Management Plan

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

Water Quality Modeling

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

Water Quality Standards

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

Water Table

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

Watershed

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

Water Body Identification Number (WBID)

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

Wetland

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

Young of the Year

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

Appendix A. Unit Conversion Chart

Table A-1. Metric - English unit conversions.

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

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.

[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

Appendix B. State and Site-Specific Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

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

> 13°C as a daily maximum water temperature,
>
> 9°C as a daily average water temperature.

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of highest annual MWMT air temperatures) is compared to the daily maximum criterion of 13°C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during these time periods. If potential natural vegetation targets are achieved yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401.*

Section 401 relates to point source wastewater treatment requirements. In this case if temperature criteria for any aquatic life use is exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3°C (IDAPA 58.01.02.401.03.a.v.).

Appendix C. Data Sources, Pathfinder Results, and Temperature Data

Table C-1. Data sources for the Goose Creek Subbasin TMDLs.

Water Body	Data Source	Type of Data	When Collected
Goose Creek and Trout Creek	DEQ State Technical Services Office	Pathfinder effective shade and stream width	July-August 2008
Goose Creek and Trout Creek	DEQ State Technical Services Office	Aerial Photo Interpretation of existing shade and stream width estimation	June-September 2008 and June 2011
Goose Creek and Trout Creek	DEQ IDASA Database	Temperature	???

Table C-2. Solar Pathfinder Field Verification Results.

aerial class	pathfinder actual	pathfinder class	delta		stream site
30	29.7	30	0		trout1
30	18.4	10	20		trout2
60	35.5	30	30		goose
			17	average	
			15.28	std dev	
			17.29	95%CI	

Figure C-1. Listing Temperature Data for Upper Goose Creek (2001IDFGTL083).

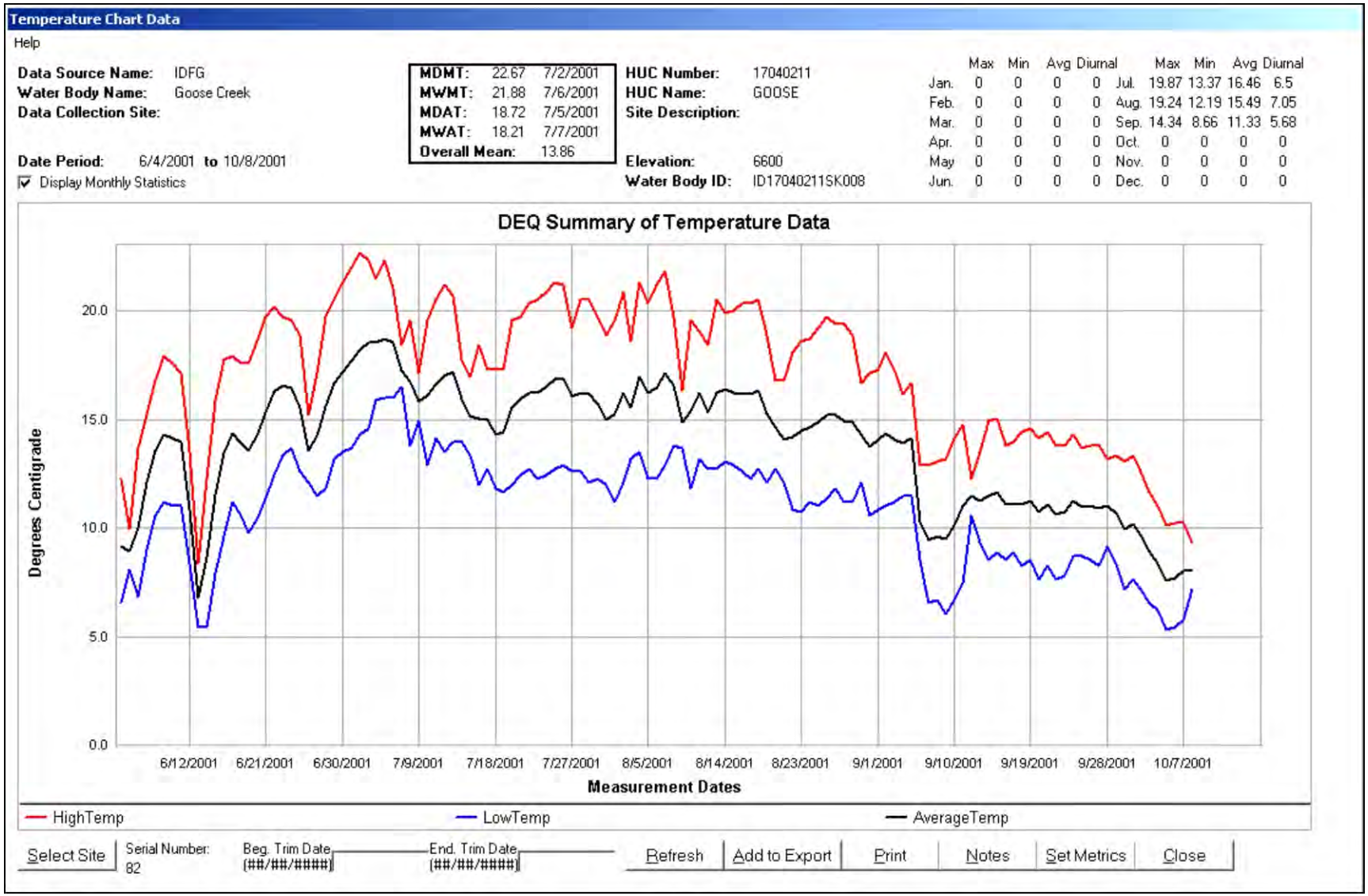


Figure C-2. Listing Temperature Data for Trout Creek (2001IDFGTL082).

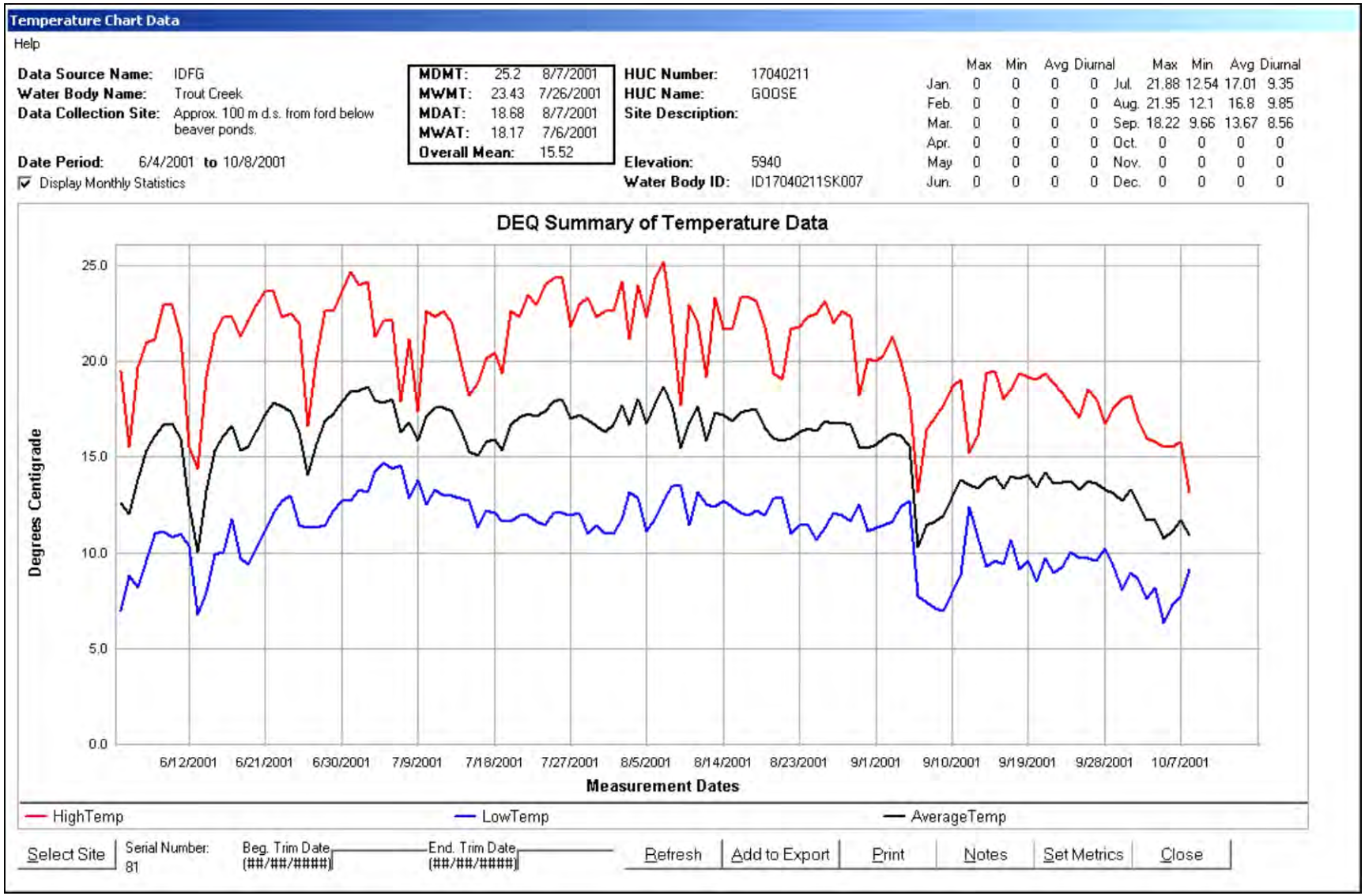
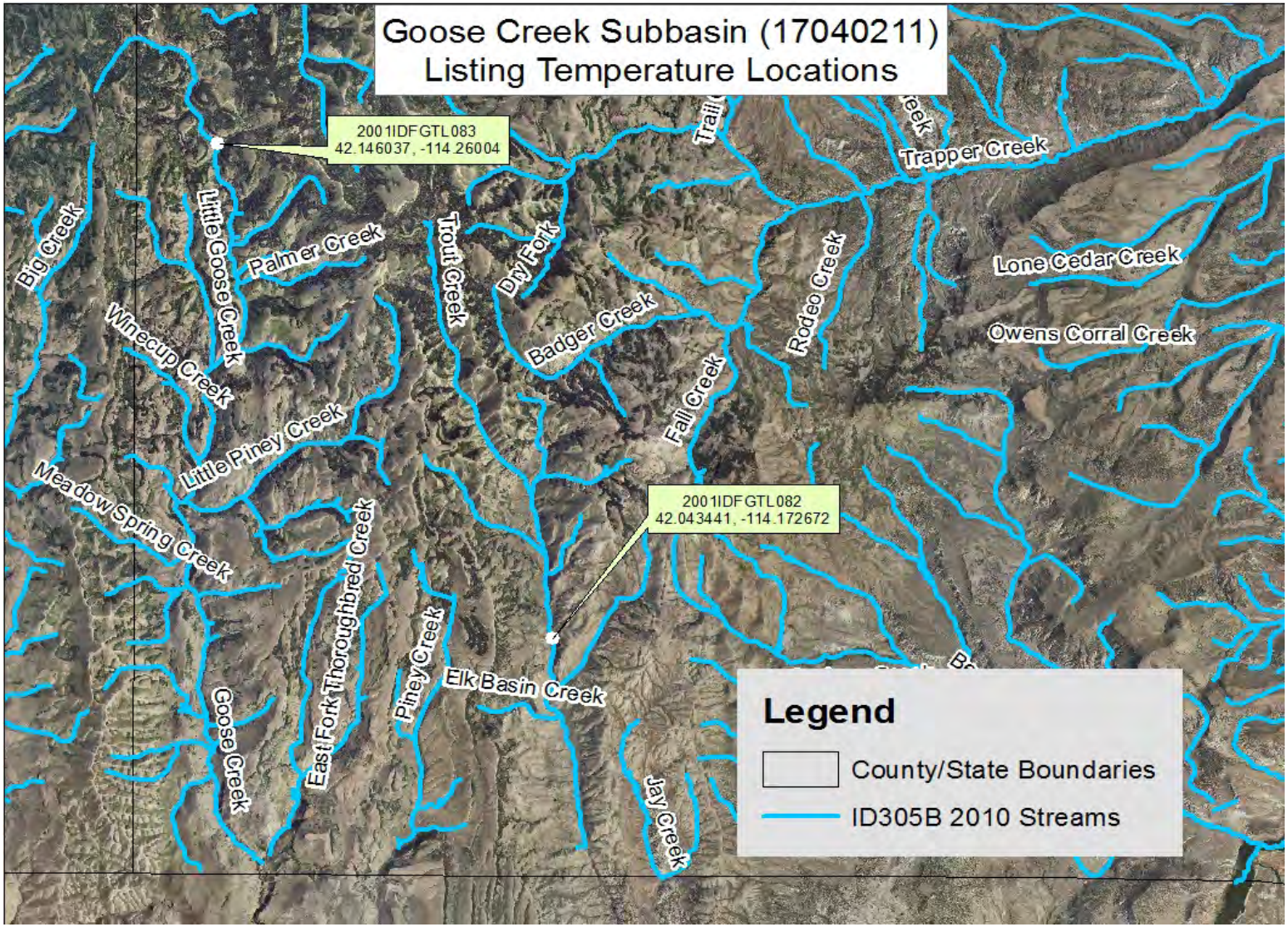


Figure C-3. Listing Temperature Data Locations.



Appendix D. Distribution List

Appendix E. Public Comments