Cassia Creek Temperature Total Maximum Daily Load:

Addendum to the Raft River Subbasin Assessment and Total Maximum Daily Loads

Public Comment Draft

State of Idaho
Department of Environmental Quality

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Cassia Creek Temperature
Total Maximum Daily Load

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Acknowledgments

Cover Photo: Raft River below Onemile Creek (Idaho Department of Environmental Quality, 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
C	Celsius
CGP	Construction General Permit
CWA	Clean Water Act
DEQ	Department of Environmental Quality
EPA	United States Environmental Protection Agency
GIS	Geographical Information Systems
HUC	Hydrologic Unit Code
IDAPA	Refers to citations of Idaho administrative rules
kWh	kilowatt-hour
LA	load allocation
LC	load capacity
m	meter
mi	mile
MOS	margin of safety
NB	natural background
NPDES	National Pollutant Discharge Elimination System
NREL	National Renewable Energy Laboratory
PNV	potential natural vegetation
SWPPP	Stormwater Pollution Prevention Plan
TMDL	total maximum daily load
U.S.	United States
U.S.C.	United States Code
WAG	Watershed Advisory Group
WLA	wasteload allocation

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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 and is included as the Category 5 list in the Integrated Report. 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 one water body in the Raft River subbasin (Cassia Creek) that has had temperature exceedances of water quality standards, either through §303(d) listing or acquired temperature data. This document only addresses the temperature TMDL for this stream. For more information about this watershed and the subbasin as a whole, see the *Raft River Subbasin Assessment and Total Maximum Daily Loads* (DEQ 2004). The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards.

Subbasin at a Glance

The Raft River subbasin (hydrologic unit code 17040210) is located in south-central Idaho southeast of Burley, Idaho (Figure A). The Raft River flows northeast into Idaho from the state of Utah near the City of Rocks National Reserve. The Raft River joins several drainages emanating from the lower Albion Mountains (Almo, Edwards, and Grape Creeks) and flows east through The Narrows below the Jim Sage Mountains. The historic Raft River channel continues north along Highway 81 to Malta and then eventually to the Snake River above Lake Walcott. Little or no water enters this channel during summer months because of dewatering for irrigated agriculture. The Cassia Creek drainage emanates from the central Albion Mountains and flows east to join the Raft River near Malta. Most waters in the Raft River valley are completely diverted for irrigated agriculture or are lost to the subsurface.

The Raft River from the Utah border to Malta was listed on Idaho's 1998 §303(d) list for temperature pollution. The U.S. Environmental Protection Agency (EPA) added streams that exceeded Idaho's temperature criteria to Idaho's 1998 §303(d) list of impaired waters. However, no streams in the Raft River subbasin were among those EPA additions. On Idaho's 2002 §303(d) list, the Raft River from the Utah border to Edwards Creek and from Cottonwood Creek to Cassia Creek was listed for temperature pollution. A temperature TMDL was completed for these two sections of the Raft River in 2004 (DEQ 2004). On Idaho's 2008 §303(d) list, Cassia Creek from Clyde Creek to Conner Creek was listed for temperature pollution. This document addresses the temperature TMDL for Cassia Creek.

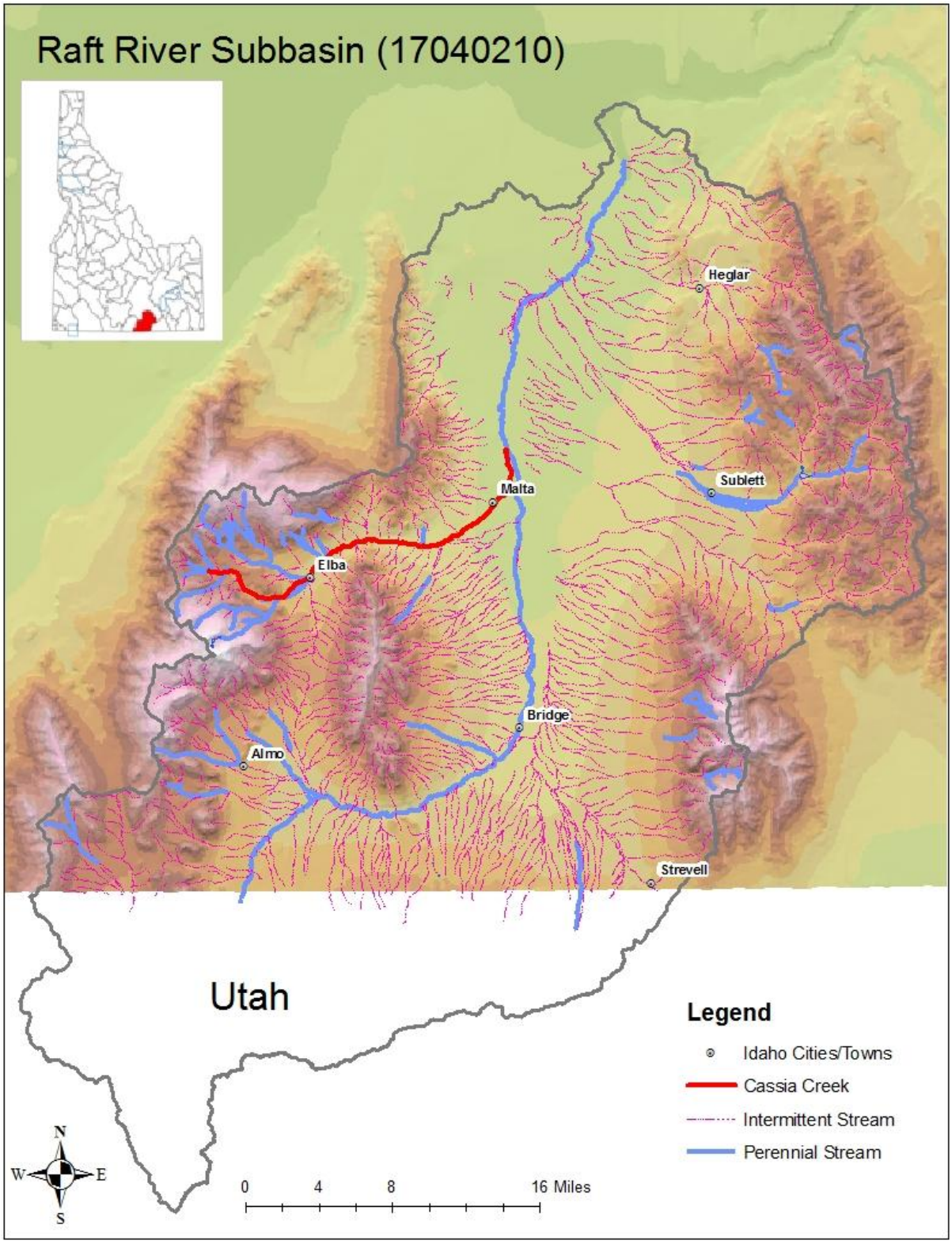

Figure A. Subbasin at a glance.

Key Findings

Effective shade targets were established for Cassia Creek based on the concept of maximum shading under potential natural vegetation resulting in natural background temperature levels (Table A). Shade targets were derived from effective shade curves developed for vegetation types in southern Idaho. Existing shade was determined from aerial photo interpretation then partially field verified with Solar Pathfinder data.

Cassia Creek lacks shade to some degree, although the stream is in relatively good condition (Table B). 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. While not much can be done to address channel dewatering, 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 focus 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)
Cassia Creek	Temperature

Table B. Summary of assessment outcomes.

Water Body Segment/ Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cassia Creek ID17040210SK007_03 ID17040210SK005_04 ID17040210SK003_04	Temperature	Yes	Move to Category 4a	Excess solar load from a lack of shade

Public Participation

The Lake Walcott Watershed Advisory Group (WAG) was created in 1995 and contributed to the original Raft River subbasin assessment and TMDL (DEQ 2004). The Lake Walcott WAG has continued to meet several times annually since the approval of the original document. They reviewed the Cassia Creek temperature TMDL document and discussed it at their July 21, 2011, meeting. The WAG was given a draft copy and was asked to submit comments to the Idaho Department of Environmental Quality (DEQ). An email was sent to the WAG members the following week that included the DEQ website address to access the draft document and comments were again requested before August 30, 2011. No comments were received. The DEQ Twin Falls Regional Office will be able to provide copies of the document by request.

The general public will be able to comment on this draft document during the public comment period.

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Introduction

This total maximum daily load (TMDL) is an addendum to the *Raft River Subbasin Assessment and Total Maximum Daily Loads* (DEQ 2004). That document, like all Idaho TMDL documents since 2001 that combine a subbasin assessment with a TMDL determination, has five sections, the first four of which are the subbasin assessment. This document contains only an addendum to the TMDL determination section (section 5) and is based on the original subbasin assessment and characteristics from the Raft River subbasin assessment and TMDL.

This document addresses one water body (Cassia Creek) in the Raft River subbasin (hydrologic unit code 17040210) that has had temperature exceedances of water quality standards, either through §303(d) listing or acquired temperature data. The Raft River from the Utah border to Malta was listed on Idaho's 1998 §303(d) list for temperature pollution. The U.S. Environmental Protection Agency (EPA) added streams that exceeded Idaho's temperature criteria to Idaho's 1998 §303(d) list of impaired waters. However, no streams in the Raft River subbasin were among those EPA additions. On Idaho's 2002 §303(d) list, the Raft River from the Utah border to Edwards Creek and from Cottonwood Creek to Cassia Creek was listed for temperature pollution. A temperature TMDL was completed for these two sections of the Raft River in 2004 (DEQ 2004). On Idaho's 2008 §303(d) list, Cassia Creek from Clyde Creek to Conner Creek was listed for temperature pollution. In this TMDL addendum, effective shade targets were established for Cassia Creek based on the concept of maximum shading under potential natural vegetation (PNV) resulting in natural background temperatures.

5. Total Maximum Daily Loads

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources so as to ensure water quality standards are met. It further allocates this load capacity among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation, and nonpoint sources, each of which receives a load allocation. Natural background contributions, when present, are considered part of the load allocation but are often broken out on their own because they represent 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 be a part of the TMDL. Practically, the margin of safety and natural background are both reductions in the load capacity available for allocation to pollutant sources.

The load capacity can be summarized by the following equation:

$$LC = MOS + NB + LA + WLA = TMDL.$$

Where:

LC = load capacity
MOS = margin of safety

NB = natural background
LA = load allocation
WLA = wasteload allocation

The equation is written in this order because it represents the logical order in which a load analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components. After the necessary margin of safety and natural background, if relevant, are determined, the remainder is allocated among pollutant sources (i.e., the load allocation and wasteload allocation). When the breakdown and allocation are complete, the result is a TMDL, which must equal the load capacity.

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.

Another step in a load analysis is the quantification of current pollutant loads by source. This step 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. 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 Instream Water Quality Targets

For the Cassia Creek temperature TMDL, the Idaho Department of Environmental Quality (DEQ) used a PNV approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) establishing that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and the natural level of shade and channel width become the target of the TMDL. The instream temperature that results from attaining these conditions is consistent with the water quality standards even if it exceeds numeric temperature criteria. See Appendix A for further discussion of water quality standards and natural background provisions.

The PNV approach is described briefly 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, see *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. The parameters that affect 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 the density of riparian vegetation and water storage in the alluvial aquifer. Streamside vegetation and channel morphology are the factors influencing shade that are most likely to have been influenced by anthropogenic activities and can be most readily corrected and addressed by a TMDL.

Depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. However, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure or estimate the amount of shade that a stream receives in a number of ways. Effective shade (i.e., that shade provided by all objects that intercept the sun as it makes its way across the sky) can be measured in a given location with a Solar Pathfinder or other optical equipment that works similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and stream aspect. 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 using aerial photography. All of these methods provide information about how much of the stream is covered and how much is exposed to direct solar radiation.

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 the development and use of shade targets. Vegetation can be removed by natural disturbance (e.g., wildfire, disease/old age, wind damage, wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade-producing vegetation. Anything less than PNV (with the exception of natural levels of disturbance and age distribution) results in the stream heating up from anthropogenically created additional solar inputs.

We can estimate potential vegetation (and therefore target shade) from models of plant community structure (i.e., shade curves for specific riparian plant communities), and we can measure or estimate existing canopy cover or shade. Comparing the two (target and existing shade) tells 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 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 Cassia Creek from visual interpretation of aerial photos. These estimates were partially field verified by measuring shade with a Solar Pathfinder at systematically located points along the stream (see below for methodology). PNV targets were determined from an analysis of probable vegetation at the stream 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, shade decreases as 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 target shade was converted to solar loads from data collected on flat-plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather station collecting these data. In this analysis, we used data from the station in Pocatello, Idaho. The difference between existing and target solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with temperature water quality standards (Appendix A). PNV shade and the associated target solar 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 considered to be consistent with the Idaho water quality standards even if they exceed numeric criteria by more than 0.3 °C.[1]

Aerial Photo Interpretation

Estimates of existing shade based on plant type and density were marked out on a 1:100,000 or 1:250,000 hydrography taking into account natural breaks in vegetation density. Each interval was assigned a single value representing the bottom of a 10% shade class (adapted from the cumulative watershed effects process, IDL 2000). For example, if shade for a particular stretch of stream was estimated somewhere between 50% and 59%, we assigned a 50% shade-class value to that section. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and stream width. Streams where the banks and water are clearly visible are usually in low shade classes (10%, 20%, or 30%). Streams with dense forest or heavy brush where no portion of the stream is visible are usually in high shade classes (70%, 80%, or 90%). More open canopies where portions of the stream may be visible usually fall into moderate shade classes (40%, 50%, or 60%).

Visual estimates made from aerial photos are strongly influenced by canopy cover and do not always take into account topography or any shading that may occur from physical features other than vegetation. It is not always possible to visualize or anticipate shade characteristics resulting from topography and landform. However, research has shown that shade and canopy cover measurements are remarkably similar (OWEB 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade. The visual estimates of shade in this TMDL were partially field verified with a Solar Pathfinder, which measures effective shade and takes into consideration other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, man-made structures).

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 location where the tracing is made. To

[1] A unit conversion table is provided in Appendix B.

adequately characterize the effective shade on a stream reach, ten traces are taken at systematic intervals along the length of the stream in question.

At each sampling location, the Solar Pathfinder was placed in the middle of the stream at about the bankfull water level. Traces were taken following the manufacturer's instructions. Systematic sampling was used because it is easiest to accomplish while still not biasing the sampling location. For each sampled reach, the sampler started at a unique location (such as 50 meters [m] from a bridge or fence line) and proceeded upstream or downstream stopping to take additional traces at fixed intervals (e.g., every 50 m, 50 paces, etc.). One can also randomly locate points of measurement by generating random numbers to be used as interval distances.

When possible, the sampler also measured bankfull widths, took notes, and photographed the stream at several unique locations while taking the traces. Special attention was given to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade-producing ones) were present. One can also take densiometer readings at the same location as Solar Pathfinder traces. These readings provide the potential to develop relationships between canopy cover and effective shade for a given stream.

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. Shadows produced by vegetation cover 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., near stream disturbance zone or bankfull width) may not be discernable from the aerial photo interpretations. This parameter must be estimated from available information. DEQ used regional curves for the major basins in Idaho—developed from data compiled by Diane Hopster of Idaho Department of Lands—to estimate natural bankfull width (Figure 1).

For the stream evaluated in this loading analysis, bankfull width was estimated based on the drainage area of the Upper Snake curve from Figure 1. Additionally, existing width was evaluated from available data. If the stream's existing width was wider than predicted by the Upper Snake curve in Figure 1, then the estimate of bankfull width from Figure 1 was used in the load analysis. If existing width was smaller, then existing width was used in the load analysis as the natural bankfull width.

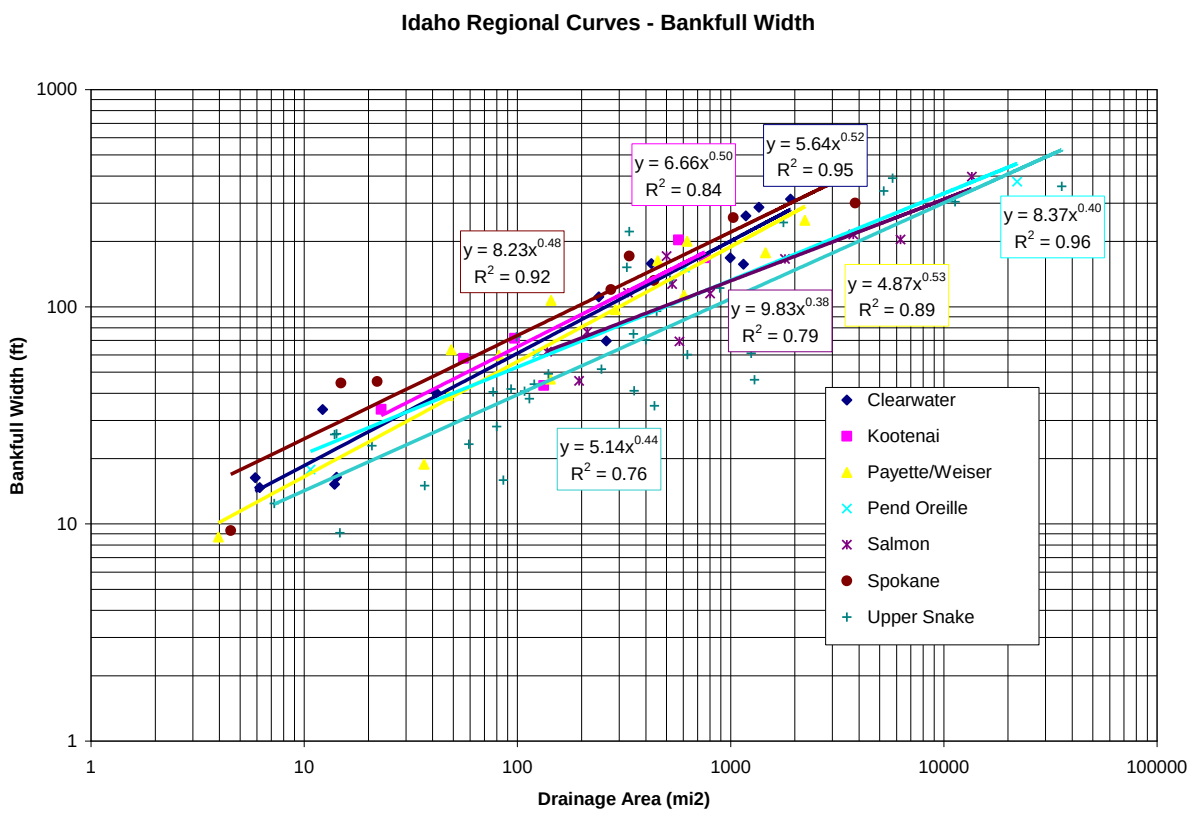

Figure 1. Bankfull width as a function of drainage area.

In general, it appears that Cassia Creek's existing width is similar to that predicted by the Upper Snake regional curve (Table 1). Curve estimates of bankfull width were used for natural and existing widths in this area where existing widths were equal to the curve estimate or for those areas where no existing data were available.

Table 1. Regional curve estimates and existing measurements of bankfull width for major streams (US = Upper Snake).

Location	area (sq mi)	US (m)	existing (m)
Cassia Cr @ Cold Spr/Flat Canyon	3.5	3	3.25
Cassia Cr bl New Canyon Cr	6.5	4	4.37, 4.25
Cassia Cr bl Stinson Cr	11.9	5	
Cassia Cr bl Dry Cr	24.8	6	
Cassia Cr bl Clyde Cr	46.9	9	8.77
Cassia Cr bl Conner Cr	96.5	12	
Cassia Cr nr Malta	127.3	13	

Design Conditions

The Raft River subbasin lies within the Northern Basin and Range ecoregion (level III) of McGrath et al. (2001). The high elevations of the Albion Mountains are within the High Elevation Forests and Shrublands level IV ecoregion 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. Lower slopes of these mountains and in the Jim Sage Mountains and Sublett Range, the Semiarid Hills and Low Mountains level IV ecoregion predominates. Vegetation is characterized as mostly sagebrush steppe with juniper woodlands prevalent on rocky outcrops. In the valleys, the Sagebrush Steppe and Saltbush-Dominated Valleys level IV ecoregions are present. The lowest valleys along the Raft River were shadescale and greasewood dominated until most were converted to irrigated agriculture.

Riparian vegetation along streams varies greatly, from high-elevation Douglas-fir (*Pseudotsuga menziesii*) or lodgepole pine (*Pinus contorta*) forests and quaking aspen (*Populus tremuloides*) stands (Figure 2) to willow-dominated areas at lower elevations. Generally the mid-elevation willow communities are lumped into a yellow willow (*Salix lutea*) type (Figure 3), and lower-elevation willow communities are dominated by a coyote willow (*S. exigua*) type (Figure 4). Cassia Creek follows this pattern with yellow willow communities dominating the upper segments and coyote willow on lower reaches.

Figure 2. Aspen-dominated riparian vegetation on upper Grape Creek.

Figure 3. Yellow willow community on Cassia Creek.

Figure 4. Typical coyote willow community (photo from Goose Creek subbasin).

Target Selection

To determine PNV shade targets for streams in the Raft River subbasin, effective shade curves developed specifically for southern Idaho were examined. In particular, we used yellow willow and coyote willow shade curves from the southern Idaho non-forest group developed from data by Hansen and Hall (2002). 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. Targets are based on averaging the individual curves for the three stream aspects (N/S, E/W, and NE/SW/NW/SE) for any given community type at a particular stream width (Tables 2 and 3).

Table 2. 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 3. Shade targets for the coyote willow vegetation type at various stream widths

Coyote willow	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m
0/180 aspect	94	87	74	64	56	50	45	41	37	34	31	29	27
45/135/225/315 aspect	94	86	72	61	53	47	42	37	34	31	29	26	25
90/270 aspect	95	89	64	50	41	34	30	27	24	22	20	18	17
Target (%)	**94**	**87**	**70**	**58**	**50**	**44**	**39**	**35**	**32**	**29**	**27**	**24**	**23**

Monitoring Points

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at 6 sites on Cassia Creek and several of its headwater streams. These Solar Pathfinder data (Appendix C, Table C-2) showed that original aerial photo interpretations were not accurate, with a tendency to overestimate by 2 or more 10% shade-class intervals. The mean difference

between Solar Pathfinder results and original interpretations was 25% ± 16.6 (mean ± 95% confidence interval). These data were used to recalibrate our visual estimates and reinterpret the original aerial photo interpretations. Existing shade at specific Solar Pathfinder locations was corrected accordingly, and existing shade values presented in this document are those corrected values.

Effective shade monitoring can take place on any reach throughout Cassia Creek and be compared to estimates of existing shade described in Table 4 and seen on Figure 5. Those areas with the largest disparity between existing and target shade 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 segment length for each estimate of existing shade varies 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 averaged together within that segment should suffice to determine new shade levels in the future.

5.2 Load Capacity

The load capacity for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the reaches within that stream (Figure 6). These loads are determined by multiplying the solar load received by a flat-plate collector (under full sun) for a given period of time by the percent of the solar radiation that is not blocked by shade (i.e., the percent open or 100 minus percent shade). In other words, if a shade target is 60% (or 0.6), and 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 from flat-plate collectors at the NREL weather station in Pocatello, Idaho. The solar loads used in this TMDL are spring/summer averages (i.e., an average load for the 6-month period from April through September). These months coincide with the time of year when stream temperatures are increasing and deciduous vegetation is in leaf. Table 4 shows the PNV shade targets and their corresponding target summer load (in kilowatt-hours [kWh] per day) that serve as the load capacities for the streams. Existing and target loads in kWh/day can be summed for the entire stream or portion of stream examined in a single load analysis table. These total loads are shown at the bottom of their respective columns in the table.

The effective shade calculations are based on a 6-month period from April through September. This time period coincides with the critical time period when temperatures affect beneficial uses such as spring and fall salmonid spawning and when cold water aquatic life criteria may be exceeded during summer months. Late July and early August typically represent the period of highest stream temperatures. However, solar gains can begin early in the spring and affect not only the highest temperatures reached later in the summer but also salmonid 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 and partially field verified with a Solar Pathfinder. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat-plate collector at the NREL weather station. Existing shade data are presented in Table 4 and Figure 5. Like load capacities (target loads), existing loads in Table 4 are presented on an area basis (kWh/ m^2/day) and as a total load (kWh/day).

Like target loads, existing loads in kWh/day are summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target load and existing load is also summed for the entire table. Should existing load exceed target load, this difference becomes the excess load (i.e., lack of shade) to be discussed in the load allocation section and as seen in Figure 7. The percent reduction (i.e., lack of shade) shown in the right-hand column of the table represents how much total excess load there is in relation to total existing load for that particular stream segment (Table 4).

Table 4. Existing and target solar loads for Cassia Creek. (Load values are gross estimates; rounding errors occur.)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
007_03	Cassia Creek	1	720	yellow willow	56%	2.71	3	2,000	5,000	50%	3.08	3	2,000	6,000	1,000	-6%
007_03	Cassia Creek	2	850		46%	3.32	4	3,000	10,000	30%	4.31	4	3,000	10,000	0	-16%
007_03	Cassia Creek	3	1600		39%	3.75	5	8,000	30,000	30%	4.31	5	8,000	30,000	0	-9%
007_03	Cassia Creek	4	1300		39%	3.75	5	7,000	30,000	40%	3.69	5	7,000	30,000	0	1%
007_03	Cassia Creek	5	110		39%	3.75	5	600	2,000	20%	4.92	5	600	3,000	1,000	-19%
007_03	Cassia Creek	6	800		34%	4.06	6	5,000	20,000	40%	3.69	6	5,000	20,000	0	0%
007_03	Cassia Creek	7	2400		34%	4.06	6	10,000	40,000	30%	4.31	6	10,000	40,000	0	-4%
007_03	Cassia Creek	8	710		34%	4.06	6	4,000	20,000	40%	3.69	6	4,000	10,000	(10,000)	0%
007_03	Cassia Creek	9	370	coyote willow	39%	3.75	7	3,000	10,000	30%	4.31	7	3,000	10,000	0	-9%
007_03	Cassia Creek	10	460		39%	3.75	7	3,000	10,000	10%	5.54	7	3,000	20,000	10,000	-29%
007_03	Cassia Creek	11	200		39%	3.75	7	1,000	4,000	40%	3.69	7	1,000	4,000	0	0%
007_03	Cassia Creek	12	440		35%	4.00	8	4,000	20,000	10%	5.54	8	4,000	20,000	0	-25%
007_03	Cassia Creek	13	400		35%	4.00	8	3,000	10,000	30%	4.31	8	3,000	10,000	0	-5%
007_03	Cassia Creek	14	850		35%	4.00	8	7,000	30,000	30%	4.31	8	7,000	30,000	0	-5%
005_04	Cassia Creek	15	850		32%	4.18	9	8,000	30,000	30%	4.31	9	8,000	30,000	0	-2%
005_04	Cassia Creek	16	260		32%	4.18	9	2,000	8,000	10%	5.54	9	2,000	10,000	2,000	-22%
005_04	Cassia Creek	17	550		32%	4.18	9	5,000	20,000	20%	4.92	9	5,000	20,000	0	-12%
005_04	Cassia Creek	18	500		32%	4.18	9	5,000	20,000	10%	5.54	9	5,000	30,000	10,000	-22%
005_04	Cassia Creek	19	2600		29%	4.37	10	26,000	110,000	20%	4.92	10	26,000	130,000	20,000	-9%
005_04	Cassia Creek	20	740		27%	4.49	11	8,100	36,000	10%	5.54	11	8,100	45,000	9,000	-17%
005_04	Cassia Creek	21	330		27%	4.49	11	3,600	16,000	30%	4.31	11	3,600	15,000	(1,000)	0%
005_04	Cassia Creek	22	1440		27%	4.49	11	16,000	72,000	20%	4.92	11	16,000	79,000	7,000	-7%
003_04	Cassia Creek	23	840		24%	4.67	12	10,000	47,000	20%	4.92	12	10,000	49,000	2,000	-4%
003_04	Cassia Creek	24	3300		24%	4.67	12	40,000	190,000	10%	5.54	12	40,000	220,000	30,000	-14%
003_04	Cassia Creek	25	1930		24%	4.67	12	23,000	110,000	20%	4.92	12	23,000	110,000	0	-4%
003_04	Cassia Creek	26	1070		24%	4.67	12	13,000	61,000	10%	5.54	12	13,000	72,000	11,000	-14%
003_04	Cassia Creek	27	1270		24%	4.67	12	15,000	70,000	20%	4.92	12	15,000	74,000	4,000	-4%
003_04	Cassia Creek	28	1900		23%	4.74	13	25,000	120,000	10%	5.54	13	25,000	140,000	20,000	-13%
003_04	Cassia Creek	29	1150		23%	4.74	13	15,000	71,000	0%	6.15	13	15,000	92,000	21,000	-23%
003_04	Cassia Creek	30	330		23%	4.74	13	4,300	20,000	10%	5.54	13	4,300	24,000	4,000	-13%
003_04	Cassia Creek	31	1100		23%	4.74	13	14,000	66,000	0%	6.15	13	14,000	86,000	20,000	-23%
003_04	Cassia Creek	32	1000		23%	4.74	13	13,000	62,000	10%	5.54	13	13,000	72,000	10,000	-13%
003_04	Cassia Creek	33	730		23%	4.74	13	9,500	45,000	0%	6.15	13	9,500	58,000	13,000	-23%
003_04	Cassia Creek	34	1200		23%	4.74	13	16,000	76,000	10%	5.54	13	16,000	89,000	13,000	-13%
003_04	Cassia Creek	35	2900		23%	4.74	13	38,000	180,000	0%	6.15	13	38,000	230,000	50,000	-23%
003_04	Cassia Creek	36	720		23%	4.74	13	9,400	45,000	10%	5.54	13	9,400	52,000	7,000	-13%
003_04	Cassia Creek	37	670		23%	4.74	13	8,700	41,000	0%	6.15	13	8,700	54,000	13,000	-23%
							Totals		1,800,000					2,000,000	270,000	

Note: All assessment unit (AU) numbers start with ID17040210SK.

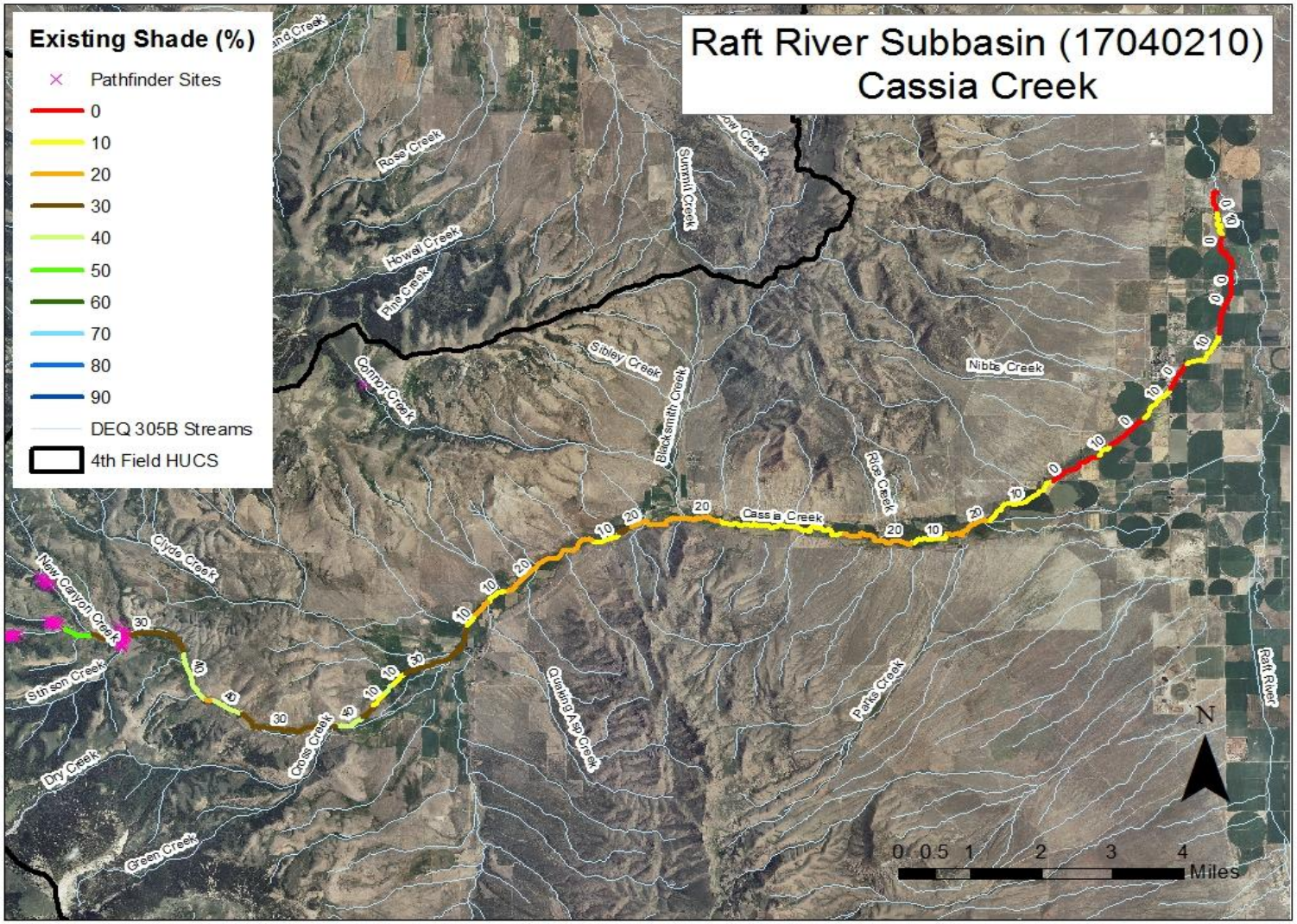

Figure 5. Existing shade (%) estimated for Cassia Creek by aerial photo interpretation.

Note: "305B" streams are unimpaired streams
HUC = hydrologic unit code

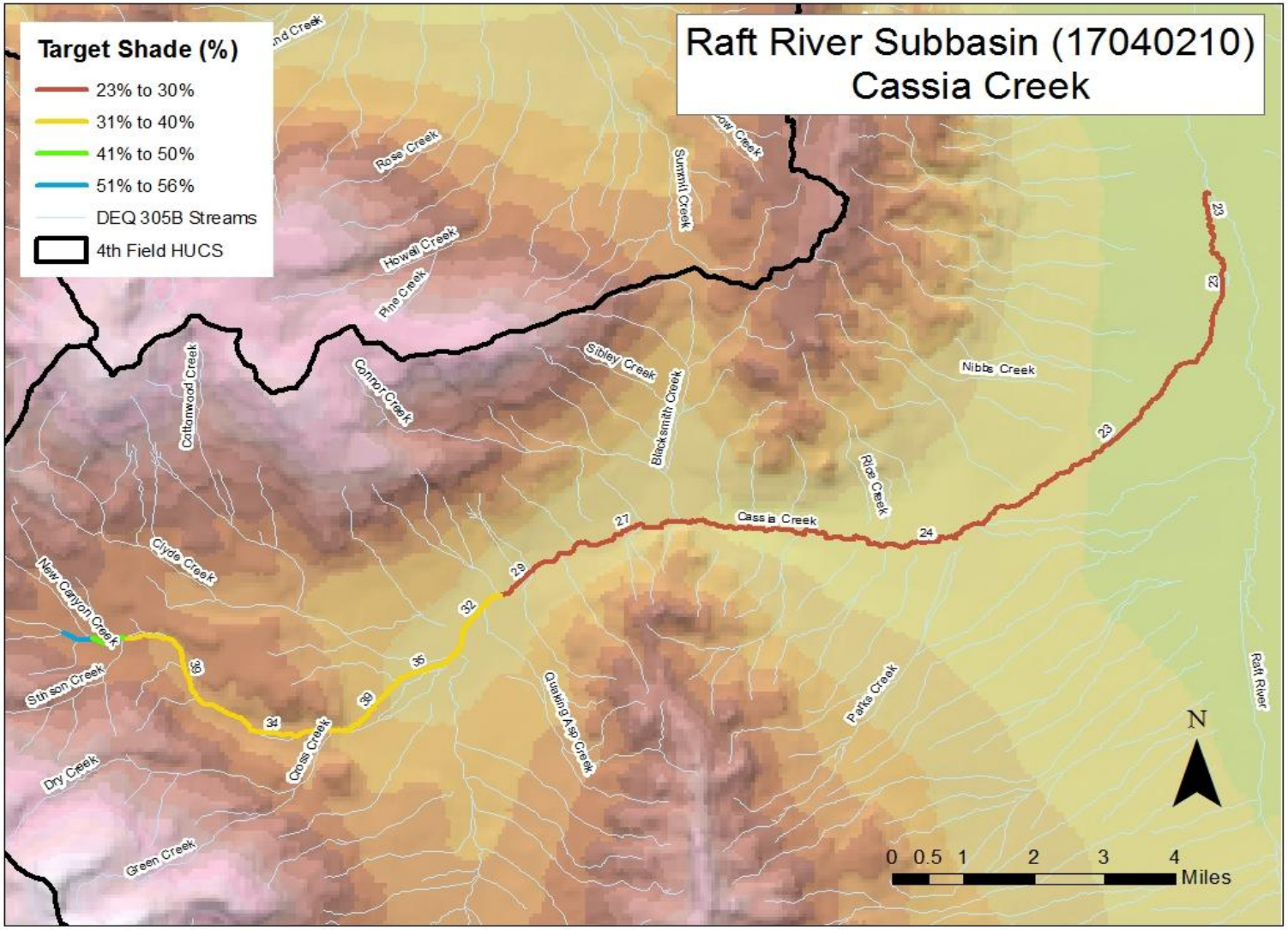

Figure 6. Target shade (%) for Cassia Creek in the Raft River subbasin.

Note: "305B" streams are unimpaired streams
HUC = hydrologic unit code

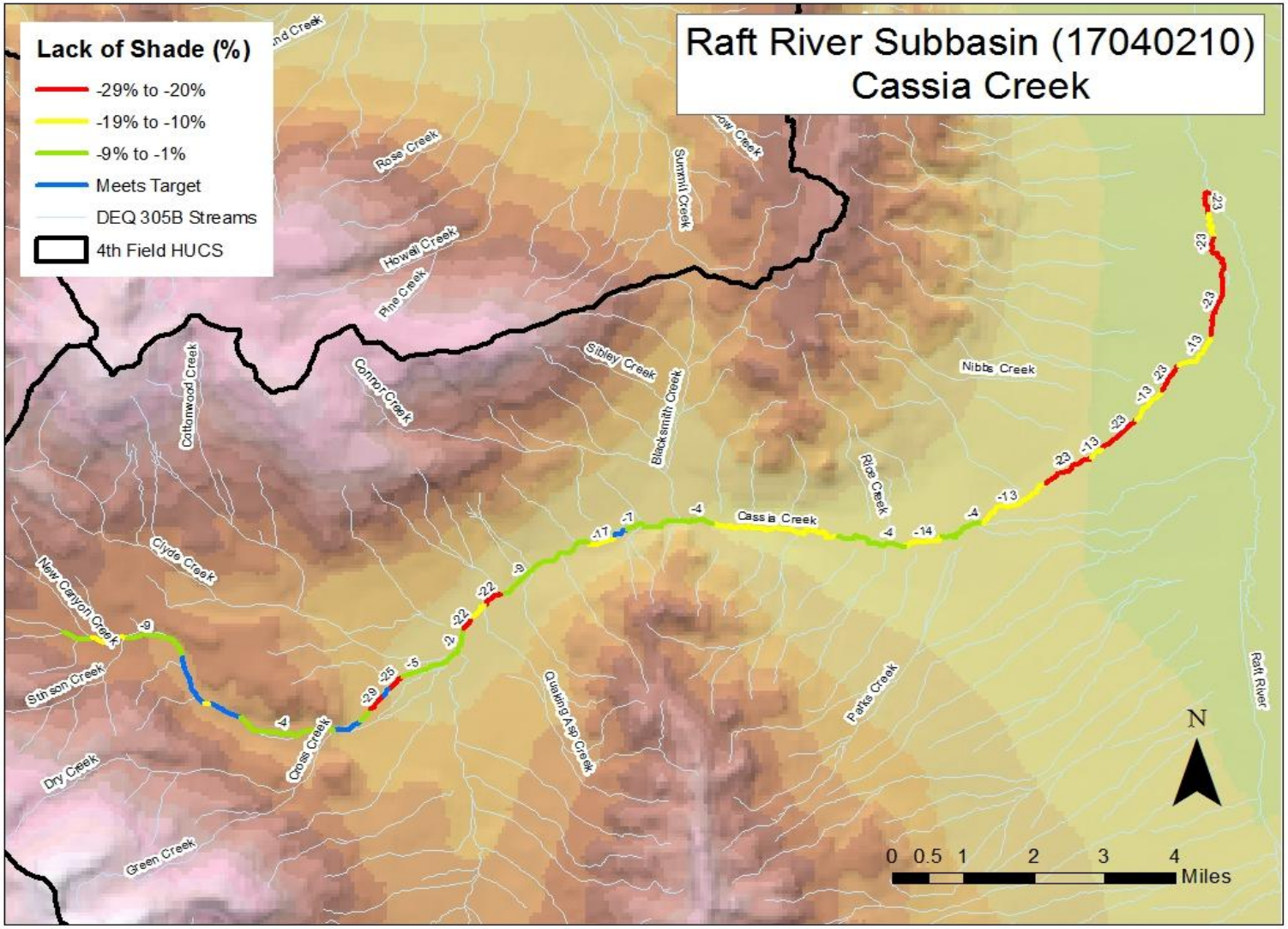

Figure 7. Lack of shade (%) for Cassia Creek in the Raft River subbasin.

Note: "305B" streams are unimpaired streams
HUC = hydrologic unit code

5.4 Load Allocation

Because this TMDL is based on PNV, 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 nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Load allocations are therefore reach specific and are dependent upon the target load for a given reach. Table 4 shows the target shade, which is converted to a target summer load by multiplying the inverse fraction (1 minus shade fraction) by the average load received by a flat-plate collector for the months of April through September. This calculation results in the load capacity of the stream, and it is necessary to achieve background conditions. At that point, there is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent upon background conditions for achieving water quality standards, all tributaries to the waters examined here need to be in natural conditions in order to prevent excess heat loads to the system.

Table 5 shows the total existing, total target, and excess heat load (kWh/day), as well as the percent reduction needed to meet target loads and the average lack of shade experienced by Cassia Creek. Although this analysis focuses on total heat loads for Cassia Creek, it is important to note that differences between existing shade and target shade, as depicted in Figure 7, are the key to successfully restoring these waters to achieving water quality standards. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts. Each load analysis table contains a final column that lists the lack of shade (%) for each segment of stream. This value is derived from the difference between existing shade and target shade for each segment. Thus, stream segments with the largest lack of shade percentages are in the worst condition with respect to shade.

Table 5. Total existing, target, and excess solar loads; percent reductions; and average lack of shade for Cassia Creek.

Water Body	Total Existing Load (kWh/day)	Total Target Load (kWh/day)	Excess Load (kWh/day)	Reduction (%)	Average Lack of Shade (%)
Cassia Creek	2,000,000	1,800,000	270,000	14	-12

Note: Values are gross estimates—rounding errors occur.

Cassia Creek appears to be in relatively good condition regarding shade, with an average lack of shade at -12% and an excess load that was only 14% of its total thermal load. There are several segments below Dry Creek, as well as in the lowest portion of the watershed where agricultural activity is predominant, that lack more than 20% shade. Roads, livestock use, and beaver activity have likely substantially reduced this closed canopy over the last 100 years. However, the upper portions of the watershed are in better condition with segments either meeting shade targets or within the same 10% class interval as the shade target and lacking shade by less than 10%.

There may be a variety of reasons why individual reaches do not meet shade targets, including natural phenomena (e.g., beaver ponds, springs, wet meadows, past natural disturbances) and/or historic land-use activities (e.g., logging, grazing, mining). It is

important that existing shade estimates for each reach be field verified to determine if shade differences are real and result from activities that are controllable. Information within this TMDL (maps and the load analysis table) should be used to guide and prioritize implementation investigations. DEQ recognizes that the information in this TMDL may need further adjustment to reflect new information and conditions in the future.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the loading analysis. Because existing shade is reported as a 10% class level and target shade is a unique integer, there is usually a difference between the two. 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 was at target level, it would be recorded as 80% existing shade in the load analysis because it falls into the 80% 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 National Pollutant Discharge Elimination System (NPDES) permitted point sources in the affected watershed and therefore no wasteload allocations. Should a point source be proposed that would have thermal consequences on these waters, then background provisions in Idaho water quality standards addressing such discharges (i.e., IDAPA 58.01.02.200.09 and IDAPA 58.01.02.401.01) should be involved (see Appendix A).

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% shade-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 nonpoint source 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 6-month period from April through September. This time period was chosen because it represents the time when the combination of increasing air and water temperatures coincide with increasing solar inputs and vegetative shade. The critical time period is June when spring salmonid spawning is occurring, July and August when maximum temperatures may exceed cold water aquatic life criteria, and September during fall salmonid spawning. Water temperature is not likely to be a problem for beneficial uses outside of this time period because of cooler weather and lower sun angle.

Construction Stormwater and TMDL Wasteload Allocations

Construction Stormwater

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

The Construction General Permit

If a construction project disturbs more than 1 acre of land (or is part of a larger common development that will disturb more than 1 acre), the operator is required to apply for a Construction General Permit (CGP) from EPA after developing a site-specific Stormwater Pollution Prevention Plan (SWPPP).

Stormwater Pollution Prevention Plan

In order to obtain the CGP, operators must develop a site-specific SWPPP. Operators must document the erosion, sediment, and pollution controls they intend to use; inspect the controls periodically; and maintain best management practices (BMPs) throughout the life of the project.

Construction Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a gross wasteload allocation for anticipated construction stormwater activities. TMDLs developed in the past that did not have a wasteload allocation for construction stormwater activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate BMPs.

Typically, specific requirements must be followed to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction stormwater management. Sediment is usually the main pollutant of concern in stormwater from construction sites. The application of specific BMPs from Idaho's *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ 2005) is generally sufficient to meet the standards and requirements of the CGP, unless local ordinances have more stringent and site-specific standards that are applicable.

5.5 Public Participation

The Lake Walcott Watershed Advisory Group (WAG) was created in 1995 and contributed to the original Raft River subbasin assessment and TMDL (DEQ 2004). The Lake Walcott WAG has continued to meet several times annually since the approval of the original document. They reviewed the Cassia Creek temperature TMDL document and discussed it at their July 21, 2011, meeting. The WAG was given a draft copy and was asked to submit comments to DEQ. An email was sent to the WAG members the following week that included the DEQ website address to access the draft document and comments were again requested before August 30, 2011. No comments were received. The DEQ Twin Falls Regional Office will be able to provide copies of the document by request.

The general public will have the opportunity to comment on this draft document during the public comment period. In the final version of this addendum, a summary of public comments will be included as Appendix D.

5.6 Implementation Strategies

Implementation strategies for TMDLs produced using PNV-based shade and solar loading should incorporate the load analysis table presented in this TMDL (Table 4). This table needs to be updated, first to field verify the existing shade levels that have not yet been field verified and second to monitor progress towards achieving reductions and TMDL goals. 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 load analysis table. Due to the inexact nature of the aerial photo interpretation technique, this table 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 time frame for implementation will follow the goals as outlined in the *Raft River Subbasin Assessment and Total Maximum Daily Loads* (DEQ 2004, p. 157), which includes a time span from year 1 through year 25.

Approach

The approach for implementation will be similar to that in the Raft River subbasin assessment and TMDL (DEQ 2004, p. 154). 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 outlined in the Raft River subbasin assessment and TMDL (DEQ 2004, p. 153). These include state and federal agencies as well as private stakeholders.

Monitoring Strategy

The monitoring strategy for implementation will be similar to that listed in the Raft River subbasin assessment and TMDL (DEQ 2004, p. 156). The strategy includes tracking the implementation progress of specific plans and tracking the progress of improving water quality by monitoring physical, chemical, and biological parameters.

5.7 Conclusions

Effective shade targets were established for Cassia Creek based on the concept of maximum shading under PNV resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for vegetation types in southern Idaho.

Existing shade was determined from aerial photo interpretation and partially field verified with Solar Pathfinder data.

Cassia Creek lacked shade to some degree when compared to target levels (Table 6), although the stream is in relatively good condition. 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. While not much can be done to address dewatered 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 focus on the largest differences between existing and target shade as locations to prioritize implementation efforts.

Table 6. Summary of assessment outcomes.

Water Body Segment/ Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Cassia Creek ID17040210SK007_03 ID17040210SK005_04 ID17040210SK003_04	Temperature	Yes	Move to Category 4a	Excess solar load from a lack of shade

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GIS Coverages

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Glossary

§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.
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.
Ambient	General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
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 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.
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.
Benthic	Pertaining to or living on or in the bottom sediments of a water body
Best Management Practices (BMPs)	Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.
Best Professional Judgment	A conclusion and/or interpretation derived by a trained and/or technically competent individual by applying interpretation and synthesizing information.
Biological Integrity	1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).
Biota	The animal and plant life of a given region.
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.
Community	A group of interacting organisms living together in a given place.

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).
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).
Disturbance	Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.
Ecosystem	The interacting system of a biological community and its non-living (abiotic) environmental surroundings.
Environment	The complete range of external conditions, physical and biological, that affect a particular organism or community.
Ephemeral Stream	A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from melting snow or other sources. Its channel is at all times above the water table (American Geological Institute 1962).

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

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

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

Flow
See *Discharge*.

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).

Geographic Information Systems (GIS)
A georeferenced database.

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 streamflow.

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 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.
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 streamflow. 2) A stream that has a period of zero flow for at least one week during most years.
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.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500 micrometer mesh (U.S. #30) screen.
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.

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.

Milligrams per Liter (mg/L)

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

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 Pollutant 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.

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 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).

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.
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.
Phosphorus	An element essential to plant growth, often in limited supply, and thus considered a nutrient.
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.
Reach	A stream section with fairly homogenous physical characteristics.
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.
Riparian	Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.
River	A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.
Runoff	The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
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.
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.
Stormwater 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.

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 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.

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.

Tributary

A stream feeding into a larger stream or lake.

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 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 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.

Appendix A. State and Site-Specific Water Quality 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 the Idaho Department of Environmental Quality (DEQ) is generally from March 15 to July 1 each year (Grafe et al. 2002). Fall spawning can occur as early as August 15 and continue with incubation into the following spring up to June 1. Per IDAPA 58.01.02.250.02.f.ii., the water quality criteria that need to be met during those time periods are as follows:

- 13 ^{o}C as a daily maximum water temperature
- 9 ^{o}C as a daily average water temperature

For the purposes of a temperature total maximum daily load (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 the highest annual maximum weekly maximum air temperatures) is compared to the daily maximum criterion of 13 ^{o}C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during certain 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:

> *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, there shall be no lowering of water quality from natural background conditions. Provided, however, that temperature may be increased above natural background conditions when allowed under Section 401.* (IDAPA 58.01.02.200.09)

Section 401 relates to point source wastewater treatment requirements. In this case, if temperature criteria for any aquatic life use are exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3 ^{o}C (IDAPA 58.01.02.401.01.c).

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Appendix B. Unit Conversion Chart

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Table B-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 = 35.31 cfs	3 cfs = 0.09 m^3/sec 3 m^3/sec = 105.94 cfs
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lb)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lb	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 = 1.55 cfs.

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

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

Table C-1. Data sources for the Raft River subbasin TMDLs.

Water Body	Data Source	Type of Data	Collection Date
Cassia Creek	DEQ State Technical Services Office	Pathfinder effective shade and stream width	August 2008
Cassia Creek	DEQ State Technical Services Office	Aerial photo interpretation of existing shade and stream width estimation	2008 and 2011
Cassia Creek	DEQ IDASA Database	Temperature	2001 and 2002

Table C-2. Solar Pathfinder results from field verification.

aerial class	pathfinder actual	pathfinder class	delta		site name
70	48.2	40	30		cold springs
60	53.3	50	10		flat canyon
60	43.4	40	20		stinson
60	36	30	30		cassia
50	55.3	50	0		new canyon
80	25.6	20	60		new canyon
			25	average	
			20.74	std dev	
			16.59	95%CI	

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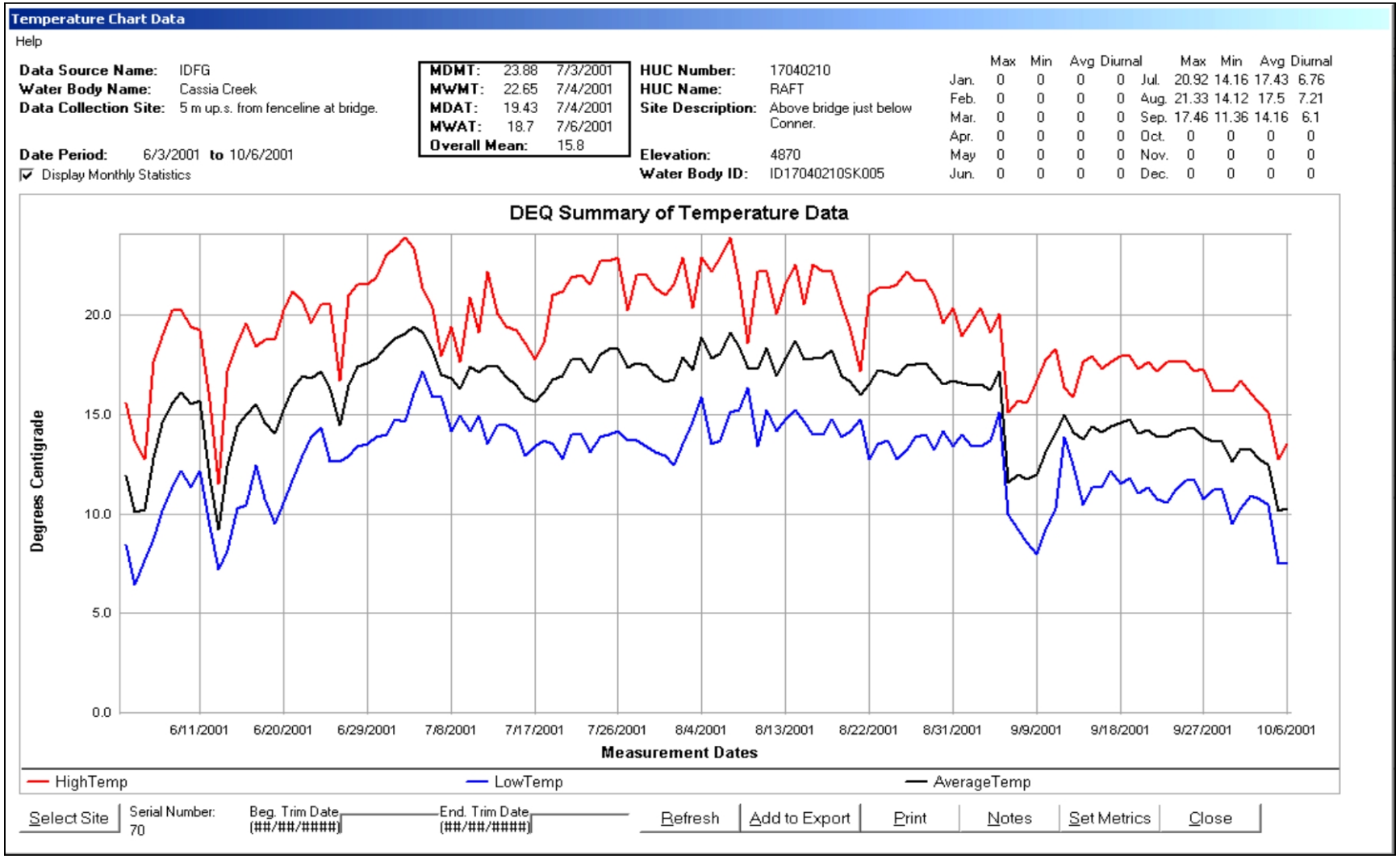

Figure C-1. Temperature data for Cassia Creek collected by the Idaho Department of Fish and Game in 2001 (2001IDFGTL071).

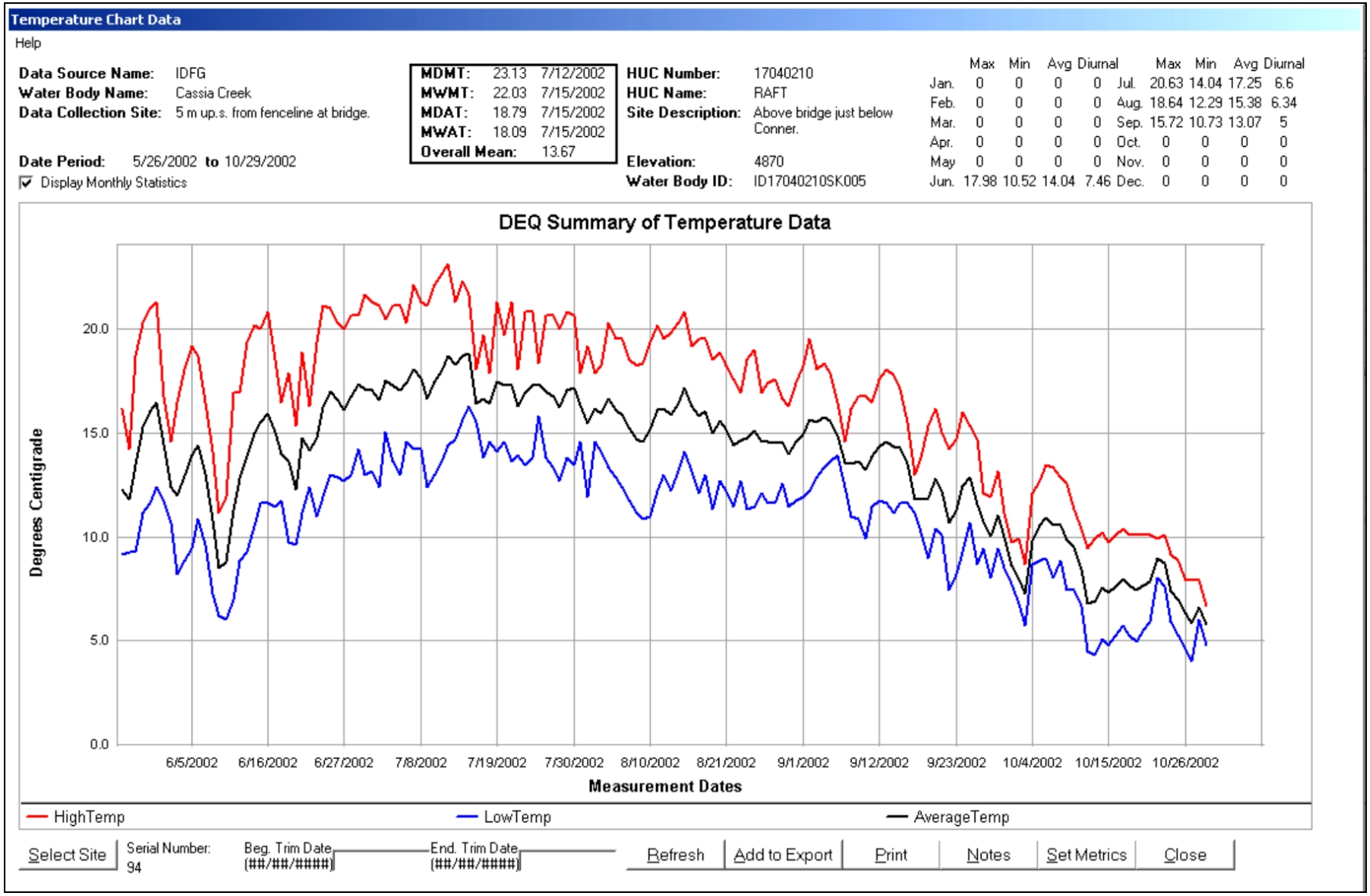

Figure C-2. Temperature data for Cassia Creek collected by the Idaho Department of Fish and Game in 2002 (2002IDFGTL071)

Appendix D. Public Comments

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