Willow Creek Subbasin Total Maximum Daily Loads

2024 Temperature, Nutrients, and Bacteria TMDLs and Five-Year Review

Hydrologic Unit Code 17040205



State of Idaho

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Many thanks to the several DEQ staff who contributed to this document over the years as well as others working to conserve or implement improvement activities within the subbasin.

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Abbreviations, Acronyms, and Symbols

§ 303(d)	refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section
§	section (usually a section of federal or state rules or statutes)
ATV	all terrain vehicle
AU	assessment unit
BLM	Bureau of Land Management
BMP	best management practice
BURP	Beneficial Use Reconnaissance Program
C	Celsius
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
cfs	cubic feet per second
cfu	colony forming unit
CGP	Construction General Permit
CSP	Conservation Stewardship Program
COLD	cold water aquatic life
CSCD	Caribou Soil Conservation District
CWA	Clean Water Act
DEQ	Idaho Department of Environmental Quality
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
ESSWCD	East Side Soil and Water Conservation District
FPA	Idaho Forest Practices Act
FSBI	fine sediment biotic index
ft	foot
GIS	geographic information system
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
IPDES	Idaho Pollutant Discharge Elimination System
ISWCC	Idaho Soil and Water Conservation Commission
kWh	kilowatt
L	liter
LA	load allocation
Lb	pound
LC	load capacity
m	meter

mi	mile
mg	milligram
mL	milliliter
mm	millimeter
MOS	margin of safety
mpn	most probable number
MS4	Municipal Separate Storm Sewer Systems
MSGP	Multi-Sector General Permit
N/A	not applicable
NB	natural background
NBSCD	North Bingham Soil Conservation District
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NREL	National Renewable Energy Laboratory
NTU	nephelometric turbidity unit
NWR	National Wildlife Refuge (Gray's Lake)
PCR	primary contact recreation
PNV	potential natural vegetation
SCR	secondary contact recreation
SEI	streambank erosion inventory
SFI	DEQ's Stream Fish Index
SHI	DEQ's Stream Habitat Index
SMI	DEQ's Stream Macroinvertebrate Index
SS	salmonid spawning
SWMP	Storm Water Management Plans
SWPP	Storm Water Prevention Plan
t	ton
TMDL	total maximum daily load
US	United States
USC	United States Code
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAG	watershed advisory group
WEPP	Water Erosion Prediction Project Model
WLA	wasteload allocation
YCT	Yellowstone Cutthroat Trout
yr	year

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 the CWA § 303, 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. The CWA § 303(d) 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 publish a priority list (a "§ 303(d) list") of impaired waters every 2 years. Currently, the priority list (§ 303(d)) is published as the list of Category 5 water bodies in Idaho's Integrated Report, which summarizes water quality throughout the state. For waters identified on the § 303(d) list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. The 2022 Integrated Report (Idaho's § 305(b) list) lists nine assessment units (AUs) in the Willow Creek subbasin as Category 5, which require the development of a TMDL (DEQ 2022). These AUs are associated with the following impairments: combined biota/habitat bioassessment, temperature, and/or *Escherichia coli* (*E. coli*). Most of these listings are the result of Beneficial Use Reconnaissance Program (BURP) surveys performed on previously unassessed streams, or the analysis of temperature and *E. coli* data collected and available after publication of the initial TMDL. The initial TMDL, *Willow Creek Subbasin Assessment and TMDLs* [hydrologic unit code 17040205], was approved by the United States Environmental Protection Agency (EPA) in 2004 (DEQ 2004) and included TMDLs developed for temperature, sediment, and nutrients.

In this document, the Idaho Department of Environmental Quality (DEQ) evaluated the nine AUs listed as Category 5 and two additional unlisted AUs with newly identified impairments. Seven TMDLs were developed for six of these AUs, including one total phosphorus TMDL, two temperature TMDLs, and four *E. coli* TMDLs. The TMDL analysis establishes water quality targets and load capacities, estimates existing pollutant loads, and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards. Implementation strategies (i.e., reasonable time frames, approaches, responsible parties, and monitoring strategies) are also identified and reviewed.

This document also contains a 5-year review of previously approved TMDLs from the 2004 Willow Creek TMDL. The review evaluates the current status (section 4) and/or revise allocations (section 5), if applicable. Overall, 23 temperature, total phosphorus, and/or sediment impaired AUs were reviewed as part of this process. For the temperature TMDL reviews, the original allocations made in the 2004 Willow Creek TMDL used a previous method to assign TMDL values. In this assessment, 18 of the 29 temperature TMDLs were revised using the current potential natural vegetation (PNV) method and daily load allocations. For the nutrient TMDL reviews, total phosphorus allocations were revised using the same method as the 2004 Willow Creek TMDL. For the sediment TMDL reviews, the original 2004 sediment TMDLs were compared to data gathered in 2016–2017 to detect any apparent trends.

The boundary of Willow Creek subbasin has changed since the previous 2004 TMDL document. The northern portion of the subbasin extends further west to include Crow Creek—source to Willow Creek (ID17040201SK007_05). The AU is listed in Category 5 of the 2022 Integrated Report (DEQ 2022).

Overall, this document describes the key physical and biological characteristics of the subbasin (section 1); water quality concerns and status (section 2); pollutant sources (section 3); recent pollution control actions and monitoring efforts (section 4); and total maximum daily loads (section 5) for the Willow Creek subbasin located in southeastern Idaho. For more detailed information about the subbasin and previous TMDLs, see the *Willow Creek Subbasin Assessment and TMDLs* (DEQ 2004).

Subbasin at a Glance

The Willow Creek subbasin is located in portions of Bingham, Bonneville, and Caribou Counties in southeastern Idaho. Three mountain ranges surround the subbasin: Caribou Range to the east, Blackfoot Range to the west, and Grays Range to the south. The Grays Lake wetland complex and its source reaches are found on the southern tip of the subbasin, where the elevation is approximately 7,000 feet. Drainage flows towards Ririe Reservoir, the lower end of the watershed, at 5,200 feet (Figure A). Below the reservoir, the waters of Willow Creek are connected to the Snake River through a complex irrigation system.

Approximately 61% of the lands within the Willow Creek TMDL are privately owned. The majority of this land is rural and used for agriculture. The Idaho Department of Lands owns and manages 19% of the lands. Within the state lands, the Idaho Department of Fish and Game manages the Tex Creek Wildlife Management Area. The remainder of the public ownership percentages include Caribou-Targhee National Forest—8% and Bureau of Land Management—3%. The United States Fish and Wildlife Service manages the Grays Lake National Wildlife Refuge within the 22,000 acre Grays Lake wetland complex. The primary land use in the subbasin is grazed rangeland, located throughout the subbasin, but mainly south of Bone. The subbasin is rural, with very small towns within its boundary. Forested areas cover 20% of the subbasin and grassland is the next largest land cover. Beneficial uses for the Willow Creek subbasin include cold water aquatic life (COLD), salmonid spawning (SS), primary contact recreation, and secondary contact recreation. Figure A shows Willow Creek subbasin and the current Category 4a and Category 5 AUs.

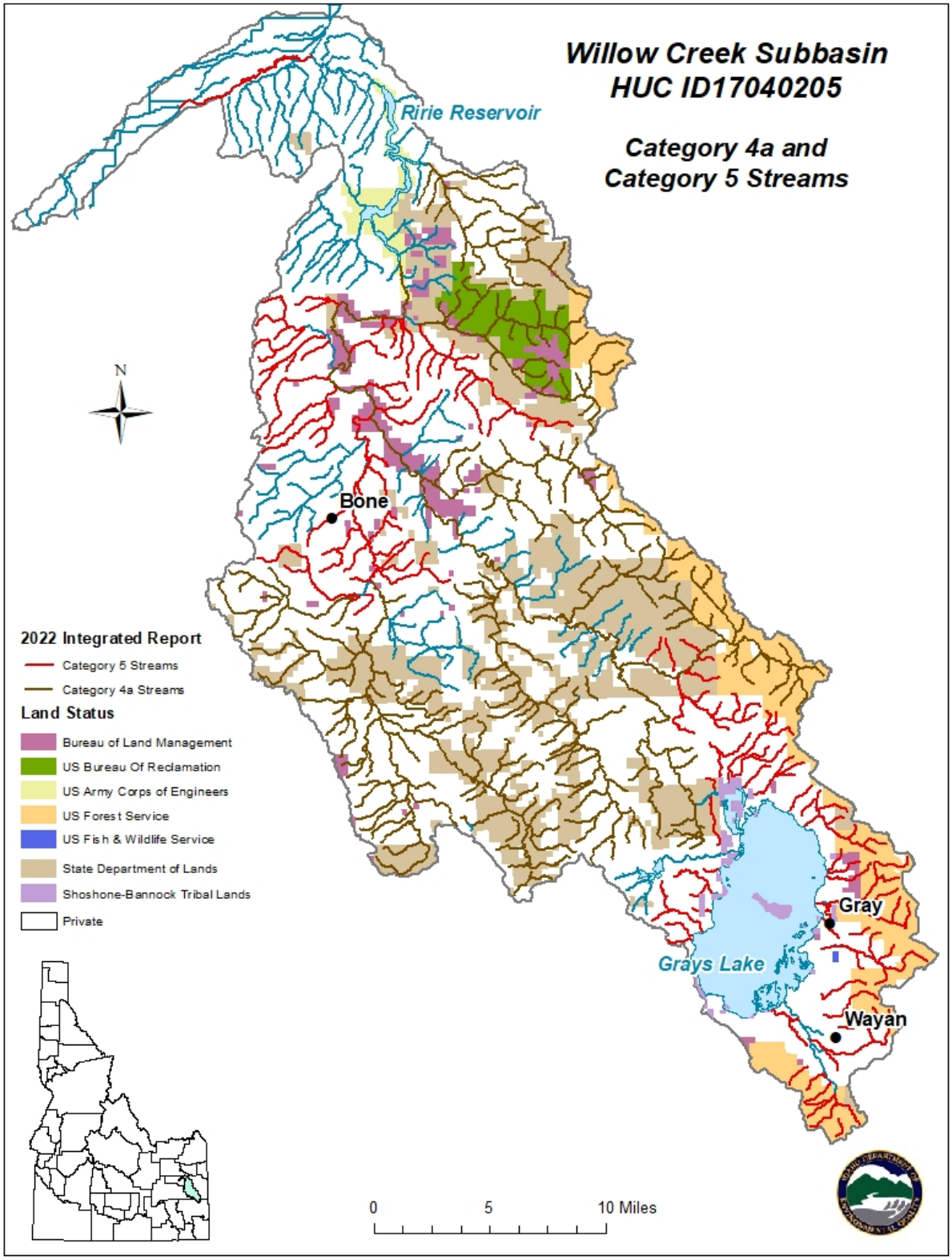


Figure A. Willow Creek subbasin showing landownership and Category 4a and Category 5 AUs.

Key Findings

DEQ developed seven new TMDLs for impaired AUs on the 2022 § 303(d) list. DEQ will continue to monitor and evaluate the impaired AUs that did not receive TMDLs as part of the analysis described in this document. The TMDL and assessment outcomes are summarized in Table A. Additionally, due to the change in boundary of the Willow Creek subbasin since the 2004 TMDL, Crow Creek—source to Willow Creek (ID17040201SK007_05) is now included in the Willow Creek subbasin. This AU is in Category 5, but a TMDL was not developed (Table A).

In 2016 and 2018, DEQ placed temperature loggers in one AU listed in Category 5 for temperature, two AUs listed in Category 5 for combined biota/habitat bioassessment and temperature, and 12 AUs listed in Category 4a for temperature. Temperature data loggers were deployed to evaluate if the AUs met temperature criteria for their beneficial uses (COLD and SS). Pursuant to Idaho's "Water Quality Standards" (IDAPA 58.01.02), numeric temperature criteria supportive of COLD are 22 °C or less for the daily maximum or 19 °C or less for a daily average. For SS, the numeric criteria are 13 °C or less for a daily maximum or 9 °C or less for a daily average. When compared to the water quality standards, SS temperature exceedances were recorded for all 15 AUs. Temperature criteria for COLD were exceeded in eight AUs.

Shade deficiencies are verified through the PNV method. For PNV temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during certain time periods. If PNV 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 groundwater sources of heat) and natural background provisions of Idaho's water quality standards apply (IDAPA 58.01.02.200.09). The PNV method was applied to 35 AUs and established effective target shade levels based on the concept of maximum shading under PNV, resulting in natural background shade levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation that was partially field verified with Solar Pathfinder data in 2014 and 2017. Target and existing shade levels were compared to determine if an AU demonstrates excess solar loads. DEQ identified excess solar loads in 20 of the AUs that were examined. Percentage reductions needed were as high as 62%. DEQ will continue to evaluate the 14 AUs that did not have excess solar loads.

DEQ collected *E. coli* samples to determine if the AUs with known or suspected *E. coli* impairment were meeting the surface water criteria for recreational use designations (IDAPA 58.01.02.251). Exceedances were documented in three previously listed AUs (in Category 5 for *E. coli* impairment) and one AU that was not previously associated with an *E. coli* impairment. As a result, *E. coli* TMDLs were developed for all four of the AUs with *E. coli* criteria exceedances (Table A).

This document also contains a 5-year review of previously developed Willow Creek subbasin TMDLs to comply with Idaho Code § 39-3611(7). As part of this review, DEQ reevaluated the TMDLs developed in 2004, reviewed progress made towards meeting established targets, and examined pollution control efforts that have occurred since the last TMDL was developed.

Following EPA's approval of the 2004 Willow Creek TMDL, many Willow Creek AUs were subsequently listed as Category 4a for nutrient/eutrophication and biological indicators. After reviewing nutrient data collected for the original 2004 TMDL, DEQ restructured and revised these TMDLs to better reflect specific nutrient impairment in the subbasin. The overall outcome of this review is one newly developed total phosphorus TMDL (discussed in section 5.3), two revised total phosphorus TMDLs, and one total phosphorus TMDLs that were reviewed but unchanged (Table A and Table B).

The voluntary implementation of best management practices (BMPs) that improve riparian cover and stream stability will be necessary to achieve TMDL targets and allocations. Mature riparian vegetation can anchor streambanks slowing sediment erosion and providing shade to stream. DEQ believes 10–20 years is a reasonable amount of time to achieve water quality standards if efforts are taken to reintroduce robust riparian plant communities. Limiting livestock access to streams can lead to more immediate water quality improvements, as bacteria and sediment loads will decrease and reduced grazing will improve riparian vegetation growth.

Table A. Summary of evaluated AUs that are unlisted and impaired or listed in Category 5.

Assessment Unit	Pollutant	TMDL Developed	Recommended Changes to Next Integrated Report	Justification
Unlisted but Impaired Assessment Unit				
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	Total phosphorus	Yes	Add total phosphorus as a Category 4a impairment once TMDL is approved.	Total phosphorus TMDL completed.
Mill Creek—source to mouth (ID17040205SK012_03)	*E. coli*	Yes	Add *E. coli* as a Category 4a impairment once TMDL is approved.	Bacteria TMDL developed.
Category 5 Assessment Units				
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Crow Creek—source to Willow Creek (ID17040201SK007_05)	Sedimentation	No	Retain in Category 5 for sediment. Move AU to Willow Creek subbasin.	Impairment needs further investigation
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
	Temperature	Yes	Move to Category 4a for temperature.	Temperature TMDL completed based on PNV.

Assessment Unit	Pollutant	TMDL Developed	Recommended Changes to Next Integrated Report	Justification
	E. coli	Yes	Move to Category 4a for *E. coli*.	Bacteria TMDL completed.
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Mud Creek—source to mouth (ID17040205SK009_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Grays Lake—1st- and 2nd-order tributaries (ID17040205SK021_02)	Temperature	Yes	Move to Category 4a for temperature.	Temperature TMDL completed based on PNV.
Gravel Creek—source to mouth (ID17040205SK023_02)	*E. coli*	Yes	Move to Category 4a for *E. coli*.	Bacteria TMDL completed.
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	*E. coli*	Yes	Move to Category 4a for *E. coli*.	Bacteria TMDL completed.
Bulls Fork—source to mouth (ID17040205SK030_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.

Table B. Summary of review and revision of existing TMDLs.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Willow Creek—Bulls Fork to Ririe Reservoir (ID17040205SK004_05)	Sediment	No	Retain in Category 4a.	Not accessible due to steep terrain and limited road access.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
	Nutrients	No	Retain in Category 4a.	Not accessible due to steep terrain and limited road access.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	Temperature	Yes	Retain in Category 4a for temperature.	Temperature TMDL revised based on PNV.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	Nutrients	No	Retain in Category 4a.	No field data collected due to denied access in 2013.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	Total phosphorus	Yes	Retain in Category 4a.	TMDL revised.
Sellars Creek—source to mouth (ID17040205SK010_02)	Temperature	Yes	Retain in Category 4a.	TMDL revised using PNV method.
Sellars Creek—source to mouth (ID17040205SK010_03)	Sediment	No	Retain in Category 4a.	Sediment trend was analyzed based on streambank erosion inventory (SEI).
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_02)	Sediment	No	Retain in Category 4a.	No flow in 2010. Impairment needs further investigation.
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation. SEI indicates no impairment.
	Total phosphorus	Yes	Retain in Category 4a.	TMDL revised.
	Temperature	Yes	Retain in Category 4a	TMDL revised using PNV method.
Mill Creek—source to mouth (ID17040205SK012_02)	Sediment	No	Retain in Category 4a.	No field data collected since 2001. Impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a	TMDL revised using PNV method.
Mill Creek—source to mouth (ID17040205SK012_03)	Sediment	No	Retain in Category 4a.	Sediment trend was analyzed based on SEI.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Willow Creek—source to Crane Creek (ID17040205SK013_02)	Sediment	No	Retain in Category 4a.	Dry in 2004. Impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	TMDL revised using PNV method.
	Total phosphorus	No	Retain in Category 4a.	Dry conditions in 2016. Impairment needs further investigation.
Willow Creek—source to Crane Creek (ID17040205SK013_03)	Nutrients	No	Retain in Category 4a.	No field data collected due to denied access in 2011.
	Temperature	Yes	Retain in Category 4a.	TMDL revised using PNV method.
Crane Creek—source to mouth (ID17040205SK014_02)	Sediment	No	Retain in Category 4a.	No field data collected due to denied access in 2004.
Crane Creek—source to mouth (ID17040205SK014_03)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation.
Grays Lake outlet—Hell Creek to mouth (ID17040205SK016_04)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Grays Lake outlet—Homer Creek to Hell Creek (ID17040205SK017_04)	Temperature	No	Retain in Category 4a	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Homer Creek—source to mouth (ID17040205SK018_02)	Sediment	No	Retain in Category 4a.	Dry in 2010. Impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised using PNV method.
Homer Creek—source to mouth (ID17040205SK018_03)	Sediment	No	Retain in Category 4a.	Sediment trend was analyzed based on SEI.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV method.
Grays Lake Outlet—Brockman Creek to Homer Creek (ID17040205SK019_04)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_02)	Temperature	No	Retain in Category 4a.	Improper assessment of intermittent, dewatered, or ephemeral stream. Does not qualify in a sampleable category for BURP assessment. Further assessment of water levels/flows are needed to potentially delist in the future.
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_04)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	Sediment	No	Retain in Category 4a	McNeil Core showed no impairment. BURP assessment is needed for further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	Sediment	No	Retain in Category 4a	Impairment needs further investigation. SEI indicates no impairment.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Brockman Creek—source to Corral Creek (ID17040205SK025_02)	Sediment	No	Retain in Category 4a	No data collection since 2003; impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Brockman Creek—source to Corral Creek (ID17040205SK025_03)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Corral Creek—source to mouth (ID17040205SK026_02)	Sediment	No	Retain in Category 4a	Impairment needs further investigation. SEI indicates no impairment.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Sawmill Creek—source to mouth (ID17040205SK027_02)	Sediment	No	Retain in Category 4a.	No data collected since 2003; impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Lava Creek—source to mouth (ID17040205SK028_02)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Lava Creek—source to mouth (ID17040205SK028_03)	Sediment	No	Retain in Category 4a.	Sediment trend analyzed based on SEI.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Hell Creek—source to mouth (ID17040205SK029_02)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Hell Creek—source to mouth (ID17040205SK029_03)	Sediment	No	Retain in Category 4a.	Sediment trend analyzed based on SEI.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Tex Creek—source to mouth (ID17040205SK031_02)	Sediment	No	Retain in Category 4a.	Last data collection in 2007 resulted in an inaccessible site; impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
	Sediment	No	Retain in Category 4a.	Sediment trend analyzed based on SEI.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Tex Creek—source to mouth (ID17040205SK031_03)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_02)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation. SEI indicates no impairment.
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_03)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation. SEI indicates no impairment.

Public Participation

An update on the Willow Creek subbasin TMDL and 5-year review was delivered to the Upper Snake Basin Advisory Group (BAG) on October 11, 2023. The Upper Snake BAG was notified of the intent to complete a final submittal to EPA and post for public comments on October 2, 2024. The public comment period was conducted in 2024. Following review of the public comments, DEQ's responses and a distribution list will be provided.

Introduction

The total maximum daily loads (TMDLs) developed in this document address seven impairments in six different assessment units (AUs) in the Willow Creek subbasin that have been placed in Category 5 of Idaho's most recent Integrated Report (DEQ 2022). The first portion of this document presents key characteristics or updated information for the subbasin assessment, which is divided into four major sections: subbasin characterization (section 1), water quality concerns and status (section 2), pollutant source inventory (section 3), and a summary of past and present pollution control efforts (section 4).

The subbasin assessment is used to develop a TMDL for each pollutant of concern for the Willow Creek subbasin. The TMDL (section 5) is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (40 CFR 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

Regulatory Requirements

This document was prepared in compliance with both federal and state regulatory requirements. The Idaho Department of Environmental Quality (DEQ) implements the Clean Water Act (CWA) in Idaho, while United States Environmental Protection Agency (EPA) oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act, in 1972. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 USC §1251). The act and the programs it has generated have changed over the years as experience and perceptions of water quality have changed. The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to ensure "swimmable and fishable" conditions. These goals relate water quality to more than just chemistry.

The 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 the CWA § 303, 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. DEQ must review those standards every 3 years, and EPA must approve Idaho's water quality standards. Idaho adopts water quality standards to protect public health and welfare, enhance water quality, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The CWA § 303(d) 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). Every 2 years states and tribes must publish a priority list (a "§ 303(d) list") of impaired waters. Currently, this list is published every 2 years as the list of Category 5 waters in Idaho's Integrated Report. For waters identified on this list, states and tribes must develop a TMDL for the pollutants, set at a level to achieve water quality standards.

DEQ monitors waters, and for those not meeting water quality standards, DEQ must establish a TMDL for each pollutant impairing the waters. However, some conditions that impair water quality do not require TMDLs. EPA considers certain unnatural conditions—such as flow alteration, human-caused lack of flow, or habitat alteration—that are not the result of discharging a specific pollutant as "pollution." TMDLs are not required for water bodies impaired by pollution, rather than a specific pollutant. A TMDL is only required when a pollutant can be identified and in some way quantified.

1 Subbasin Characterization

Features of the Willow Creek subbasin, tributary watersheds, and descriptions of individual streams are discussed extensively in the *Willow Creek Subbasin Assessment and TMDLs* (DEQ 2004). Comprehensive biological and instream water quality data were presented and analyzed in that document. This TMDL summarizes pertinent characteristics and provides additional data that currently affect water quality and beneficial uses in the Willow Creek subbasin (Figure 1).

The primary land use in the Willow Creek subbasin is grazed rangeland. Rangelands are located throughout the subbasin but especially south of the town of Bone. Forested areas cover 20% of the subbasin. The next largest land cover type is grassland, which is found intermittently throughout the subbasin. A majority of the grazing and cropland is concentrated in the upper portion of the subbasin, north of Bone and surrounding Ririe Reservoir. Winter wheat/spring barley/fallow or winter wheat/spring fallow rotations are typical for dry cropland areas. Minor portions of the subbasin are surface-irrigated hayland with a small grains/alfalfa hay rotation. Another minor land use is dryland pasture seeded with brome, Idaho fescue, orchard grass, and wheatgrasses. Wetlands are found near Grays Lake and cover 6% of the subbasin.

The Willow Creek subbasin is rural, with very small towns within its boundary. Bone, population 2 (2006), and Herman (no population recorded in census) are located in Bonneville County, and the town of Wayan, population 247 (US Census 2020), is located in Caribou County. There are no point source discharge facilities in the subbasin, and the principal economic activity is agriculture. For a more detailed description of the subbasin and its attributes, see the Willow Creek subbasin TMDLs (DEQ 2004).

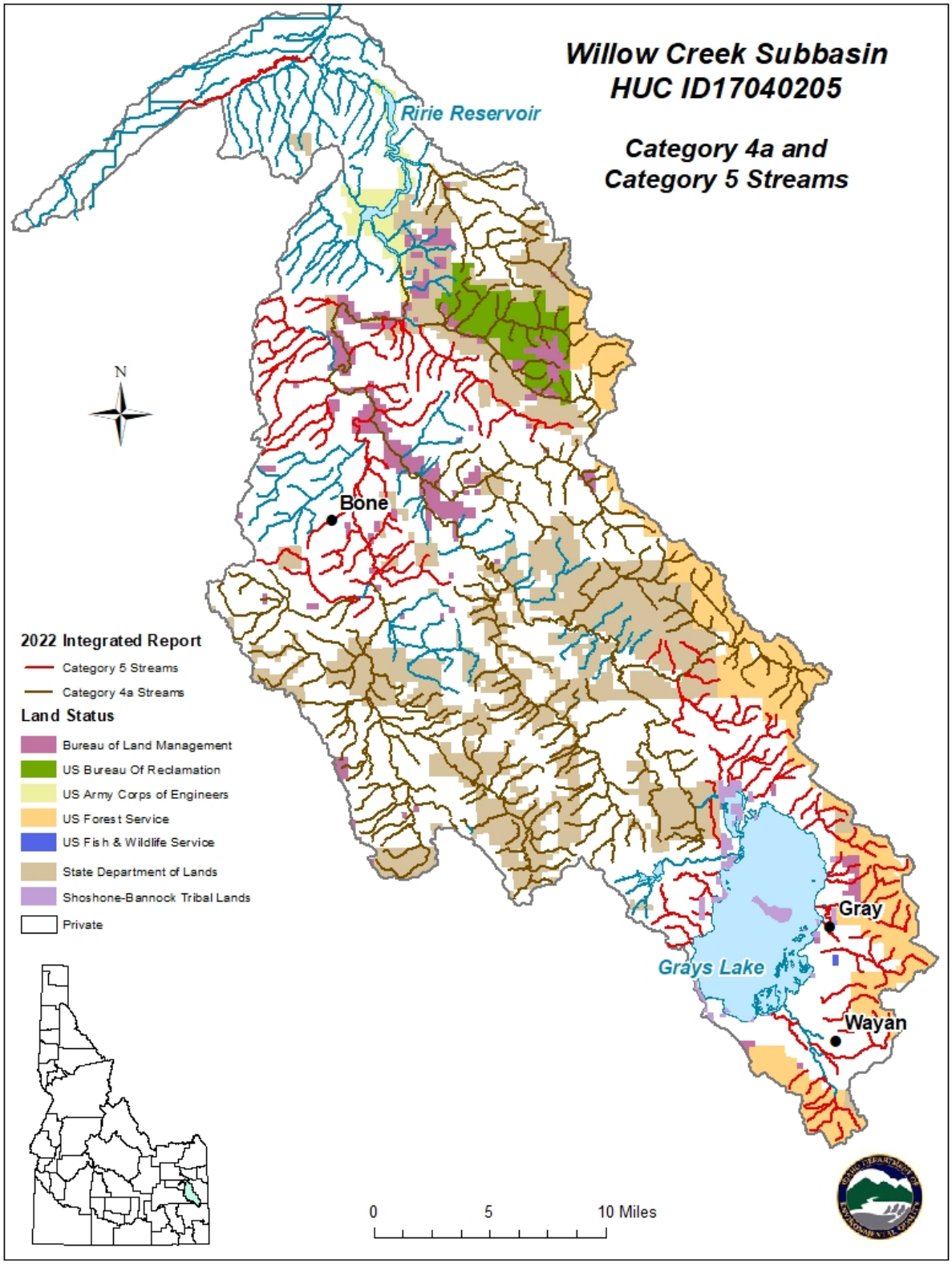


Figure 1. Map of the Category 4a and Category 5 AUs and land status in the Willow Creek subbasin.

2 Water Quality Concerns and Status

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

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

2.1.1 Assessment Units

AUs are groups of similar streams that have similar land use practices, ownership, or land management. However, stream order is the main basis for determining AUs—even if ownership and land use change significantly, the AU usually remains the same for the same stream order.

Using AUs to describe water bodies offers many benefits, primarily that all waters of the state are defined consistently. AUs are a subset of water body identification numbers, which allows them to relate directly to the water quality standards.

2.1.2 Listed Waters

Table 1 summarizes the original listings and the associated pollutants for each § 303(d)-listed AU in the subbasin (i.e., AUs in Category 5 of the Integrated Report).

Table 1. § 303(d)-listed AUs in the Willow Creek subbasin.

Assessment Unit	Listed Pollutants	Listing Basis
Crow Creek—source to Willow Creek (ID17040201SK007_05)	Sediment	1994 § 303(d) list
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	Combined biota/habitat bioassessments	1998 § 303(d) list
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	Temperature	2014 § 303(d) list
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	Combined biota/habitat bioassessments	2001 § 303(d) list
	Temperature	2022 § 303(d) list
	Escherichia coli (*E. coli)*	2010 § 303(d) list
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	Temperature	2014 § 303(d) list
Mud Creek—source to mouth (ID17040205SK009_02)	Combined biota/habitat bioassessments	2001 § 303(d) list
	Temperature	2022 § 303(d) list
Grays Lake outlet—1st- and 2nd-order tributaries (ID17040205SK021_02)	Temperature	2016 § 303(d) list

Assessment Unit	Listed Pollutants	Listing Basis
Gravel Creek—source to mouth (ID17040205SK023_02)	*E. coli*	2022 § 303(d) list
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	*E. coli*	2010 § 303(d) list
Bulls Fork—source to mouth (ID17040205SK030_02)	Combined biota/habitat bioassessments	1998 § 303(d) list
	Temperature	2022 § 303(d) list

2.2 Applicable Water Quality Standards and Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as described briefly in Appendix A. The *Water Body Assessment Guidance* (DEQ 2016) provides a more detailed description of beneficial use identification for use assessment purposes.

Beneficial uses include the following:

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

2.2.1 Beneficial Uses in the Subbasin

Most AUs assigned to the main stem Willow Creek have salmonid spawning (SS), the most sensitive cold water aquatic life (COLD) beneficial use, as a designated use (Table 2). Fish surveys performed in the Willow Creek subbasin in the 1980s and in the early 2000s found that "cutthroat trout were observed in all listed streams, with the exception of Long Valley Creek" (DEQ 2004). In cases where no beneficial uses have been designated, all streams in the Willow Creek subbasin must meet the water quality standards criteria that support COLD and secondary contact recreation (Appendix B).

The type of use identified for each AU arises from Idaho's water quality standards and data presented in the 2004 TMDL. If information about the designated or existing uses is not found in these resources, DEQ presumes that most Idaho waters will support COLD and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these presumed uses, DEQ applies the numeric cold water and recreation criteria to undesignated waters.

Beneficial uses are protected by a set of water quality criteria that include *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity, and

narrative criteria for pollutants such as sediment and nutrients (IDAPA 58.01.02.250–251). More information about numeric and narrative criteria is provided in Appendix B.

Narrative criteria for excess sediment are described in IDAPA:

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

Narrative criteria for excess nutrients are described in IDAPA:

> Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. (IDAPA 58.01.02.200.06)

Table 2. Willow Creek subbasin beneficial uses of Category 4a and 5 streams.

Assessment Unit	Assessment Unit Category	Beneficial Uses[a]	Type of Use
Crow Creek—source to Willow Creek (ID17040201SK007_05)	5	COLD, SCR	Presumed
Willow Creek—Bulls Fork to Ririe Reservoir (ID17040205SK004_05)	4a	COLD, SCR	Designated
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	4a, 5	COLD, SS, PCR	Designated
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	4a, 5	COLD, PCR	Designated
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	4a	COLD, SS, SCR	Designated
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	5	COLD, SS, PCR	Designated
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	4a, 5	COLD, SS, SCR	Designated
Mud Creek—source to mouth (ID17040205SK009_02)	5	COLD, SS, SCR	Existing
Sellars Creek—source to mouth (ID17040205SK010_02)	4a	COLD, SCR, SS	Existing
Sellars Creek—source to mouth (ID17040205SK010_03)	4a	COLD, SCR, SS	Existing
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_02)	4a	COLD, SCR	Designated
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	4a	COLD, SS, PCR	Designated
Mill Creek—source to mouth (ID17040205SK012_02)	4a	COLD, SCR, SS	Existing
Mill Creek—source to mouth (ID17040205SK012_03)	4a	COLD, SCR, SS	Existing
Willow Creek—source to Crane Creek (ID17040205SK013_02)	4a	COLD, SS, PCR	Designated
Willow Creek—source to Crane Creek (ID17040205SK013_03)	4a	COLD, SCR	Designated

Assessment Unit	Assessment Unit Category	Beneficial Uses[a]	Type of Use
Crane Creek—source to mouth (ID17040205SK014_02)	4a	COLD, SCR, SS	Existing
Crane Creek—source to mouth (ID17040205SK014_03)	4a	COLD, SCR, SS	Presumed
Grays Lake outlet—Hell Creek to mouth (ID17040205SK016_04)	4a	COLD, SCR	Presumed
Grays Lake outlet—Home Creek to Hell Creek (ID17040205SK017_04)	4a	COLD, SCR	Presumed
Homer Creek—source to mouth (ID17040205SK018_02)	4a	COLD, SCR	Presumed
Homer Creek—source to mouth (ID17040205SK018_03)	4a	COLD, SS, SCR	Existing
Grays Lake outlet—Brockman Creek to Homer Creek (ID17040205SK019_04)	4a	COLD, SCR, SS	Presumed
Grays Lake outlet—Grays Lake to Brockman Creek (ID17040205SK020_02)	4a	COLD, SCR	Presumed
Grays Lake outlet—Grays Lake to Brockman Creek (ID17040205SK020_04)	4a	COLD, SCR	Presumed
Grays Lake—1st and 2nd order tributaries (ID17040205SK021_02)	5	COLD, SS, SCR	Existing
Gravel Creek—source to mouth (ID17040205SK023_02)	5	COLD, SCR, SS	Existing
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	4a, 5	COLD, SCR, SS	Existing
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	4a	COLD, SCR	Presumed
Brockman Creek—source to Corral Creek (ID17040205SK025_02)	4a	COLD, SCR, SS	Existing
Brockman Creek—source to Corral Creek (ID17040205SK025_03)	4a	COLD, SCR	Presumed
Corral Creek—source to mouth (ID17040205SK026_02)	4a	COLD, SCR	Existing
Sawmill Creek—source to mouth (ID17040205SK027_02)	4a	COLD, SCR	Presumed
Lava Creek—source to mouth (ID17040205SK028_02)	4a	COLD, SCR	Presumed
Lava Creek—source to mouth (ID17040205SK028_03)	4a	COLD, SCR, SS	Existing
Hell Creek—source to mouth (ID17040205SK029_02)	4a	COLD, SCR	Existing
Hell Creek—source to mouth (ID17040205SK029_03)	4a	COLD, SCR	Existing
Bulls Fork—source to mouth (ID17040205SK030_02)	5	COLD, SCR, SS	Presumed
Tex Creek—source to mouth (ID17040205SK031_02)	4a	COLD, SS, SCR	Existing
Tex Creek—source to mouth (ID17040205SK031_03)	4a	COLD, SCR	Existing

Assessment Unit	Assessment Unit Category	Beneficial Uses[a]	Type of Use
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_02)	4a	COLD, SCR, SS	Existing
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_03)	4a	COLD, SCR	Presumed

Notes: cold water aquatic life (COLD), salmonid spawning (SS), primary contact recreation (PCR), secondary contact recreation (SCR)

2.2.2 Protection of Downstream Uses

Idaho's water quality standards require that all waters "shall maintain a level of water quality at their pour point into downstream waters that provides for the attainment and maintenance of the water quality standards of those downstream waters, including waters of another state or tribe" (IDAPA 58.01.02.070.08).

The Willow Creek subbasin's outlet discharges to the Snake River—Dry Bed Creek to river mile 791 (ID17040201SK001_04) near the city of Idaho Falls. The Snake River—Dry Bed Creek to river mile 791 is designated for COLD, SS, and PCR. This AU is currently in Category 3 as not assessed for beneficial use support. The downstream American Falls subbasin has the same beneficial uses as the Willow Creek subbasin. The TMDLs assessed in this document protect the downstream designated and existing uses. The AUs with TMDLs in this document do not discharge to tribal or interstate water bodies.

The potential natural vegetation (PNV) temperature TMDL was developed to achieve stream temperature equivalent to natural background conditions. If stream temperatures exceed numeric temperature criteria when PNV targets are achieved, and there are no other anthropogenic sources of heat load, the stream temperature is equivalent to natural background temperature or natural conditions, consistent with IDAPA 58.01.02.09.209. The allocations developed in the PNV temperature TMDLs achieve natural background temperatures that protect beneficial uses and do not contribute to downstream temperature impairments.

Narrative targets for sediment impaired waters are provided in Idaho's water quality standards: "Sediment shall not exceed quantities specified in Sections 250 and 252, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Section 350" (IDAPA 58.01.02.200.08). The allocations in the 2004 sediment TMDLs were developed to meet nonpoint source sediment targets that protected beneficial uses and would not contribute to downstream sediment impairments.

In Idaho's water quality standards (IDAPA 58.01.02.251.01), the following is the numeric criteria for beneficial uses: *E. coli* colonies may not exceed a geometric mean of 126 colony forming units per milliliter (cfu/mL) for five samples collected every 3 to 11 days within a 45-day period. The allocations developed for the *E. coli* TMDLs in this document protect beneficial uses and do not contribute to downstream bacteria impairments.

2.2.3 Water Quality Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of water quality criteria, which include *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (Appendix B), and *narrative* criteria for pollutants such as sediment and nutrients (IDAPA 58.01.02.250–251). The bacteria and temperature numeric criteria (Table 3) apply to the AUs discussed in this document.

Narrative criteria for excess sediment are described in the water quality standards:

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

Narrative criteria for excess nutrients are described in the water quality standards:

> Surface waters of the state shall be free from excess nutrients that can cause visible slime growth or other nuisance aquatic growths impairing designated beneficial uses. (IDAPA 58.01.02.200.06)

Table 3. Selected numeric criteria supportive of beneficial uses in Idaho's water quality standards.

Parameter	Primary Contact Recreation (PCR)	Secondary Contact Recreation (SCR)	Cold Water Aquatic Life (COLD)	Salmonid Spawning[a] (SS)
Water Quality Standards: IDAPA 58.01.02.250–251				
Bacteria				
Geometric mean	<126 *Escherichia coli* (*E. coli)* /100 mL[b]	<126 *E. coli* /100 mL	—	—
Statistical Value Threshold	≤410 *E. coli* /100 mL	≤410 *E. coli* /100 mL	—	—
Temperature[c]	—	—	22 °C or less daily maximum; 19 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average

a During spawning and incubation periods for inhabiting species
b *Escherichia coli* per 100 milliliters
c Temperature exemption: Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the 90th percentile of the 7-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.
Notes: does not apply (—)

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.050.02. The procedure relies heavily upon biological parameters provided in the *Water Body Assessment Guidance* (DEQ 2016). This guidance requires DEQ to use the most complete data available to make beneficial use support status determinations.

2.3 Summary and Analysis of Existing Water Quality Data

The water quality data described below were collected after the approved 2004 Willow Creek subbasin TMDL to evaluate sediment, temperature, total phosphorus, and bacteria impairments. Multiple government agencies have collected data in the Willow Creek subbasin. The United States Geological Survey (USGS) provided flow data. The Idaho Department of Fish and Game (IDFG) and United States Forest Service (USFS) provided fish data and restoration information. The Natural Resources Conservation Service (NRCS) provided restoration information, and the Idaho Department of Water Resources (IDWR) provided water rights data. DEQ collected and provided the following data: Beneficial Use Reconnaissance Program (BURP), temperature, *E. coli*, nutrients, streambank erosion inventory (SEI), PNV, and Solar Pathfinder. Data gathered for this TMDL was analyzed to establish the current status of water bodies and compare to water quality data gathered and analyzed in the Willow Creek subbasin TMDL (DEQ 2004).

2.3.1 Biological and Habitat Data

Data collections in the Willow Creek subbasin since the 2004 TMDL include periodic BURP assessment-level sampling and specific sediment and nutrient sampling for TMDL purposes. The BURP monitoring protocol uses standardized procedures to collect aquatic insects, conduct fish surveys, measure water chemistry, and document habitat conditions in streams and rivers to determine support of beneficial uses. Aquatic insects and fish can be very sensitive to changes in water quality, so their presence, abundance, and health indicate the overall quality of a water body. BURP data are evaluated against assessment thresholds using the *Water Body Assessment Guidance* (DEQ 2016) to determine if the water body is meeting standards and supporting beneficial uses.

The BURP monitoring protocol provides data on three important stream quality indicators: macroinvertebrates, fish, and habitat. A stream macroinvertebrate index (SMI2) is generated from six or seven metrics based on the benthic macroinvertebrate assemblages in reference streams and depending on stream site class [i.e., mountains, foothills, or plains, plateaus, or broad valleys]. A stream fish index (SFI2) includes five to six metrics based on the species present, abundance of the different species, and abundance of tolerant/intolerant individuals. A stream habitat index (SHI2) uses both quantitative and qualitative measures of stream habitat, including substrate composition, channel structure, streamside vegetation, and streambank condition. Index scores (condition ratings) from the monitoring samples are compared with statistical reference index scores and used along with available physical and chemical data to determine whether an AU supports its beneficial uses. A score < 2 is considered not supporting and a score of ≥ 2 is considered fully supporting. Not assessed (NA) or (–) indicates data for the index were not evaluated.

Establishing water quality trends using BURP data is challenging in the Willow Creek subbasin based on limited access due to private landownership and widespread intermittent/ephemeral stream permanence conditions. Several streams have only been visited once or have yet to be visited since the outset of the program (Table 4). Proper site selection that is characteristic of

the AU is important in providing a representative assessment of water quality. Table 4 summarizes the BURP scores for Willow Creek subbasin from 2004 to 2019.

Table 4. BURP scores for Willow Creek subbasin (2004–2019).

Assessment Unit Number	BURP Site ID	2022 Integrated Report Category	SMI2	SFI2	SHI2	Average Rating
ID17040205SK005_04	2013SDEQA233	5, 4a	Denied Access			
ID17040205SK005_05	2006SIDFA005	4a	Inaccessible			
	2016SIDFA001		2	2	3	2.33
	2019SIDFA052		Inaccessible			
ID17040205SK010_02	2014SPOCA007	4a	3	3	3	3.00
	2014SPOCA008		3	3	2	2.67
ID17040205SK010_03	2010SDEQA139	4a	Inaccessible			
	2016SIDFA002		2	1	2	1.67
ID17040205SK011_02	2010SDEQA081	4a	Dry			
ID17040205SK011_04	2016SIDFA009	4a	Unsampleable—Beaver Complex			
ID17040205SK012_03	2004SIDFA138	4a	Inaccessible			
	2010SDEQA187		Inaccessible			
	2016SIDFA008		2	1	3	2.00
ID17040205SK013_02	2004SIDFA141	4a	Dry			
ID17040205SK013_03	2011SPOCA034	4a	Inaccessible			
ID17040205SK014_02	2004SIDFA133	4a	Dry			
	2004SIDFA134		Inaccessible			
ID17040205SK014_03	2004SIDFA140	4a	Inaccessible			
	2010SDEQA107		Dry			
	2010SDEQA1967		—	—	1	—
ID17040205SK017_04	2007SIDFA047	4a	Inaccessible			
	2010SDEQA142		Lake/Reservoir			
ID17040205SK018_02	2010SDEQA079	4a	Dry			
ID17040205SK018_03	2004SIDFA018		—	—	1	—
	2004SIDFA139	4a	1	—	1	1.0
	2010SDEQA199		Inaccessible			
	2016SIDFA003		1	2	2	1.67
ID17040205SK019_04	2010SDEQA155	4a	Lake/Reservoir			
	2015SDEQA238		2	—	2	2.00
ID17040205SK021_02	2007SIDFA045	5	Inaccessible			
	2008SIDFA006		Dry			
	2013SDEQA221		3	—	3	3.00
ID17040205SK023_02	2013SPOCA075	5	2	2	3	2.33
	2016SIDFA005		2	2	3	2.33
	2019SIDFA013		1	3	3	2.33
ID17040205SK024_03	2008SIDFA133	4a	Dry			
ID17040205SK028_03	2016SIDFA004	4a	2	2	2	2.00
ID17040205SK029_03	2005SIDFA081	4a	Dry			
	2006SIDFA004		Inaccessible			
ID17040205SK031_02	2007SIDFA046	4a	Inaccessible			
ID17040205SK031_03	2004SIDFA009	4a	Inaccessible			
	2008SIDFA005		Inaccessible			
	2008SIDFA126		1	—	2	1.50
	2016SIDFA007		Dry			
ID17040205SK032_03	2016SIDFA006	4a	Unsampleable—Beaver Complex			

BURP site assessments post 2004 have not been performed for AUs listed in combined biota/habitat bioassessments in Category 5 of the 2022 Integrated Report (DEQ 2022). The AUs, ID17040205SK005_02, ID17040205SK008_02, ID17040205SK009_02, and ID17040205SK030_02, will remain in Category 5 for combined biota/habitat bioassessments for the next Integrated Report cycle.

2.3.2 Flow Data

The USGS maintains a discharge gaging station below the confluence of Tex and Willow Creeks, and above the influence of Ririe Reservoir. Flow data are available from USGS at *https://waterdata.usgs.gov/nwis/inventory/?site_no=13057940&agency_cd=USGS.* Increases and decreases in flow tend to follow the weather pattern, with high flows during spring runoff lasting until mid-June, and low flows occurring in the fall and lasting into mid-October (Figure 2).

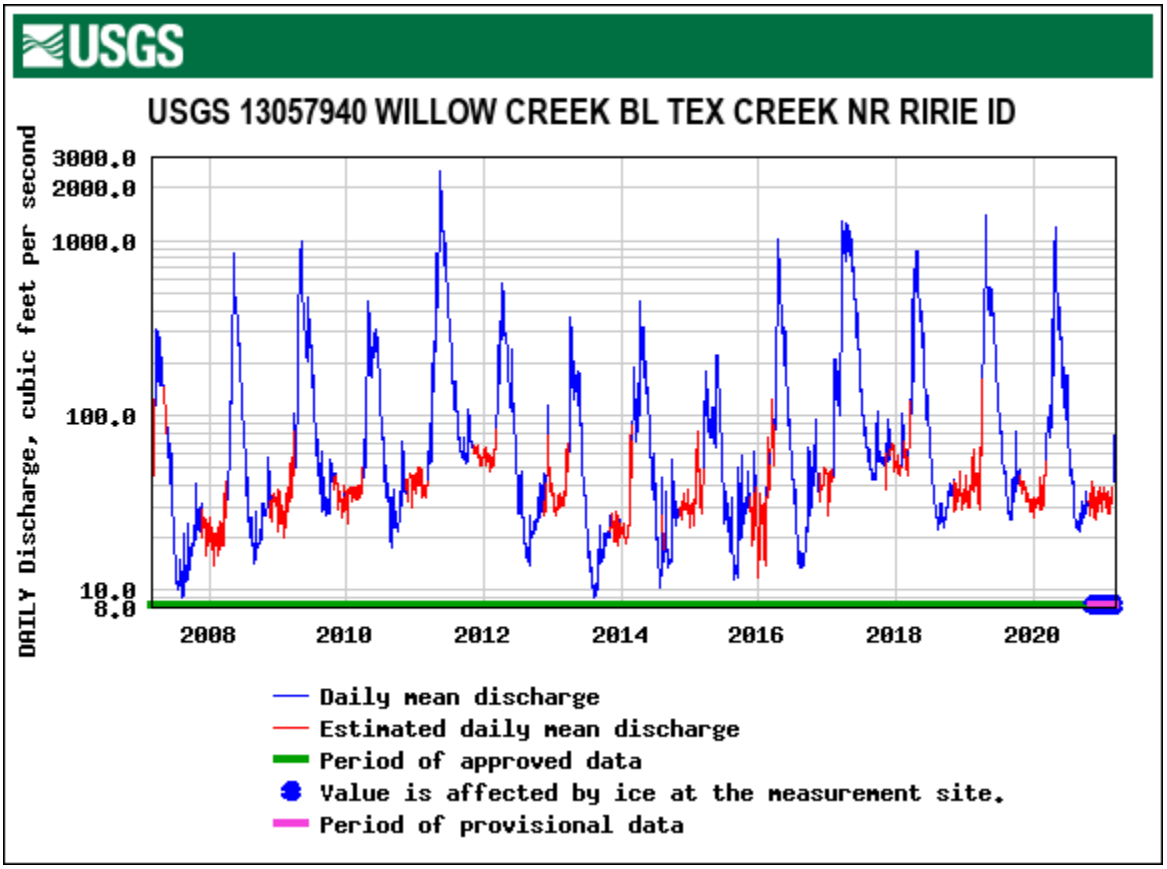


Figure 2. Mean discharge, Willow Creek below Tex Creek, near Ririe, Idaho (USGS 2021).

2.3.3 Water Column Data

Data generated through monitoring efforts undertaken by DEQ is used in the TMDL analysis and provided in Appendix C.

2.3.4 Temperature

For this TMDL, DEQ's Idaho Falls Regional Office staff deployed temperature data loggers in Category 5-listed tributaries to Willow Creek. Temperature logger data recorded during the critical time period of midsummer to early fall 2011, 2016, and 2017 showed that stream temperatures in these tributaries exceed SS criteria the majority of the time and can exceed COLD criteria (Appendix C). Recent temperature data are consistent with data generated for the original Willow Creek subbasin assessment and TMDLs (DEQ 2004), which resulted in temperature TMDLs for 13 water bodies that included 29 AUs. This new TMDL document assigns TMDLs organized on AU designation. Two temperature TMDLs were completed, and 18 temperature TMDLs were revised. The current data and relative lack of implementation projects aimed at riparian plant restoration undertaken since the 2004 TMDL resulted in stream temperatures in excess of criteria throughout the subbasin.

2.3.5 Potential Natural Vegetation for Temperature TMDLs

For the Willow Creek subbasin temperature TMDLs, a PNV approach was used (section 5.1). Idaho's 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 to be a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and the natural level of shade and channel width become the target of the TMDL. The instream temperature that results from attainment of these conditions is consistent with the water quality standards, although it may exceed numeric temperature criteria.

The PNV temperature TMDLs result in the quantification of nonpoint source solar heat load to Willow Creek and its tributaries, and call for an increase in the shade provided by riparian vegetation to reduce instream temperatures.

In the recent DEQ monitoring effort, existing shade was measured on a subsample of representative AU reaches using a Solar Pathfinder. This device traces the outline of shade-producing objects on specialized charts called solar path charts, which allowed crews to measure the existing shade available to Willow Creek and its tributaries. Detailed field notes identifying the remnant riparian species currently providing shade to these streams were also taken to define the composition of the riparian community. Once the riparian community type is defined, a shade curve can be selected that models available shade for the riparian community at its potential. Existing shade measurements can then be compared to potential shade estimates, at the same stream widths, and the resulting shade deficit can be expressed as the temperature load reduction. Most streams surveyed exhibited a shade deficit when compared to potential shade targets. Since the PNV method was not used in the original TMDL (DEQ 2004), all AUs resulting in shade deficiency based on this method received a revised TMDL. Ten of the 29 AUs listed for temperature in Category 4a did not lack shade in the reaches examined. Four of the six AUs listed for temperature in Category 5 did not lack shade in the reaches examined. Section 5.1 provides further discussion.

2.3.6 *E. coli* Bacteria

Idaho's water quality standards (IDAPA 58.01.02.251.01) state that the numeric criterion for *E. coli* is not to exceed 126 *E. coli*/100 mL based on the geometric mean of five samples taken 3 to 11 days over a 45-day period or a statistical threshold value of 410 *E. coli*/100 mL in more than 10% of samples collected over a 45-day period. A geometric mean is applied to minimize random variability in data associated with surface waters prone to short-term episodic spikes in bacteria concentrations. *E. coli* samples were collected from six AUs with known or suspected *E. coli* impairments. Four of the six exceeded the geometric mean standard. As a result, DEQ developed a new *E. coli* TMDL (section 5.2). Future projects aimed at reducing stream temperatures can also reduce *E. coli* load by discouraging direct access to the stream by livestock as riparian areas are replanted and given an opportunity to establish.

2.3.7 Sediment Monitoring

Six of the 22 AUs listed in Category 4a for sedimentation in the 2022 Integrated Report (DEQ 2022) were investigated using BURP data to determine if sedimentation improved (2004–present). The BURP habitat index score (SHI2) is calculated from individual metric scores in the following categories: instream cover, large organic debris, percent fines less than 2 millimeters (mm) in wetted width, embeddedness, number of Wolman size classes, channel shape (undercut), percent bank cover, percent canopy cover, disruptive pressures, and zone of influence. Additional details about the BURP protocol are discussed in section 2.3.1.

As a component of the SHI score, the Wolman pebble count can be helpful in determining a sediment impairment. Overall, the data collected with the Wolman pebble count indicates the number of different particle sizes found in a survey sample. If a streambed has a greater diversity in particle size and a higher Wolman score, this usually indicates that the stream is not likely impaired with sediment. The estimate of percent fines (< 2 mm), collected during the Wolman pebble count, can also be used to evaluate the potential sediment impairment.

The fine sediment biotic index (FSBI) index score is a component of the BURP macroinvertebrate index score (SMI2). It assesses fine sediment (< 2 mm) impacts on macroinvertebrate communities. The FSBI score is the sum of the FSBI value of all taxa from four of the most sediment sensitive macroinvertebrate categories. Each taxon is assigned a fine sediment tolerance category based on a taxon's 75th percentile of occurrence. The more sensitive the taxa is to sediment, the higher the value it is assigned (Relyea et al. 2010). It is generally assumed that the higher the FSBI score (i.e., ≥ 100), the more sediment sensitive macroinvertebrates are present and the less likely the stream is to have a sediment impairment. Discussion of the BURP data about sediment for the 5-year review is found in section 4.1.3.

In 2016 and 2017, DEQ conducted SEIs on 11 Category 4a AUs in the Willow Creek subbasin for the 5-year review of the 2004 completed TMDLs. The SEI survey method was used to complete TMDLs in the original TMDL (DEQ 2004). The SEI is used to measure streambank stability by estimating erosion rates in and sediment loads to streams. SEI is a qualitative evaluation of channel shape, streambank stability, and riparian vegetation developed using field methods

outlined by the NRCS as a tool to evaluate erosion condition on streambanks, gullies, and roads (NRCS 1983). When an eroding streambank is identified in the field during an SEI, the streambank height and length are measured and recorded. Six streambank characteristics are ranked in the field, and corresponding erosion rates and target erosion rates are calculated using a spreadsheet. Streambank erosion values obtained from the sample reach can be extrapolated to adjacent streambanks of similar condition with the same land uses to estimate direct annual sediment inputs from streambank erosion. Streambank erosion up to 20% is considered a natural phenomenon, so when streambank stability is at 80%, load capacity is considered met (Overton et al. 1995). Discussion of the SEI surveys and trend analysis compared to the 2004 TMDL is found in section 4.1.3. The SEI calculation worksheets are included in Appendix C.

McNeil sediment core samples were taken and assessed for ID17040205SK024_02. This analysis describes size composition of bottom materials in identified salmonid spawning locations (McNeil and Ahnell 1964). McNeil sediment core samples are taken by working a cylinder 4 to 6 inches into spawning habitat. The sediment collected is separated by grain size and measured to calculate the percentage of depth fines at the sample location. The percentage of intergravel fines less than 6.35 mm in diameter is correlated with expected fry survival. DEQ has a target for volcanic, granitic, and sedimentary watersheds that is less than 28% fine sediment (< 6.35 mm diameter) in identifiable spawning habitat. The McNeil sediment core analysis can be used to potentially list or delist AUs. The analysis for ID17040205SK024_02 showed no impairment for sediment. However, BURP data has not been collected since 1998 for this AU, warranting a site visit. Section 4.1.6 provides further discussion.

2.3.8 Nutrients

Water samples to determine nutrient concentrations were collected in 2016 from two AUs listed for total phosphorus impairment in Category 4a and one AU that is not listed. Water samples were collected approximately every 2 weeks from the beginning of June to the middle of September, with the same method used in the 2004 TMDL. This time frame captured the highest amount of nutrients within the stream at elevated flows due to runoff. These samples were tested for total phosphorus and nitrogen as NO_2 + NO_3 resulting in two revised TMDLs for total phosphorus, one new TMDL for total phosphorus, and no TMDLs for nitrogen as nitrite + nitrate. Several AUs included in Category 4a for nutrients were not sampled due to a lack of access (ID17040205SK004_05, ID17040205SK005_04, and ID17040205SK013_03) or dry conditions (ID17040205SK013_02).

2.3.9 Fisheries Management

The IDFG *Fisheries Management Plan 2013-2018* describes the species present, habitat conditions, and fisheries management practices applied in the Willow Creek subbasin (IDFG 2013):

> The 95 miles of streams in the Willow Creek drainage above Ririe Reservoir are mainly in narrow canyons and contain brook trout and genetically pure Yellowstone cutthroat trout. Water flows vary from extremes of several thousand cubic feet per second during runoff to a few cubic feet per second in late

summer and winter. Intense grazing combined with drought conditions have contributed to poor riparian habitat in the upper watershed. Water quantity and quality has suffered as a result. The Natural Resource Conservation Service (NRCS) has identified the Willow Creek drainage as one of the ten worst soil erosion areas in the United States. A water quality program has been initiated to reduce loss of top soils and improve the water quality of Willow Creek above Ririe Dam. Riparian habitat improvement through improved grazing management is a high priority on both state and private lands. IDFG is working with the NRCS, the Eastern Idaho Grazing Association, and other local groups to facilitate improvements in resource management practices.

Cutthroat trout in the mainstem areas of Willow Creek and Grays Lake Outlet are likely dependent on downstream movement from tributary spawning and nursery areas. Most tributaries of Willow Creek contain native populations of Yellowstone cutthroat trout and/or non-native brook trout. Though brown trout have been stocked and found in the past, none have been collected in population surveys conducted from 2000 through 2005. Native cutthroat trout populations are presently depressed in the drainage but remain viable. Low flows and degraded habitat have impacted many of the smaller headwater tributaries in the Willow Creek drainage. With a return to normal snowpack years the Department will consider supplemental hatchery releases on a case-by-case basis where fish populations have been impacted. This may include those drainages managed as wild trout.

Over-harvest of cutthroat trout once contributed to the decline of this species but restrictive harvest regulations have reduced angling exploitation as a threat. Cutthroat trout presently dominate the catch in some tributaries; however, angling effort has been minimal in recent years. Hatchery catchable rainbow trout and brown trout fingerlings are no longer stocked in the Willow Creek drainage above Ririe Reservoir. No wild rainbow trout have been found in the Willow Creek drainage and genetic surveys in 1999 and 2000 have documented that Willow Creek cutthroat trout are free of rainbow trout introgression. Since 2011, the Willow Creek Drainage has been closed to all harvest of cutthroat trout.

2.3.10 Status of Beneficial Uses

The majority of current beneficial use support status determinations in the Willow Creek subbasin show a lack of beneficial use support, whether those uses are designated or existing. The main beneficial uses impacted within the Willow Creek subbasin are COLD, SS, PCR, and SCR. DEQ personnel have largely been denied access to most of the private land in the subbasin, and it is difficult to determine the extent to which current agricultural water supply withdrawals are exacerbating these low stream flow issues and contributing to higher stream temperatures that result in a lack of beneficial use support.

2.4 Assessment Unit Summary

A summary of the data analysis, literature review, and field investigations and a list of conclusions for AUs included in Category 4a and Category 5 of the 2022 Integrated Report follows. This section includes changes that will be documented in the next Integrated Report once the TMDLs in this document have been approved by EPA. The proposed changes in this section are not considered official until reviewed and approved by EPA during the next Integrated Report submittal process.

ID17040201SK007_05, Crow Creek—source to Willow Creek

- Listed for sediment in Category 5 in the 2022 Integrated Report in the Idaho Falls subbasin (DEQ 2022). The subbasin boundary changed incorporating this AU into Willow Creek subbasin, but the AU number still reflects the Idaho Falls subbasin.
- The AU consists of main stem of Willow Creek downstream of Ririe Reservoir. AU is located in the most northern portion of the subbasin.
- No sediment data was collected for this AU.
- The AU should remain in Category 5 for sediment.

ID17040205SK004_05, Willow Creek—Bulls Fork to Ririe Reservoir

- Listed for temperature, sediment, and nutrients in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of main stem of Willow Creek just upstream of Ririe Reservoir in the northern portion of the subbasin.
- The 2004 Willow Creek subbasin temperature TMDL was not revised based on PNV methodology. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. AU should remain in Category 4a for temperature.
- No field data was collected for this AU since the 2004 TMDL document.
- The AU should remain in Category 4a for sediment and nutrients.

ID17040205SK005_02, Willow Creek—Birch Creek to Bulls Fork

- Listed for temperature in Category 4a and combined biota/habitat bioassessments in Category 5 in the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries to Willow Creek including Rock, Noon, and Badger Creeks. AU is located north of Bone in the northwestern portion of the subbasin.
- The 2004 Willow Creek subbasin temperature TMDL was revised due to considerable changes in methodology. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A temperature TMDL was revised using the PNV analysis for this AU. AU should remain in Category 4a for temperature.
- The SEI performed on Rock Creek indicates excess erosion. SEIs are not used as an assessment tool. The last BURP assessment was in 1997 and resulted in a failing score. More field investigation for sedimentation is warranted. AU should remain in Category 5 for combined biota/habitat bioassessments.
- The AU was unlisted for *E. coli* but evaluated in 2016. Five *E. coli* bacteria samples taken from Rock Creek resulted in a geometric mean of 110.8 cfu/100 mL and a statistical threshold value of 145.4 cfu/100 mL, meeting the criteria standards. No *E. coli* TMDL was created.

ID17040205SK005_04, **Willow Creek—Birch Creek to Bulls Fork**

- Listed for temperature in Category 5 and nutrients in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of the main stem of Willow Creek. AU is located north of Bone in the northwestern portion of the subbasin.
- The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not completed for this AU. AU should remain in Category 5 for temperature.
- The last attempt to conduct a BURP assessment for this AU was in 2013 but access was denied.
- Nutrient data was not collected for this AU due to denied access. AU should remain in Category 4a for nutrients.

ID17040205SK005_05, Willow Creek—Birch Creek to Bulls Fork

- Listed for temperature in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of the main stem of Willow Creek. AU is located north of Bone in the northwestern portion of the subbasin.
- The AU was accessed by BURP in 2016 with a passing score of 2.33 and a flow of 50 cubic feet per second (cfs). An attempt to visit the site in 2006 and 2019 resulted in no score due to inaccessibility because of high flows.
- Temperature logger data from 2016 show beneficial use criteria were exceeded.
- The 2004 Willow Creek subbasin temperature TMDL was not revised based on PNV methodology. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. AU should remain in Category 4a for temperature in the next Integrated Report.
- Additionally, this AU was a part of the completed nutrient TMDL in 2004. However, it was never added to the § 303(d) list. Sampling efforts in 2003 and 2016 have consistently shown exceedances in total phosphorus concentrations in this AU, and a TMDL was completed. Nitrogen as nitrite + nitrate sampling resulted in no exceedance. This unlisted AU should be listed in Category 4a for total phosphorus once the TMDL is approved.

ID17040205SK008_02, **Willow Creek—Mud Creek to Birch Creek**

- Listed in Category 5 for combined biota/habitat bioassessments, temperature, and *E. coli* in the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries of Willow Creek including Twin and Canyon Creeks just southeast of Bone in the west-central portion of the subbasin.

- Temperature logger data in 2018 show beneficial use criteria were exceeded. Solar Pathfinder readings taken on Mud and Twin Creeks showed a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was completed for this AU. AU should move to Category 4a for temperature once TMDL is approved.
- Five *E. coli* bacteria samples taken from Canyon Creek resulted in a geometric mean of 241.9 cfu/100 mL and a statistical threshold value of 951.1 cfu/100 mL, failing the criteria standards. A bacteria TMDL was completed. The AU should move to Category 4a for *E. coli* once TMDL is approved.
- Low SMI, SHI, and SFI scores generated from BURP data resulted in the original listing for combined biota/habitat bioassessment. Little stream condition data is available for this AU as the last BURP assessment was completed in 1997. A 2014 SEI resulted in no load reduction needed, suggesting sediment is not a likely cause of impairment. However, SEIs are not used as an assessment tool. More field investigation for sedimentation is warranted. AU should remain in Category 5 for combined biota/habitat bioassessments.

ID17040205SK008_04, **Willow Creek—Mud Creek to Birch Creek**

- Listed for temperature in Category 5 and total phosphorus in Category 4a in the 2022 Integrated Report (DEQ 2022). The total phosphorus listing was previously under the nutrient/eutrophication biological indicators parameter in earlier integrated reporting cycles.
- The AU consists of the main stem of Willow Creek east of Bone in the central portion of the subbasin.
- The last BURP site assessment was in 1995 resulting in a failing score.
- The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not completed for this AU. AU should remain in Category 5 for temperature.
- The 2016 bacteria concentration samples resulted in an exceedance of the total phosphorus criteria but not an exceedance of the nitrogen as nitrite + nitrate criteria. The total phosphorus TMDL was revised based on the 2016 sampling event. The AU should remain in 4a for total phosphorus.
- Five *E. coli* bacteria samples taken from Willow Creek resulted in a geometric mean of 61 cfu/100 mL and a statistical threshold value of 252.8 cfu/100 mL, passing the criteria standards. A bacteria TMDL was not completed.

ID17040205SK009_02, Mud Creek—source to mouth

- Listed in Category 5 for combined biota/habitat bioassessments and temperature in the 2022 Integrated Report (DEQ 2022).
- The AU consists of Mud Creek located south of Bone in the western portion of the subbasin.
- Temperature logger data in 2020 show SS and COLD beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not completed for this AU.
- Low SMI, SHI, and SFI scores generated from BURP data in 1997 resulted in the original listing for combined biota/habitat bioassessment. A 2014 SEI resulted in no load reduction needed, suggesting sediment is not a likely cause of impairment. However, SEIs are not used as an assessment tool. More field investigation for sedimentation is warranted. AU should remain in Category 5 for combined biota/habitat bioassessments.

ID17040205SK010_02, Sellars Creek—source to mouth

- Listed for temperature in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of Sellars and South Fork Sellars Creeks southwest of Bone in the western portion of the subbasin.
- Data from a BURP assessment at both creeks in 2014 resulted in passing scores of 2.67 and 3.00.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a.

ID17040205SK010_03, Sellars Creek—source to mouth

- Listed for temperature and sedimentation in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of Sellars Creek south of Bone in the western portion of the subbasin.
- Data from a BURP assessment from 2016 resulted in a failing score of 1.67 due to the fish index. The habitat score showed improvement over time based on scores from 2001 and 2003.
- Temperature logger data collected in 2016 show SS and COLD beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU.

- The SEI performed on Sellars Creek in 2016 shows a lack of stable banks but an overall improving trend compared to 2004 TMDL. AU should remain in Category 4a for sedimentation.

ID17040205SK011_02, Willow Creek—Crane Creek to Mud Creek

- Listed for sedimentation/siltation in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries of Willow Creek including Seventy, Strawberry, and Hancock Creeks south of Bone in the west-central portion of the subbasin.
- Several attempts to collect BURP data in 2010 and 2003 for this AU resulted in dry, no flow conditions.
- No other field data was collected. AU should remain in Category 4a for sediment.

ID17040205SK011_04, Willow Creek—Crane Creek to Mud Creek

- Listed for temperature, total phosphorus, and sedimentation/siltation in Category 4a in the 2022 Integrated Report (DEQ 2022). The total phosphorus listing was previously under the nutrient/eutrophication biological indicators parameter in earlier Integrated Report cycles.
- The AU consists of Willow Creek south of Bone in the west-central portion of the subbasin.
- The last BURP assessment in 2016 was not sampled due to a presence of a beaver complex.
- Temperature logger data collected in 2016 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a.
- Nutrient samples for the AU resulted in exceedance of total phosphorus criteria but not nitrogen as nitrite + nitrate criteria. The TMDL was revised. AU should remain in Category 4a for total phosphorus.
- The SEI performed on Willow Creek in 2016 shows improvement of stable banks compared to 2004. Further field investigation for sediment is warranted. AU should remain in Category 4a.

ID17040205SK012_02, Mill Creek—source to mouth

- Listed for temperature and sediment in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries of Willow Creek including Alley Lyons, Mill, Levi Hawkley, and Buckley Creeks. AU is south of Bone in the western portion of the subbasin.
- A BURP site assessment has not been completed since 2001.
- Temperature logger data collected in 2018 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream

widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a for temperature.
- No field investigation of sediment was performed. AU should remain in Category 4a for sediment.

ID17040205SK012_03, Mill Creek—source to mouth

- Listed for temperature and sedimentation/siltation in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of Mill Creek south of Bone in the western portion of the subbasin.
- A BURP assessment of the site in 2016 received an overall score of 2.0 with good macroinvertebrate and habitat scores. Previous visits resulted in inaccessibility in 2010 and access denied in 2004.
- Temperature logger data collected in 2016 show SS and COLD beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. AU should remain in Category 4a for temperature.
- The SEI performed on Mill Creek in 2016 shows a lack of stable banks when compared to the 2004 TMDL. AU should remain in Category 4a for sediment.
- *E. coli* bacteria samples taken from Mill Creek, which is unlisted for *E. coli*, resulted in a geometric mean of 128.4 cfu\100 mL and a statistical threshold value of 1,130.9 cfu\100 mL, exceeding the criteria standards. An *E. coli* TMDL was completed. AU should be listed in Category 4a in the next Integrated Report once the *E. coli* TMDL is approved.

ID17040205SK013_02, Willow Creek—source to Crane Creek

- Listed for temperature, sediment, and total phosphorus in Category 4a in the 2022 Integrated Report (DEQ 2022). The total phosphorus listing was previously under the nutrient/eutrophication biological indicators parameter in earlier Integrated Report cycles.
- The AU consists of Pack Saddle, Deer, and Willow Creeks west of Grays Lake in the western most portion of the subbasin.
- The last attempt to collect BURP data was in 2004 and resulted in no score due to dry conditions.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a for temperature.
- No field investigation of sediment was performed. AU should remain in Category 4a for sediment.
- Nutrient data was not collected in 2016 due to dry conditions. AU should remain in Category 4a for total phosphorus.

ID17040205SK013_03, Willow Creek—source to Crane Creek

- Listed for temperature and nutrient/eutrophication biological indicators in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of Willow Creek west of Grays Lake in the western most portion of the subbasin.
- A BURP site assessment was attempted in 2011. Access was denied.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a for temperature.
- Nutrients data was not collected due to denied access. The AU should remain in Category 4a for nutrient/eutrophication biological indicators.

ID17040205SK014_02, Crane Creek—source to mouth

- Listed for sediment in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries of Willow Creek including Spring, Sheep, Middle, and Crane Creeks. AU is located west of Grays Lake in the southwestern portion of the subbasin.
- Two BURP site assessments in 2004 on different tributaries were not conducted due to dry conditions and denied access.
- No field investigation of sedimentation was performed. AU should remain in Category 4a for sediment.

ID17040205SK014_03, Crane Creek—source to mouth

- Listed for sediment in Category 4a in the 2022 Integrated Report (DEQ 2022).
- The AU consists of Crane Creek west of Grays Lake in the western portion of the subbasin.
- Two BURP site assessments from 2010 resulted both in no scores because the habitat index was the only score at a 1.0 and the other site had dry conditions. An assessment in 2004 was not scored due to inaccessibility.
- No field investigation of sedimentation was performed. AU should remain in Category 4a for sediment.

ID17040205SK016_04, Grays Lake outlet—Hell Creek to mouth

- Listed for temperature in Category 4a in the 2022 Integrated Report (DEQ 2022).
- AU consists of Grays Lake Outlet northeast of Bone in the central portion of the subbasin.
- The last BURP site assessment was in 1995 with a failing score of 1.33.
- The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed.

A PNV temperature TMDL was not revised for this AU. AU should remain in Category 4a for temperature.

ID17040205SK017_04, Grays Lake outlet—Homer Creek to Hell Creek

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Grays Lake Outlet east of Bone in the central portion of the subbasin.
- The AU has not been assessed using BURP—in 2010, the attempted site exhibited lentic conditions and in 2007, the attempted site was inaccessible.
- The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. AU should remain in Category 4a for temperature.

ID17040205SK018_02, Homer Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries of Willow Creek including Chicken, Evert, and Homer Creeks. The AU is located northwest of Grays Lake in south-central portion of the subbasin.
- The BURP monitoring was last attempted in this AU in 2010, but the stream was dry.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a for temperature.
- No field investigation of sedimentation was performed. AU should remain in Category 4a for sediment.

ID17040205SK018_03, Homer Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Homer Creek northwest of Grays Lake in the south-central portion of subbasin.
- The BURP data in 2016 resulted in an overall score of 1.67 with passing fish and habitat scores. In 2010, the site was inaccessible. In 2004, the site resulted in very low scores.
- Temperature logger data collected in 2016 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a for temperature.
- The SEI performed on Homer Creek in 2016 shows a continuous lack of stable banks compared to the 2004 TMDL. AU should remain in Category 4a for sediment.

ID17040205SK019_04, Grays Lake outlet—Brockman Creek to Homer Creek

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Grays Lake Outlet northwest of Grays Lake in the central portion of the subbasin.
- The BURP data in 2015 resulted in an overall passing score of 2.0 with no fish index score. In 2010, the site was deemed inappropriate for BURP monitoring, because conditions were too similar to lake or reservoir (lentic) conditions.
- Temperature logger data collected in 2016 show COLD and SS beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. AU should remain in Category 4a for temperature.

ID17040205SK020_02, Grays Lake outlet—Grays Lake to Brockman Creek

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Grays Lake Outlet tributaries just downstream of Grays Lake in the southern portion of the subbasin.
- No BURP data exists for this AU.
- Aerial imagery from Grays Lake outlet showed a lack of channel formation. Improper assessment of intermittent, dewatered, or ephemeral stream. Does not qualify in a sampleable category for BURP assessment. A PNV temperature TMDL was not revised, as no definable channel is present. Flow data should be collected to evaluate and potentially move this AU to Category 4c in the future. The AU should remain in Category 4a for temperature.

ID17040205SK020_04, Grays Lake outlet—Grays Lake to Brockman Creek

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Grays Lake Outlet just downstream of Grays Lake in the southern portion of the subbasin.
- Last BURP data was collected in 2003, with a failing score of 1.0.
- Temperature logger data collected in 2018 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.

ID17040205SK021_02, **Grays Lake—1st- and 2nd-order tributaries**

- Listed for temperature in Category 5 of the 2022 Integrated Report (DEQ 2022).
- The AU consists of tributaries to Grays Lake including Grays Lake and Clark, Eagle, Harrison, Jones, North Fork Eagle, Willow, and Bridge Creeks. The AU surrounds Grays Lake in the southern portion of the subbasin.

- The BURP data in 2013 resulted in an overall score of 3.0. The last two attempts to conduct a BURP site assessment were in 2008 and 2007 with no score because of dry conditions and inaccessibility, respectively.
- Temperature logger data in 2016 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was completed for this AU. The AU should move to Category 4a for temperature in the next Integrated Report once the PNV temperature TMDL is approved.

ID17040205SK023_02, Gravel Creek—source to mouth

- Listed for *E. coli* in Category 5 of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Gravel and Wayan Creeks south of Wayan in the southern most portion of the subbasin.
- *E. coli* bacteria samples taken from Gravel Creek resulted in a geometric mean of 229.5 cfu\100 mL and a statistical threshold value of 847.6 cfu\100 mL, exceeding the criteria standards. An *E. coli* TMDL was completed. The AU should be moved to Category 4a in the next Integrated Report once the *E. coli* TMDL is approved.

ID17040205SK024_02, Brockman Creek—Corral Creek to mouth

- Listed for *E. coli* in Category 5 and sediment and temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Brockman, Duckworth, House, and Shirley Creeks. The AU is north of Grays Lake in the eastern portion of the subbasin.
- The BURP data was last assessed in 1998 with an overall failing score.
- *E. coli* bacteria samples taken from Shirley Creek resulted in a geometric mean of 441.5 cfu\100 mL and a statistical threshold value of 1,755.0 cfu\100 mL, exceeding the mean criteria standards. An *E. coli* bacteria TMDL was completed. The AU should be moved to Category 4a of the Integrated Report once the *E. coli* bacteria TMDL is approved.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.
- A McNeil sediment core was performed resulting in 27% fines just under the 28% fines threshold. While this assessment shows the AU to be improving, further BURP investigation is warranted. AU should remain in Category 4a for sediment.

ID17040205SK024_03, Brockman Creek—Corral Creek to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Brockman Creek north of Grays Lake in the eastern portion of the subbasin.

- The last BURP site assessment was in 2008 resulting in no score because of dry conditions.
- Temperature logger data collected in 2016 show SS and COLD beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. The AU should remain in Category 4a for temperature.
- The SEI performed on Brockman Creek in 2017 shows bank stability improvement compared to the 2004 TMDL. Further field investigation of sedimentation is warranted. The AU should remain in Category 4a for sediment.

ID17040205SK025_02, Brockman Creek—source to Corral Creek

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Brockman Creek north of Grays Lake in the eastern most portion of the subbasin.
- The last BURP data was collected in 2003 resulting in an overall failing score or 1.0.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.
- No field investigation for sedimentation was performed. The AU should remain in Category 4a for sediment.

ID17040205SK025_03, Brockman Creek—source to Corral Creek

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Brockman Creek north of Gray Lake in the eastern portion of the subbasin.
- No BURP data exist for this AU.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.

ID17040205SK026_02, Corral Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Corral Creek north of Grays Lake in the eastern portion of the subbasin.
- The last BURP assessment was conducted in 2003 with an overall failing score of 1.0.

- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.
- The SEI performed on Corral Creek in 2017 shows an improvement in bank stability compared to the 2004 TMDL. Further field investigation of sedimentation is warranted. The AU should remain in Category 4a for sediment.

ID17040205SK027_02, Sawmill Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Sawmill Creek north of Grays Lake in the eastern portion of the subbasin.
- The last BURP assessment was conducted in 2003 with an overall failing score of 1.0.
- The PNV analysis shows that this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. AU should remain in Category 4a for temperature.
- No field investigation of sediment was performed. AU should remain in Category 4a for sediment.

ID17040205SK028_02, Lava Creek—source to mouth

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Lava, North Fork Lava, and South Fork Lava Creeks located north of Grays Lake in the eastern portion of the subbasin.
- The last BURP assessment was conducted in 1996 with an overall failing score of 1.67.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.

ID17040205SK028_03, Lava Creek—source to mouth

- Listed for temperature and sedimentation in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Lava Creek located northwest of Grays Lake in the eastern portion of the subbasin.
- The last BURP assessment was conducted in 2016 with an overall passing score of 2.0 with each index receiving a score of 2.0.
- Temperature logger data collected in 2016 show SS and COLD beneficial use criteria were exceeded. The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.

- The SEI performed on Lava Creek in 2016 shows a continuous lack of stable banks when compared to 2004 TMDL. The AU should remain in Category 4a for sediment.

ID17040205SK029_02, Hell Creek—source to mouth

- Listed for temperature in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Hell and Dan Creeks located east of Bone in the eastern portion of the subbasin.
- The last BURP assessments were conducted in 2003 resulting in dry stream conditions.
- The PNV analysis and aerial imagery shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.

ID17040205SK029_03, Hell Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Hell Creek located east of Bone in the eastern portion of the subbasin.
- The last BURP assessments were conducted in 2006 and 2005 resulting in inaccessible and dry conditions, respectively.
- Temperature logger data collected in 2016 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. The AU should remain in Category 4a for temperature.
- The SEI performed on Hell Creek in 2016 shows a lack of stable banks when compared to the 2004 TMDL. The AU should remain in Category 4a for sediment.

ID17040205SK030_02, **Bulls Fork—source to mouth**

- Listed for combined biota/habitat bioassessments and temperature in Category 5 of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Bulls Fork located northeast of Bone in the northeastern portion of the subbasin.
- Low SMI, SHI, and SFI scores generated from BURP data resulted in the original listings for combined biota/habitat bioassessment. Little stream condition data exists for this AU as the last BURP assessment was completed in 1997 and documented as dry in 2003. A 2014 SEI resulted in no load reduction needed, suggesting sediment is not a likely cause of impairment. However, SEIs cannot be used as an assessment tool. Further field investigation of sedimentation is warranted. The AU should remain in Category 5 for combined biota/habitat bioassessments.

- Temperature logger data in 2017 and 2018 show SS beneficial use criteria were exceeded. The PNV analysis shows this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not completed for this AU. The AU should remain in Category 5 for temperature.

ID17040205SK031_02, Tex Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Carlisle, Indian Fork, Peterson, Pipe , and Tex Creeks. The AU is located northeast of Bone in the northeastern portion of the subbasin.
- The last BURP assessment attempt was in 2007, but it was inaccessible.
- The PNV analysis shows this AU has a lack of available shade from riparian vegetation when compared to shade targets for similar vegetation types and stream widths resulting in an excess solar load. A PNV temperature TMDL was revised for this AU. The AU should remain in Category 4a for temperature.
- No field investigation of sedimentation was performed. The AU should remain in Category 4a for sediment.

ID17040205SK031_03, Tex Creek—source to mouth

- Listed for temperature and sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Tex Creek just upstream of Ririe Reservoir in the northeastern portion of the subbasin.
- The BURP assessment visit in 2016 had dry conditions. In 2008, one visit resulted in an overall failing score of 1.5, and on a second attempt, the site was inaccessible. A visit in 2004 had limited access.
- Temperature logger data collected in 2016 show SS beneficial use criteria were exceeded. The PNV analysis shows that this AU is currently meeting its shade targets. The analysis considers the entire AU and includes stream segments that are not meeting shade targets. Other sources of disturbance may be contributing to the elevated stream temperatures. Further investigation of potential excess heat load should be completed. A PNV temperature TMDL was not revised for this AU. The AU should remain in Category 4a for temperature.
- The SEI performed on Tex Creek in 2016 shows a continued lack of stable banks compared to the 2004 TMDL. The AU should remain in Category 4a for sediment.

ID17040205SK032_02, Meadow Creek—source to Ririe Reservoir

- Listed for sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Blue, Deep, Meadow, Mud Spring, and Spring Creeks. The AU is east of Ririe Reservoir in northeastern portion of subbasin.

- The last two BURP site assessment attempts were in 2003 and had dry stream conditions.
- The SEI conducted in Meadow Creek in 2017 shows improved streambank stability compared to the 2004 TMDL. Further field investigation of sedimentation is warranted. AU should remain in Category 4a for sediment.

ID17040205SK032_03, Meadow Creek—source to Ririe Reservoir

- Listed for sediment in Category 4a of the 2022 Integrated Report (DEQ 2022).
- The AU consists of Meadow Creek east of Ririe Reservoir in the northeast portion of the subbasin.
- Data from the BURP site assessment in 2016 was not collected because of the presence of a beaver complex.
- The SEI performed on Meadow Creek in 2017 shows improvement in bank stability when compared to the 2004 TMDL. Further field investigation of sedimentation is warranted. The AU should remain in Category 4a for sediment.

3 Pollutant Source Inventory

Pollutant sources fall into two broad classes: point sources and nonpoint sources. The CWA defines point sources as discernable, confide, and discrete conveyances, including but not limited to pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operations, or vessel or other floating craft, from which pollutants are or may be discharged (CWA § 502(14)). Some examples of common point sources include discharges from municipal waste water treatment facilities, mines, and industrial operations. Nonpoint source is defined as any source of water pollution that does not meet the legal definition of point source as defined by the CWA. Nonpoint sources of pollution generally result from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. Nonpoint source pollution, unlike point sources, comes from many diffuse sources. Nonpoint source pollution can include excess fertilizers applied to agricultural or residential areas; sediment from constructions sites, crop and forested lands, and eroding streambanks; bacteria for livestock and pet waste; atmospheric deposition, and others (EPA 2020).

Pollution within the Willow Creek subbasin is primarily from nonpoint sediment, temperature, nutrients, and bacteria loading.

3.1 Point Sources

No known point sources discharge directly to the Willow Creek subbasin tributaries. Willow Creek subbasin is rural with very small towns (population < 250) within its borders and no municipal or industrial dischargers that would need an Idaho Pollutant Discharge Elimination (IPDES) permit. There are also no fish hatcheries, a common discharger in rural watersheds, within the subbasin.

3.2 Nonpoint Sources

Most of the land use in the Willow Creek subbasin is agriculture and rangeland. Nonpoint sources of pollution associated with these land uses include increased sediment delivery, temperature loading, and elevated bacteria.

The primary source of nonpoint source pollution to the majority of streams in the Willow Creek subbasin results from riparian habitat degradation. Reduced shade from riparian vegetation on portions of streams is a significant contributor to temperature loading from solar radiation. As stabilizing vegetation is removed from streambanks, they become unstable and erode increasing sediment loads. *E. coli* levels are also often associated with riparian grazing and increased sediment and temperature loading. Unpaved roads provide another source of nonpoint source pollution as fine sediment can leave roads and enter streams during rainfall events.

3.3 Pollutant Transport

Pollutant transport refers to the pathway by which pollutants move from the pollutant source to cause a problem or water quality violation in the receiving water body. Streambank erosion, road erosion, and mass wasting are the three principal sources of sediment load in the subbasin—erosion from these sources peaks during spring runoff and occasional high precipitation events.

4 Pollution Control Efforts and Monitoring

In addition to developing new TMDLs for impaired streams within the Willow Creek subbasin, this document contains a 5-year review of previously developed Willow Creek subbasin TMDLs to comply with Idaho Code § 39-3611(7). The 5-year review evaluates the current water quality status of the streams, for which TMDLs have already been developed and describes current water quality status and monitoring DEQ completed during the field seasons. Pollution control efforts that have occurred since the last developed TMDL is also discussed in this section.

4.1 TMDL Review and Status

4.1.1 Temperature Monitoring

Temperature TMDLs that were established in 2004, were reanalyzed using the newer PNV method. Eighteen out of 29 AUs received revised TMDLs (Table B). The remaining 11 AUs did not show any shade deficiencies with the new method. Therefore, no changes were made and should remain in Category 4a until further assessment is conducted. The analysis of the PNV method for all listed AUs is further discussed in section 5.1.

4.1.2 Nutrient Monitoring

High nutrient concentrations in the water column along with nuisance levels of aquatic plant growth were detected in Willow Creek, according to the 2004 TMDL. To address the excess nutrients, allocations for total phosphorus and nitrogen were developed for Willow Creek in 2004 prescribing a 23% and 67% reduction in loading, respectively. Numeric criteria used for the allocations for total phosphorus and nitrogen as nitrite + nitrate in the water column were targets less than 0.05 mg/L and less than 0.3 mg/L, respectively.

Three AUs are listed in Table 5 for nutrient/eutrophication biological indicators: ID17040205SK004_05, ID17040205SK005_04, and ID17040205SK013_03. Sampling has not been performed in these AUs since the original TMDL due to lack of access, landowner permission, or dry conditions. No changes were made, and the AUs should remain in Category 4a until further assessment is conducted.

Table 5. Category 4a AUs listed in the 2022 Integrated Report for nutrients.

Assessment Unit	Pollutant
Willow Creek—Bulls Fork to Ririe Reservoir (ID17040205SK004_05)	Nutrient/eutrophication biological indicators
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	Nutrient/eutrophication biological indicators
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	Total phosphorus
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	Total phosphorus
Willow Creek—source to Crane Creek (ID17040205SK013_02)	Total phosphorus
Willow Creek—source to Crane Creek (ID17040205SK013_03)	Nutrient/eutrophication biological indicators

Three AUs are listed in Table 5 for total phosphorus. AUs ID17040205SK008_04 and ID17040205SK011_04 were sampled in 2016 for total phosphorus and nitrogen as nitrite + nitrate (Table 6). The nitrogen samples continue to meet criteria; however, total phosphorus samples continue to exceed criteria based on the same numeric targets used in the 2004 nutrient TMDL. Additionally, in the previous TMDL document, combined AUs represented water bodies that were commonly used to create one TMDL instead of a TMDL created for each individual AU. This TMDL was revised to show an individual TMDL for each AU. Revised TMDLs for AUs ID17040205SK008_04 and ID17040205SK011_04 are further discussed in section 5.3 with an unlisted AU that received a total phosphorus TMDL due to exceedance of criteria (ID17040205SK005_05). ID17040205SK013_02 was not sampled in 2016 due to dry conditions and should remain in Category 4a with no revision.

Table 6. 2016 nutrient-based water quality summary data from AUs listed in Category 4a for Willow Creek subbasin. These results show the highest concentration from samples collected.

Assessment Unit	Latitude	Longitude	Average Discharge (cfs)	N as NO_2 + NO_3 (mg/L)	Total Phosphorus (mg/L)
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	43.3092	-111.7744	25.8	0.009	0.067
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	43.2488	-111.7531	17.6	0.016	0.071

4.1.3 Sediment Monitoring

The 2004 TMDL established sediment loads for impaired streams within the Willow Creek subbasin. There are 22 AUs listed for sediment in the 2022 Integrated Report but not all were reviewed due to limited field access and data collection. Monitoring data was collected using SEIs, BURP site assessments, and McNeil sediment core quality data. Monitoring points for the TMDLs were chosen in areas that are publicly accessible and represent the subbasin. The objective of these monitoring efforts is to evaluate the long-term recovery of the subbasin, better understand natural variability, track the progress of implementation projects, and evaluate best management practices (BMPs) as they are developed.

Idaho's "Water Quality Standards" (IDAPA 58.01.02) for sediment is narrative; no specific quantitative value is established in Idaho code. Numeric targets for the TMDLs were set using a collection of literature sources that provided information relating numeric values to the attainment of beneficial uses. Table 7 outlines numeric sediment targets set for the TMDLs in the Willow Creek subbasin (DEQ 2004).

Table 7. Pollutant targets established for the Willow Creek subbasin.

Pollutant	Parameter	Numeric Target
Sediment	Streambanks	>80% stability
Sediment	Unimproved/unsurfaced roadways	50% the current loading rate
Sediment	Subsurface sediment	<28% fine sediment (<6.35 mm)

No major changes in land use, landownership, or population in the subbasin have occurred since the TMDL was approved in 2004 that would have either significantly improved or degraded water quality in the Willow Creek subbasin. For the most part, land use, landownership, and population have remained unchanged. Beneficial uses for AUs in the Willow Creek subbasin are presented in section 2.2.1, Table 2.

Load capacities were determined by calculating the load of sediment to the stream from eroding streambanks when 80% of the banks are stable with no erosion (natural condition or load capacity). Current loads were calculated using SEI estimates of current bank conditions. These two loads are compared to assess how much excess sediment is entering the stream from the banks and what percent reduction of the load is needed to meet target loads (Table 8). Further explanation is found in the 2004 Willow Creek subbasin TMDL (DEQ 2004). In the 2004 TMDL, Meadow Creek received total load allocations using both SEIs and the Water

Erosion Prediction Project Model (WEPP) to evaluate sediment delivery from unsurfaced roads. WEPP modeling was conducted for both Tex and Meadow Creeks in 2004, but an additional sediment load was only added to the total load allocation on Meadow Creek. The load allocations were converted from ton per mile per year (t/mi/yr) as they were originally reported in the 2004 TMDL to pound per mile per day (lb/mi/day) using the ratio of 2,000 lb/1 ton x 1 yr/365 day.

Table 8. 2004 sediment load allocations for Willow Creek subbasin.

Assessment Unit		Current Load Existing Erosion Rate (lb/mi/day)	Load Capacity Erosion Rate (lb/mi/day)	Load Allocation Total Erosion Rate Reduction (lb/mi/day)	Total Erosion % Reduction to Meet Load Capacity
Sellars Creek—source to mouth (ID17040205SK010_03)		1,666	60	-1,605	96
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_02)		1,578	60	-1,518	96
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)		1,167	77	-1,090	93
Mill Creek—source to mouth (ID17040205SK012_03)		142	44	-99	68
Crane Creek—source to mouth (ID17040205SK014_03)		942	137	-805	86
Homer Creek—source to mouth (ID17040205SK018_03)		2,252	110	-1,978	95
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)		2,104	137	-1,967	93
Corral Creek—source to mouth (ID17040205SK026_02)		1,222	99	-1,140	92
Sawmill Creek—source to mouth (ID17040205SK027_02)		1,863	104	-1,759	94
Lava Creek—source to mouth (ID17040205SK028_03)		2,942	88	-2,855	97
Hell Creek—source to mouth (ID17040205SK029_03)		2,203	214	-1,989	90
Tex Creek—source to mouth (ID17040205SK031_03)		44	22	-22	50
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_02)	Bank	268	110	-159	59
	Road	60	33	-27	45
	Total	329	142	-186	57

Note: 2004 TMDL conversion from t/mi/yr to lb/mi/day using the ratio of 2,000 lb/1ton x 1 yr/365 day.

4.1.4 Streambank Erosion Inventories

In 2016 and 2017, DEQ conducted SEIs for several Category 4a AUs, as part of the 5-year review of the existing TMDLs from 2004 (Table 9). The SEI surveys were performed on representative

stream segments to determine whether management practices, implemented since the 2004 TMDL, are potentially reducing sediment loads and bank erosion. The SEIs are not used as an assessment tool, and the values calculated for loads are not meant to update the previous TMDLs. However, the results can be used as a trend analysis tool to compare loads and bank stability to indicate when an AU is potentially improving or declining in habitat condition. Additional detail about SEIs is discussed in section 2.3.7. The SEI calculation worksheets are included in Appendix C.

Table 9. SEI sampling locations for AUs listed in Category 4a for sediment.

Assessment Unit	Downstream		Upstream	
	Latitude	Longitude	Latitude	Longitude
Sellars Creek—source to mouth (ID17040205SK010_03)	43.3608	-111.8347	43.2622	-111.8345
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	43.2488	-111.7533	43.2470	-111.7551
Mill Creek—source to mouth (ID17040205SK012_03)	43.2171	-111.7973	43.2172	-111.7996
Homer Creek—source to mouth (ID17040205SK018_03)	43.2029	-111.6387	43.2014	-111.6376
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	43.2123	-111.4933	43.2145	-111.4900
Corral Creek—source to mouth (ID17040205SK026_02)	43.2657	-111.4533	43.2409	-111.4568
Lava Creek—source to mouth (ID17040205SK028_03)	43.2576	-111.5739	43.2585	-111.5734
Hell Creek—source to mouth (ID17040205SK029_03)	43.3294	-111.6818	43.3296	-111.6812
Tex Creek—source to mouth (ID17040205SK031_03)	43.4331	-111.7099	43.4333	-111.7060
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_02 and ID17040205SK032_03)	43.5161	-111.6908	43.5128	-111.6904

Percent bank stability measures progress toward reaching a surrogate sediment target of at least 80% bank stability. Increasing streambank stability is a means of reducing subsurface fine sediment deposition, which affects COLD and SS habitats. Table 10 shows bank stability comparison between TMDL data from 2004 to data collected in the 2016–2017 field season.

Table 10. Bank stability comparison of SEI data.

Assessment Unit	2017 Bank Stability (%)	2004 Bank Stability (%)	Condition Trend
Sellars Creek—source to mouth (ID17040205SK010_03)	64.5	—	—-
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	91.5	73.2	Improving
Mill Creek—source to mouth (ID17040205SK012_03)	65	90.2	Declining
Homer Creek—source to mouth (ID17040205SK018_03)	0	77.2	Declining

Assessment Unit	2017 Bank Stability (%)	2004 Bank Stability (%)	Condition Trend
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	99.6	50	Improving
Corral Creek—source to mouth (ID17040205SK026_02)	99.8	50	Improving
Lava Creek—source to mouth (ID17040205SK028_03)	48.1	76.2	Declining
Hell Creek—source to mouth (ID17040205SK029_03)	37.8	78.2	Declining
Tex Creek—source to mouth (ID17040205SK031_03)	9.1	57	Declining
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_03)	99.9	89.8	Improving

Bank stability appears to be improving in four out of nine AUs by 10% to 50% (Table 10). The other five AUs show a trend toward declining conditions since 2004 with one AU not compared (Table 10). The percent load reduction necessary to meet streambank stability targets are compared to the previous TMDL effort to determine the overall trend in stream sediment loads (Table 11). Investigation of aerial imagery shows that land use and road condition have not changed since the 2004 TMDL, so the road erosion sediment load calculated for Meadow Creek in 2004 was not applied in this 5-year review for comparison.

Table 11. TMDL load allocation comparison based on SEI data.

Assessment Unit	2017 Sediment Load (lb/mile/day)	2017 Reduction Required (%)	2004 Sediment Load (lb/mile/day)	2004 Reduction Required (%)
Sellars Creek—source to mouth (ID17040205SK010_03)	395	85	1,666	96
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	6	0	1,167	93
Mill Creek—source to mouth (ID17040205SK012_03)	104	65	142	68
Homer Creek—source to mouth (ID17040205SK018_03)	1,200	95	2,252	95
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	15	0	2,104	93
Corral Creek—source to mouth (ID17040205SK026_02)	3	0	1,238	92
Lava Creek—source to mouth (ID17040205SK028_03)	537	83	2,942	97
Hell Creek—source to mouth (ID17040205SK029_03)	263	78	2,203	90
Tex Creek—source to mouth (ID17040205SK031_03)	1,507	90	44	50

Assessment Unit	2017 Sediment Load (lb/mile/day)	2017 Reduction Required (%)	2004 Sediment Load (lb/mile/day)	2004 Reduction Required (%)
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_03)	1	0	268	59

Note: 2004 TMDL conversion from t/mi/yr to lb/mi/day using the ratio of 2,000 lb/1ton x 1 yr/365 day.

The sediment loads have improved in 8 of 10 AUs examined (Table 11). Of these, four AUs apparently no longer require a load reduction (Table 11); however, this warrants further investigation and collection of additional field data to determine if sedimentation is still an existing impairment in these AUs.

4.1.5 Habitat Data

In sediment monitoring cases, the BURP habitat score (SHI2) is referenced along with the FSBI index score, which is a component of the BURP macroinvertebrate (SMI2) score. Additional details about BURP protocol is discussed in section 2.3. Table 12 presents six AUs listed for sediment along with the breakdown of their average SHI2 scores and FSBI score.

Table 12. BURP data for AUs assessed since 2004 with sediment TMDLs in the Willow Creek subbasin.

Assessment Unit	% Bank Stability (Average)	FSBI Score (Average)	% Fines (Average)	Wolman Score (Average)	SHI2 Habitat Scores (Average)
Sellars Creek—source to mouth (ID17040205SK010_03)	87	50	19	7	2
Mill Creek—source to mouth (ID17040205SK012_03)	100	0	36	9	3
Crane Creek—source to mouth (ID17040205SK014_03)	60	0	20	8	1
Homer Creek—source to mouth (ID17040205SK018_03)	98	30	7	10	2
Lava Creek—source to mouth (ID17040205SK028_03)	32	0	17	9	2
Tex Creek—source to mouth (ID17040205SK031_03)	91	0	95	5	2

Sellars Creek (ID17040205SK010_03) has a high FSBI score, Wolman score, and bank stability with a low % fines score portraying good quality habitat for biotic integrity. The SEI suggests a sediment load reduction is still needed—however, erosional conditions appear to be improving compared to the 2004 TMDL. During the SEI, it was noted that the area was grazed and trampled by animals and that a road followed along the creek. DEQ recommends another BURP site visit to provide additional assessment status.

Willow Creek (ID17040205SK011_04) was not monitored using BURP due to the presence of a beaver complex. The SEI indicated that a reduction in sediment load was not further needed. Further field investigation is warranted to assess the status of the sediment loading.

Mill Creek (ID17040205SK012_03) received a high SHI2 score including 100% bank stability. However, slightly elevated % fines and an FSBI score of 0 indicate there could still be an issue with sediment—a potential source being sediment transport from the upstream AU. The 2016 SEI survey, located along the 2016 BURP site, indicated that sediment reduction was still needed according to bank stability due to grazing and trampling of animals. However, the site has slightly improved when compared to the 2004 TMDL. Due to inconsistent finds, DEQ recommends another BURP site visit to further investigate sediment loading.

Crane Creek (ID17040205SK014_03) received a failing SHI2 score along with low bank stability and FSBI scores. An SEI was not conducted this AU. Homer Creek (ID17040205SK018_03), similar to Sellars Creek, has a high Wolman score and bank stability with low % fines and an overall SHI2 score of 2.0 indicating good habitat. However, the FSBI score is low, and the overall BURP score failed due to the SMI2 score. The SEI showed sediment reduction is still needed but little progress has resulted since the 2004 TMDL. DEQ noted that the area was heavily grazed. Additionally, the SEI survey was not located along the BURP site. Since both tools were performed in 2016, DEQ recommends another BURP site visit to better assess current conditions of sediment for the AU.

Brockman Creek (ID17040205SK024_03), Corral Creek (ID17040205SK026_02), and Meadow Creeks (ID17040205SK032_02 and ID17040205SK032_03) have not had a BURP assessment since before 2004. The SEI surveys performed on the creeks indicate there is no longer a sediment issue from bank instability. DEQ recommends conducting BURP site assessments before these AUs are considered for potential delisting. Lava Creek (ID17040205SK028_03) received a passing SHI2 score but had low bank stability and FSBI score. The SEI also indicated that sediment loading from bank instability showed the need for continued load reduction but is improving overall compared to the 2004 TMDL.

Hell Creek (ID17040205SK029_03) did not receive BURP scores due to dry and inaccessible conditions. The SEI indicated that a reduction in sediment load is still needed. Further field investigation should be attempted to assess the status of the sediment impairment from the BURP perspective. A BURP assessment along Tex Creek (ID17040205SK031_03) in 2008 resulted in a SHI2 score that passed but indicated that a sediment impairment still exists due to high % fines, low FSBI score, and lower Wolman pebble count score. The overall average BURP score failed due to low SMI2 score and no score for SFI2. Another BURP visit in 2016 noted dry conditions and no samples taken. An SEI was performed in 2016 near the 2016 BURP visit indicating sediment load reduction still necessary as it portraying declining conditions when compared to 2004 TMDL. DEQ noted that the channel was influenced by a culvert, road, and animal access and grazing.

Streambank erosion conditions appear to be to improving along four AUs and decreasing along five AUs. For the AUs that are meeting the 80% bank stability target, further investigation will

determine the extent of fine sediment deposition in stream bottoms and how sediment deposition impacts applicable beneficial uses. If fine sediment deposition in those AUs is determined to be at a level to support applicable beneficial uses, sediment could be removed as an impairment to the AU. Stream stabilization BMPs should continue to be implemented in the subbasin to make progress towards bank stability and fine sediment targets.

4.1.6 McNeil Sediment Core Quality Data

In 2020, DEQ collected fine sediment samples via McNeil method on Shirley Creek, within the Brockman Creek—Corral Creek AU (ID17040205SK024_02). McNeil sediment core samples can describe size composition of bottom materials in identified salmonid spawning locations (McNeil and Ahnell 1964). McNeil sediment core samples are taken by working a cylinder 4 to 6 inches into spawning habitat. The sediment collected is separated by grain size and measured to calculate the percentage of depth fines at the sample location. The percentage of intergravel fines less than 6.35 mm in diameter is correlated with expected fry survival. DEQ has a target for volcanic, granitic, and sedimentary watersheds that is less than 28% fine sediment (< 6.35 mm diameter) in identifiable spawning habitat. The McNeil sediment core worksheets are included in Appendix C.

Brockman Creek (ID17040205SK024_03) and its 2nd-order tributaries (ID17040205SK024_02) are listed in Category 4a for sediment/siltation. In Shirley Creek (ID17040205SK 024_02), streambed sediment composition met the 28% target with 27% fines. Although this assessment is showing the AU is improving, further investigation including a BURP site visit is warranted. If fine sediment deposition in those AUs is determined at a level to support applicable beneficial uses, sediment could be removed as an impairment. BMPs and streambank stabilization would contribute to improving streambed sediment size composition.

4.2 Past and Present Pollution Control Efforts

4.2.1 Responsible Parties

Table 13 summarizes the federal, state, and local governments; individuals; or entities involved in or responsible for implementing the TMDL.

Table 13. Designated management agencies and responsibilities for implementing the Willow Creek subbasin TMDLs.

Designated Management Agency	Resource Responsibility
Idaho Soil and Water Conservation Commission	Agriculture
Bureau of Land Management (BLM)	BLM land
US Forest Service (USFS) Caribou-Targhee National Forest	USFS land
US Fish and Wildlife Service	Grays Lake National Wildlife Refuge
Idaho Department of Fish and Game	Tex Creek Wildlife Management Area
Idaho Department of Lands	State endowment lands, timber harvest, and mining
County road departments: Bonneville and Bingham Counties	County roads

4.2.2 Activities Accomplished from 2005 to 2009

The Willow Creek watershed implementation plan indicates that annual status reviews should assess stated time frames and ensure BMPs are installed according to standards and specifications. The plan states that BMP effectiveness monitoring should be conducted on completed installations to ensure that the installation was adequate, is consistently operated with the correct maintenance schedules, and the BMPs are relatively effective in reducing water quality impacts. Table 14 outlines BMPs completed from 2005 to 2009. Beyond 2009, the extent to which BMPs have been installed, willing landowners have come forward, and nonpoint source pollutants have been reduced is unknown.

Table 14. Federal BMPs completed in the Willow Creek subbasin from 2005 to 2009.

Best Management Practice	BMP Number	Units	2005	2006	2007	2008	2009	Total
Access Control	472	Acre	—	—	—	—	3,801.5	3,801.5
Brush Management	314	Acre	—	1,904.3	—	—	320.0	2,224.3
Conservation Cover	327	Acre	708.7	1,732.0	1,421.8	746.0	4,833.8	9,442.3
Conservation Completion Incentive	—	—	—	—	1.0	—	—	1.0
Critical Area Planting	342	Acre	—	—	—	—	1.0	1.0
Fence	382	Feet	5,843.9	18,710.0	18,174.4	3,910.5	8,312.0	54,950.8
Forage Harvest Management	511	Acre	—	242.8	—	357.1	2,602.1	3,202.0
Heavy Use Area Protection	561	Acre	—	0.3	0.1	—	—	0.4
Irrigation Water Conveyance, Pipeline, High-Pressure, Underground, Plastic	430DD	Feet	—	—	—	—	6,536.0	6,536.0
Irrigation Water Conveyance, Pipeline, Steel	430FF	Feet	—	—	—	—	35.0	35.0
Irrigation Water Management	449	Acre	—	—	—	—	29.1	29.1
Nutrient Management	590	Acre	—	—	—	29.1	—	29.1
Pest Management	595	Acre	383.4	161.0	5,850.1	3,982.3	4,015.1	14,391.9
Pipeline	516	Feet	4,784.0	17,571.0	10,207.0	10,681.0	1,293.0	44,536.0
Prescribed Grazing	528	Acre	520.0	—	11,341.3	7,722.6	5,094.8	24,678.7
Pumping Plant	533	—	—	—	—	—	1.0	1.0
Spring Development	574	—	15.0	15.0	15.0	8.0	1.0	54.0
Streambank and Shoreline Protection	580	Feet	—	—	—	—	400.0	400.0
Structure for Water Control	587	—	—	—	—	—	1.0	1.0
Tree/Shrub Establishment	612	Acre	—	—	—	—	1.0	1.0

Best Management Practice	BMP Number	Units	2005	2006	2007	2008	2009	Total
Upland Wildlife Habitat Management	645	Acre	654.1	618.6	6,931.0	8,474.9	4,845.6	21,524.2
Use Exclusion	472	Acre	280.4	189.4	1,368.4	3,617.5	—	5,455.7
Waste Storage Facility	313	—	—	—	—	—	1.0	1.0
Water Well	642	—	—	1.0	—	—	—	1.0
Watering Facility	614	—	14.0	25.0	17.0	16.0	1.0	73.0

4.2.3 Activities Accomplished from 2010 to 2020

The following land agencies provided information about projects accomplished in the Willow Creek subbasin since 2010: USFS (Caribou-Targhee National Forest), Bureau of Land Management (BLM), Idaho Department of Lands (IDL), NRCS, and IDFG. This section does provided a definitive list of projects accomplished within the Willow Creek subbasin. Further details and information about the following projects can be acquired from the managing agency or responsible group.

Project information may have been reported by multiple groups, as projects are often accomplished through cross-agency cooperation. One example is remediation after the 2016 Henry's Creek Fire that burned a total of 52,830 acres, including portions of Ririe Reservoir and Willow and Tex Creeks. The wildfire burned 20,335 acres within the Tex Creek Wildlife Management Area, which supports critical deer, elk, and moose winter range. The Tex Creek Wildlife Management Area is made up of BLM, IDFG, State of Idaho, and Bureau of Reclamation lands. The wildfire left the landscape vulnerable to accelerated erosion and excess sediment entering Tex and Willow Creeks. Following Henrys Creek Fire, BLM and IDFG have completed projects to stabilize, restore, and revegetate burned areas, reducing the sediment loads to streams in the Willow Creek subbasin.

4.2.3.1 United States Forest Service Projects—Caribou-Targhee National Forest

Brockman Road Improvements (2010)—The USFS reconstructed and or relocated the northern 6 miles of the Brockman Road. They replaced and upsized all major road/stream crossing culverts to improve stream health. The agency bladed, reshaped, and placed approximately 13,100 cubic yards of 3/4-inch crushed aggregate on the entire 12 miles of road to improve drainage and reduce erosion and sediment delivery to streams.

Corral Creek Livestock Grazing Exclosure (2010)—The USFS installed approximately 0.75 miles of fence to close a section of Corral Creek to sheep grazing. The project improved stream channel and riparian area health. Beaver and fish habitat has greatly improved over the years.

North Fork Eagle Creek All Terrain Vehicle (ATV) Trail # 451 on Soda Zone (2010)—The USFS and Idaho Department of Parks and Recreation performed 1 mile of heavy trail maintenance to improve drainage and reduce erosion and sediment delivery (Figure 3 and Figure 4).



Figure 3. Trail dozer working on the North Fork Eagle Creek ATV trail.



Figure 4. Montpelier/Soda Zone—Rolling dip installed to prevent down cutting of trail while forcing runoff into vegetated areas away from streams.

South Fork Bear Creek Trailhead Road (2011)—The USFS upsized two road/stream crossing culverts in the headwaters of Brockman Creek. They also improved the 2 miles of road prism by graveling and installing additional road drainage features (FS RD 083) (Figure 5).



Figure 5. New stream and overflow culverts on Brockman Creek.

Brockman Road (2011)—The USFS installed floodplain overflow culverts at the Brockman Creek and Sawmill Creek crossings. The culverts were enlarged in 2010, but flooding during the 2011 runoff demonstrated a need for further improvements. Several overflow culverts were installed on the floodplains to better accommodate runoff events.

Skyline Road (2011)—The USFS improved the 3-mile road segment from the Brockman Road to Commissary Ridge (FS RD 017) junction. The improvements included fixing drainage problems and laying a new gravel surface. The USFS also improved the 10.8-mile segment from

Commissary Ridge (FS RD 017) to the Fall Creek road (FS RD 077). Road improvements included fixing drainage problems, realigning several segments of the road, and laying a new gravel surface. Ditches were maintained and new culverts were added to improve drainage around the roadway. Approximately 632 feet of 18-inch corrugated steel pipe and 174 feet of 24-inch corrugated steel pipe were installed for drainage. The agency realigned the road in areas where snowmelt and moisture made the road impassable and prone to erosion. The new gravel surface provides a more stable surface and less erosion (Figure 6 and Figure 7).









Figure 6. Before—Lack of road drainage and erosion of the road surface.

Figure 7. After—Road surface was prepared, drainage was installed, and the road was graveled.

North Fork Eagle Creek Trail 451 culvert replacement/bridge construction (2012)—The ATV bridge was reconstructed and enlarged to improve trail conditions and stream health (Figure 8).



Figure 8. North Fork Eagle Creek trail bridge construction reduced sediment loads entering the river.

Gravel Creek ATV Bridge (Trail #330) (2013)—The USFS installed a new bridge to better accommodate stream health and trail user safety.

Gravel Creek Area Trail #332 Relocation (2013)—The USFS relocated approximately 500 feet of trail and installed 25 drainage dips to move traffic out of a wet spring area. Twenty-five drainage dips were reconstructed.

North Fork Eagle Creek Trail #451 Relocation (2013)—The USFS relocated 1.3 miles of trail and installed two bridges to reduce erosion and improve trail and stream conditions.

Morgan Meadows Road (FR189) drainage improvement work (2014)—The USFS conducted major reconstruction and drainage work including 19 drainage dips on 2.4 miles of the Morgan Meadows road (FR RD 189). New drainage dips were installed on the upper dugway to reduce water delivery to a slump-prone area. A slumped section of road was repaired. Several new dips were constructed to reduce sediment delivery to a perennial tributary of Bridge Creek and Morgan Meadow. A braided, wallowed wet crossing was reconstructed at the west end of Morgan Meadow (Figure 9–Figure 12).



Figure 9. New dip constructed on lower section of road 189.



Figure 10. New dip installed to reduce sediment to Morgan Meadow.



Figure 11. West end Morgan Meadow wet crossing before.



Figure 12. Wallowed wet crossing of Morgan Meadow repaired.

Tex Creek ATV Trail Bridge (2015)—The USFS worked with Idaho Parks and Recreation to eliminate an ATV trail ford and install trail bridge on upper Tex Creek, which improved trail user safety and the stream health (Figure 13).



Figure 13. Bridge crossing reduced sediment load to stream.

Henry's Creek Fire Road Obliteration (2016)—The USFS worked with Henry's Creek Fire personnel to rehabilitate an unauthorized road. The road obliteration began northeast of a bend in the road where a relatively flat area exists to allow for vehicle turn-around. A track hoe ripped the road and 20-person hand crew scattered slash onto the road (Figure 14).



Figure 14. Road obliteration on USFS lands.

North Fork Eagle Creek Corral (2016)—The livestock grazing permittee moved a livestock corral away from the riparian area and stream to improve water quality.

Trail 443 Improvements–Bridge Creek (2019)—The USFS used a trail dozer to complete heavy maintenance and a minor reroute on the gullied portion of Trail 443 in the Bridge Creek watershed (Figure 15).



Figure 15. Closed and rehabilitated trails.

Skyline and Brockman Road Beaver Deceivers (2020)—The USFS and IDFS rebuilt four beaver deceivers on four road/stream crossings: one on Skyline Road and three on Brockman Road. The repair work will protect roads from erosion while ensuring beaver habitat is maintained.

4.2.3.2 Bureau of Land Management

Heart L and Hell Creek Grazing Allotments (2015)—The BLM made livestock grazing management changes to benefit watershed health including adjusting the northern boundary of the Heart L allotment. This change allowed the BLM to remove approximately 1 mile of previous boundary fence located in the bottom of Grays Lake Outlet drainage and construct a new fence on top of the ridge. The new boundary fence was approximately 1.5 miles and offered riparian protection, reducing grazing impacts along 1 mile of Grays Lake Outlet.

Loertscher Allotment—The BLM, in coordination with the adjacent landowner and allotment permittee, made cattle distribution improvements to reduce livestock use and impacts to water quality. The permittee conducted private land forage seeding and alternative water to reduce livestock reliance on 2.5 miles of Willow Creek.

Elkington Allotment—The BLM, in coordination with the adjacent landowner and allotment permittee, made cattle distribution improvements to reduce livestock use and impacts to water quality. The permittee conducted private land forage seeding and alternative water to reduce livestock reliance on approximately 1.3 miles of Willow Creek.

Post Henry's Creek Wildfire Emergency Stabilization and Rehabilitation—The BLM installed 20 wood/straw bale structures or wattles throughout various drainages and lopped and scattered

dead junipers to create stabilizing erosion barrier along steep slopes adjacent to Willow Creek near Kepps Crossing. Crews treated 47 acres with Imazapic to reduce cheatgrass and repaired protection fences around Kepps Crossing parking area. The BLM and IDFG collaborated on aerial application of a seed mix of native and nonnative grasses and forbs and mountain big sagebrush. BLM treated 1,150 acres and IDFG treated 1,950 acres in the area. The nonnative species consisted of alfalfa and sainfoin, per IDFG. The BLM surveyed 5,130 acres of BLM land for noxious weed growth following the 2016 Henry's Creek fire. As a result, BLM treated 31 sites totaling 126 acres in 2017 and 7 sites totaling 57 acres in 2018.

Noxious Weed and Invasive Species Control

- 2010–2020—approximately 8 to 100 acres treated annually along roadsides
- 2017—15 acres of hillside musk thistle treated in the middle of roadside switchbacks
- 2018—100 acres of noxious weeds treated near Cloward's during a cooperative workday with Bonneville County
- 2020—380 acres treated via aerial application along the rim of Willow Creek Canyon from Cloward's to Kepp's Crossing

4.2.3.3 National Resource Conservation Service

The NRCS works with landowners to implement BMPs on private lands. Since 2010, the NRCS has helped private landowners implement programs including one contract to install an off-site watering facility and a fenced water crossing. Three Conservation Stewardship Program (CSP) contracts that resulted in 6,545 acres of BMPs implemented including: reduced herbicide use, moving livestock concentration areas (salt and mineral licks, feeding areas) away from water bodies, and implementing compatible grazing management.

4.2.3.4 Idaho Department of Fish and Game

Gully and Road Restoration at Kepp's Crossing Adjacent to Willow Creek—Following the 2016 Henry's Creek Fire, the IDFG worked to reduce sediment loads by decommissioning closed roads and stabilizing erosive gullies. In October 2019, the IDFG recontoured unstable gullies and replaced several old hay bale erosion control structures with rock grade control structures (Figure 16–Figure 18). The IDFG obliterated and scarified closed roads and maintained the fence that prevents unauthorized motorized vehicles from accessing the road. In November 2019, IDFG placed erosion control coir mats and straw wattles over newly disturbed areas to prevent further sediment delivery into Willow Creek. The areas were then reseeded with a mix consisting of Siberian Wheatgrass, Snake River Wheatgrass, Streambank Wheatgrass, Scarley Globemallow, Lewis Flax, Basalt Milkvetch, Palmers Penstemon, Sainfoin, Fernleaf Biscuitroot, and Small Burnet. The following year, the area was reseeded again with a mixture of Alfalfa, Small Burnet, Sainfoin, Western Yarrow, Basin Wildrye, Big Bluegrass, Snake River Wheatgrass, and Bitterbrush.



Figure 16. (Left) Gully along county road before being reshaped and stabilized with fabric and rock. (Right) Former gully along county road 1 year after recontoured and stabilized with erosion control coir mat, straw wattles, rock grade control structures, and seeding. Most of area is covered by newly established vegetation to aid in further stabilization.



Figure 17. (Left) Old hay bale erosion control structure replaced by rock grade control structure. (Right) Former gully perpendicular to county road after recontoured and stabilized with erosion control coir mat, straw wattles, rock grade control structures, and seeding. Most of the area is covered by newly established vegetation to aid in further stabilization.



Figure 18. (Left) Closed roads at Kepp's Crossing following the 2016 Henrys Creek Fire. Without proactive measures, the highly erosive nature of the soil and lack of vegetation would result in significant sedimentation into Willow Creek. (Right) Closed road 1 year after obliterated and scarified, stabilized with erosion control straw wattles, and seeding. After 1 year, most of the area is covered by newly established vegetation to aid in further stabilization.

Fencing of Tex Creek Wildlife Management Area Boundary—Five miles of fencing along the Tex Creek Wildlife Management Area boundary was destroyed by the Henry's Creek Fire. Fencing along the boundary prevents unauthorized livestock from accessing the area and impacting water quality of Tex Creek. IDFG reconstructed a total of 2.6 miles of fence, of which 0.65 miles was reconstructed as let-down fence. The fence can be laid down to better accommodate migration of wildlife during certain times of the year. All fencing reconstructed is wildlife friendly with strands at 18, 30, and 42 inches from the ground. The top two strands are made of barbed wire while the bottom strand is made of smooth wire to allow animals to slip underneath the fence more easily.

Fish Sampling—The IDFG sampled Tex Creek in 2020 and found multiple age classes of Yellowstone Cutthroat Trout (YCT), and in their October 2020 fall gill-net sampling in Ririe Reservoir, IDFG observed the highest number of YCT on record. In 2020, IDFG conducted the first population estimate of YCT in the tailwater section of Willow Creek downstream of Ririe Reservoir. The IDFG estimated 341 (±142; 95% confidence interval) YCT in a 1-mile section of stream beginning at Ririe Dam and extending downstream to the first pump station.

The IDFG is installing a passive integrated transponder array at the Willow Creek and Tex Creek confluence to monitor YCT populations within the Willow Creek watershed. This monitor will assess the population structure of YCT to gain an understanding of the importance that Ririe Reservoir plays in the YCT population.

4.2.3.5 Idaho Department of Lands

Crane Creek Project (Section 17, T3S, R41E and Section 13, T3S, R40E)—In 2018, the IDL upgraded two existing water systems from generator power to solar power. Before the upgrade, the water system was used infrequently. The water system provides an alternative water source cattle to reduce livestock pressure on Crane Creek.

Grays Lake Outlet Project (Sections 21 and 27, T3S, R24E)—The IDL upgraded two existing water systems from generator power to solar power. Before the upgrade, the water system was used regularly. The upgrade to solar power will prevent pauses in use when the generator runs out of fuel or breaks down. The system in section 27 will reduce livestock pressure in Grays Lake Outlet and the headwaters of Homer Creek. The system in section 21 will reduce livestock pressure from Grays Lake Outlet. This project initially began in 2000 and was completed in 2006. The lessee, IDL, and DEQ provided the necessary funding.

Willow Creek Project (Sections 25, 26, and 27, T2S, R40E)—Since 2006, the lessee has installed an extensive water system including a well, storage tank, and multiple troughs to reduce livestock pressure on Willow and Hancock Creeks. In the future, the lessee is considering converting to solar power. This project includes both an east and west system, and the lessee is now working on a similar project to the south on deeded lands.

5 Total Maximum Daily Loads

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources 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, which receive load allocations. Wasteload allocations may be composited for certain types of point sources, such as general permits, but typically each point source is given a wasteload allocation. Each nonpoint source load may receive a load allocation or the sources may be aggregated with a single load allocation for all nonpoint source loads. Natural background contributions, when present, are considered part of the load allocation but may be treated separately because they represent a part of the load not subject to control. Because of uncertainties about quantifying loads and the relation of specific loads to attaining water quality standards, the rules regarding TMDLs (40 CFR 130) require a margin of safety be included in the TMDL. Practically, the margin of safety and natural background are both reductions in the load capacity available for allocation to anthropogenic pollutant sources.

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. If the MOS is explicit (i.e., a specific amount or proportion of the

load capacity) and the natural background is separated from other nonpoint sources, those loads are subtracted from the overall load capacity, and the remaining load 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, determining critical conditions can be more complicated than it may initially appear.

Another step in a load analysis is quantifying current pollutant loads by source. This step allows for the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary for pollutant trading to occur. A load is fundamentally a quantity of 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 (40 CFR 130.2). 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 when consistent with applicable water quality standards.

5.1 Temperature TMDLs

5.1.1 Instream Water Quality Targets

DEQ used a PNV approach to analyze the 29 AUs listed in Category 4a with existing temperature TMDLs, and the additional 6 AUs listed in Category 5 with temperature impairments that need TMDLs. Idaho's water quality standards include a provision (IDAPA 58.01.02.200.09) 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 for temperature TMDLs, the natural level of shade and channel width become the TMDL target. The instream temperature that results from attaining these conditions is consistent with the water quality standards.

The PNV approach is described briefly below. The procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in detail in *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and de Varona 2009). The manual also provides a more complete discussion of shade and its effects on stream water temperature.

The TMDLs established in the 2004 Willow Creek subbasin assessment (DEQ 2004) were based on temperature criteria without the calculation of a maximum daily load. Load allocations were set to reduce stream water temperature that would meet criteria. Revising the TMDLs from the 2004 subbasin assessment using the PNV methodology establishes daily heat load targets as controlled by the potential natural amount and type of riparian vegetation that would be present before a human-caused disturbance.

5.1.1.1 Factors Controlling Water Temperature in Streams

Several important factors contribute heat to a stream, including groundwater temperature, air temperature, and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most controllable. 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 (i.e., structure) affects riparian vegetation density and water storage in the alluvial aquifer. Riparian 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.

Riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. However, depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. The shade that a stream receives can be measured 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 with other optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and stream aspect.

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 surface is shaded and how much is exposed to direct solar radiation.

5.1.1.2 Potential Natural Vegetation for Temperature TMDLS

PNV along a stream is the riparian plant community that could grow to an overall mature state, although some level of natural disturbance is usually included in developing and using shade targets. Vegetation can be removed by disturbance either naturally (e.g., wildfire, disease/old age, wind damage, and wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, and erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar load to the stream without any anthropogenic removal of shade-producing vegetation. Vegetation levels less than PNV (except for natural levels of disturbance and age distribution) result in the stream heating up from additional anthropogenically created solar inputs.

DEQ estimates PNV (and target shade) from models of plant community structure (shade curves for specific riparian plant communities), and measures or estimates existing canopy cover or shade. Comparing the two (target and existing shade) indicates how much excess solar load the stream is receiving and what potential exists 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 disturbed by human activity may require additional restoration above and beyond natural recovery.

Existing and PNV shade were converted to solar loads from data collected on flat-plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations collecting these data. In this case, DEQ used the average loads from the Helena, Montana, and Pocatello, Idaho, stations. The difference between existing and target solar loads, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards.

PNV shade and the associated solar loads are assumed to be the natural condition; stream temperatures under PNV conditions are assumed to be natural (as long as no point sources or other anthropogenic sources of heat exist in the watershed) and are considered to be consistent with Idaho's water quality standards, even if they exceed numeric criteria.

5.1.1.2.1 Existing Shade Estimates

Existing shade was estimated for 34 AUs from visual interpretation of aerial photos. Estimates of existing shade based on plant type and density were marked out as stream segments on a 1:100,000 or 1:250,000 hydrography, taking into account natural breaks in vegetation density. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. Each segment 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 stream segment was estimated somewhere between 50% and 59%, DEQ assigned a 50% shade class to that segment. 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.

5.1.1.2.2 Solar Pathfinder Field Verification

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at 22 sites in 2014 and 2017 (Figure 19). The Solar Pathfinder is a device that allows tracing 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 adequately characterize the effective shade on a stream segment, 10 traces are taken at systematic or random 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. Ten traces were taken following the manufacturer's instructions (i.e., orient to south and level). Systematic sampling was used because it is easiest to accomplish without biasing the sampling location. For each sampled segment, the sampler started at a unique location, such as 50 to 100 meters from a bridge or fence line, and proceeded upstream or downstream taking additional traces at fixed intervals (e.g., every 50 meters, 50 paces). Alternatively, points of measurement can be randomly located by generating random numbers as interval distances.

When possible, the sampler also measured bankfull widths, took notes, and photographed the landscape of the stream at several unique locations while taking 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. Densiometer readings can also be taken 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.

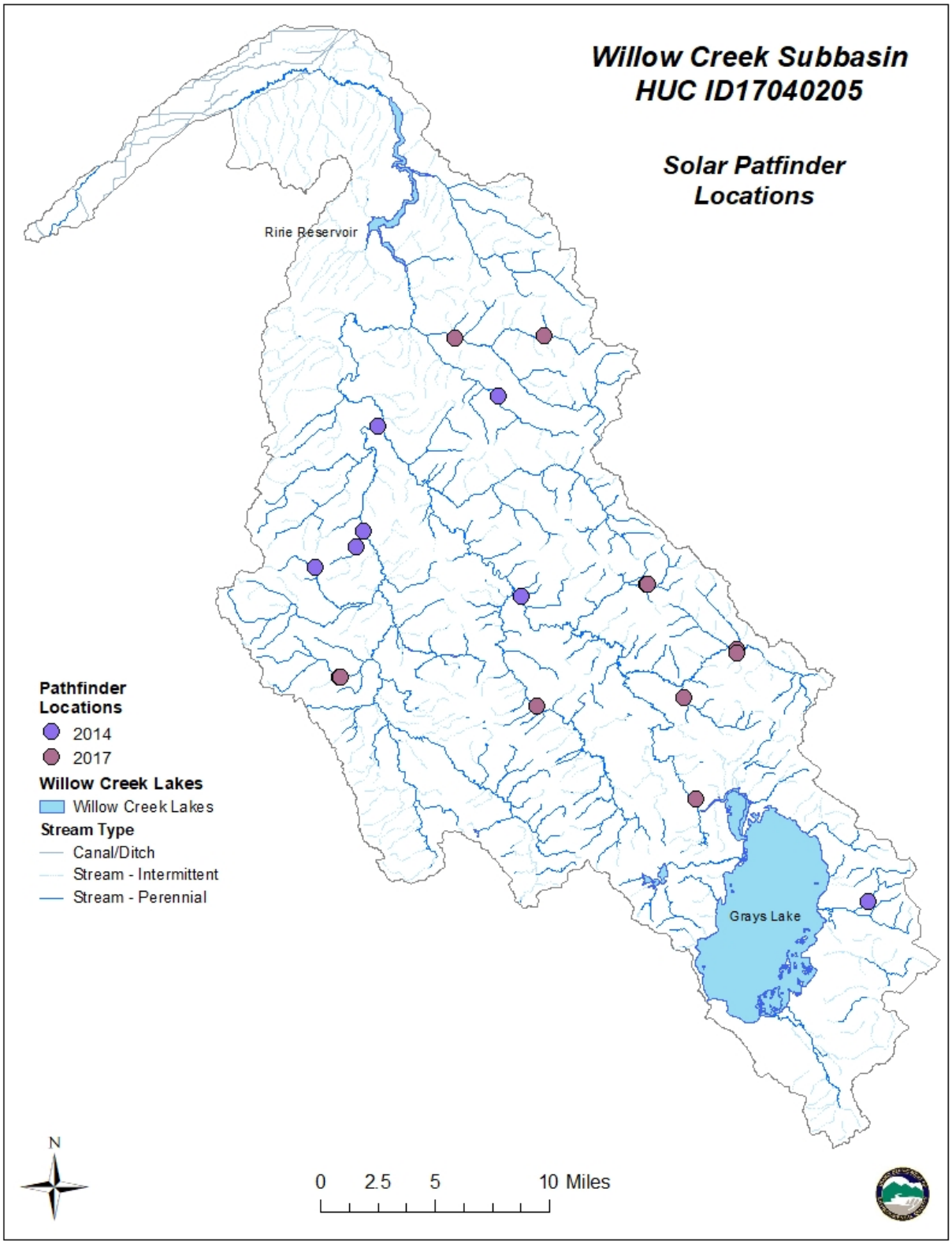


Figure 19. Willow Creek subbasin Solar Pathfinder locations.

The results of the Solar Pathfinder field verification showed the original aerial interpretation of existing shade was accurate at six of the 22 sites; was within 10% at seven sites; was within 20% at four sites; and had a difference > 20% at the remaining five sites. These data were used to correct the interpretation at the site locations with a > 20% difference and to calibrate the eyes as a new interpretation on stream locations that were not field-verified (Table 15).

Table 15. Solar Pathfinder field verification results in the Willow Creek subbasin.

Solar Pathfinder Site	Assessment Unit Number	Aerial Classification	Solar Pathfinder Measurement	Solar Pathfinder Classification	Classification Difference[a]
Rock Creek_01	ID17040205SK005_02	40	42	40	0
Rock Creek_02	ID17040205SK005_02	40	43	40	0
Willow Creek_01	ID17040205SK005_04	40	30	30	1
Mud Creek	ID17040205SK008_02	10	14	10	0
Twin Creek	ID17040205SK008_02	40	44	40	0
Willow Creek_02	ID17040205SK008_04	30	19	10	2
Mill Creek_01	ID17040205SK012_03	40	21	20	2
Mill Creek_02	ID17040205SK012_03	0	6	0	0
Homer Creek_01	ID17040205SK018_03	50	21	20	3
Homer Creek_02	ID17040205SK018_03	30	15	10	2
Grays Lake Outlet_02	ID17040205SK019_04	20	17	10	1
Grays Lake Outlet_02	ID17040205SK020_04	10	2	0	1
North Fork Eagle Creek	ID17040205SK021_02	50	41	40	1
Shirley Creek	ID17040205SK024_02	10	14	10	0
Brockman Creek	ID17040205SK025_03	60	17	10	5
Corral Creek	ID17040205SK026_02	20	30	30	-1
Lava Creek_01	ID17040205SK028_02	50	14	10	4
Lava Creek_02	ID17040205SK028_02	40	29	20	2
Bulls Fork	ID17040205SK030_02	30	43	40	-1
Indian Fork	ID17040205SK031_02	60	74	70	-1
Tex Creek_01	ID17040205SK031_03	70	30	30	4
Tex Creek_02	ID17040205SK031_03	60	27	20	4

[a] Mean = 1.3; Standard Deviation = 1.8; 95% Confidence Interval = 0.8

5.1.1.2.3 Target Shade Determinations

The 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 (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 plant community can provide more shade at any given channel width.

5.1.1.2.4 Natural Bankfull Widths

Stream width must be known to calculate target shade because the width of a stream affects the amount of shade the stream receives. Bankfull width is used because it best approximates the width between the points on either side of the stream where riparian vegetation starts. Measures of current bankfull width may not reflect widths present under PNV (i.e., natural widths). As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase so that streams become wider and shallower. Shade 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 eroded away.

Existing bankfull width may not be discernible from aerial photo interpretation and may not reflect natural bankfull widths, so this parameter must be estimated for the majority of the streams in this analysis. Where data were available, DEQ used bankfull widths collected in the field by BURP crews and water quality personnel. Where field measurements were not available, DEQ used regional curves for the major basins in Idaho—developed from data compiled by Diane Hopster, IDL—to estimate natural bankfull width (Figure 20).

For each stream evaluated in the load analysis, natural bankfull width was estimated based on the drainage area of the Upper Snake Basin curve (Figure 20). Although estimates from other curves were examined (i.e., Salmon, Payette/Weiser), the Upper Snake Basin curve was ultimately chosen because of its proximity to the Willow Creek watershed and similarities in geology and climate.

Existing widths and natural widths are the same in load tables when no data exist to support making them differ.

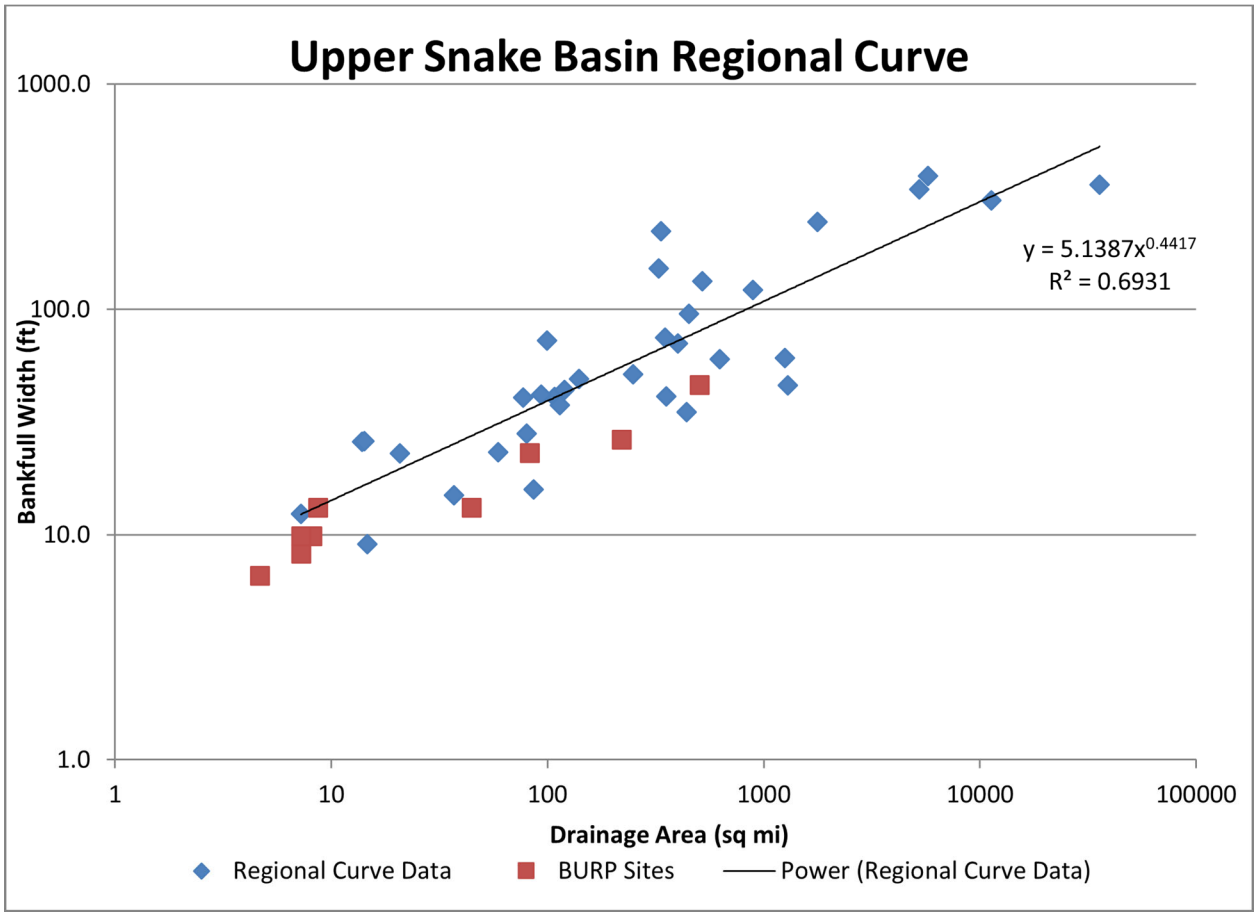


Figure 20. Bankfull width as a function of drainage area.

5.1.1.3 Design Conditions

The Willow Creek subbasin is classified in the Middle Rockies Level III ecoregion but shares many common characteristics with the Northern Basin and Range ecoregion, which describes the Blackfoot River subbasin to the south. Level IV ecoregions, Cold Valleys and Partly Forested Mountains, characterize the two major land types found in the Willow Creek subbasin. The Partly Forested Mountains, occurring from 6,000 to 9,000 feet, support open-canopied forests comprised of Douglas fir, lodgepole pine, and aspen on north-facing slopes. South-facing slopes are dominated by mountain brush and sagebrush. These relatively steep, forested mountains slope downward to the foothills, terraces, alluvial fans, and bottomlands that make up the Cold Valleys ecoregion. Hillsides consist mostly of sagebrush steppe, while vegetation in the bottomlands consists of sedges, rushes, and willows (McGrath et al. 2001).

5.1.1.4 Shade Curve Selection

To determine PNV shade targets for the Willow Creek subbasin, effective shade curves from the Targhee National Forest group and the southern Idaho nonforest group were examined (Table 16) (Shumar and de Varona 2009). These curves were produced using vegetation community modeling of Idaho plant communities. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. For the Willow Creek subbasin, curves for

the most similar vegetation type were selected for shade target determinations. Shade curves for forest patches on headwater streams were selected from Targhee National Forest Ecological Unit Inventory (Bowerman et al. 1999) as drawn on their maps. In some cases, no shade curves were developed for the specific ecological unit described, and an attempt was made to match the unit with a similar vegetation type in the inventory of shade curves in Shumar and de Varona (2009). Table 16 shows the matched shade curve with the corresponding unit. Ecological units encountered along the streams examined include forest types in the higher elevation headwaters, and a willow-dominated type on mid-elevation stream segments. Most shrub-dominated riparian areas outside of the national forest were placed in the Geyer willow/sedge vegetation type of the Southern Idaho Nonforest Group as a typical mid-elevation willow type. Higher elevation areas were identified as subalpine fir/Douglas fir types. The shade investigation identified several ephemeral drainages that were clearly dry channels with no vegetation, as seen on the aerial photographs and confirmed by field visits. Based on the evidence observed in the field and the lack of channel formation observed in aerial imagery it is unlikely these channels would contain sufficient optimum flow for a sufficient amount of time to support designated beneficial uses of the AUs. Any stream flow or surface water present in these channels during the summer months when the PNV methodology is most concerned (April-September) is most likely of such short duration and volume that it would contribute an insignificant amount of heat load to the AUs. As such, intermittent stream sections as identified in the 1:24,000 scale National Hydrography Dataset were excluded from the PNV analysis.

Table 16. Shade curves used as targets for streams (Shumar and de Varona 2009).

Targhee National Forest Ecological Unit Group	Southern Idaho Nonforest Group
Subalpine fir - Cool forest	Big sagebrush - Cool, moist shrub steppe
Douglas fir- Warm forest	Graminoid riparian
Douglas fir/Sagebrush - Flatland ecotone	Geyer willow/Graminoid riparian
	Quaking aspen

5.1.1.5 Water Quality Monitoring Points

DEQ placed temperature loggers in streams listed in Category 5 for temperature and combined biota/habitat bioassessment impairments and in streams in Category 4a for temperature for which new PNV TMDLs and load allocations were developed. Table 17 shows the locations where DEQ monitored stream temperature in 2016 and 2018.

Table 17. Temperature logger locations.

Assessment Unit	Year	Latitude	Longitude
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	2016	43.39827	-111.79209
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	2018	43.30204	-111.78122
Mud Creek—source to mouth (ID17040205SK009_02)	2020	43.29207	-111.82885
Sellars Creek—source to mouth (ID17040205SK010_03)	2016	43.26228	-111.83479
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	2016	43.24878	-111.75307
Mill Creek—source to mouth (ID17040205SK012_02)	2018	43.23585	-111.79397

Assessment Unit	Year	Latitude	Longitude
Mill Creek—source to mouth (ID17040205SK012_03)	2016	43.21812	-111.79347
Homer Creek—source to mouth (ID17040205SK018_03)	2016	43.26797	-111.64738
Grays Lake Outlet—Brockman Creek to Homer Creek (ID17040205SK019_04)	2016	43.26843	-111.64431
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_04)	2018	43.13546	-111.49539
Grays Lake—1st- and 2nd-order tributaries (ID17040205SK021_02)	2016	43.06502	-111.34992
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	2016	43.22262	-111.47979
Lava Creek—source to mouth (ID17040205SK028_03)	2016	43.25737	-111.57411
Hell Creek—source to mouth (ID17040205SK029_03)	2016	43.33018	-111.67989
Bulls Fork—source to mouth (ID17040205SK030_02)	2018	43.43134	-111.71577
Tex Creek—source to mouth (ID17040205SK031_03)	2016	43.43321	-111.71107

Numeric monitoring in any of the temperature-impaired or shade-deficient AUs should be based on the statewide protocols. A robust riparian canopy aimed at preventing excess solar loads to streams is essential to successfully implementing the PNV temperature TMDLs. DEQ staff examined data and aerial photos to estimate existing shade percentages along the AUs. In the field, DEQ conducts shade monitoring by collecting Solar Pathfinder data to verify the amount of existing shade on a stream estimated by the aerial interpretation. Table 18 shows the locations where DEQ monitored shade using Solar Pathfinders. Target shade is estimated with data and software that is compared to the estimated existing shade. The difference between existing and target shade is used to determine the locations along the AU where restoration activities should be focused. In the next 5-year review cycle, aerial interpretations of the existing shade conditions and shade monitoring along any AU segment by collecting Solar Pathfinder data will confirm progress made toward maintaining or achieving the shade targets provided in the TMDLs. DEQ's existing methods and quality assurance programs outline required elements for both the monitoring plans and beneficial use assessments.

Table 18. Solar Pathfinder monitoring locations.

Stream Name	Solar Pathfinder Site	Assessment Unit Number	Year	Latitude	Longitude
Rock Creek	Rock Creek_01	ID17040205SK005_02	2014	43.3851	-111.7967
Rock Creek	Rock Creek_02	ID17040205SK005_02	2014	43.3806	-111.7971
Willow Creek	Willow Creek_01	ID17040205SK005_04	2014	43.3758	-111.7600
Mud Creek	Mud Creek	ID17040205SK008_02	2014	43.2868	-111.8169
Twin Creek	Twin Creek	ID17040205SK008_02	2014	43.3039	-111.7806
Willow Creek	Willow Creek_02	ID17040205SK008_04	2014	43.3095	-111.7757
Mill Creek	Mill Creek_01	ID17040205SK012_03	2017	43.2172	-111.7982
Mill Creek	Mill Creek_02	ID17040205SK012_03	2017	43.2181	-111.8007
Homer Creek	Homer Creek_01	ID17040205SK018_03	2017	43.1953	-111.6307

Stream Name	Solar Pathfinder Site	Assessment Unit Number	Year	Latitude	Longitude
Homer Creek	Homer Creek_02	ID17040205SK018_03	2017	43.1947	-111.6277
Grays Lake Outlet	Grays Lake Outlet Gray_02	ID17040205SK019_04	2014	43.2651	-111.6399
Grays Lake Outlet	Grays Lake Outlet_01	ID17040205SK020_04	2017	43.1332	-111.4951
North Fork Eagle Creek	North Fork Eagle Creek	ID17040205SK021_02	2014	43.0658	-111.3485
Shirley Creek	Shirley Creek	ID17040205SK024_02	2017	43.1989	-111.5021
Brockman Creek	Brockman Creek	ID17040205SK025_03	2017	43.2263	-111.4525
Corral Creek	Corral Creek	ID17040205SK026_02	2017	43.2284	-111.4539
Lava Creek	Lava Creek_01	ID17040205SK028_02	2017	43.2702	-111.5326
Lava Creek	Lava Creek_02	ID17040205SK028_02	2017	43.2698	-111.5287
Bulls Fork	Bulls Fork	ID17040205SK030_02	2014	43.3949	-111.6563
Indian Fork	Indian Fork	ID17040205SK031_02	2017	43.4298	-111.6130
Tex Creek	Tex Creek_01	ID17040205SK031_03	2017	43.4311	-111.6935
Tex Creek	Tex Creek_02	ID17040205SK031_03	2017	43.4293	-111.6904

5.1.2 Load Capacity

The load capacity, also referred to as target load in this document, for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the segments within that stream. These loads are determined by multiplying the solar load measured by a flat-plate collector (under full sun) for a given period of time by the fraction of the solar radiation that is not blocked by shade (i.e., the percent open or 100% minus percent shade). In other words, if a shade target is 60% (or 0.6), the solar load hitting the stream under that target is 40% of the load hitting the flat-plate collector under full sun. The target solar load for each segment identified is then summed to determine the target solar load for the entire AU. The target solar load can be summarized with the following equation:

$$\sum seg = seg_1 + seg_2 + seg_3 + \cdots + seg_n$$

Where:

$$\text{seg} = NREL\ Collector\ kWh/m^2/day \times\ (1\ - Target\ Shade\ Percentage)$$

DEQ obtained solar load data from flat-plate collectors at the NREL weather stations in Helena, Montana, and Pocatello, Idaho. The solar load data used in this TMDL analysis are spring/summer averages (i.e., an average load for the 6-month period from April through September). As such, load capacity calculations are also based on this 6-month period, which coincides with the time of year when stream temperatures are increasing, deciduous vegetation is in leaf, and fish spawning is occurring. During this period, temperatures may affect

beneficial uses such as spring and fall salmonid spawning and 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.

Figure 21 shows the PNV shade targets. The tables in Appendix C also show corresponding target summer loads (in kilowatt-hours per square meter per day [$kWh/m^2/day$] and kWh/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 each table. Because load calculations involve stream segment area calculations, the segment's channel width typically only has one or two significant figures that dictate the level of significance of the corresponding loads. One significant figure in the resulting load can create rounding errors when existing and target loads are subtracted. The totals row of each load table represents total loads with two significant figures in an attempt to reduce apparent rounding errors.

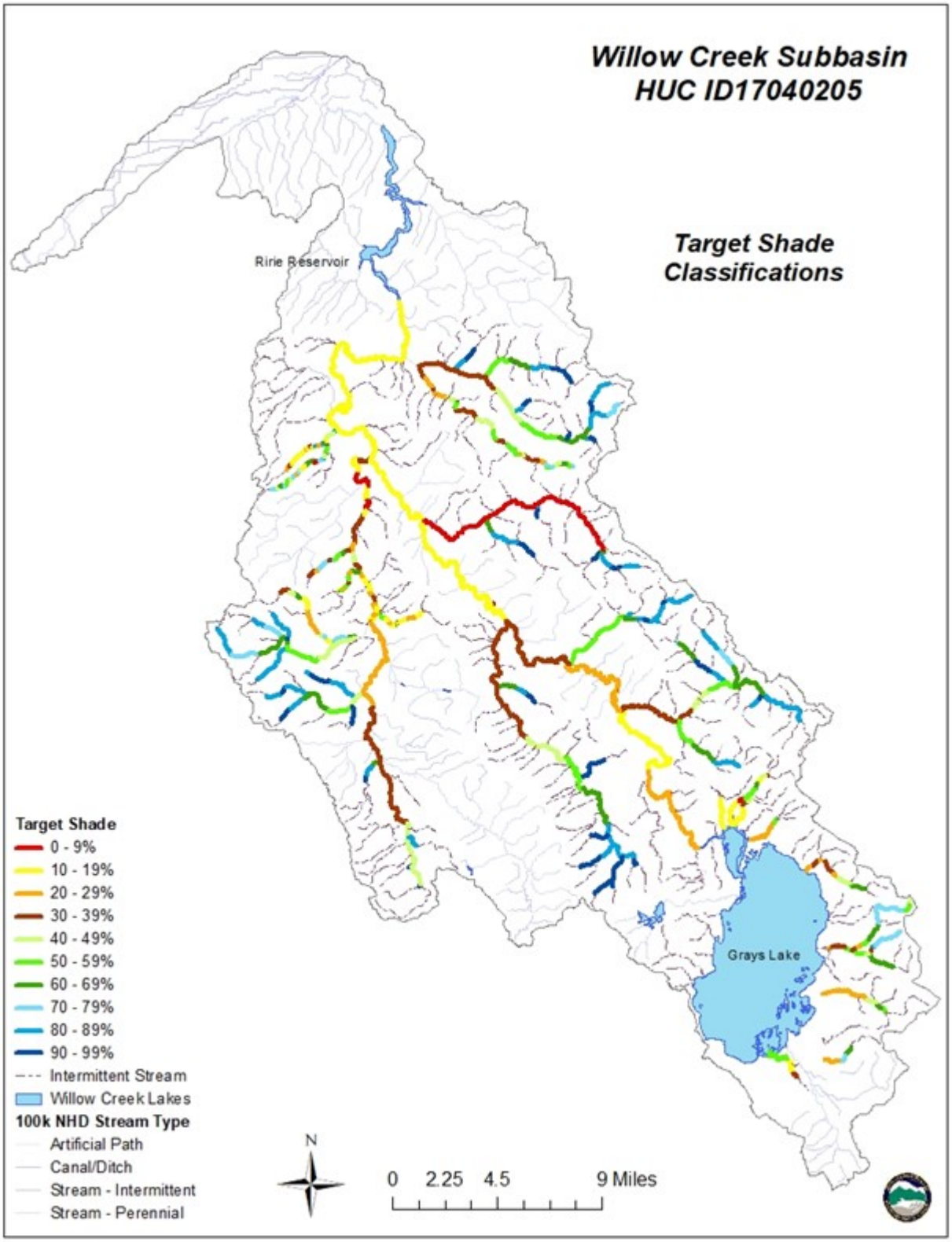


Figure 21. Target shade values for the Willow Creek subbasin.

5.1.3 Estimates of Existing Pollutant Loads

Regulations allow that loads "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(g)). The existing solar load for each segment identified is then summed to determine the existing solar load for the entire AU. The existing solar load can be summarized with the following equation:

$$\sum seg = seg_1 + seg_2 + seg_3 + \cdots + seg_n$$

Where:

$$\text{seg} = NREL\ Collector\ kWh/m^2/day \times\ (1\ -Existing\ Shade\ Percentage)$$

Existing loads in the temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations (Figure 22). Currently, no permitted point sources exist in the affected AUs. 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 Appendix C. Like load capacities (target loads), existing loads are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day). Existing loads in kWh/day are also summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target and existing load is also summed for the entire table. If existing load exceeds target load, this difference becomes the excess load (i.e., shade deficit), discussed next in the load allocation section.

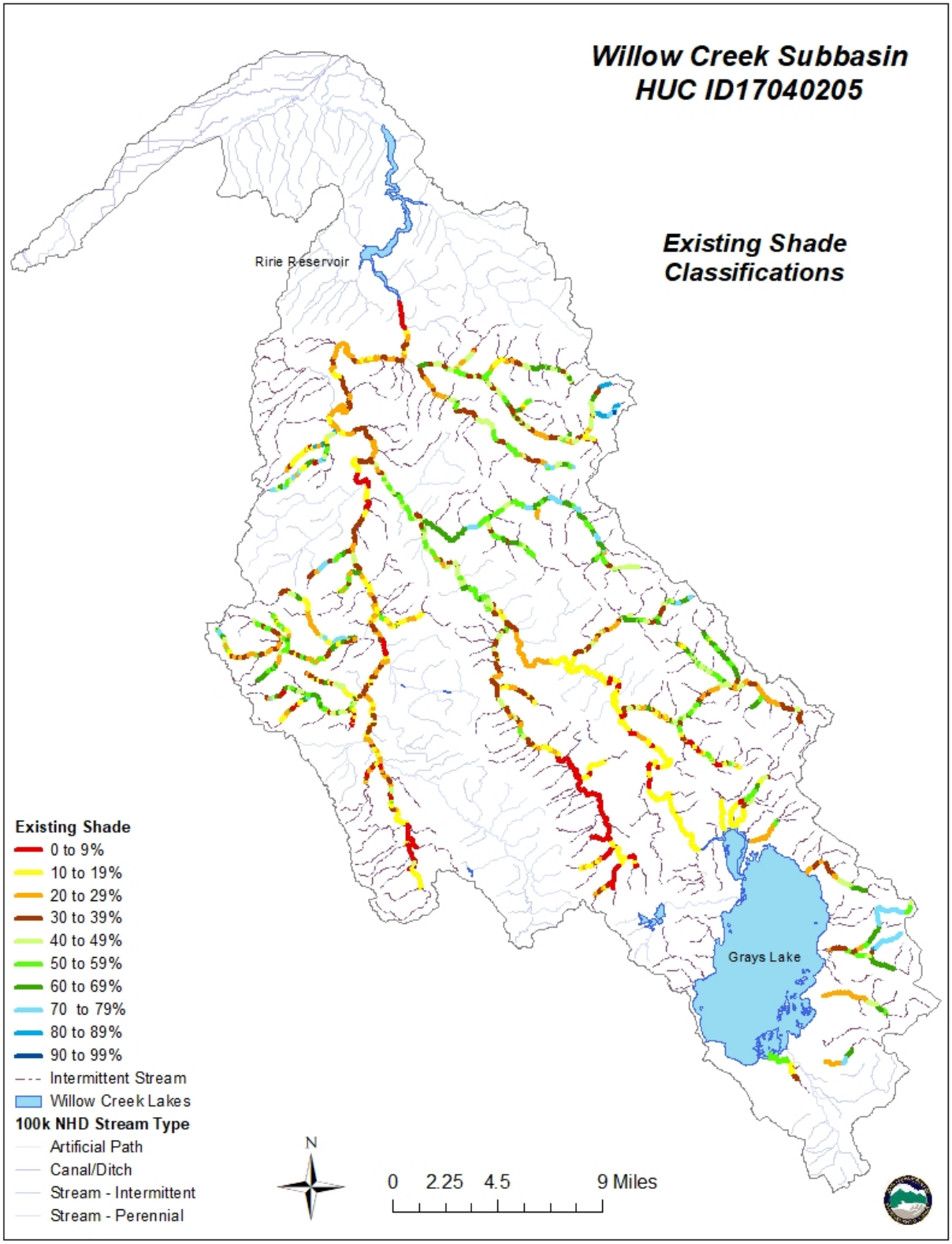


Figure 22. Existing shade estimated from aerial photo interpretation of the Willow Creek subbasin.

Table 19 shows the total existing solar load and the average lack of shade for each AU examined. The AU with the largest existing load was found on the 5th-order segment of Willow Creek from Birch Creek to Bulls Fork (ID17040205SK005_05) with 2.2 million kWh/day. The smallest existing load was found on a short 3rd-order segment AU of Brockman Creek (ID17040205SK025_03) with 9,000 kWh/day. Each load analysis table in Appendix C contains a column that lists the shade deficit on the stream segment. This value is derived from subtracting target shade from existing shade for each segment. Stream segments with the largest lack of shade have the greatest capacity for improvement. The average lack of shade derived from the last column in each load analysis table is also listed in Table 19 and provides a general level of comparison among streams. Segment-specific lack of shade values are provided in Appendix C for each AU.

Table 19. Current solar loads from nonpoint sources in Willow Creek subbasin.

Assessment Unit	Total Existing Load (kWh/day)	Average Lack of Shade (%)
Category 4a Assessment Units		
Willow Creek—Bulls Fork to Ririe Reservoir (ID17040205SK004_05)	720,000	0%
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	78,000	-8%
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	2,200,000	0%
Sellars Creek—source to mouth (ID17040205SK010_02)	88,000	-48%
Sellars Creek—source to mouth (ID17040205SK010_03)	120,000	0%
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	620,000	0%
Mill Creek—source to mouth (ID17040205SK012_02)	69,000	-42%
Mill Creek—source to mouth (ID17040205SK012_03)	74,000	0%
Willow Creek—source to Crane Creek (ID17040205SK013_02)	230,000	-28%
Willow Creek—source to Crane Creek (ID17040205SK013_03)	170,000	-3%
Grays Lake Outlet—Hell Creek to mouth (ID17040205SK016_04)	530,000	0%
Grays Lake Outlet—Home Creek to Hell Creek (ID17040205SK017_04)	960,000	0%
Homer Creek—source to mouth (ID17040205SK018_02)	120,000	-62%
Homer Creek—source to mouth (ID17040205SK018_03)	640,000	-8%
Grays Lake Outlet—Brockman Creek to Homer Creek (ID17040205SK019_04)	1,700,000	0%
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_02)	N/A	N/A

Assessment Unit	Total Existing Load (kWh/day)	Average Lack of Shade (%)
Category 4a Assessment Units		
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_04)	1,500,000	-4%
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	94,000	-20%
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	290,000	0%
Brockman Creek—source to Corral Creek (ID17040205SK025_02)	71,000	-24%
Brockman Creek—source to Corral Creek (ID17040205SK025_03)	9,000	-3%
Corral Creek—source to mouth (ID17040205SK026_02)	26,000	-30%
Sawmill Creek—source to mouth (ID17040205SK027_02)	27,000	-37%
Lava Creek—source to mouth (ID17040205SK028_02)	33,000	-33%
Lava Creek—source to mouth (ID17040205SK028_03)	90,000	-5%
Hell Creek—source to mouth (ID17040205SK029_02)	50,000	-25%
Hell Creek—source to mouth (ID17040205SK029_03)	230,000	0%
Tex Creek—source to mouth (ID17040205SK031_02)	140,000	-29%
Tex Creek—source to mouth (ID17040205SK031_03)	270,000	0%
Category 5 Assessment Units		
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	300,000	0%
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	66,000	-7%
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	990,000	0%
Mud Creek—source to mouth (ID17040205SK009_02)	55,000	0%
Grays Lake Outlet—1st- and 2nd-order tributaries (ID17040205SK021_02)	340,000	-16%
Bulls Fork—source to mouth (ID17040205SK030_02)	190,000	-19%

Note: AUs that are bolded have not been field verified by Solar Pathfinder monitoring.

5.1.4 Load Allocation

Because this TMDL is based on PNV, which is equivalent to natural background load, the load allocation is essentially the desire to achieve natural background conditions. However, 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. Therefore, load allocations are stream

segment specific and depend upon the target load for a given segment. Figure 23 shows the shade deficit, the difference between existing and target shade levels. Appendix C load tables show the target shade and corresponding target summer loads. The target load (i.e., load capacity) is necessary to achieve natural background conditions. These factors together represent the TMDL for the AUs considered and use the TMDL equation presented at the beginning of this section. No opportunity exists to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL depends upon natural background conditions for achieving water quality standards, all tributaries to the waters examined here must be in natural conditions to prevent excess heat loads to the system.

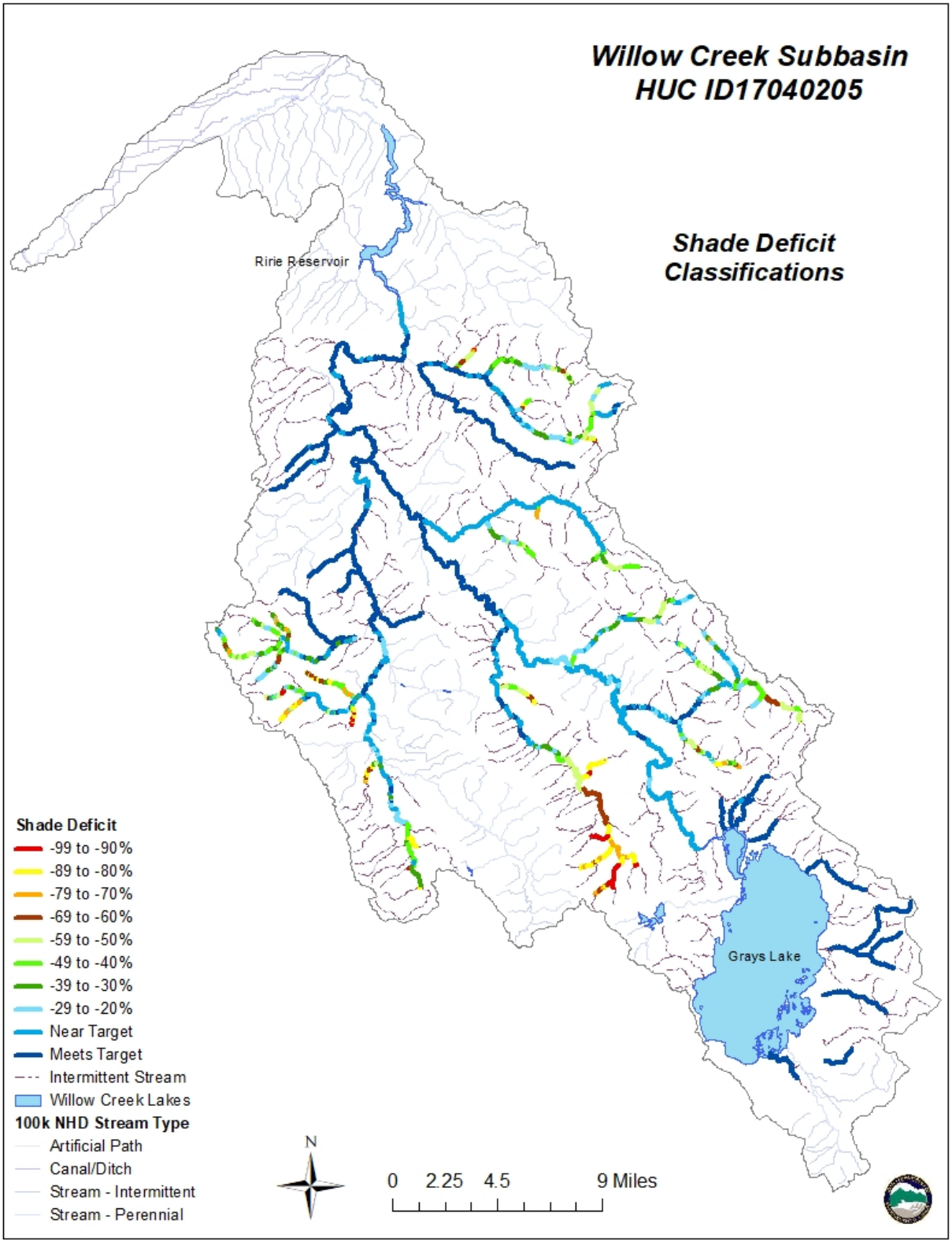


Figure 23. Shade deficit calculations for the Willow Creek subbasin.

Table 20 shows the target and excess loads for each AU examined. The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths thus greater surface area.

Although this TMDL analysis focuses on total solar loads, it is important to note that differences between existing and target shade, as depicted in Figure 23, 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 greatest percent reduction needed to meet target solar loads as locations to prioritize implementation efforts.

Table 20. Target solar loads for nonpoint sources in Willow Creek subbasin.

Assessment Unit	Total Target Load	Excess Load (% Reduction)
	(kWh/day)	
Category 4a Assessment Units		
Willow Creek—Bulls Fork to Ririe Reservoir (ID17040205SK004_05)	760,000	0 (0)
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	77,000	1,200 (2)
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	2,600,000	0 (0)
Sellars Creek—source to mouth (ID17040205SK010_02)	29,000	62,000 (70)
Sellars Creek—source to mouth (ID17040205SK010_03)	120,000	0 (0)
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	600,000	19,000 (3)
Mill Creek—source to mouth (ID17040205SK012_02)	37,000	32,000 (46)
Mill Creek—source to mouth (ID17040205SK012_030)	81,000	0 (0)
Willow Creek—source to Crane Creek (ID17040205SK013_02)	130,000	98,000 (43)
Willow Creek—source to Crane Creek (ID17040205SK013_03)	160,000	11,000 (6)
Grays Lake Outlet—Hell Creek to mouth (ID17040205SK016_04)	860,000	0 (0)
Grays Lake Outlet—Home Creek to Hell Creek (ID17040205SK017_04)	1,400,000	0 (0)
Homer Creek—source to mouth (ID17040205SK018_02)	43,000	73,000 (61)
Homer Creek—source to mouth (ID17040205SK018_03)	580,000	64,000 (10)
Grays Lake Outlet—Brockman Creek to Homer Creek (ID17040205SK019_04)	1,800,000	0 (0)
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_02)	N/A	N/A

Assessment Unit	Total Target Load	Excess Load (% Reduction)
	(kWh/day)	
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_04)	1,400,000	40,000 (3)
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	68,000	26,000 (28)
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	310,000	0 (0)
Brockman Creek—source to Corral Creek (ID17040205SK025_02)	46,000	26,000 (37)
Brockman Creek—source to Corral Creek (ID17040205SK025_03)	8,000	1,000 (11)
Corral Creek—source to mouth (ID17040205SK026_02)	18,000	8,800 (34)
Sawmill Creek—source to mouth (ID17040205SK027_02)	14,000	15,000 (56)
Lava Creek—source to mouth (ID17040205SK028_02)	13,000	21,000 (64)
Lava Creek—source to mouth (ID17040205SK028_03)	84,000	6,000 (7)
Hell Creek—source to mouth (ID17040205SK029_02)	41,000	9,600 (19)
Hell Creek—source to mouth (ID17040205SK029_03)	400,000	0 (0)
Tex Creek—source to mouth (ID17040205SK031_02)	94,000	42,000 (30)
Tex Creek—source to mouth |(ID17040205SK031_03)	310,000	0 (0)
Category 5 Assessment Units		
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	330,000	0 (0)
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	61,000	3,900 (6)
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	1,100,000	0 (0)
Mud Creek—source to mouth (ID17040205SK009_02)	61,000	0 (0)
Grays Lake Outlet—1st- and 2nd-order tributaries (ID17040205SK021_02)	320,000	24,000 (7)
Bulls Fork—source to mouth (ID17040205SK030_02)	190,000	0 (0)

The 1st- and 2nd-order tributaries of Sellars Creek (ID17040205SK010_02) require the largest percentage reduction at 70%. Additionally, the data suggest that most 1st- and 2nd-order systems within the subbasin require the greatest excess load reduction. Percent reductions for these systems are commonly in the 60% to 70% range. This range is due to (a) the areas of each tributary stream being summed during the shade analysis to represent the entire AU and (b) to the land use changes occurring along the streams as they leave areas like Cranes Flat or the

Outlet Valley that hold lower gradient streams before they enter draws and shallow canyons found lower in the subbasin. Land use changes that occur along the streams as they leave the forested headwaters and run out onto the lower gradient agricultural and ranching lands can impact on solar load. Where the land use is dominated by agriculture, irrigation, and grazing, stream segments have been modified, diverted, dammed, denuded of vegetation, and channelized. Among the many detriments to stream health created by these land uses, solar load to the water remaining in the stream channel is increased, and the amount of suitable habitat available to aquatic life is decreased.

Streams located in more remote, steep canyons with limited access generally show lower excess solar load reductions necessary to meet target values. The remnant riparian vegetation in these AUs nearly achieves target shade values where it has been left intact. For the 5th-order segment of Willow Creek where the solar load was measured at the highest value in the subbasin, the AU is meeting target solar loads. Other AUs that also meet target shade values include two segments of Grays Lake Outlet found from Homer Creek to its mouth, and Brockman Creek from Corral Creek to its mouth.

For AUs where PNV analyses show no excess solar load (i.e. no shade deficit), additional assessments are needed to demonstrate beneficial uses are supported and stream temperatures are consistent with natural background temperatures. Alternatively, AUs meeting shade targets may be candidates for future site-specific temperature criteria.

A certain amount of excess load is potentially created by the existing or target shade difference inherent in the load analysis. Because existing shade is reported as a 10% shade class, and target shade is a unique integer between 0% and 100%, a difference usually exists between the two. For example, say a particular stream segment has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that segment were at target level, it would be recorded as 80% in the load analysis because it falls into the 80% existing shade class. An automatic difference of 6% could be attributed to the MOS.

5.1.4.1 Water Diversion

Stream temperature may be affected by water diversion for water rights purposes. Flow diversion reduces the amount of water exposed to a given level of solar radiation in the stream channel that can result in increased water temperature in the channel. Flow loss in the channel also affects the ability of the near-stream environment to support shade-producing vegetation, increasing solar load to the channel.

Although these water temperature effects may occur, nothing in this TMDL supersedes any water appropriation in the affected watershed. Section 101(g), the Wallop Amendment, was added to the CWA as part of the 1977 amendments to address water rights:

> It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this chapter. It is the further policy of Congress that nothing in this chapter shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with

> State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

Additionally, Idaho's water quality standards indicate the following:

> The adoption of water quality standards and the enforcement of such standards is not intended to…interfere with the rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations which have been granted to them under the statutory procedure… (IDAPA 58.01.02.050.01)

This TMDL has not quantified what impact, if any, diversions are having on stream temperature. Water diversions are allowed for in state statute, and it is possible for a water body to be 100% allocated. Diversions notwithstanding, reaching shade targets as discussed in the TMDL will protect what water remains in the channel and allow the stream to meet water quality standards for temperature. This TMDL will lead to cooler water by achieving shade that would be expected under natural conditions and water temperatures resulting from that shade. DEQ encourages local landowners and water rights holders to voluntarily do whatever they can to help instream flow and keep channel water cooler for aquatic life.

5.1.4.2 Margin of Safety

The MOS in this TMDL is considered implicit in the design as described above. 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, which likely underestimates actual shade in the load analysis. Although the load 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.

5.1.4.3 Seasonal Variation

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

5.1.4.4 Natural Background

For PNV temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during certain time periods. If PNV 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 groundwater sources of heat) and natural background provisions of Idaho's 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)

5.2 *E. coli* Bacteria TMDLs

5.2.1 Instream Water Quality Targets

Bacteria TMDLs were developed for four AUs in the Willow Creek subbasin, including the 1st- and 2nd-order tributaries to Willow Creek: Mud Creek to Birch Creek (ID17040205SK008_02), Mill Creek—source to mouth (ID17040205SK012_03), tributaries to Gravel Creek—source to mouth (ID17040205SK023_02), and tributaries to Brockman Creek—Corral Creek to mouth (ID17040205SK024_02).

5.2.1.1 Design Conditions

The *E. coli* concentration target of 126 *E. coli*/100 mL must be met at all times to protect beneficial uses. During the summer when growing season occurs, increased grazing activity, warm temperatures and low stream flows can all contribute to higher concentrations of bacteria compared to other times of the year. Due to these increased influences, *E. coli* sampling was performed in late summer. Streamflow data was not collected at the time of bacteria sampling, and no USGS gaging stations are located on any of the streams where TMDLs were developed. In the absence of flow measurements, a web-based application called StreamStats (USGS 2016) was used to calculate critical low flow conditions for the monitoring locations listed in Table 21. Calculating the bacteria TMDLs based on the summer season when *E. coli* is anticipated to be the greatest allows for the maximum reduction needed, addressing reduction loads throughout other seasons as the water quality standard for *E. coli* remain in effect throughout the year.

Table 21. *E. coli* sampling locations in Willow Creek subbasin that are impaired.

Water Body	Assessment Unit Name	Years Monitored	Latitude	Longitude
Canyon Creek	ID17040205SK008_02	2010, 2011	43.3122	-111.7947
Mill Creek	ID17040205SK012_03	2016	43.2180	-111.7936
Gravel Creek	ID17040205SK023_02	2019	42.9403	-111.3800
Shirley Creek	ID17040205SK024_02	2010, 2011	43.1983	-111.5018

5.2.1.2 Target Selection

Idaho's water quality standards (IDAPA 58.01.02.251.01) state that the numeric criterion for *E. coli* is not to exceed 126 *E. coli*/100 mL based on the geometric mean of a minimum of five

samples taken 3 to 11 days over a 45-day period or a statistical threshold value of 410 *E. coli*/100 mL in more than 10% of representative samples collected over a 45-day period.

A geometric mean is applied to minimize random variability in data associated with surface waters prone to short-term episodic spikes in bacteria concentrations.

5.2.1.3 Water Quality Monitoring Points

E. coli samples were collected from AUs with known and suspected *E. coli* impairments. Of AUs without a known *E. coli* impairment, only Mill Creek was found to have an *E. coli* impairment. Figure 24 shows the bacteria monitoring locations for AUs that received a TMDL. Additional *E. coli* sampling results, locations, and StreamStats data are listed in Appendix C.

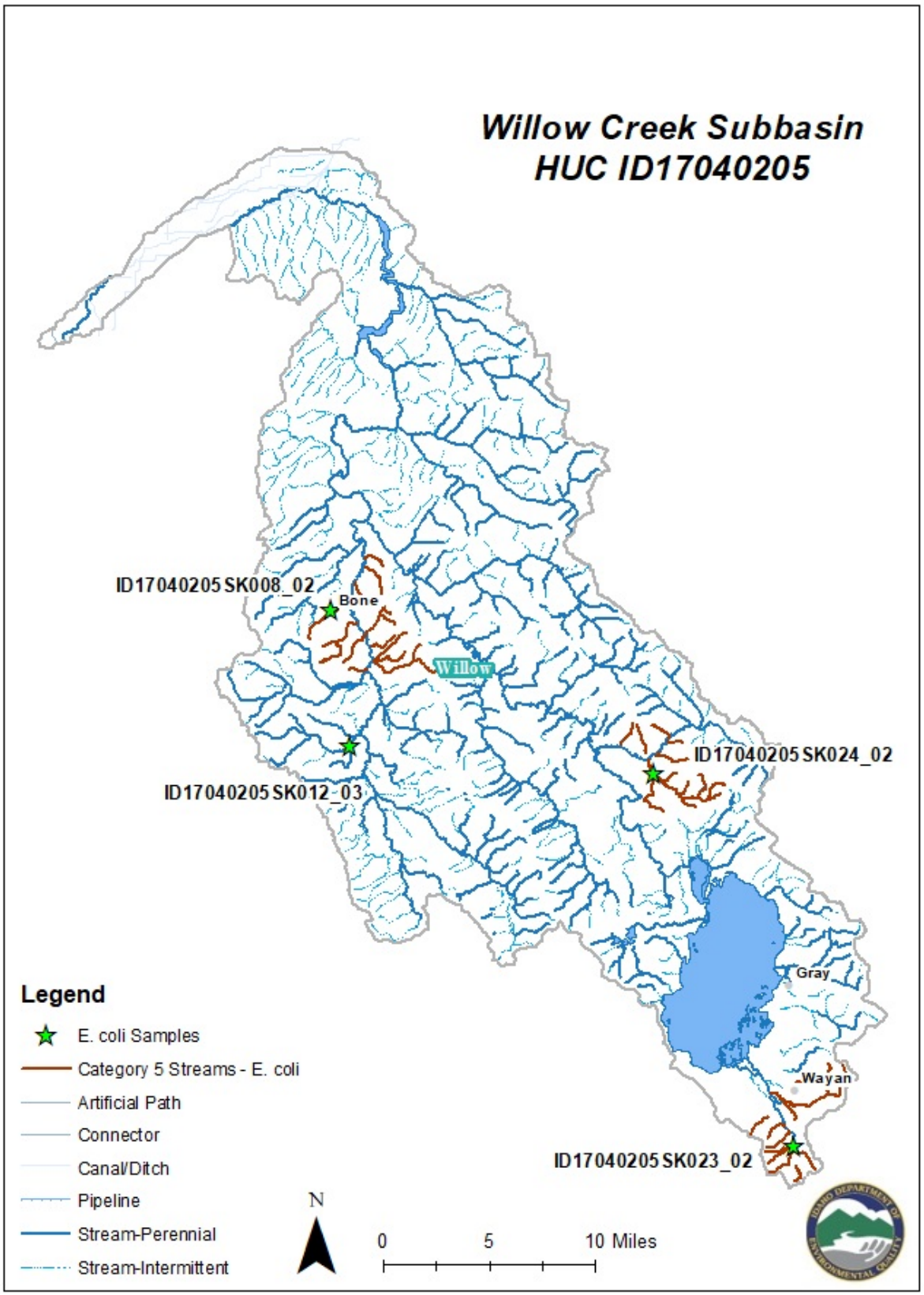


Figure 24. Willow Creek subbasin *E. coli* sampling locations.

5.2.2 Load Capacity

In bacteria TMDLs, the water quality standard is the load capacity of a system. The load capacity presented is based on various seasonal and annual flows. The load capacity is calculated as a function of 126 cfu/100 mL as the target and the flow of the monitored AU according to the following example calculation:

$$Load\ capacity\ \left(\frac{\text{cfu}}{day}\right) = \text{flow}\left(\frac{ft^3}{second}\right) \times target\ \left(\frac{cfu}{100\ mL}\right) \times 28{,}316.8\left(\frac{mL}{ft^3}\right) \times 86{,}400\left(\frac{second}{day}\right)$$

Where:

Critical low flow is cubic feet per second (cfs).
126 colony forming units (cfu) / 100 milliliters (mL) is the *E. coli* target.
28,316.8 mL per cubic foot is the volume conversion.
86,400 seconds per day is the time conversion.

Since the load capacity depends on flow, as the flow increases the load capacity increases; therefore, the load capacity estimate is considered flow variable. Table 22 provides the load capacities for the AUs with *E. coli* impairments at different stream flows.

Flow rates were generated by StreamStats, an application that delineates drainage basins, measures basin characteristics and estimates streamflow statistics for ungaged sites. Flow rates were estimated for low flow (7-day average flow expected to flow every 10 years), peak flow (10 year), and September flows (50% or median) to show comparisons. The September flow rates were used to calculate loads because in this month flow rates are consistently the lowest according to StreamStats. Multiple flow statistics were used for each AU to demonstrate the load capacity depends on flow and is considered flow variable.

Table 22. *E. coli* bacteria load capacities for Willow Creek subbasin (based on TMDL target of 126 cfu/100 mL).

Assessment Unit	Stream Flow Stat	Flow (cfs)	Load Capacity (cfu/day)
Canyon Creek (ID17040205SK008_02)	September median	2.0	6.17E+09
	7Q10	0.016	4.93E+07
	10-year peak	43.6	1.34E+11
Mill Creek (ID17040205SK012_03)	September median	10.6	3.27E+10
	7Q10	0.089	2.74E+08
	10-year peak	122	3.76E+11
Gravel Creek (ID17040205SK023_02)	September median	2.04	6.29E+09
	7Q10	0.211	6.50E+08
	10-year peak	70.9	2.19E+11
Shirley Creek (ID17040205SK024_02)	September median	7.97	2.46E+10
	7Q10	0.0615	1.90E+08
	10-year peak	120	3.70E+11

5.2.3 Estimates of Existing Pollutant Loads

Regulations for loadings "…may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(g)). The existing pollutant load is based on the most recent bacteria data. Table 23 provides the existing pollutant loads for the AUs with *E. coli* exceedances calculated on the critical low flow (i.e., September median flow). Samples were collected during the mid-to-late-summer months when flows are lower than the spring peak but still generally consistent and usually present. Current *E. coli* loads are calculated using the following formula:

$$Existing\ load\ \left(\frac{\text{cfu}}{day}\right) = \text{flow}\left(\frac{ft^3}{second}\right) \times geometric\ mean\ \left(\frac{cfu}{100\ mL}\right) \times 28{,}316.8\left(\frac{mL}{ft^3}\right) \times 86{,}400\left(\frac{second}{day}\right)$$

Where:

Critical low flow is cubic feet per second (cfs).
Geometric mean in colony forming units (cfu)/100 milliliters (mL) is the *E. coli* concentration.
28,316.8 mL per cubic foot is the volume conversion.
86,400 seconds per day is the time conversion.

Table 23. *E. coli* bacteria existing pollutant load.

Water Body	Assessment Unit	Flow (cfs)	Measured Concentration (cfu/100 mL)	Existing Pollutant Load (cfu/day)
Canyon Creek	ID17040205SK008_02	2.0	241.9	1.18E+10
Mill Creek	ID17040205SK012_03	10.6	128.4	3.33E+10
Gravel Creek	ID17040205SK023_02	2.04	229.6	1.15E+10
Shirley Creek	ID17040205SK024_02	7.97	441.5	8.61E+10

5.2.4 Load Allocations

Table 24 lists the *E. coli* load allocations and necessary load reductions for the AUs with measured concentrations exceeding the standard. The TMDL allocates 10% of the load capacity to an explicit MOS, 10% of the load capacity to natural background, and the remaining 80% to the load allocation. More than 50% reduction in existing load is required for three of the four streams.

Table 24. Nonpoint source *E. coli* load allocations for Willow Creek subbasin.

Assessment Unit	Load Capacity (cfu/day)	Natural Background (cfu/day)	Margin of Safety (cfu/day)	Load Allocation (cfu/day)	Total Existing Load (cfu/day)	Load Reduction (cfu/day)	Percent Reduction (%)
Canyon Creek (ID17040205SK008_02)	6.17E+09	6.17E+08	6.17E+08	4.93E+09	1.18E+10	6.90E+09	58
Mill Creek (ID17040205SK012_03)	3.27E+10	3.27E+09	3.27E+09	2.61E+10	3.33E+10	7.16E+09	21
Gravel Creek (ID17040205SK023_02)	6.29E+09	6.29E+08	6.29E+08	5.03E+09	1.15E+10	6.43E+09	56
Shirley Creek (ID17040205SK024_02)	2.46E+10	2.46E+09	2.46E+09	1.97E+10	8.61E+10	6.64E+10	77

5.2.4.1 Margin of Safety

Establishing a TMDL requires identifying an MOS to account for uncertainty as required by federal regulation (40 CFR 130). The MOS is not allocated to any sources of a pollutant. An MOS is expressed as either an implicit or explicit portion of a water body's load capacity that is reserved to allow for uncertainty about the relationship between the pollutant loads and the quality of the receiving water body.

DEQ selected a 10% explicit MOS based on uncertainty associated with *E. coli* field duplicate measurements. Field duplicates are two samples collected at the same site and time following the same sampling and analytical procedures. Based on data available in DEQ's *E. coli* database at the time this TMDL was developed, the arithmetic mean absolute difference in concentration between field duplicate samples (|original – duplicate|), where the original sample result was less than the *E. coli* criterion (126 most probable number per 100 milliliters [mpn/100 mL]), was 10.7 mpn/100 mL (based on 39 duplicate pairs collected across Idaho from 2016 to 2019). This value represents the average *E. coli* measurement uncertainty for individual sample results below the criterion and corresponds to 8.5% of 126 mpn/100 mL. A 10% MOS was selected to be conservative (protective) considering the limited data available for this TMDL.

5.2.4.2 Seasonal Variation

This TMDL is based on summer *E. coli* loads. In the affected watersheds, concentrations of bacteria are likely to be the highest during the summer growing season. Grazing activity increases the bacterial load, warm temperatures encourage bacterial growth or slow their die-off, and diminished stream flows reduce the dilution capacity of streams. This season is also the time period when secondary contact recreation is most likely to occur. While recreational water contact is less likely outside of the summer season, it may occur at any time during the year. Likewise, it is less likely that grazing will occur on these streams beyond late October. But, because both contact recreation and livestock access to the streams could occur at any time, water quality standards for *E. coli* remain in effect throughout the year.

5.2.4.3 Natural Background

Natural background sources of *E. coli* are inherent in the Willow Creek subbasin, as wildlife are present throughout the basin. Natural background loads in the Willow Creek subbasin are unknown and cannot be quantified, so individual allocations are not included in the TMDLs. As such an additional 10% of the bacterial load has been allocated to natural background sources as an initial estimate that may be refined as more information becomes available in the future.

5.3 Nutrient TMDLs

5.3.1 Instream Water Quality Targets

High nutrient concentrations in the water column along with nuisance levels of aquatic plant growth were detected in Willow Creek, according to the 2004 TMDL. To address the excess nutrients, one phosphorus load allocation was developed for Willow Creek in 2004 prescribing a

23% reduction in total phosphorus loading. At the time of writing, individual AUs were not commonly used to create TMDLs respective to individual AUs. This TMDL will revise the original load allocation to apply individual TMDLs for two of the three AUs listed for total phosphorus in the 2022 Integrated Report using the same method as in the 2004 TMDL.

Additionally, Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05) was never listed as impaired for nutrients in the 2004 TMDL or in the 2022 Integrated Report. However, total phosphorus samples taken in 2003 and most recently in 2016 indicated elevated concentrations that exceed the water quality standard.

5.3.1.1 Design Conditions

In 2016, water samples for total phosphorus were collected approximately every 2 weeks from the beginning of June to the middle of September, the same method used in the 2004 TMDL. This time frame captured the highest amount of nutrients within the stream at elevated flows due to runoff. Total phosphorus load reductions were developed based on the highest load recorded and the loading capacity at the loading measured discharge.

5.3.1.2 Target Selection

Idaho's "Water Quality Standards" (IDAPA 58.01.02) for nutrients are narrative. Numeric targets for the TMDLs were set using a collection of literature sources that provided information relating numeric values to the attainment of beneficial uses. The numeric target for total phosphorus in the water column is less than 0.05 mg/L. This numeric target is the same used for total phosphorus in the nutrient TMDL in the Willow Creek subbasin (DEQ 2004).

5.3.1.3 Water Quality Monitoring Points

Water samples to determine nutrient concentrations of total phosphorus along with discharge measurement were collected at two AUs currently listed in Category 4a and one AU not listed (Table 25). All three AUs sampled resulted in exceedances of the numeric criteria for total phosphorus. Additionally, nitrogen as NO_2 + NO_3 was also sampled, but results met the criteria for nitrogen discussed in section 4. Sampling results are located in Appendix C. Figure 25 shows the nutrient monitoring map of the AUs where samples were collected.

Table 25. Nutrient-based water quality summary data from Willow Creek in 2016 showing highest concentration from samples collected.

Assessment Unit	Latitude	Longitude	Average Discharge (cfs)	N as NO_2 + NO_3 (mg/L)	Total Phosphorus (mg/L)
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	43.3983	-111.7921	60.6	0.005	0.086
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	43.3092	-111.7744	25.8	0.009	0.067
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	43.2488	-111.7531	17.6	0.016	0.071

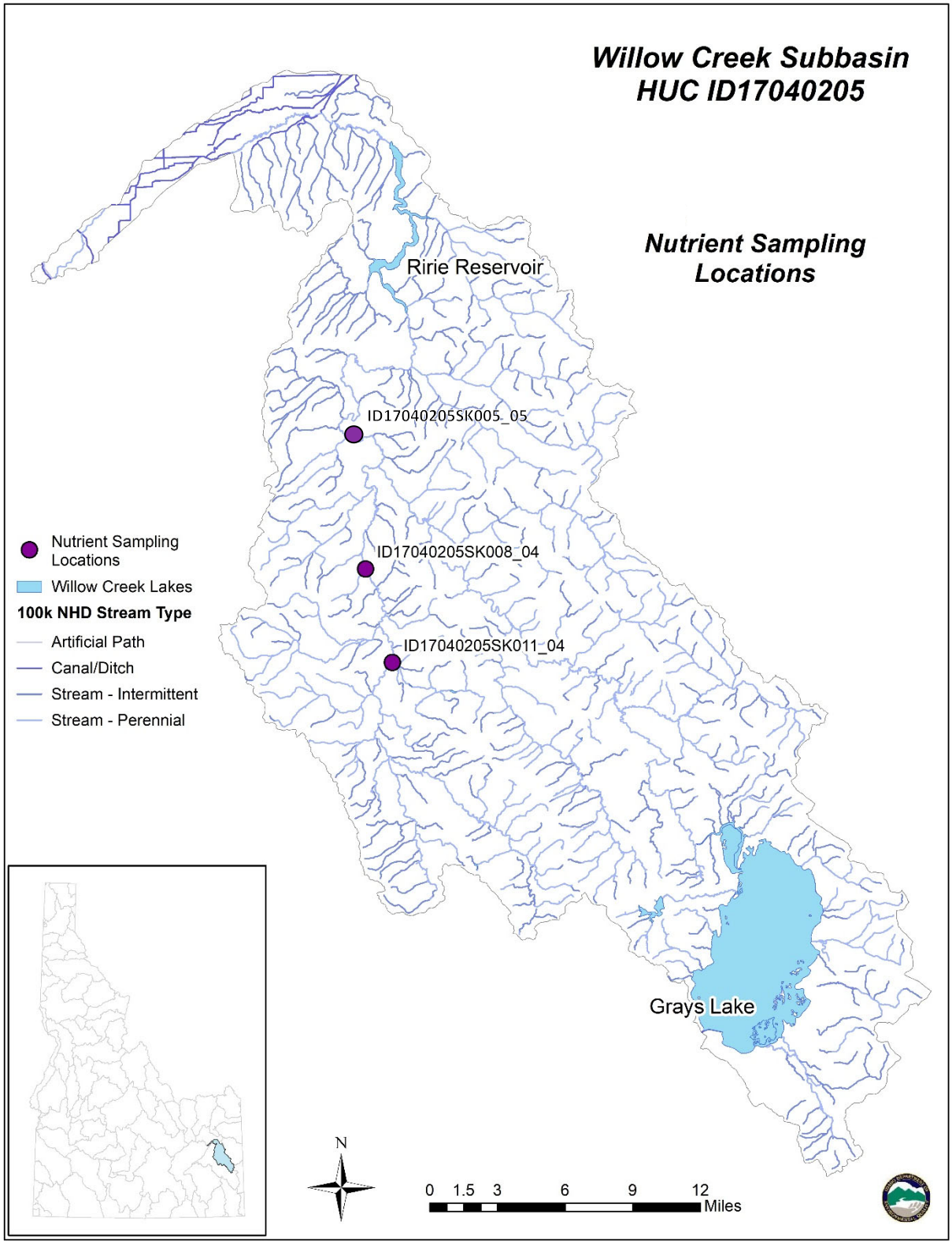


Figure 25. Nutrient monitoring locations in the Willow Creek subbasin.

5.3.2 Load Capacity

The 2004 Willow Creek subbasin established nutrient loading capacity based on the water quality standard target of 0.05 mg/L of total phosphorus from a flow-based prospective to best suit a system with a varying flow regime and visualize the loading capacity at flows ranging from one to 2,500 cfs. Flow ranges were based on the minimum and maximum streamflows recorded at Willow Creek below Tex Creek (USGS gage #13057940). The load capacity is calculated as a function of 0.05 mg/L as the target and the flow of the monitored AU according to the following example calculation:

$$Load\ capacity\ \left(\frac{\text{lb}}{day}\right) = \text{flow}\left(\frac{ft^3}{second}\right) \times target\ \left(\frac{0.05\ mg}{1\ L}\right) \times 2.2E^{-6}\left(\frac{lb}{mg}\right) \times 28.32\left(\frac{L}{ft^3}\right) \times 86{,}400\left(\frac{second}{day}\right)$$

Where:

Flow is cubic feet per second (cfs).
0.05 milligrams (mg) per liter (L) is the total phosphorus target.
$2.2E^{-6}$ pound (lb) per mg is the unit conversion
28.32 L per cubic foot (ft^3) is the volume conversion.
86,400 seconds per day is the time conversion.

Figure 26 illustrates the load capacity graph for total phosphorus at a given flow established in the 2004 TMDL (DEQ 2004). The load capacity is assumed to not change based on season or location.

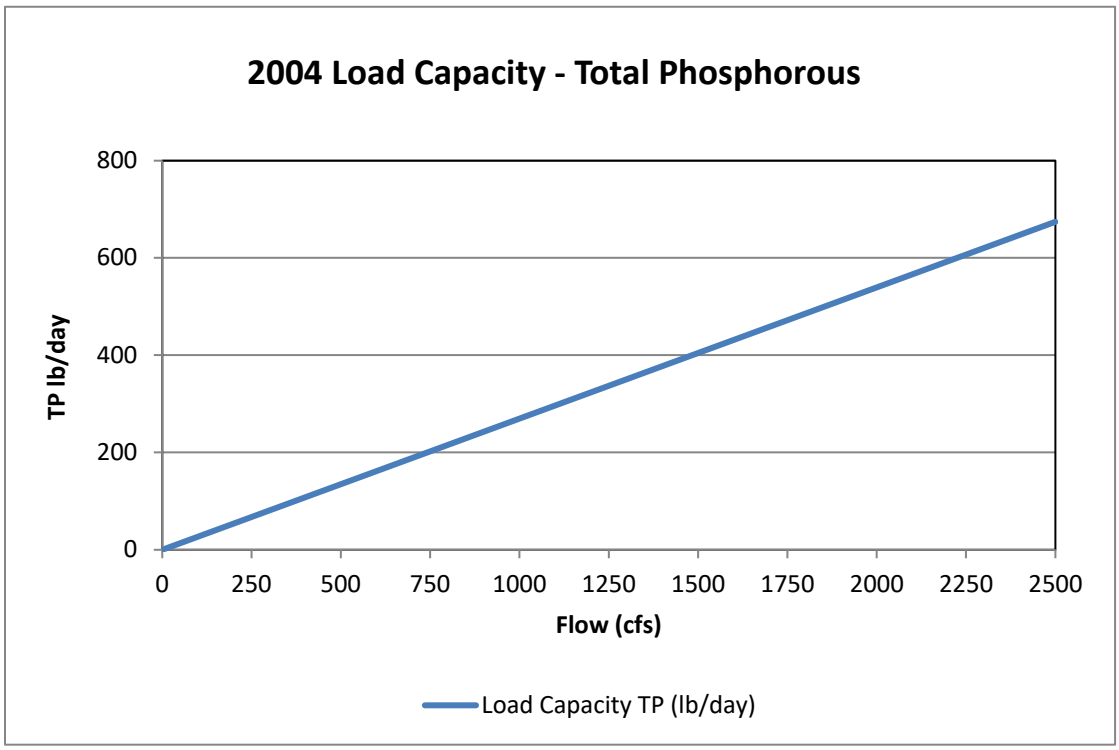


Figure 26. Total phosphorous load capacity established in the 2004 TMDL (DEQ 2004).

The load capacity was calculated for each AU based on the observed flows associated with the highest concentration of total phosphorus samples and the water quality target (Table 26).

Table 26. Total phosphorus load capacities.

Assessment Unit	Streamflow (cfs)	Total Phosphorus Target Concentration (mg/L)	Total Phosphorus Load Capacity (lb/day)
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	123	0.05	33.11
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	56	0.05	15.07
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	35	0.05	9.42

5.3.3 Estimates of Existing Pollutant Loads

Regulations for loadings "…may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(g)). The total phosphorus existing loads for each AU were calculated based on the highest concentration measured and its associated flow for a period collected approximately every 2 weeks from June to September in 2016 using the following formula:

$$Existing\ load\ \left(\frac{\text{lb}}{day}\right) = \text{flow}\left(\frac{ft^3}{second}\right) \times concentration\ \left(\frac{mg}{1\ L}\right) \times 2.2E^{-6}\left(\frac{lb}{mg}\right) \times 28.32\left(\frac{L}{ft^3}\right) \times 86{,}400\left(\frac{second}{day}\right)$$

Where:

Flow is cubic feet per second (cfs).
Total phosphorus concentration is milligrams (mg) per liter (L).
$2.2E^{-6}$ pound (lb) per mg is the unit conversion.
28.32 L per cubic foot (ft^3) is the volume conversion.
86,400 seconds per day is the time conversion.

Table 27 provides the existing pollutant loads for the AUs with total phosphorus exceedances. Figure 27 shows the existing total phosphorus loads compared to the load capacity.

Table 27. Existing loads of total phosphorus for three AUs in Willow Creek subbasin.

Assessment Unit	Streamflow (cfs)	Total Phosphorus Existing Load (lb/day)
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	123	57
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	56	20
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	35	13

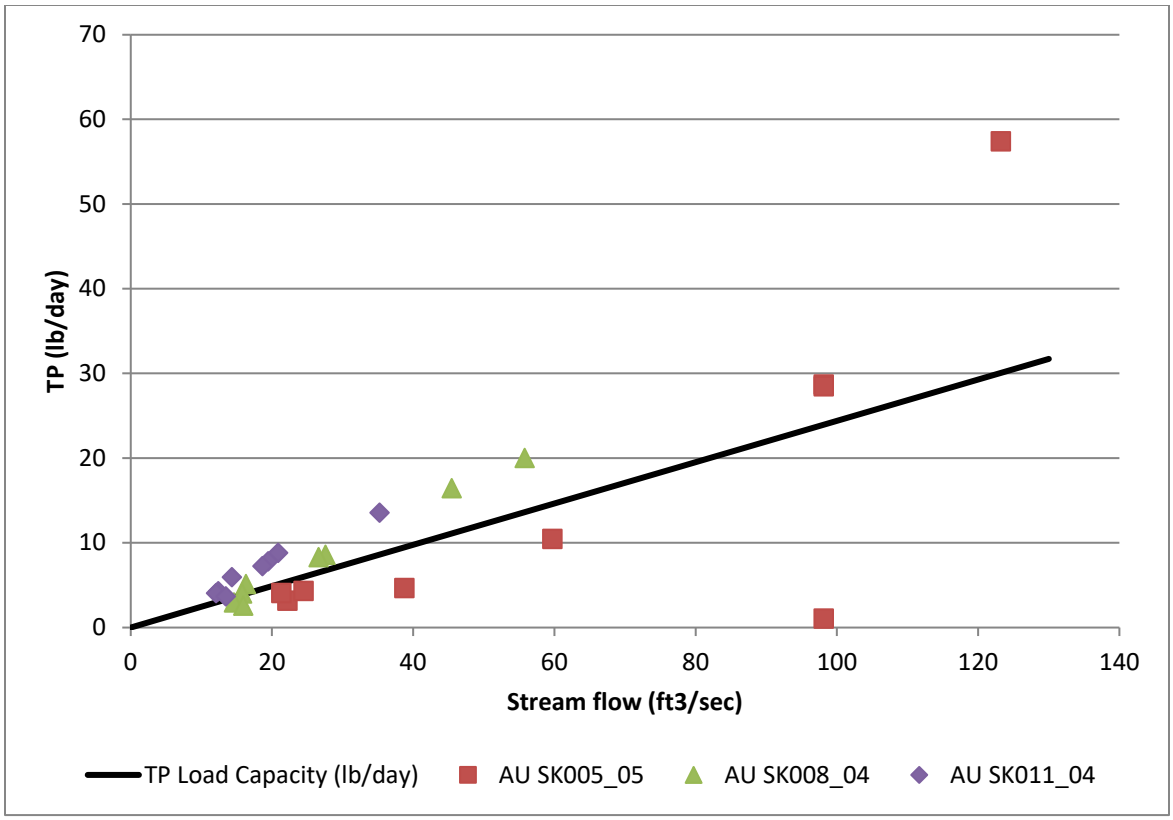


Figure 27. Total phosphorus loads based on streamflow for the Willow Creek subbasin.

5.3.4 Load Allocations

The TMDL allocates 10% of the load capacity to an explicit MOS, 10% of the load capacity to natural background, and the remaining 80% to the load allocation (Table 28). All load allocations are dedicated to nonpoint sources. No attempt was made to divide the allocation among different nonpoint source activities.

Table 28. 2016 load calculations with natural background and MOS taken into consideration.

Assessment Unit	Load Capacity (lb/day)	Natural Background (lb/day)	Margin of Safety (lb/day)	Load Allocation (lb/day)	Total Existing Load (lb/day)	Load Reduction (lb/day)	Percent Reduction (%)
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	33.11	3.31	3.31	26.48	57.00	30.52	54
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	15.07	1.51	1.51	12.06	20.00	7.94	40
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	9.42	0.94	0.94	7.54	13.00	5.46	42

Nutrient load calculations set for the Willow Creek subbasin from the 2004 TMDL set a 23% reduction target for total phosphorus. Reduction targets were not divided by AUs in the 2004 TMDL. Three reduction targets are now associated with three individual AUs in Willow Creek

subbasin that are unlisted or in Category 4a. A 40% to 54% reduction in total phosphorus load is still necessary to meet the target across the AUs evaluated.

5.3.4.1 Margin of Safety

Establishing a TMDL requires identifying an MOS to account for uncertainty as required by federal regulation (40 CFR 130). The MOS is not allocated to any sources of a pollutant. An MOS is expressed as either an implicit or explicit portion of a water body's load capacity that is reserved to allow for uncertainty about the relationship between the pollutant loads and the quality of the receiving water body. The TMDL allocates 10% of the load capacity to an explicit MOS.

5.3.4.2 Seasonal Variation

Nutrient concentrations generally vary as a function of streamflow and agricultural activities. Nutrient TMDLs are developed based on the periods where highest concentrations of nutrients would be expected in the streams and rivers; generally, this occurs during peak growing season when stream flows fluctuate from high flows of spring runoff to low flows of late summer. While the reductions are estimated using inputs from peak growing season, the concentration target of 0.05 mg/L is expected to be met year-round.

5.3.4.3 Natural Background

Natural background loads for total phosphorus in the Willow Creek subbasin are unknown, so individual allocations are not included in the TMDLs. As such an additional 10% of the nutrient load has been allocated to natural background sources as an initial estimate that may be refined as more information becomes available in the future.

5.4 Combined Biota/Habitat Bioassessments

Four AUs are listed in Category 5 of the 2022 Integrated Report for combined biota/habitat bioassessments: ID17040205SK005_02, ID17040205SK008_02, ID17040205SK009_02, and ID17040205SK030_02. SEIs were performed for these AUs in 2016 and 2017. One of the five AUs (ID17040205SK005_02) indicated excess sediment from the SEI. However, SEIs cannot be used as an assessment tool. No BURP data has been collected for these AUs since the 2004 TMDL, and investigation into causes of impairment should be a priority in the upcoming field seasons. All four AUs should remain in Category 5 for the next Integrated Report.

5.5 Reasonable Assurance

When TMDLs are developed for water bodies that are impaired by point sources only, the issuance of an IPDES or NPDES permit provides reasonable assurance that the waste load allocation in the TMDL will be achieved. When a TMDL is developed for water bodies impaired by both point and nonpoint sources, the TMDL must provide reasonable assurance that the load allocation will be achieved through nonpoint source controls for the TMDL to be

approvable. For water bodies impaired only by nonpoint sources, a demonstration of reasonable assurance is not required (EPA 2002).

While a demonstration of reasonable assurance is not required in this TMDL, the State of Idaho relies on the *Idaho Nonpoint Source Management Plan 2020-2025*, TMDL implementation plans, § 319 grants, local stakeholders, and agency partners to promote voluntary implementation of nonpoint source controls that may be required to meet the reductions specified in a TMDL's load allocations. A discussion those groups are provided in this section and more specific discussion of TMDL implementation strategies are found in section 5.7.

The CWA § 319 requires each state to develop and submit a nonpoint source management plan. The *Idaho Nonpoint Source Management Plan 2020-2025* was approved by EPA in December 2020 (DEQ 2020). The plan identifies programs to achieve implementation of nonpoint source BMPs, includes a schedule for program milestones, outlines key agencies and agency roles, is certified by the state attorney general to ensure that adequate authorities exist to implement the plan, and identifies available funding sources.

Idaho's Nonpoint Source Management Program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. One of the prominent programs described in the plan is the provision for public involvement, including basin advisory groups and watershed advisory groups (WAGs). The Willow Creek WAG is the designated WAG for the Willow Creek subbasin.

Idaho's water quality standards refer to existing authorities to control nonpoint pollution sources in Idaho. Some of these authorities and responsible agencies are listed in Table 29.

Table 29. State of Idaho's regulatory authority for nonpoint pollution sources.

Authority	Water Quality Standard	Responsible Agency
Rules Pertaining to the Idaho Forest Practices Act (IDAPA 20.02.01)	58.01.02.350.03(a)	Idaho Department of Lands
Solid Waste Management Rules and Standards (IDAPA 58.01.06)	58.01.02.350.03(b)	Idaho Department of Environmental Quality
Individual/Subsurface Sewage Disposal Rules (IDAPA 58.01.03)	58.01.02.350.03(c)	Idaho Department of Environmental Quality
Stream channel Alteration Rules (IDAPA 37.03.07)	58.01.02.350.03(d)	Idaho Department of Water Resources
Rathdrum Prairie Sewage Disposal Regulations (Panhandle District Health Department)	58.01.02.350.03(e)	Idaho Department of Environmental Quality/Panhandle District Health Department
Rules Governing Exploration, Surface Mining and Closure of Cyanidation Facilities (IDAPA 20.03.02)	58.01.02.350.03(f)	Idaho Department of Lands
Dredge and Placer Mining Operations in Idaho (IDAPA 20.03.01)	58.01.02.350.03(g)	Idaho Department of Lands
Rules Governing Dairy Waste (IDAPA 02.04.14)	58.01.02.350.03(h)	Idaho State Department of Agriculture

Idaho uses a voluntary approach to address agricultural nonpoint sources; however, regulatory authority is found in the water quality standards (IDAPA 58.01.02.350.01–03). IDAPA 58.01.02.055.07 refers to the *Idaho Agricultural Pollution Abatement Plan* (ISWCC 2015), which provides direction to the agricultural community about approved BMPs. A portion of the Ag Plan outlines responsible agencies or elected groups (soil conservation districts) that will take the lead if nonpoint source pollution problems must be addressed. For agricultural activity, the Ag Plan assigns the local soil conservation districts to assist the landowner/operator with developing and implementing BMPs to abate nonpoint source pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may seek injunctive relief for those situations determined to be an imminent and substantial danger to public health or the environment (IDAPA 58.01.02.350.02(a)).

Idaho's water quality standards and wastewater treatment requirements specify that if water quality monitoring indicates that water quality standards are not being met, even with the use of BMPs or knowledgeable and reasonable practices, the state may request that the designated agency evaluate and/or modify the BMPs to protect beneficial uses. If necessary, the state may seek injunctive or other judicial relief against the operator of a nonpoint source activity in accordance with the DEQ director's authority provided in Idaho Code § 39-108 (IDAPA 58.01.02.350). The water quality standards list designated agencies responsible for reviewing and revising nonpoint source BMPs: the Idaho Department of Lands for timber harvest activities, oil and gas exploration and development, and mining activities; Idaho Soil and Water Conservation Commission for grazing and agricultural activities; Idaho Transportation Department for public road construction; Idaho State Department of Agriculture for aquaculture; and DEQ for all other activities (IDAPA 58.01.02.010.24).

5.6 Reserve for Growth

A growth reserve has not been included in this TMDL. The entire load capacity has been allocated to the existing sources in the watershed. Any new sources will need to obtain an allocation from the existing load allocation to meet Idaho's water quality standards criteria. Low population density and static land use trends in the watershed led to the decision not to incorporate a reserve.

5.7 Implementation Strategies

Activities, structures, and management strategies within the Willow Creek subbasin TMDL implementation plan include BMPs appropriate for reducing agricultural impacts to water quality in the subbasin. Implementation strategies for TMDLs produced using PNV-based shade and solar loads should incorporate the load analysis tables presented in section 5.1. These load analysis tables must be updated, first to field verify the remaining existing shade levels and second to monitor progress toward 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 tables. Due to the inexact nature of the aerial photo

interpretation technique, existing shade compared to PNV conditions show relative differences in reductions. Implementation strategies should include Solar Pathfinder monitoring to field verify the AUs that have not been ground-truthed and mark progress toward achieving desired load reductions.

There may be a variety of reasons that individual stream segments do not meet shade targets, including natural phenomena (e.g., beaver ponds, springs, wet meadows, and past natural disturbances) and/or historic land-use activities (e.g., logging, grazing, and mining). It is important that existing shade for each stream segment be field verified to conclude if shade differences exist and result from activities that are controllable. Information within this TMDL (maps and load analysis tables) should be used to guide and prioritize implementation investigations to provide optimal improvement. The information in this TMDL may need further adjustment to reflect new information and conditions in the future.

Similar requirements necessary for temperature TMDL implementation are also needed to implement sediment and bacteria TMDLs. Improvements in riparian communities will both help stabilize the streambank and limit bacteria pathways into the stream channel. Successful implementation presumes that the Willow Creek subbasin undergo changes in land management that may be coupled with additional exclosure fencing, which is effective at improving riparian density.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or significant progress is not being made toward achieving the goals. Reasonable assurance (section 5.5) for the TMDL to meet water quality standards is based on the implementation strategy.

5.7.1 Time Frame

Implementing the temperature TMDL relies on riparian area management practices that will provide a mature canopy cover to shade the stream and prevent excess solar loading. Because implementation depends on mature riparian communities to substantially improve stream temperatures, DEQ believes 10–20 years may be a reasonable amount time for achieving water quality standards. Shade targets will not be achieved all at once. Given their smaller bankfull widths, smaller streams may reach targets sooner than larger streams.

DEQ believes that a time frame of 5–10 years is required to begin streambank stabilization and initial identification of diminished volumes of fine sediment. Given their smaller bankfull widths, smaller streams may reach targets sooner than larger streams. DEQ estimates that without new sediment inputs, removing the fines on the substrate and redeveloping the thalweg will take approximately 5 years.

E. coli impairments are extremely variable by season and mitigation options. For example, exclosure fencing can cause nearly instant improvement. If the primary source for the *E. coli* is not from domesticated animal sources, the time frame is more difficult to reconcile and adjust via restoration activities.

Successfully achieving the TMDL target and allocations will depend in part on voluntary measures and be influenced by available funding, cost-sharing, willing partners, and opportunities for water quality trading. DEQ and the designated WAG will continue to reevaluate TMDLs on a 5-year cycle. During the 5-year review, implementation actions completed, in progress, and planned will be reviewed, and pollutant load allocations will be reassessed accordingly.

5.7.2 Approach to Meeting Allocations

DEQ anticipates that improved riparian management practices in the long run will stabilize streambanks, reduce sedimentation, increase canopy cover, and lower stream temperatures. Implementing these riparian zone recovery practices will contribute to overall improvement in stream morphology and habitat, shifting stream health towards beneficial use attainment.

The designated management agencies, WAG, and other appropriate public process participants are expected to implement the following:

- Develop BMPs to achieve load allocations.
- Give reasonable assurance that management measures will meet load allocations through both quantitative and qualitative analysis of management measures.
- Adhere to measurable milestones for progress.
- Develop a timeline for implementation, with reference to costs and funding.
- Develop a monitoring plan to determine if BMPs are being implemented, if individual BMPs are effective, if load allocations and wasteload allocations are being met, and whether or not water quality standards are being met.

Funding provided under CWA § 319 and other funds will be used to encourage voluntary projects to reduce nonpoint source pollution.

5.7.2.1 Wasteload Allocation

There are no known NPDES-permitted point sources in the affected watersheds and no wasteload allocations. If a point source is proposed that would have thermal consequences on these waters, background provisions in Idaho's water quality standards addressing such discharges (IDAPA 58.01.02.200.09; IDAPA 58.01.02.401.01) should be involved (Appendix B).

5.7.2.2 Storm Water Waste Load Allocation

There are currently no storm water facilities that discharge to water bodies addressed in this TMDL. Because there are no storm water facilities impacting impaired water bodies in this TMDL, no wasteload allocations are included for storm water activities.

Construction General Permits

Under the conditions of the Construction General Permits (CGPs) operators are required develop a Storm Water Prevention Plan (SWPP) before submitting a Notice of Intent for permit coverage. The SWPP must include a description of storm water controls to meet the effluent

limits of the construction general permit. Erosion controls requirements contained in the CGP are expected to meet water quality standards. The relevant conditions to control storm water sources include but are not limited to the following:

- Maintain natural buffers when a water of the United States is within 50 feet of the earth disturbances.
- Direct storm water to vegetated areas to maximum storm water infiltration and filtering.
- Install sediment controls along the perimeter areas of the site that will receive pollutant discharges.
- Minimize sediment track out.
- Manage stockpiles or land clearing debris.
- Protect storm drains inlets.
- Preserve native topsoil.

In addition to the conditions listed above, an operator discharging to a water body with a TMDL must increase frequency of inspections to ensure erosion controls are functioning properly and monitor turbidity to ensure numeric turbidity criteria are not exceeded when the construction site is discharging. If turbidity monitoring identifies the numeric turbidity criterion is exceeded, the operator must stop construction activities, take immediate actions to address the cause of exceedances, and notify a DEQ regional office within 24 hours (EPA 2017).

DEQ does not intend the wasteload allocation for CGPs in this TMDL to be implemented as load limits to permits. DEQ assumes the CGP requirements provided adequate controls for sediment and sediment-bound nutrients to provide consistency with the intent of the TMDL. Additionally, future dischargers that require a CGP are considered consistent with the TMDL if they apply for permit coverage and implement the requirements of the CGP, including a SWPP.

Multi-Sector General Permits

Similar to the CGPs, the Multi-Sector General Permits (MSGPs) require the operator to develop a SWPP before submitting a Notice of Intent. The SWPP must identify pollutants that may be exposed to storm water and identify pollution control measures that will be implemented to meet the non-numeric technology-based limits, water quality based effluent limits, or other limits specific to the industry type. For existing MSGP discharges to impaired waters with EPA-approved TMDL, EPA is required to inform operators if additional measures are needed for the discharge to consistent with the assumptions and requirements of the applicable TMDL (EPA 2015). To be consistent with the assumptions of requirements of this TMDL the operator must retain storm water permit coverage under the IPDES or NPDES permit and properly implement and maintain all BMPs required by the permit.

New MSGP dischargers to waters with EPA-approved TMDLs are ineligible for permit coverage unless the operator conducts one of the following: prevents all exposure to storm water of the pollutants for which the water body is impaired and retains documentation of procedures taken to prevent exposure on site with a SWPP; provides technical information or other documentation to demonstrate the pollutants of concern are not present on the site, or

demonstrates to EPA the discharge is expected to meet applicable water quality standards (EPA 2015). DEQ assumes that future discharges are consistent with the intent of the TMDL if the operator can demonstrate exposure of TMDL pollutants to storm water will not occur or pollutants of concern are not present. If the new MSGSP dischargers cannot demonstrate these conditions, they may use part of the load capacity that has been reserved for growth or demonstrate the discharge from the facility will not exceed any concentration-based targets established in the TMDL.

DEQ recommends monitoring for pollutants that are addressed in the TMDL. Certain industries covered by the MSGP may already be required to monitor pollutants addressed in this TMDL. Renewed IPDES/NPDES permits should include monitoring to ensure MSGPs are consistent with the TMDL targets. During future permit cycles, the monitoring results should be reviewed to demonstrate MSGP sources provide consistency with the TMDL. If monitoring results show consistency with the TMDL, additional monitoring can be suspended. If monitoring results show inconsistency with the TMDL, additional BMP requirements should be added to future permit cycles. Additional BMP requirements should focus on reducing the pollutant loads by the necessary reductions to meet the targets established in the TMDL. DEQ recommends permit writers match additional BMP requirements with the BMP identified as effective for reducing TMDL pollutants as discussed in the *Idaho Catalog of Storm Water Best Management Practices* (DEQ 2005).

Municipal Separate Storm Sewer System

Federal regulations require Municipal Separate Storm Sewer Systems (MS4) permits to include conditions to reduce the discharge of pollutants from MS4 to the maximum extent practical. This regulation includes management practices, control techniques and system, design, and engineering methods, and other provisions the administrator or state determine as appropriate for the control of pollutants (33 U.S.C § 1342(p)). MS4 permits generally rely on developing and implementing a suite of BMPs designed to reduce pollutants to the maximum extent practical. MS4 permittees are required to develop Storm Water Management Plans (SWMP) to implement permit requirements including BMPs. Additionally, MS4 permits contain requirements to submit summaries of monitoring results.

DEQ assumes the MS4 permittees address their storm water wasteload allocation through implementation of BMPs consistent with the requirement to reduce pollutants by the maximum extent practical. In future permit cycles, DEQ recommends permit writers review applicable monitoring data to evaluate MS4 discharges consistency with the wasteload allocation of this TMDL. If available data suggest inconsistency with the wasteload allocations in the TMDL, it is recommended future permits require additional BMP implementation. Additional BMP requirements should focus on reducing pollutant addressed in this TMDL.

5.7.2.3 Load Allocation

The *Willow Creek Subbasin TMDL Agricultural Implementation Plan* (ISWCC 2011) was developed several years following the Willow Creek subbasin TMDL (DEQ 2004). The plan identifies BMPs for implementation on agricultural lands. These BMPs were intended to help

meet the requirements of the TMDL load allocations by reducing the amount of agricultural pollutants entering water bodies. A number of projects were implemented in the Willow Creek subbasin based on BMPs developed.

Funding provided under the CWA § 319 and other funds will be used to encourage voluntary projects to reduce nonpoint source pollution. The ISWCC and NRCS also provide many loan and grant opportunities to implement BMPs. Additional funding sources are found in the *Willow Creek Subbasin TMDL Agricultural Implementation Plan* (ISWCC 2011).

5.7.3 Responsible Parties

DEQ and the designated management agencies in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. In Idaho, these agencies, and their federal and state partners, are charged by the CWA to lend available technical assistance and other appropriate support to local efforts for water quality improvements. Designated state agencies are responsible for assisting with preparing specific implementation plans, particularly for those resources for which they have regulatory authority or programmatic responsibilities:

- Idaho Department of Lands for timber harvest, oil and gas exploration and development, and mining
- Idaho Soil and Water Conservation Commission for grazing and agricultural activities
- Idaho Transportation Department for public road construction
- Idaho State Department of Agriculture for aquaculture
- Idaho Department of Fish and Game
- United States Fish and Wildlife Service
- Caribou-Targhee National Forest
- Bureau of Land Management
- Conservation commission, conservation districts, and NRCS
- DEQ for all other activities

In addition to the designated management agencies, the public—through the WAG and other equivalent organizations or processes—will have opportunities to be involved in developing the implementation plan to the maximum extent practical. Public participation will significantly affect public acceptance of the document and the proposed control actions. Stakeholders (e.g., landowners, local governing authorities, taxpayers, industries, and land managers) are the most educated regarding the pollutant sources and will be called upon to help identify the most appropriate control actions for each area. Experience has shown that the best and most effective implementation plans are those developed with substantial public cooperation and involvement.

5.7.3.1 Conservation Commission, Conservation Districts, and NRCS

The Idaho Soil and Water Conservation Commission (ISWCC) works with the East Side Soil and Water Conservation District (ESSWCD), North Bingham Soil Conservation District (NBSCD), Caribou Soil Conservation District (CSCD), Idaho Association of Soil Conservation Districts, and

United States Department of Agriculture NRCS to reach common goals and successfully deliver conservation programs within the Willow Creek subbasin. Conservation assistance is provided by three ISWCC districts (ESSWCD, NCSCD, and CSCD) and three NRCS offices.

In the Willow Creek subbasin implementation plan, ISWCC outlines agricultural BMPs designed to reduce the amount of nonpoint source pollutants entering water bodies in the subbasin. Suggested BMPs are listed for each specific land type or use and are intended to be "developed and implemented on-site with willing individual agricultural landowners and operators" (ISWCC 2011). The plan includes public outreach and monitoring components.

5.7.3.2 Bureau of Land Management

The BLM Upper Snake Field Office identified several management actions to promote the overall health of BLM lands in the Upper Snake River region. Proposed actions specific to water quality and stream health include riparian plantings, fencing, and upland shrub planting. For more information on BLM proposed actions, see the *Upper Snake Habitat Restoration Planting Project Environmental Assessment* (BLM 2013).

5.7.3.3 Caribou-Targhee National Forest

The Caribou-Targhee National Forest, Dubois Ranger District, manages riparian grazing on forest land in the drainage (Leffert 2005) according to these guidelines:

- Canopy cover of 80% or more
- Well-vegetated streambanks with minimal livestock trampling
- Overhanging vegetation available on 50% or more of the streambank to provide fish cover

The Caribou-Targhee National Forest also publishes grazing allotment management guidelines that list BMPs specific to forest grazing allotments.

5.7.3.4 US Fish and Wildlife Service

The United States Fish and Wildlife Service (USFWS) manages the Grays Lake National Wildlife Refuge (NWR) by implementing the following wildlife and habitat goals:

- Maintain and protect the existing integrity of functional native habitat and restore the natural range of variability and resiliency of degraded habitats.
- Provide high-quality forage and cover habitat to increase fitness of migratory birds.
- Provide supplemental on-refuge forage base for carbohydrate and protein requirements of migratory waterfowl and landbirds within the Pacific and Rocky Mountain migratory corridors.
- Collect, synthesize, and manage science-based information to guide the management of Grays Lake NWR.
- Increase public understanding and appreciation of the Grays Lake NWR (USFWS 2012).

5.7.3.5 Idaho Department of Fish and Game

The IDFG manages the Tex Creek Wildlife Management Area using specific goals for both the wildlife management area and the larger Willow Creek subbasin:

- Restore native Cutthroat Trout populations in Willow Creek and tributaries.
- Improve riparian habitat throughout the Willow Creek drainage.
- Work for habitat and stream flow protection and enhancement.
- Seek out willing landowners for riparian exclusionary fencing projects.
- Implement projects that reduce or eliminate sediment additions to the Willow Creek drainage.
- Develop collaborative approach with other agencies and volunteer networks to implement rehabilitation activities resulting from effects of the 2016 Henrys Creek fire (IDFG 2016).

Riparian habitat improvement through better grazing management is a high priority on both state and private lands. IDFG is working with NRCS, Eastern Idaho Grazing Association, and other local groups to facilitate improvements in resource management practices (IDFG 2013).

5.7.3.6 Idaho Department of Lands

The IDL, the designated state agency responsible for administering and enforcing the Forest Practices Act (FPA) on all forestland in the state, submitted an implementation plan for timber harvest in the Willow Creek subbasin (IDL 2000). The actual harvest and processing of trees into logs has relatively little impact on water quality. Rather, the main impact to water quality is from the construction and use of timber harvest roads. To address sediment delivery into streams from roads, specific BMPs are identified in the FPA. As part of administering the FPA, IDL will monitor and inspect timber harvests for compliance with the FPA. If inadequate BMP implementation is identified, IDL will use standard FPA enforcement procedures to rectify the situation.

The IDL is also the designated lead agency for surface mining practices on state land and will continue to work collaboratively with all state and federal agencies in implementing the 1971 Surface Mining Act.

5.7.4 Implementation Monitoring Strategy

The objectives of a monitoring strategy are to demonstrate long-term recovery, better understand natural variability, track project and BMP implementation, and track the effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the reasonable assurance component of the TMDL implementation plan.

Monitoring will provide information on progress made toward achieving TMDL allocations and water quality standards and will help in the interim evaluation of progress, including in the development of 5-year reviews and future TMDLs.

BURP monitoring, as prescribed in the *Water Body Assessment Guidance* (DEQ 2016), is used to collect data on AUs and to determine the support status of an AU's beneficial uses. BURP monitoring, in conjunction with temperature, sediment, nutrient and bacteria monitoring, provide comprehensive tracking of the water quality in the Willow Creek subbasin.

Effective shade monitoring can take place on any segment throughout the Willow Creek subbasin and be compared to existing shade estimates (Appendix C and section 5.1). Those areas with the largest disparity between existing and target shade should be monitored with Solar Pathfinders to verify existing shade levels and determine progress toward meeting shade targets. Many existing shade estimates have not been field verified, so they may require adjustment during the implementation process. Stream segment length for each estimate of existing shade varies depending on the 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 toward target levels. Ten equally spaced Solar Pathfinder measurements averaged together within that segment should suffice to determine new shade levels in the future.

Sediment monitoring can either take place at the same location where a previous SEI identified a sediment impairment (Appendix C) or a location representative of an AU where a sediment impairment has been confirmed (section 4.1.3). Results of this SEI monitoring can be compared to previous SEI monitoring to evaluate whether sedimentation problems are improving and if implementation measures have succeeded.

Bacteria monitoring can take place in the same locations where bacteria sampling occurred in an AU with a bacteria TMDL (section 5.2). Samples should be taken during the critical time of the year (May–October) and compared to Idaho's water quality standards to determine if the implemented BMPs have been effective. The three AUs found to have *E. coli* impairments should be sampled again in the future.

Nutrient monitoring can take place in the same locations where total phosphorus sampling occurred in an AU with a total phosphorus TMDL (section 5.3). Samples should be taken approximately every 2 weeks from the beginning of June to the middle of September. This time frame captured the highest amount of nutrients within the stream at elevated flows due to runoff. Concentration results can be compared to Idaho's water quality standards to determine if the implemented BMPs have been effective. The three AUs found to have total phosphorus impairments should be sampled again in the future.

The implementation plan will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. Implementation plan monitoring will include watershed monitoring and BMP monitoring.

6 Conclusions

Current data led to the conclusion that stream temperatures in excess of criteria are pervasive throughout the Willow Creek subbasin. The PNV TMDLs were revised for 18 Category 4a AUs and created for two Category 5-listed AUs. Because several streams in a given subwatershed are described with the same AU, all streams within an AU that needed a new temperature TMDL were included in the analysis. The PNV temperature TMDLs presented in section 5.1 quantify the nonpoint source solar heat load to Willow Creek and its tributaries. Table A and B summarize the assessment outcomes for waters listed in Category 4a and Category 5 of the 2022 Integrated Report (DEQ 2022).

E. coli sampling and the resultant calculated geometric mean concentrations and statistical threshold values, led to developing *E. coli* bacteria TMDLs on four AUs: Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02), Mill Creek—source to mouth (ID17040205SK012_03), Gravel Creek—source to mouth (ID17040205SK023_02), and Brockman Creek—Corral Creek to mouth (ID17040205SK024_02). Mill Creek was previously unassessed for bacteria, but sampling efforts revealed *E. coli* exceedances.

Total phosphorus sampling led to the revision of two TMDLs for Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04) and Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04). Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05) was a part of a completed TMDL for total phosphorus in 2004; however, the AU was never added to the § 303(d) list. This led to developing a total phosphorus TMDL for this AU. Sampling efforts have consistently shown exceedances in total phosphorus concentrations in this AU, and a TMDL was completed. Nitrogen as nitrite + nitrate sampling was conducted during field visits, but no exceedance of criteria occurred.

Future restoration projects aimed at reducing stream temperature should also help stabilize the banks and reduce direct access to the streams by cattle, which should further reduce the amount of sediment, nutrients, and *E. coli* conveyed to these streams. A growth reserve is not included in the TMDLs. Unless the load capacity is increased, future sources will need to acquire a load allocation from existing allocations to meet Idaho's water quality standards criteria.

A summary of evaluated AUs that are impaired but not listed, listed in Category 5, or listed in Category 4a are presented in Table 30 and 31 with recommended changes to the listing status for the next Integrated Report.

Table 30. Summary of evaluated AUs that are unlisted and impaired or listed in Category 5.

Assessment Unit	Pollutant	TMDL Developed	Recommended Changes to Next Integrated Report	Justification
Unlisted but Impaired Assessment Unit				
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	Total phosphorus	Yes	Add total phosphorus as a Category 4a impairment once TMDL is approved.	Total phosphorus TMDL completed.
Mill Creek—source to mouth (ID17040205SK012_03)	*E. coli*	Yes	Add *E. coli* as a Category 4a impairment once TMDL is approved.	Bacteria TMDL developed.
Category 5 Assessment Units				
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Crow Creek—source to Willow Creek (ID17040201SK007_05)	Sedimentation	No	Retain in Category 5 for sediment. Move AU to Willow Creek subbasin.	Impairment needs further investigation
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
	Temperature	Yes	Move to Category 4a for temperature.	Temperature TMDL completed based on PNV.
	E. coli	Yes	Move to Category 4a for *E. coli*.	Bacteria TMDL completed.
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Mud Creek—source to mouth (ID17040205SK009_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.

Assessment Unit	Pollutant	TMDL Developed	Recommended Changes to Next Integrated Report	Justification
Grays Lake—1st- and 2nd-order tributaries (ID17040205SK021_02)	Temperature	Yes	Move to Category 4a for temperature.	Temperature TMDL completed based on PNV.
Gravel Creek—source to mouth (ID17040205SK023_02)	*E. coli*	Yes	Move to Category 4a for *E. coli*.	Bacteria TMDL completed.
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	*E. coli*	Yes	Move to Category 4a for *E. coli*.	Bacteria TMDL completed.
Bulls Fork—source to mouth (ID17040205SK030_02)	Combined biota/habitat	No	Retain in Category 5 for combined biota/habitat.	BURP site assessment and further field analysis for sediment are warranted.
	Temperature	No	Retain in Category 5 for temperature.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.

Table 31. Summary of review and revision of existing TMDLs.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Willow Creek—Bulls Fork to Ririe Reservoir (ID17040205SK004_05)	Sediment	No	Retain in Category 4a.	Not accessible due to steep terrain and limited road access.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
	Nutrients	No	Retain in Category 4a.	Not accessible due to steep terrain and limited road access.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_02)	Temperature	Yes	Retain in Category 4a for temperature.	Temperature TMDL revised based on PNV.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_04)	Nutrients	No	Retain in Category 4a.	No field data collected due to denied access in 2013.
Willow Creek—Birch Creek to Bulls Fork (ID17040205SK005_05)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Willow Creek—Mud Creek to Birch Creek (ID17040205SK008_04)	Total phosphorus	Yes	Retain in Category 4a.	TMDL revised.
Sellars Creek—source to mouth (ID17040205SK010_02)	Temperature	Yes	Retain in Category 4a.	TMDL revised using PNV method.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Sellars Creek—source to mouth (ID17040205SK010_03)	Sediment	No	Retain in Category 4a.	Sediment trend was analyzed based on streambank erosion inventory (SEI).
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_02)	Sediment	No	Retain in Category 4a.	No flow in 2010. Impairment needs further investigation.
Willow Creek—Crane Creek to Mud Creek (ID17040205SK011_04)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation. SEI indicates no impairment.
	Total phosphorus	Yes	Retain in Category 4a.	TMDL revised.
	Temperature	Yes	Retain in Category 4a	TMDL revised using PNV method.
Mill Creek—source to mouth (ID17040205SK012_02)	Sediment	No	Retain in Category 4a.	No field data collected since 2001. Impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a	TMDL revised using PNV method.
Mill Creek—source to mouth (ID17040205SK012_03)	Sediment	No	Retain in Category 4a.	Sediment trend was analyzed based on SEI.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Willow Creek—source to Crane Creek (ID17040205SK013_02)	Sediment	No	Retain in Category 4a.	Dry in 2004. Impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	TMDL revised using PNV method.
	Total phosphorus	No	Retain in Category 4a.	Dry conditions in 2016. Impairment needs further investigation.
Willow Creek—source to Crane Creek (ID17040205SK013_03)	Nutrients	No	Retain in Category 4a.	No field data collected due to denied access in 2011.
	Temperature	Yes	Retain in Category 4a.	TMDL revised using PNV method.
Crane Creek—source to mouth (ID17040205SK014_02)	Sediment	No	Retain in Category 4a.	No field data collected due to denied access in 2004.
Crane Creek—source to mouth (ID17040205SK014_03)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation.
Grays Lake outlet—Hell Creek to mouth (ID17040205SK016_04)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Grays Lake outlet—Homer Creek to Hell Creek (ID17040205SK017_04)	Temperature	No	Retain in Category 4a	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
	Sediment	No	Retain in Category 4a.	Dry in 2010. Impairment needs further investigation.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
Homer Creek—source to mouth (ID17040205SK018_02)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised using PNV method.
Homer Creek—source to mouth (ID17040205SK018_03)	Sediment	No	Retain in Category 4a.	Sediment trend was analyzed based on SEI.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV method.
Grays Lake Outlet—Brockman Creek to Homer Creek (ID17040205SK019_04)	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_02)	Temperature	No	Retain in Category 4a.	Improper assessment of intermittent, dewatered, or ephemeral stream. Does not qualify in a sampleable category for BURP assessment. Further assessment of water levels/flows are needed to potentially delist in the future.
Grays Lake Outlet—Grays Lake to Brockman Creek (ID17040205SK020_04)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Brockman Creek—Corral Creek to mouth (ID17040205SK024_02)	Sediment	No	Retain in Category 4a	McNeil Core showed no impairment. BURP assessment is needed for further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Brockman Creek—Corral Creek to mouth (ID17040205SK024_03)	Sediment	No	Retain in Category 4a	Impairment needs further investigation. SEI indicates no impairment.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Brockman Creek—source to Corral Creek (ID17040205SK025_02)	Sediment	No	Retain in Category 4a	No data collection since 2003; impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Brockman Creek—source to Corral Creek (ID17040205SK025_03)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Corral Creek—source to mouth (ID17040205SK026_02)	Sediment	No	Retain in Category 4a	Impairment needs further investigation. SEI indicates no impairment.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Sawmill Creek—source to mouth (ID17040205SK027_02)	Sediment	No	Retain in Category 4a.	No data collected since 2003; impairment needs further investigation.

Assessment Unit	Pollutant	TMDL(s) Revised	Recommended Changes to Next Integrated Report	Justification
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Lava Creek—source to mouth (ID17040205SK028_02)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Lava Creek—source to mouth (ID17040205SK028_03)	Sediment	No	Retain in Category 4a.	Sediment trend analyzed based on SEI.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Hell Creek—source to mouth (ID17040205SK029_02)	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Hell Creek—source to mouth (ID17040205SK029_03)	Sediment	No	Retain in Category 4a.	Sediment trend analyzed based on SEI.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Tex Creek—source to mouth (ID17040205SK031_02)	Sediment	No	Retain in Category 4a.	Last data collection in 2007 resulted in an inaccessible site; impairment needs further investigation.
	Temperature	Yes	Retain in Category 4a.	Temperature TMDL revised based on PNV.
Tex Creek—source to mouth (ID17040205SK031_03)	Sediment	No	Retain in Category 4a.	Sediment trend analyzed based on SEI.
	Temperature	No	Retain in Category 4a.	Analysis completed using PNV method. No shade deficiencies observed. Impairment needs further investigation.
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_02)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation. SEI indicates no impairment.
Meadow Creek—source to Ririe Reservoir (ID17040205SK032_03)	Sediment	No	Retain in Category 4a.	Impairment needs further investigation. SEI indicates no impairment.

This document was prepared with input from the public, as described in Appendix E. Following the public comment period, comments and DEQ responses will also be included in this appendix, and a distribution list will be included in Appendix F.

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GIS Coverages

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reading and understanding its limitations. The data could include technical inaccuracies or typographical errors. The Department of Environmental Quality may update, modify, or revise the data used at any time, without notice.

Glossary

§ 303(d)

Refers to section 303 subsection "d" of the Clean Water Act. Section 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 United States Environmental Protection Agency approval.

Assessment Unit (AU)

A group of similar streams that have similar land use practices, ownership, or land management. However, stream order is the main basis for determining AUs. All the waters of the state are defined using AUs, and because AUs are a subset of water body identification numbers, they tie directly to the water quality standards so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

Beneficial Use

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

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.

Exceedance

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

Fully Supporting

In compliance with water quality standards and within the range of biological reference conditions for all designated and existing beneficial uses as determined through the *Water Body Assessment Guidance* (DEQ 2016).

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

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

Load Capacity (LC)

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, a margin of safety, and natural background contributions, it becomes a total maximum daily load.

Margin of Safety (MOS)	An implicit or explicit portion of a water body's load capacity set aside to allow for uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. The margin of safety 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 margin of safety is not allocated to any sources of pollution.
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 nonirrigated lands used for grazing, crop production, and silviculture; rural roads; 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 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* (DEQ 2016).
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 plants.
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 that alter the functioning of natural processes and produce undesirable environmental and health effects. Pollution includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A 1st-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.
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

	basis. 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.
Wasteload Allocation (WLA)	
	The portion of receiving water's load 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 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, aquatic habitat, or industrial processes.
Water Quality Standards	
	State-adopted and United States 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.

Appendix A. Beneficial Uses

Idaho's water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses.

Existing Uses

Existing uses under the Clean Water Act are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards" (40 CFR 131.3). The existing instream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.051.01). Existing uses need to be protected, whether or not the level of water quality to fully support the uses currently exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that supported salmonid spawning since November 28, 1975, but does not now due to other factors, such as blockage of migration, channelization, sedimentation, or excess heat.

Designated Uses

Designated uses under the Clean Water Act are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained" (40 CFR 131.3). Designated uses are simply uses officially recognized by the state. In Idaho, these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Multiple uses often apply to the same water; in this case, water quality must be sufficiently maintained to meet the most sensitive use (designated or existing). Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are described in Idaho's water quality standards (IDAPA 58.01.02.100) and specifically listed by water body in sections 110–160.

Undesignated Surface Waters and Presumed Use Protection

In Idaho, due to a change in scale of cataloging waters in 2000, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations (IDAPA 58.01.02.110–160). The water quality standards have three sections that address nondesignated waters. Sections 101.02 and 101.03 specifically address nondesignated man-made waterways and private waters. Man-made waterways and private waters have no presumed use protections. Man-made waters are protected for the use for which they were constructed unless otherwise designated in the water quality standards. Private waters are not protected for any beneficial uses unless specifically designated in the water quality standards.

All other undesignated waters are addressed by section 101.01. Under this section, absent information on existing uses, DEQ presumes that most Idaho waters will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To

protect these so-called presumed uses, DEQ applies the numeric cold water and recreation criteria to undesignated waters. If in addition to presumed uses, an additional existing use (e.g., salmonid spawning) exists, then the additional numeric criteria for salmonid spawning would also apply (e.g., intergravel dissolved oxygen, temperature) because of the requirement to protect water quality for that existing use. However, if some other use that requires less stringent criteria for protection (such as seasonal cold aquatic life) is found to be an existing use, then a use designation (rulemaking) is needed before that use can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Appendix B. State and Site-Specific Water Quality Standards and Criteria

Table B-1. Selected numeric criteria supportive of designated beneficial uses in Idaho's water quality standards.

Parameter	Primary Contact Recreation	Secondary Contact Recreation	Cold Water Aquatic Life	Salmonid Spawning[a]
Water Quality Standards: IDAPA 58.01.02.250–251				
Bacteria				
Geometric mean	<126 *E. coli*/100 mL[b]	<126 *E. coli*/100 mL	—	—
Statistical Threshold Value	≤410 *E. coli*/100 mL	≤410 *E. coli*/100 mL	—	—
pH	—	—	Between 6.5 and 9.0	Between 6.5 and 9.5
Dissolved oxygen (DO)	—	—	DO exceeds 6.0 milligrams/liter (mg/L)	**Water Column DO**: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater **Intergravel DO**: DO exceeds 5.0 mg/L for a 1-day minimum and exceeds 6.0 mg/L for a 7-day average
Temperature[c]	—	—	22 °C or less daily maximum; 19 °C or less daily average **Seasonal Cold Water**: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average **Bull Trout**: Not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June–August; not to exceed 9 °C daily average in September and October
Turbidity	—	—	Turbidity shall not exceed background by more than 50 nephelometric turbidity units (NTU) instantaneously or more than 25 NTU for more than 10 consecutive days.	—
Ammonia	—	—	Ammonia not to exceed calculated concentration based on pH and temperature.	—
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR 131				
Temperature	—	—	—	7-day moving average of 10 °C or less maximum daily temperature for June–September

[a] During spawning and incubation periods for inhabiting species
[b] *Escherichia coli* per 100 milliliters
[c] Temperature exemption: Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the 7-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.

Appendix C. Data Sources

Table C-1. Data sources for Willow Creek subbasin assessment.

Water Body/Area	Data Source	Type of Data	Collection Date
Willow Creek subbasin	DEQ State Technical Services Office, DEQ Idaho Falls Regional Office	Aerial photo interpretation, Solar Pathfinder data collection, temperature logger data collection, bankfull width measurements and estimations	2010–2017

Willow Creek Subbasin E. Coli Data

Table C-2. *E. coli* sample results for Willow Creek subbasin.

Rock Creek—source to mouth		**ID17040205SK005_02**
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
9/10/2014	108.6	**110.8**
9/15/2014	105.0	**Statistical Threshold Value**
9/18/2014	151.5	**145.4**
9/22/2014	115.3	
9/25/2014	83.9	
Willow Creek—Mud Creek to Birch Creek		**ID17040205SK008_02**
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
6/23/2010	488.8	**689.1**
7/21/2010	>2419.2	
8/26/2010	>2419.2	
9/28/2010	78.9	
9/7/2011	248.9	**241.9**
9/15/2011	260.3	**Statistical Threshold Value**
9/22/2011	172.2	**951.1**
9/28/2011	61.7	
10/5/2011	1203.3	
8/28/2020	816.4	—
Willow Creek—Mud Creek to Birch Creek		**ID17040205SK008_04**
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
8/28/2020	62.4	**61.1**
9/4/2020	37.4	**Statistical Threshold Value**
9/11/2020	13.2	**252.8**
9/18/2020	248.1	
9/25/2020	111.2	
Sellars Creek—source to mouth		**ID17040205SK010_03**
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
8/31/2016	135.4	—
Mill Creek—source to mouth		**ID17040205SK012_03**
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
8/31/2016	>2419.2	**128.3**
9/7/2016	58.1	**Statistical Threshold Value**
9/14/2016	121.1	**1130.9**
9/21/2016	56.3	
9/28/2016	36.4	
Homer Creek—source to mouth		**ID17040205SK018_03**
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
8/31/2016	67.7	—

Gravel Creek—source to mouth		ID17040205SK023_02
Sample Date	**Result**	**Geometric Mean**
8/14/2019	727	**229.5**
8/20/2019	325.5	**Statistical Threshold Value**
8/23/2019	78	**847.6**
8/28/2019	435.2	
9/3/2019	79.4	

Shirley Creek—source to mouth		ID17040205SK024_02
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
6/23/2010	201.4	**172.7**
7/21/2010	517.2	
8/26/2010	261.3	
9/28/2010	32.7	
9/7/2011	648.8	**441.5**
9/15/2011	613.1	**Statistical Threshold Value**
9/22/2011	980.4	**1755.0**
9/28/2011	66.3	
10/5/2011	648.8	

Rock Creek—source to mouth		ID17040205SK028_03
Sample Date	**Result ($^{cfu}/_{100mL}$)**	**Geometric Mean**
8/31/2016	218.7	—

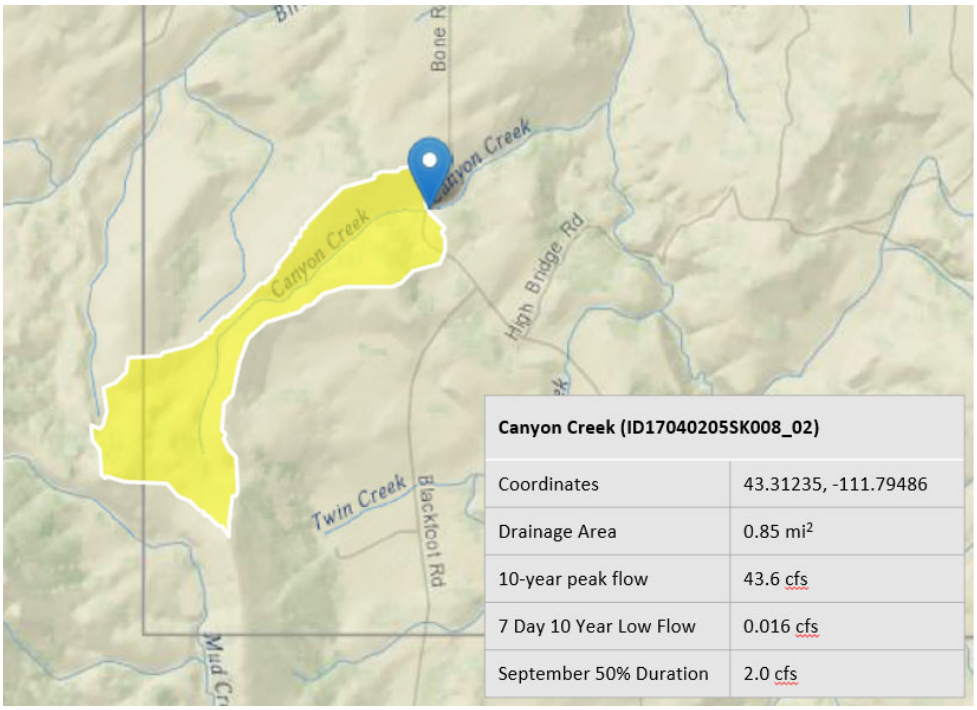


Figure C-1 .StreamStats data for Canyon Creek ID17040205SK008_02.

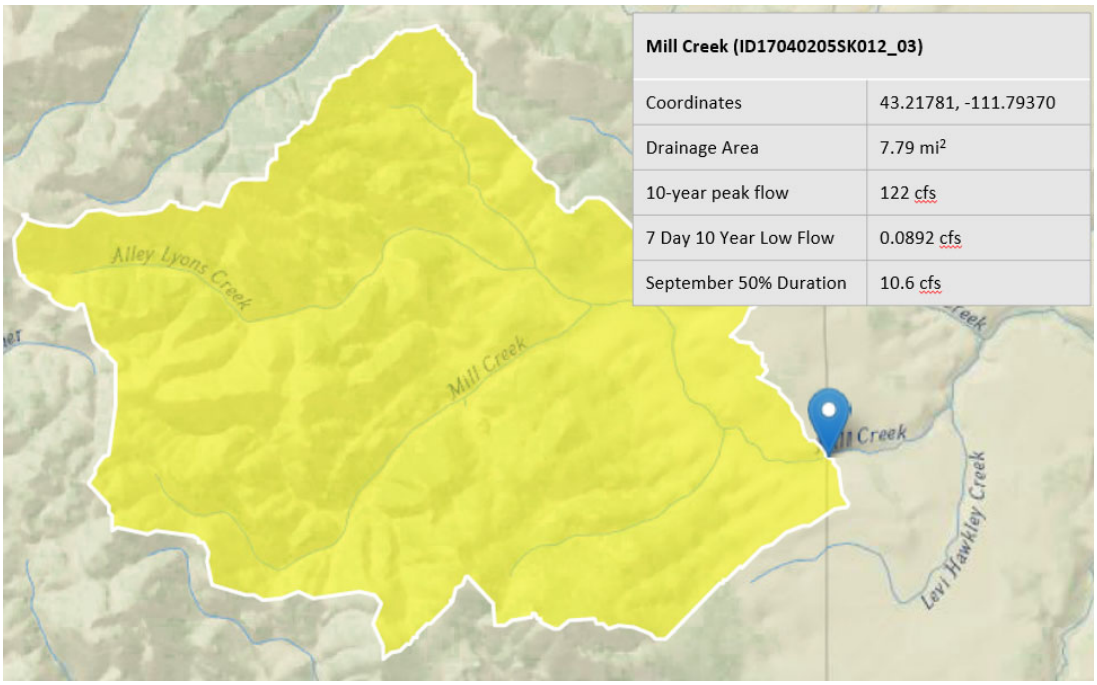


Figure C-2. StreamStats data for Mill Creek ID17040205SK012_03.

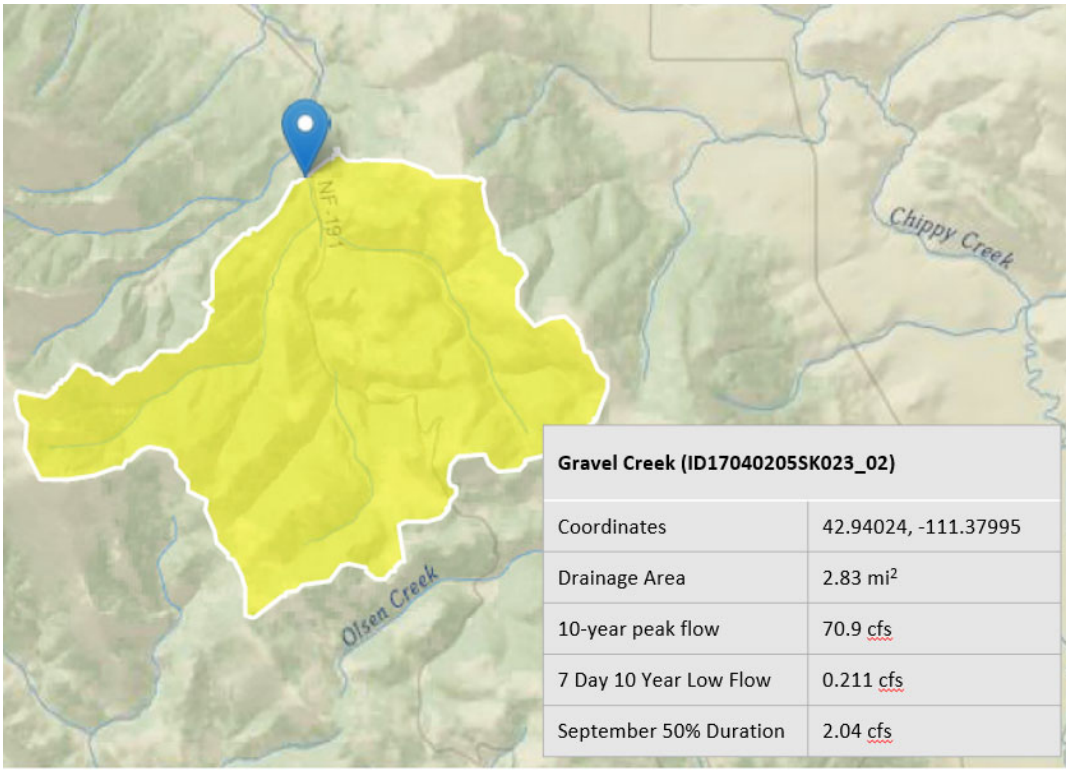


Figure C-3. StreamStats data for Gravel Creek ID17040205SK023_02.

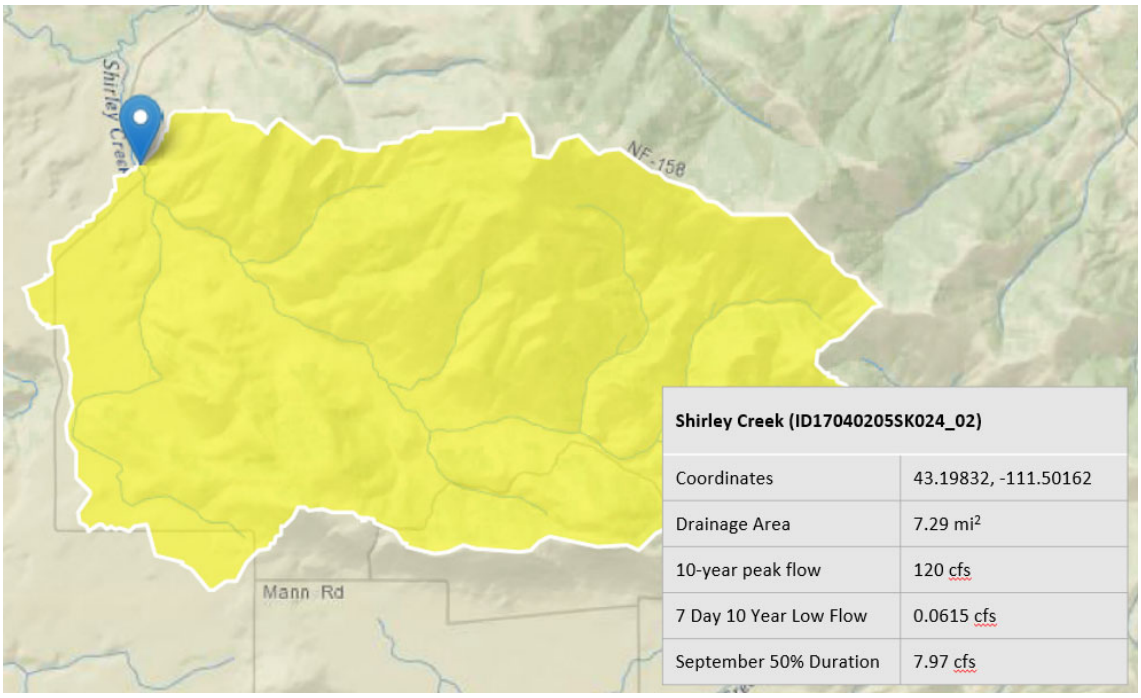


Figure C-4. StreamStats data for Shirley Creek ID17040205SK024_02.

Willow Creek Subbasin Nutrient Data

Table C-3. 2016 nutrient data.

Stream Name	Assessment Unit	Sample Date	Sample Time	Stream Flow (cfs)	Total Phosphorous (mg/L)	Total Phosphorous (lb/day)
2016 Nutrient Data						
Willow Creek	005_05	6/1/2016	9:00	123.1922	0.086430	**57.405**
Willow Creek	005_05	6/13/2016	9:15	98.13276	0.002001	1.059
Willow Creek	005_05	6/13/2016	9:15	98.13276	0.054230	28.691
Willow Creek	005_05	6/13/2016	9:15	98.13276	0.053850	28.490
Willow Creek	005_05	6/27/2016	9:00	59.6912	0.032480	10.453
Willow Creek	005_05	7/12/2016	9:15	38.73996	0.022270	4.651
Willow Creek	005_05	7/25/2016	9:53	22.17544	0.026560	3.175
Willow Creek	005_05	8/8/2016	9:14	24.46861	0.032800	4.327
Willow Creek	005_05	9/7/2016	9:30	21.3214	0.035460	4.076
Willow Creek	005_05	9/21/2016	9:30	21.94144	ND	ND
Willow Creek	008_04	6/1/2016	11:00	55.773	0.06659	**20.023**
Willow Creek	008_04	6/13/2016	10:45	45.45392	0.06713	16.451
Willow Creek	008_04	6/27/2016	10:30	27.5823	0.05778	8.592
Willow Creek	008_04	7/12/2016	10:30	26.60115	0.05796	8.312
Willow Creek	008_04	7/25/2016	10:30	16.30538	0.05846	5.139
Willow Creek	008_04	8/8/2016	10:25	15.7635	0.04734	4.023
Willow Creek	008_04	8/22/2016	10:30	14.6094	0.03754	2.957
Willow Creek	008_04	9/7/2016	10:30	15.93121	0.03011	2.586
Willow Creek	008_04	9/21/2016	10:30	14.65897	ND	ND
Willow Creek	011_04	6/1/2016	1:00	35.2326	0.07138	**13.559**
Willow Creek	011_04	6/13/2016	12:45	20.87917	0.07828	8.812
Willow Creek	011_04	6/27/2016	11:30	19.46483	0.07448	7.816
Willow Creek	011_04	7/12/2016	11:30	18.65655	0.07213	7.255
Willow Creek	011_04	7/25/2016	12:08	14.32452	0.07708	5.953
Willow Creek	011_04	8/8/2016	11:53	12.38895	0.06398	4.273
Willow Creek	011_04	8/22/2016	11:45	12.080865	0.06213	4.047
Willow Creek	011_04	9/7/2016	11:55	13.45155	0.05078	3.683
Willow Creek	011_04	9/21/2016	12:30	12.19644	ND	ND

Willow Creek Subbasin Temperature Logger Data

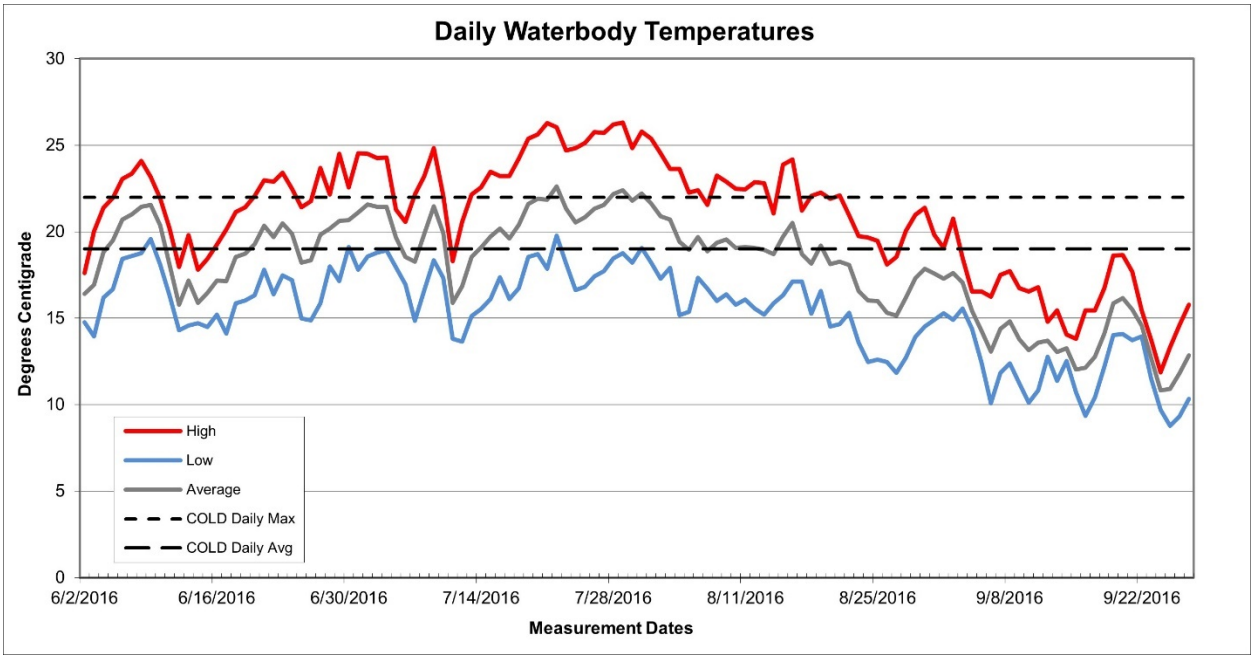


Figure C-5. Temperature data for Willow Creek ID17040205SK005_05.

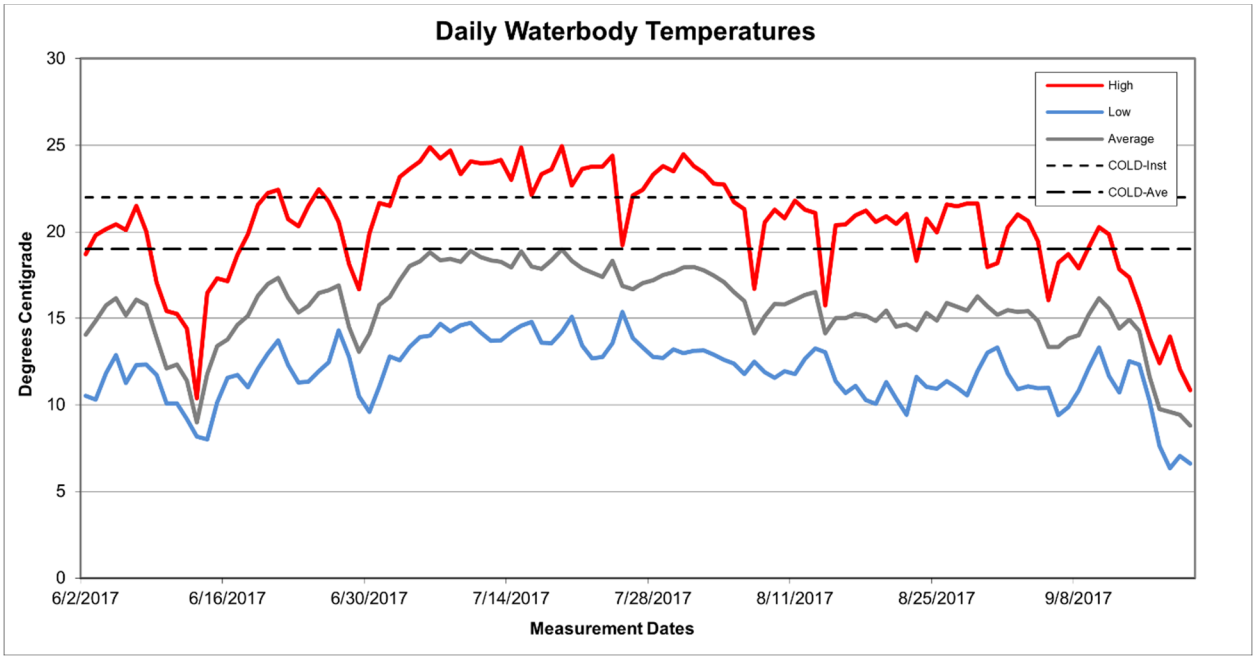


Figure C-6. Temperature data for Twin Creek ID17040205SK008_02.

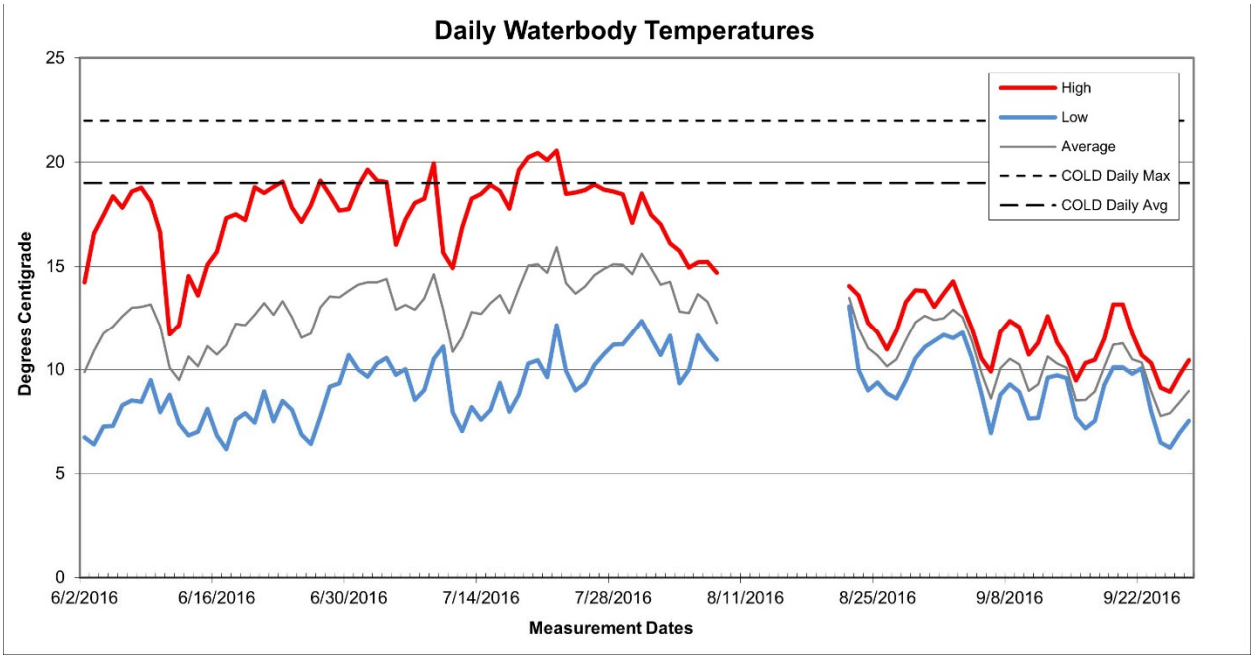


Figure C-7. Temperature Data for Sellars Creek ID17040205SK010_03.

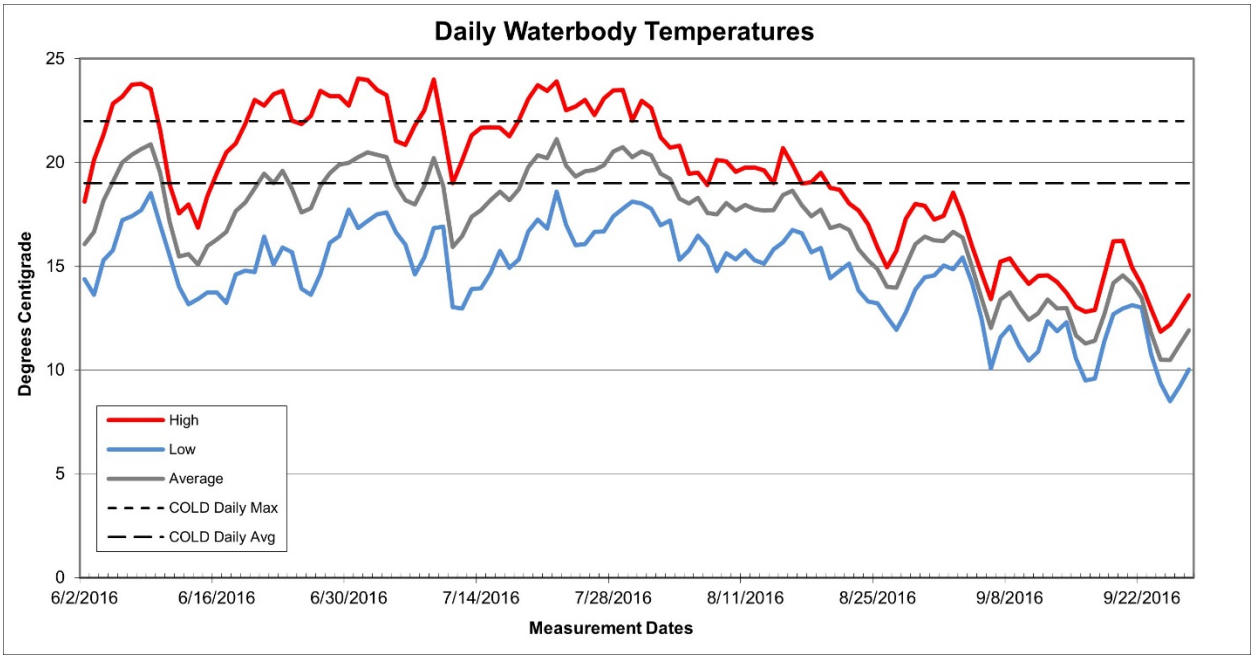


Figure C-8. Temperature data for Willow Creek ID17040205SK011_04.

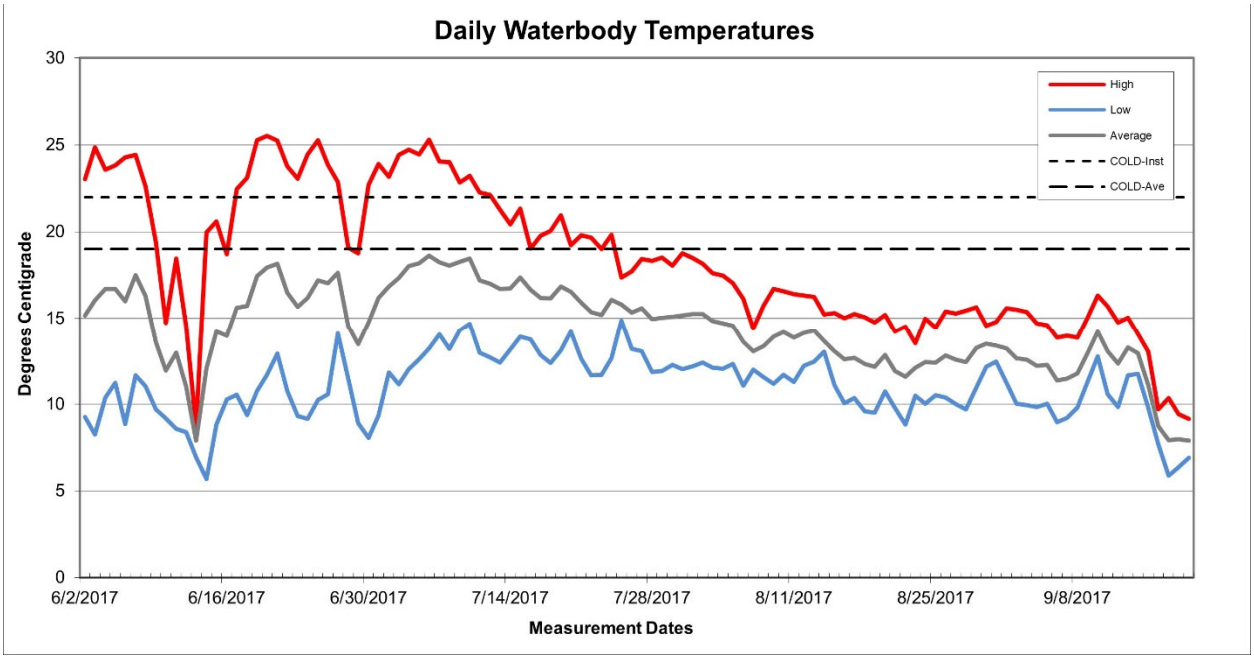


Figure C-9. Temperature data for Bucks Creek ID17040205SK012_02.

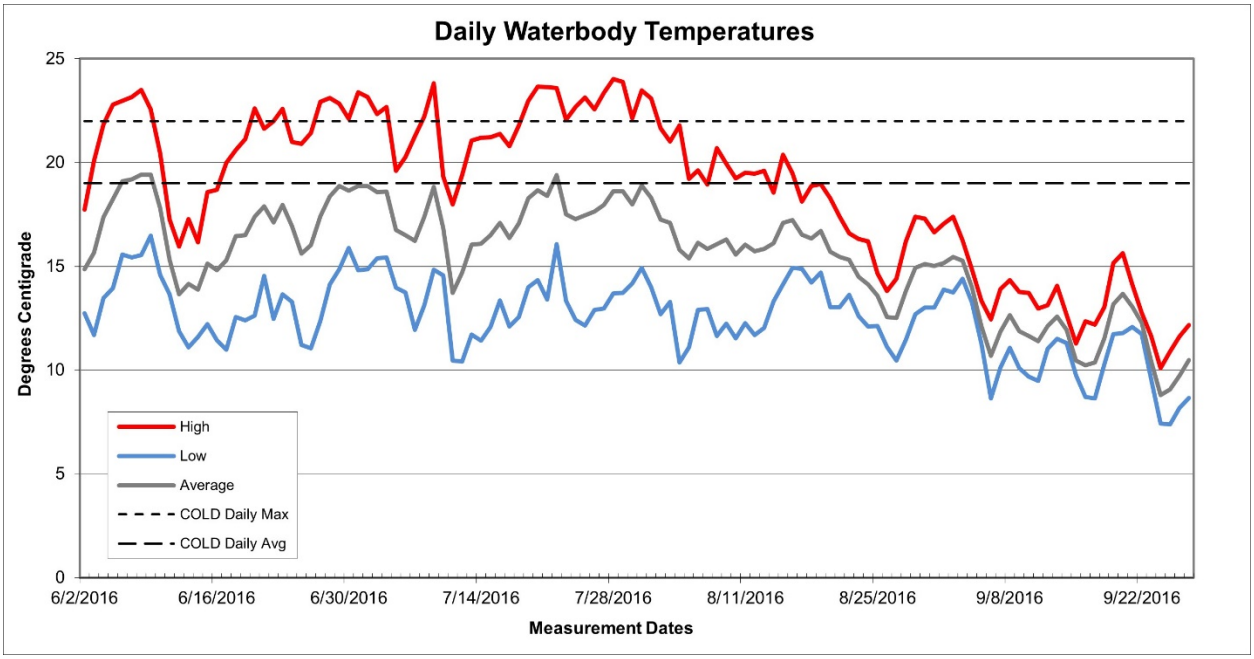


Figure C-10. Temperature data for Mill Creek ID17040205SK012_03.

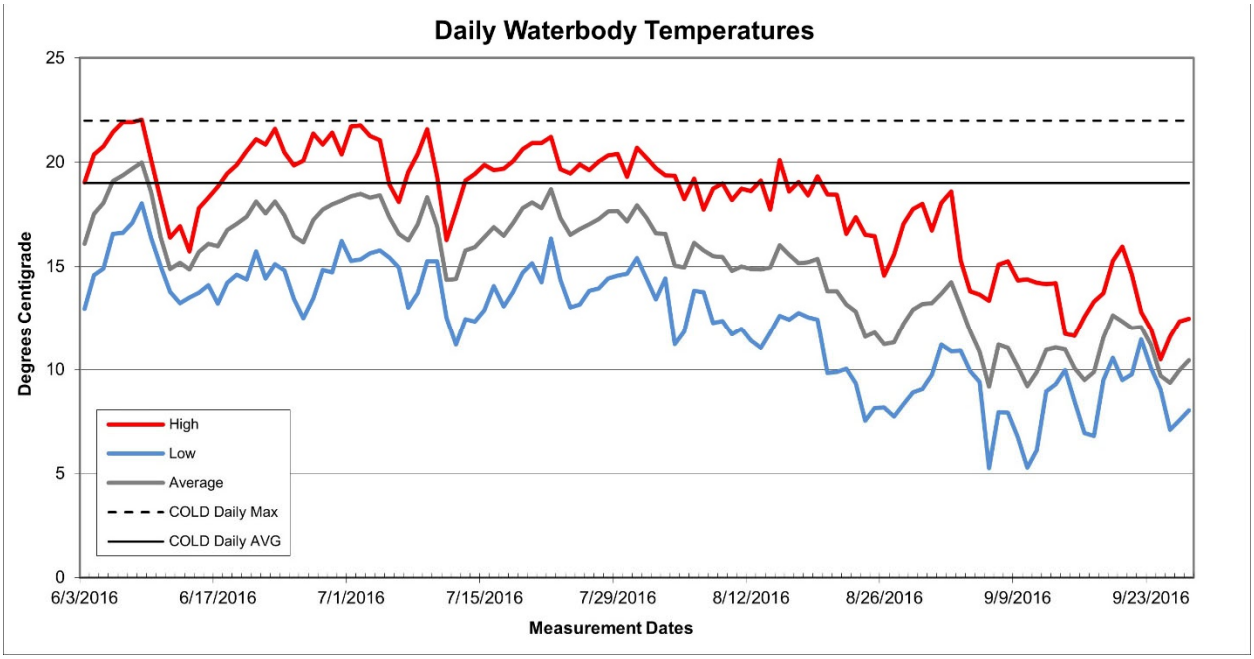


Figure C-11. Temperature data for Homer Creek ID17040205SK018_03

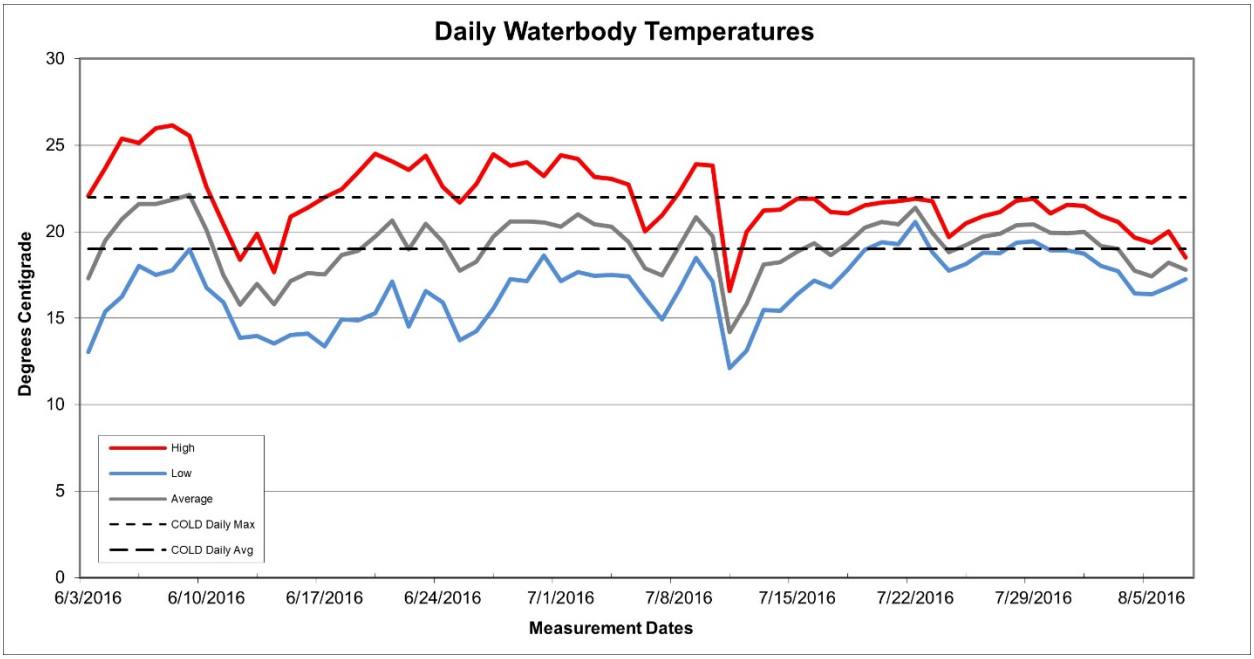


Figure C-12. Temperature data from Grays Lake Outlet ID17040205SK019_04

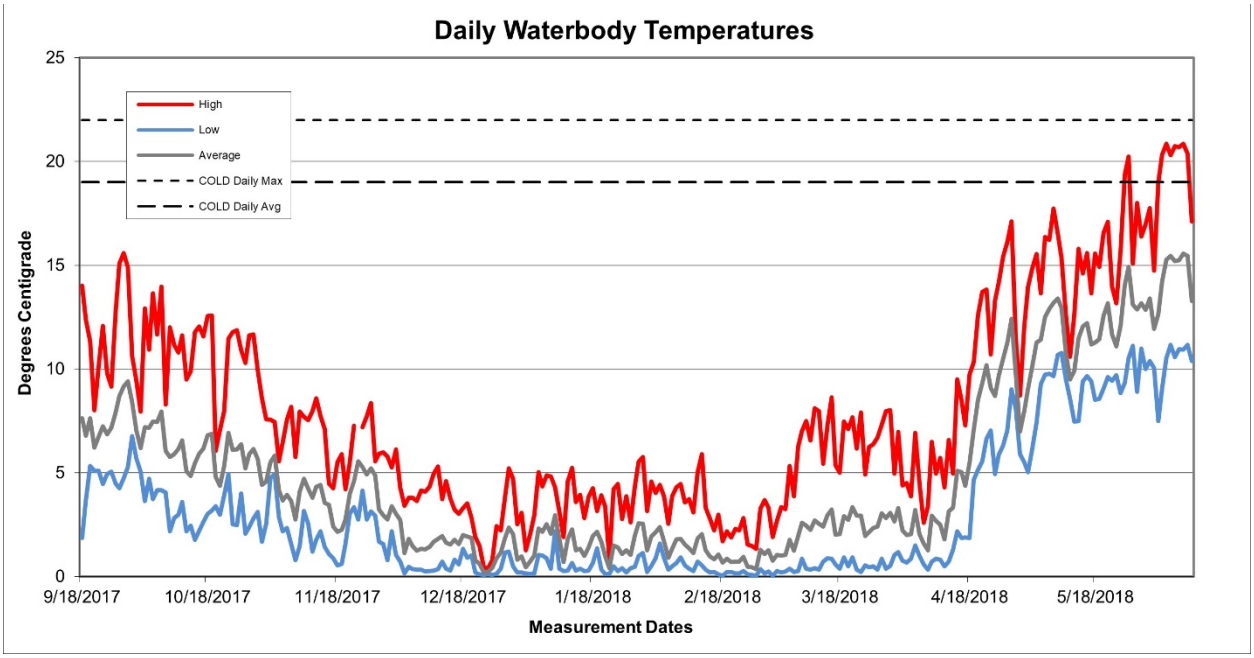


Figure C-13. Temperature date from Grays Lake Outlet ID17040205SK020_04.

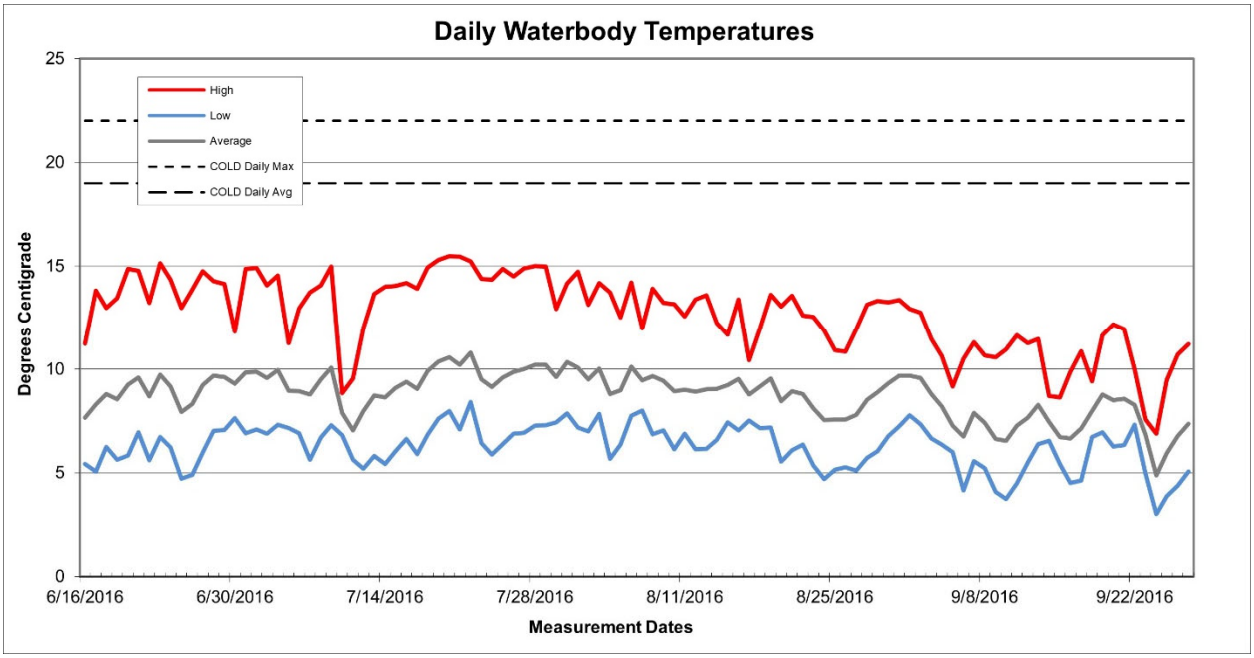


Figure C-14. Temperature data from North Fork Eagle Creek ID17040205SK021_02.

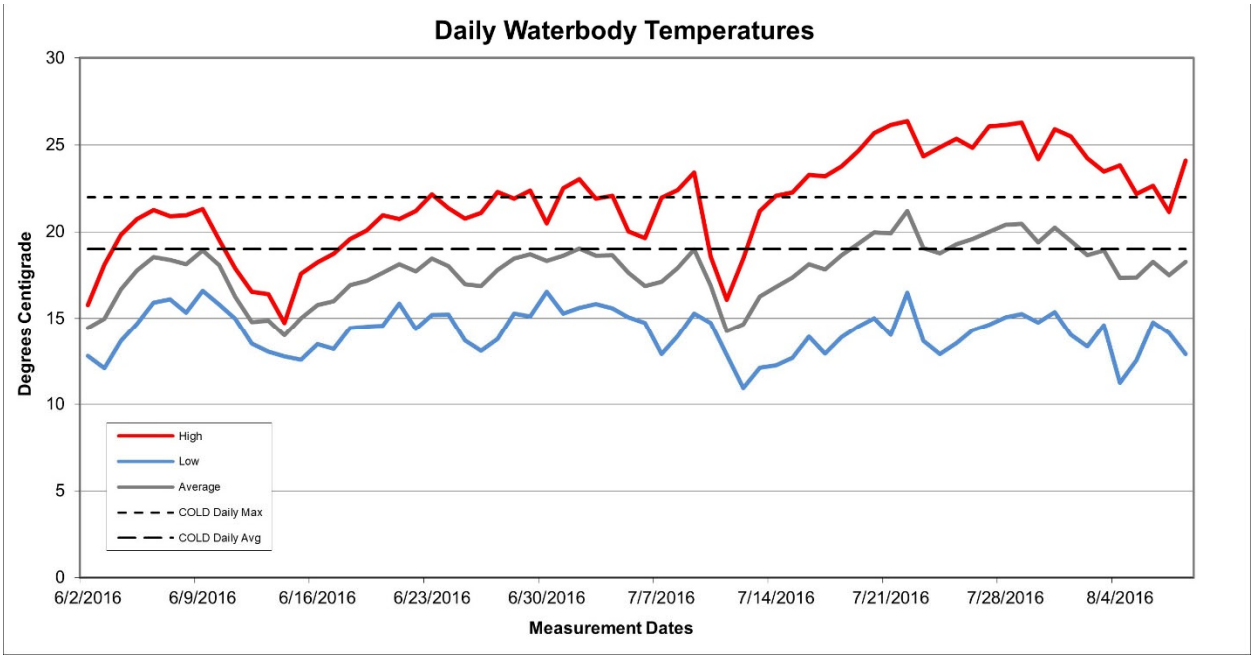


Figure C-15. Temperature data for Brockman Creek ID17040205SK024_03.

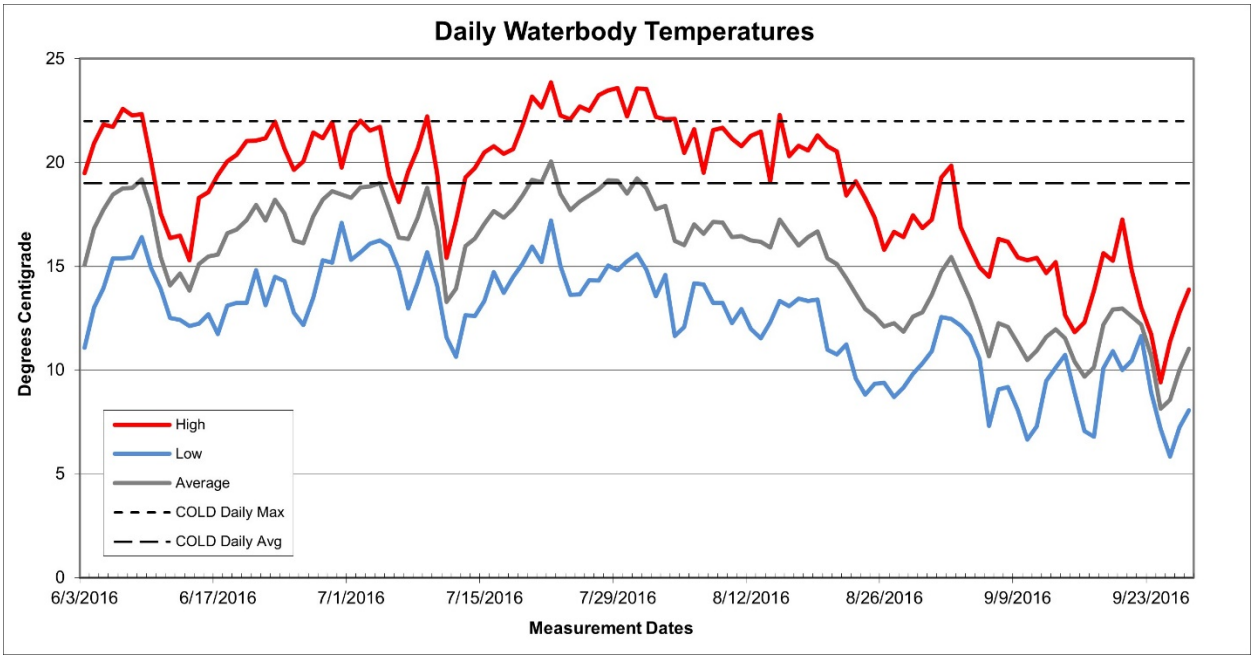


Figure C-16. Temperature data for Lava Creek ID17040205SK028_03.

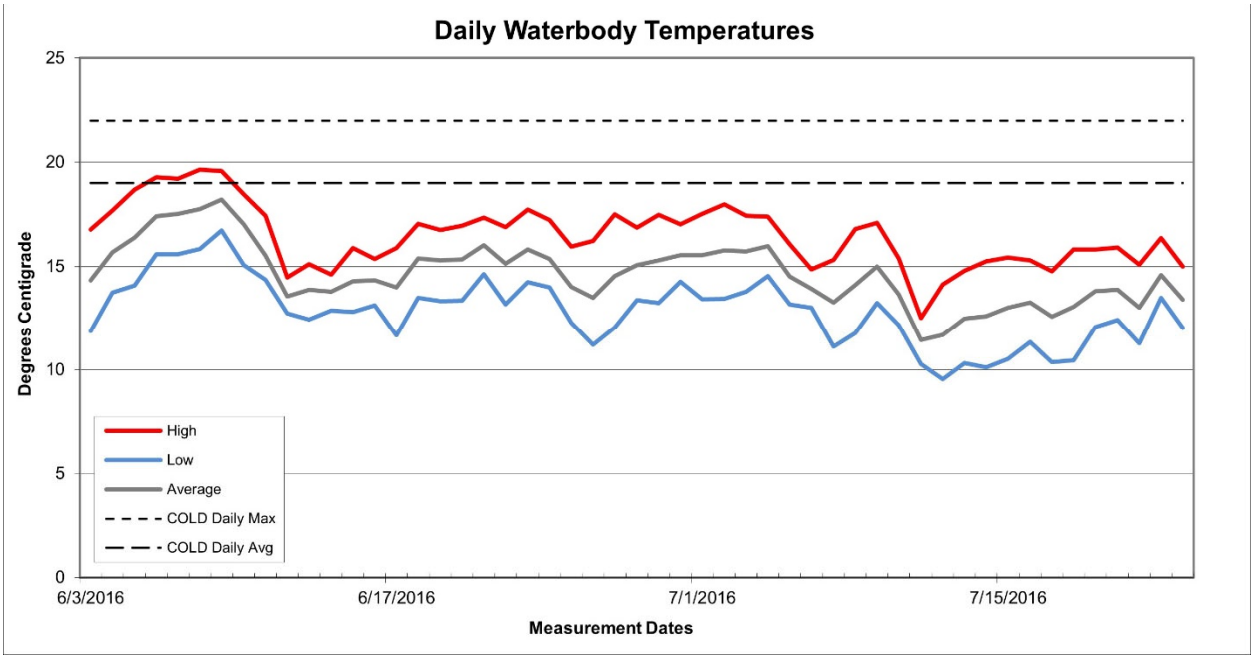


Figure C-17. Temperature data for Hell Creek ID17040205SK029_03.

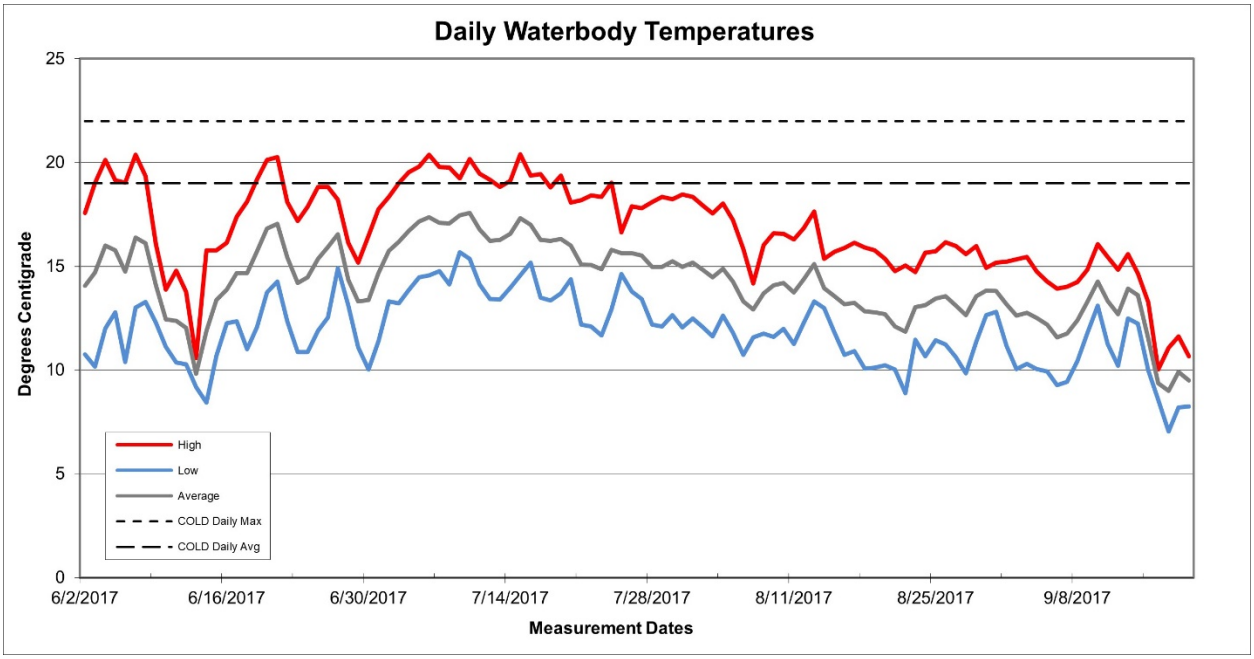


Figure C-18. Temperature data for Bulls Fork ID17040205SK030_02.

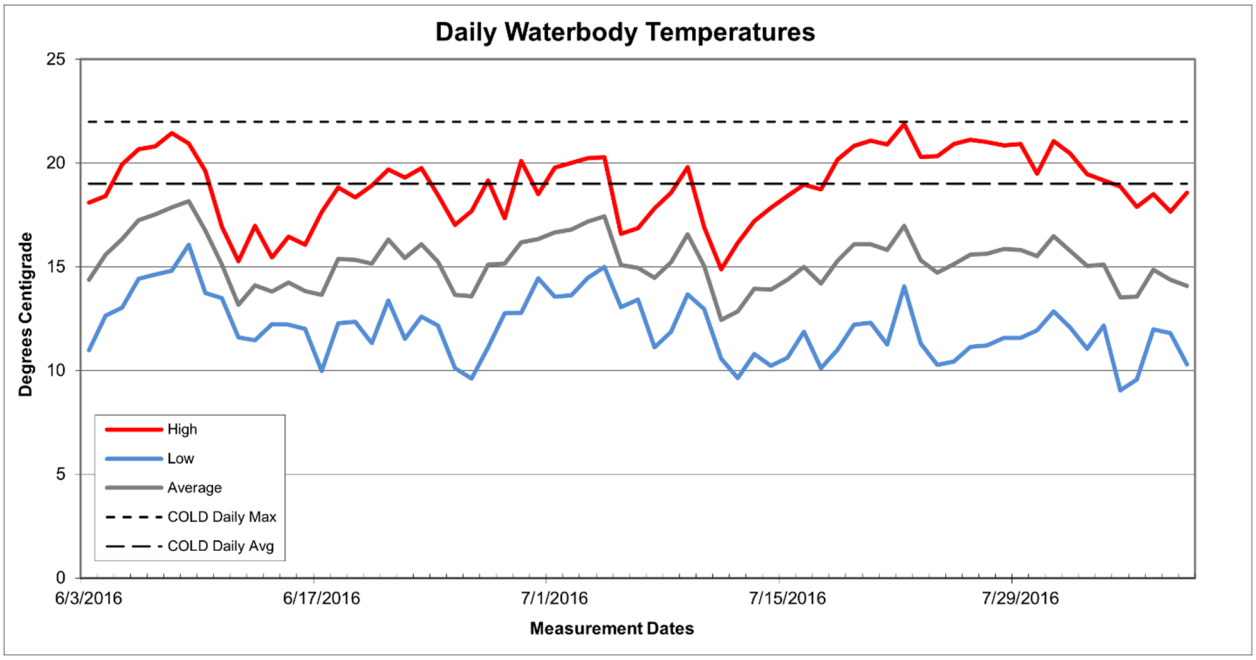
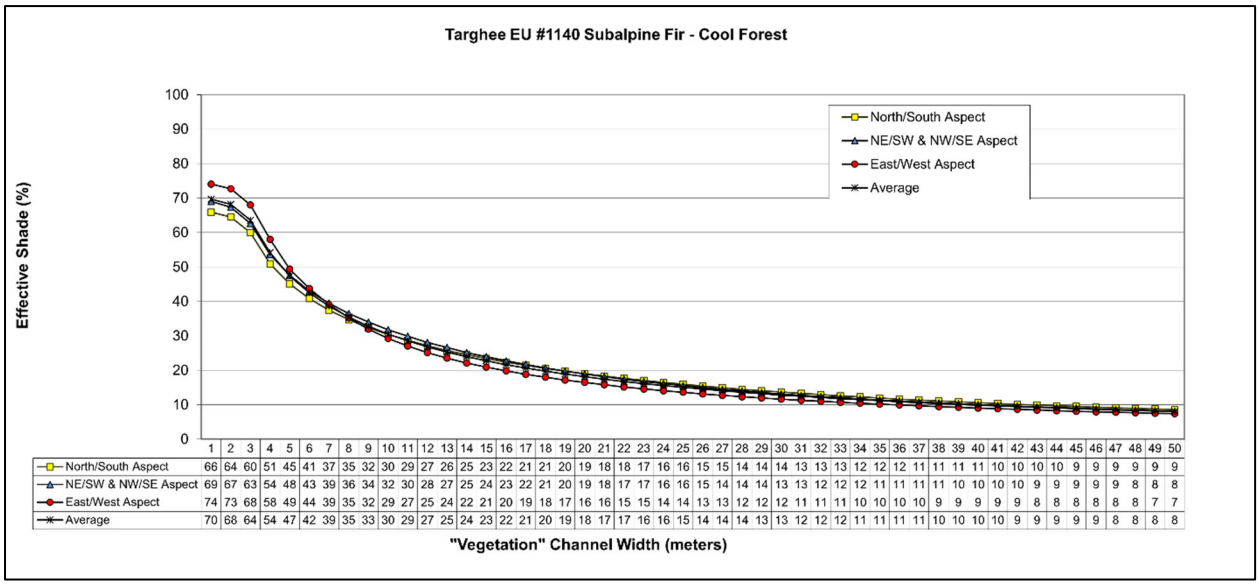


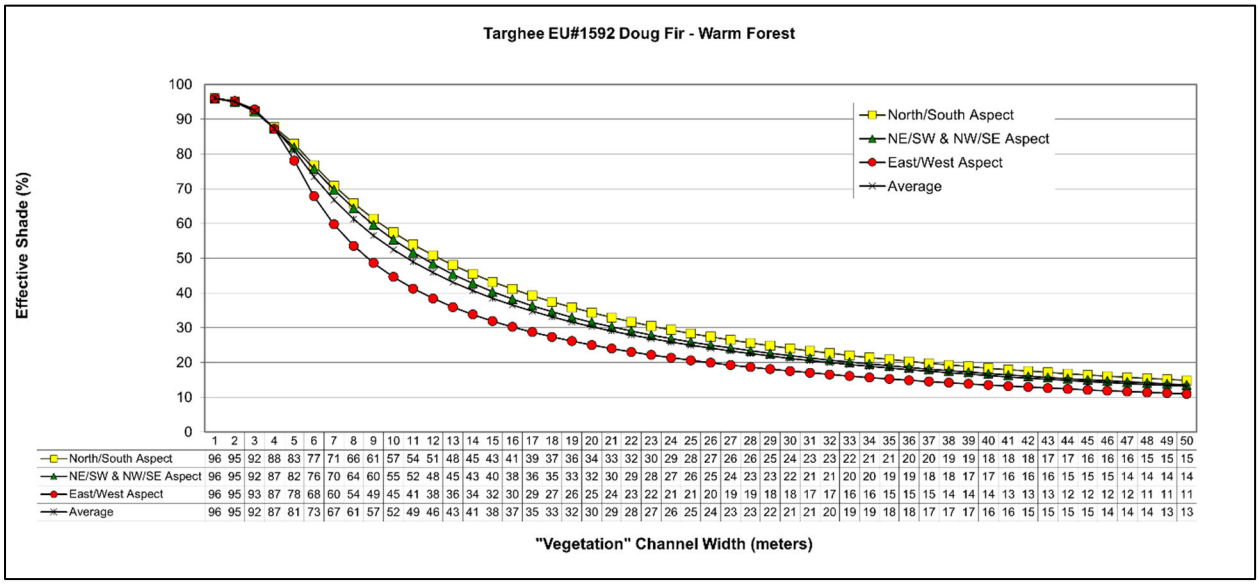
Figure C-19. Temperature data for Tex Creek ID17040205SK031_03.

Shade Curves Used for Target Shade Analysis



"Vegetation" Channel Width (meters)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
North/South Aspect	66	64	60	51	45	41	37	35	32	30	29	27	26	25	23	22	21	21	20	19	18	18	17	16	16	15	15	14	14	14	13	13	13	12	12	12	11	11	11	11	10	10	10	10	9	9	9	9	9	9
NE/SW & NW/SE Aspect	69	67	63	54	48	43	39	36	34	32	30	28	27	25	24	23	22	21	20	19	18	17	17	16	16	15	14	14	14	13	13	12	12	12	11	11	11	11	10	10	10	10	9	9	9	9	9	8	8	8
East/West Aspect	74	73	68	58	49	44	39	35	32	29	27	25	24	22	21	20	19	18	17	16	16	15	15	14	14	13	13	12	12	12	11	11	11	10	10	10	10	9	9	9	9	9	8	8	8	8	8	8	8	7
Average	70	68	64	54	47	42	39	35	33	30	29	27	25	24	23	22	21	20	19	18	17	17	16	16	15	14	14	14	13	13	12	12	12	11	11	11	11	10	10	10	10	9	9	9	9	8	8	8	8	8

Figure C-20. Shade curve for Subalpine fir - Cool forest vegetation type.



"Vegetation" Channel Width (meters)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
North/South Aspect	96	95	92	88	83	77	71	66	61	57	54	51	48	45	43	41	39	37	36	34	33	32	30	29	28	27	26	26	25	24	23	23	22	21	21	20	20	19	19	18	18	18	17	17	16	16	16	15	15	15
NE/SW & NW/SE Aspect	96	95	92	87	82	76	70	64	60	55	52	48	45	43	40	38	36	35	33	32	30	29	28	27	26	25	24	23	23	22	21	21	20	20	19	19	18	18	17	17	16	16	16	15	15	15	14	14	14	14
East/West Aspect	96	95	93	87	78	68	60	54	49	45	41	38	36	34	32	30	29	27	26	25	24	23	22	21	21	20	19	19	18	18	17	17	16	16	15	15	15	14	14	14	13	13	13	12	12	12	12	11	11	11
Average	96	95	92	87	81	73	67	61	57	52	49	46	43	41	38	37	35	33	32	30	29	28	27	26	25	24	23	23	22	21	21	20	19	19	18	18	17	17	17	16	16	15	15	15	15	14	14	14	13	13

Figure C-21. Shade curve for Douglas fir - Warm forest vegetation type.

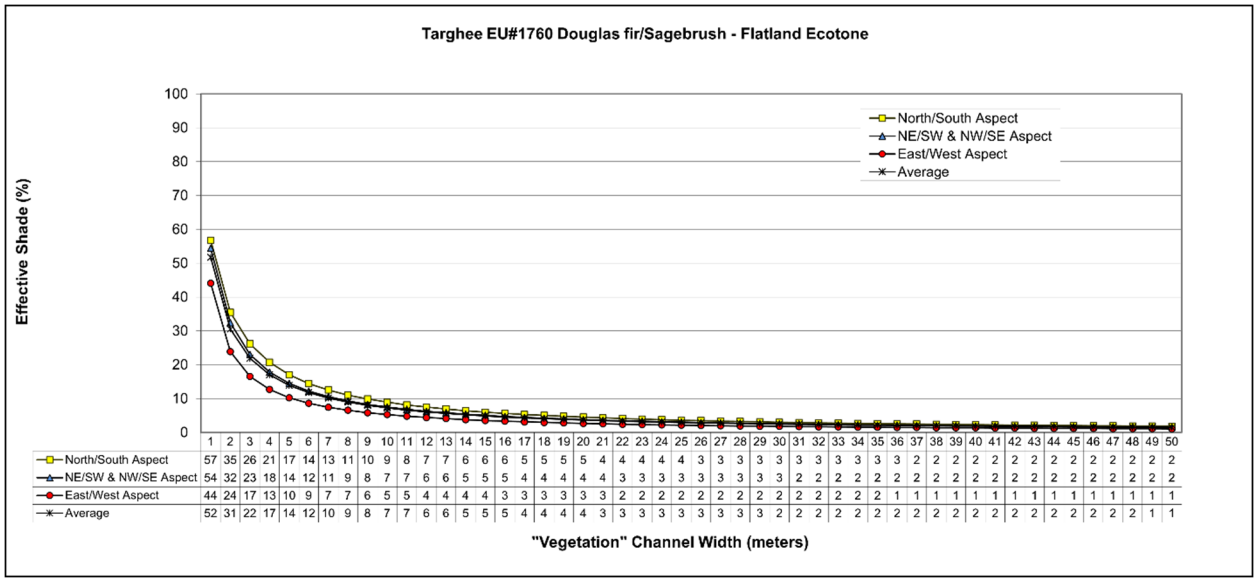


Figure C-22. Shade curve for Douglas fir/Sagebrush - flatland ecotone vegetation type.

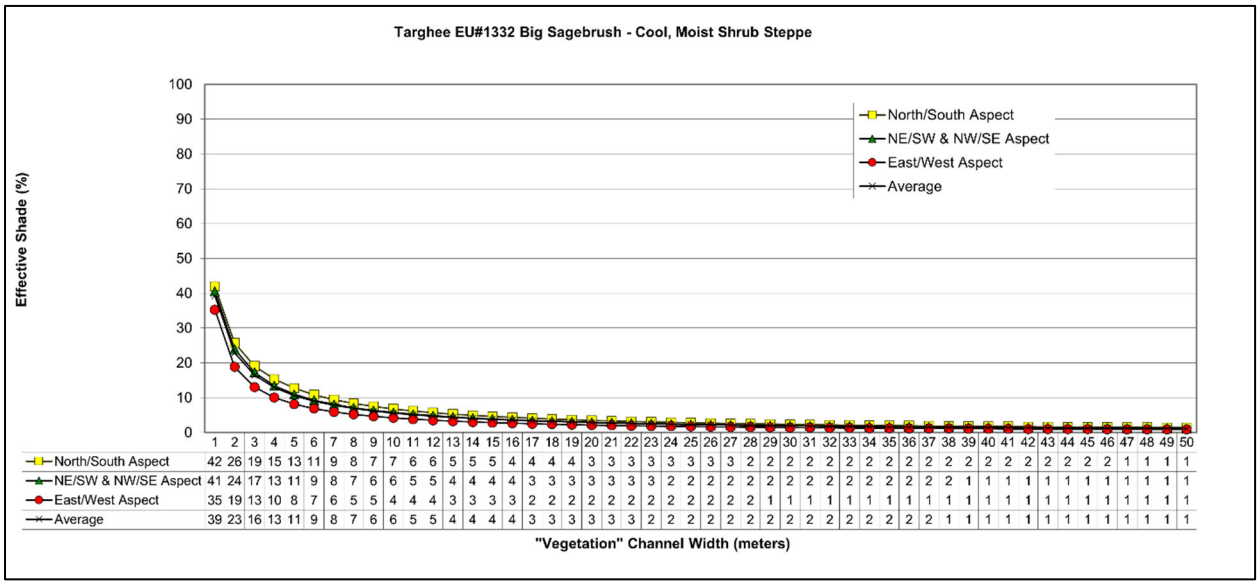


Figure C-23. Shade curve for Big sagebrush - Cool, moist shrub steppe vegetation type.

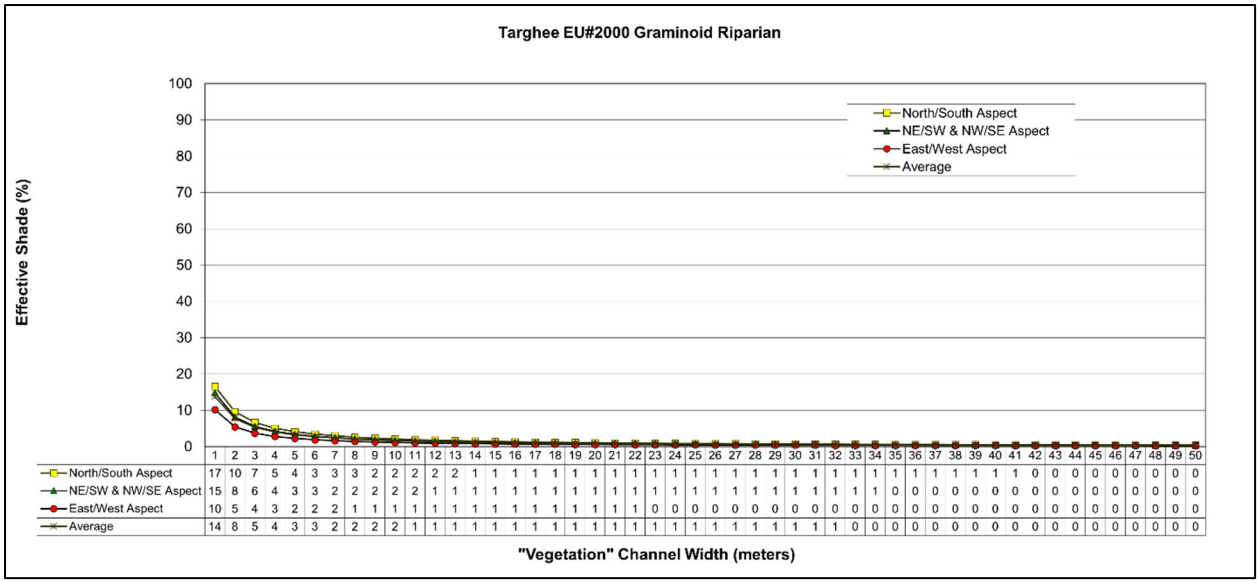


Figure C-24. Shade curve for Grass riparian vegetation type.

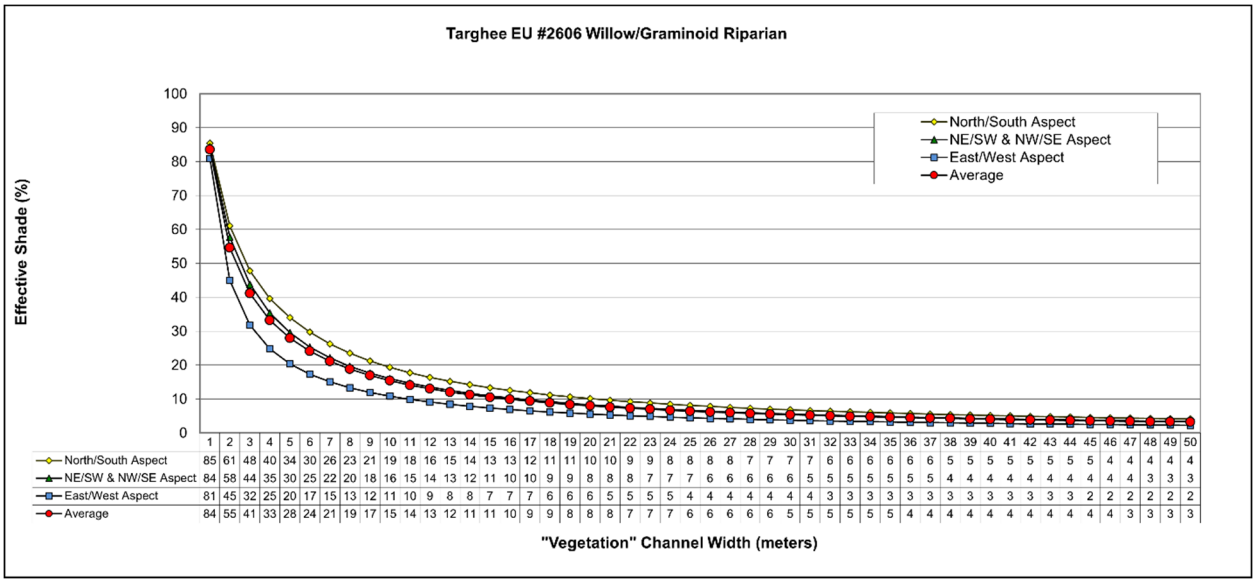
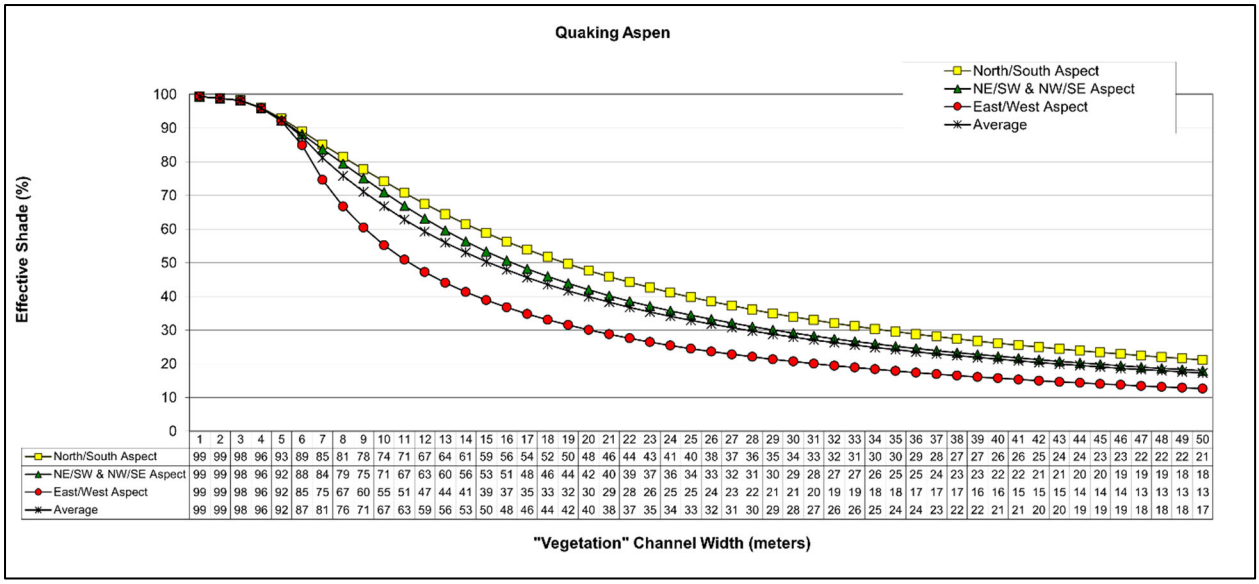


Figure C-25. Shade curve for Geyer willow/Grass riparian vegetation type.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
North/South Aspect	99	99	98	96	93	89	85	81	78	74	71	67	64	61	59	56	54	52	50	48	46	44	43	41	40	38	37	36	35	34	33	32	31	30	30	29	28	27	27	26	26	25	24	24	23	23	22	22	22	21
NE/SW & NW/SE Aspect	99	99	98	96	92	88	84	79	75	71	67	63	60	56	53	51	48	46	44	42	40	39	37	36	34	33	32	31	30	29	28	27	27	26	25	25	24	23	23	22	22	21	21	20	20	19	19	19	18	18
East/West Aspect	99	99	98	96	92	85	75	67	60	55	51	47	44	41	39	37	35	33	32	30	29	28	26	25	25	24	23	22	21	21	20	19	19	18	18	17	17	17	16	16	15	15	15	14	14	14	13	13	13	13
Average	99	99	98	96	92	87	81	76	71	67	63	59	56	53	50	48	46	44	42	40	38	37	35	34	33	32	31	30	29	28	27	26	26	25	24	24	23	22	22	21	21	20	20	19	19	19	18	18	18	17

Figure C-26. Shade curve for Quaking aspen vegetation type.

Existing and Target Solar Loads for the Willow Creek Subbasin

Notes: Significant figures are determined by the lowest level in the calculation, typically that of the channel width. Some rounding errors may result.

Table C-4. Existing and target solar loads for Willow Creek - Bulls Fork to Ririe Reservoir (ID17040205SK004_05).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
004_05	Willow Creek	100	Geyer Willow	572	26	6%	5.78	15,000	87,000	20%	4.92	15,000	74,000	14%	(13,000)
004_05	Willow Creek	101	Geyer Willow	289	26	6%	5.78	7,500	43,000	10%	5.54	7,500	42,000	4%	(1,000)
004_05	Willow Creek	102	Geyer Willow	748	26	6%	5.78	19,000	110,000	30%	4.31	19,000	82,000	24%	(28,000)
004_05	Willow Creek	103	Geyer Willow	413	26	6%	5.78	11,000	64,000	20%	4.92	11,000	54,000	14%	(10,000)
004_05	Willow Creek	104	Geyer Willow	837	26	6%	5.78	22,000	130,000	10%	5.54	22,000	120,000	4%	(10,000)
004_05	Willow Creek	105	Geyer Willow	2185	26	6%	5.78	57,000	330,000	0%	6.15	57,000	350,000	-6%	20,000
			Total Solar Loading						*760,000*				*720,000*		*-42,000*

Table C-5. Existing and target solar loads for Willow Creek - Birch Creek to Bulls Fork (ID17040205SK005_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
005_02	Noon Creek	7	Big Sagebrush	288	1	39%	3.75	300	1,000	20%	4.92	300	1,000	-19%	0
005_02	Noon Creek	8	Big Sagebrush	216	1	39%	3.75	200	800	30%	4.31	200	900	-9%	100
005_02	Noon Creek	9	Big Sagebrush	421	1	39%	3.75	400	2,000	10%	5.54	400	2,000	-29%	0
005_02	Noon Creek	10	Big Sagebrush	1067	1	39%	3.75	1,000	4,000	10%	5.54	1,000	6,000	-29%	2,000
005_02	Noon Creek	11	Geyer Willow	163	2	55%	2.77	300	800	20%	4.92	300	1,000	-35%	200
005_02	Noon Creek	12	Geyer Willow	243	2	55%	2.77	500	1,000	10%	5.54	500	3,000	-45%	2,000
005_02	Noon Creek	13	Big Sagebrush	171	2	23%	4.74	300	1,000	0%	6.15	300	2,000	-23%	1,000
005_02	Noon Creek	14	Big Sagebrush	305	2	23%	4.74	600	3,000	10%	5.54	600	3,000	-13%	0
005_02	Noon Creek	15	Quaking Aspen	193	2	99%	0.06	400	20	80%	1.23	400	500	-19%	500
005_02	Noon Creek	16	Big Sagebrush	131	2	23%	4.74	300	1,000	20%	4.92	300	1,000	-3%	0
005_02	Noon Creek	17	Geyer Willow	396	2	55%	2.77	800	2,000	80%	1.23	800	1,000	25%	(1,000)
005_02	Noon Creek	18	Geyer Willow	161	2	55%	2.77	300	800	60%	2.46	300	700	5%	(100)

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
005_02	Rock Creek	6	Geyer Willow	423	1	84%	0.98	400	400	70%	1.85	400	700	-14%	300
005_02	Rock Creek	7	Geyer Willow	166	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
005_02	Rock Creek	9	Geyer Willow	251	1	84%	0.98	300	300	60%	2.46	300	700	-24%	400
005_02	Rock Creek	11	Geyer Willow	196	1	84%	0.98	200	200	70%	1.85	200	400	-14%	200
005_02	Rock Creek	12	Geyer Willow	543	1	84%	0.98	500	500	50%	3.08	500	2,000	-34%	2,000
005_02	Rock Creek	13	Big Sagebrush	227	1	39%	3.75	200	800	40%	3.69	200	700	1%	(100)
005_02	Rock Creek	14	Geyer Willow	326	2	55%	2.77	700	2,000	70%	1.85	700	1,000	15%	(1,000)
005_02	Rock Creek	15	Geyer Willow	256	2	55%	2.77	500	1,000	20%	4.92	500	2,000	-35%	1,000
005_02	Rock Creek	16	Geyer Willow	211	2	55%	2.77	400	1,000	70%	1.85	400	700	15%	(300)
005_02	Rock Creek	17	Geyer Willow	198	2	55%	2.77	400	1,000	40%	3.69	400	1,000	-15%	0
005_02	Rock Creek	18	Geyer Willow	231	2	55%	2.77	500	1,000	10%	5.54	500	3,000	-45%	2,000
005_02	Rock Creek	19	Geyer Willow	810	2	55%	2.77	2,000	6,000	60%	2.46	2,000	5,000	5%	(1,000)
005_02	Rock Creek	21	Geyer Willow	216	3	41%	3.63	600	2,000	0%	6.15	600	4,000	-41%	2,000
005_02	Rock Creek	22	Geyer Willow	124	3	41%	3.63	400	1,000	30%	4.31	400	2,000	-11%	1,000
005_02	Rock Creek	23	Geyer Willow	322	3	41%	3.63	1,000	4,000	70%	1.85	1,000	2,000	29%	(2,000)
005_02	Rock Creek	25	Geyer Willow	120	3	41%	3.63	400	1,000	80%	1.23	400	500	39%	(500)
005_02	Rock Creek	26	Geyer Willow	152	3	41%	3.63	500	2,000	40%	3.69	500	2,000	-1%	0
005_02	Rock Creek	27	Geyer Willow	316	3	41%	3.63	900	3,000	60%	2.46	900	2,000	19%	(1,000)
005_02	Rock Creek	28	Geyer Willow	261	3	41%	3.63	800	3,000	50%	3.08	800	2,000	9%	(1,000)
005_02	Rock Creek	30	Geyer Willow	270	3	41%	3.63	800	3,000	60%	2.46	800	2,000	19%	(1,000)
005_02	Rock Creek	31	Geyer Willow	136	4	33%	4.12	500	2,000	30%	4.31	500	2,000	-3%	0
005_02	Rock Creek	32	Geyer Willow	398	4	33%	4.12	2,000	8,000	10%	5.54	2,000	10,000	-23%	2,000
005_02	Rock Creek	33	Geyer Willow	479	4	33%	4.12	2,000	8,000	40%	3.69	2,000	7,000	7%	(1,000)
005_02	Rock Creek	34	Geyer Willow	506	4	33%	4.12	2,000	8,000	80%	1.23	2,000	2,000	47%	(6,000)
			Total Solar Loading						*77,000*				*78,000*		*1,200*

Table C-6. Existing and target solar loads Willow Creek - Birch Creek to Bulls Fork (ID17040205SK005_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
005_04	Willow Creek	99	Geyer Willow	546	15	11%	5.47	8,200	45,000	10%	5.54	8,200	45,000	-1%	0
005_04	Willow Creek	100	Geyer Willow	457	15	11%	5.47	6,900	38,000	20%	4.92	6,900	34,000	9%	(4,000)
005_04	Willow Creek	101	Geyer Willow	284	15	11%	5.47	4,300	24,000	20%	4.92	4,300	21,000	9%	(3,000)
005_04	Willow Creek	102	Geyer Willow	277	15	11%	5.47	4,200	23,000	10%	5.54	4,200	23,000	-1%	0
005_04	Willow Creek	103	Geyer Willow	1410	15	11%	5.47	21,000	110,000	30%	4.31	21,000	90,000	19%	(20,000)
005_04	Willow Creek	104	Geyer Willow	998	16	10%	5.54	16,000	89,000	10%	5.54	16,000	89,000	0%	0
			Total Solar Loading						*330,000*				*300,000*		*-27,000*

Table C-7. Existing and target solar loads for Willow Creek - Birch Creek to Bulls Fork (ID17040205SK005_05).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
005_05	Willow Creek	74	Geyer Willow	854	16	10%	5.54	14,000	77,000	20%	4.92	14,000	69,000	10%	(8,000)
005_05	Willow Creek	75	Geyer Willow	1158	16	10%	5.54	19,000	110,000	20%	4.92	19,000	93,000	10%	(17,000)
005_05	Willow Creek	76	Geyer Willow	971	17	9%	5.60	17,000	95,000	30%	4.31	17,000	73,000	21%	(22,000)
005_05	Willow Creek	77	Geyer Willow	1027	17	9%	5.60	17,000	95,000	30%	4.31	17,000	73,000	21%	(22,000)
005_05	Willow Creek	78	Geyer Willow	406	17	9%	5.60	6,900	39,000	20%	4.92	6,900	34,000	11%	(5,000)
005_05	Willow Creek	79	Geyer Willow	838	18	9%	5.60	15,000	84,000	10%	5.54	15,000	83,000	1%	(1,000)
005_05	Willow Creek	80	Geyer Willow	977	18	9%	5.60	18,000	100,000	20%	4.92	18,000	89,000	11%	(11,000)
005_05	Willow Creek	81	Geyer Willow	324	18	9%	5.60	5,800	32,000	10%	5.54	5,800	32,000	1%	0
005_05	Willow Creek	82	Geyer Willow	2510	19	8%	5.66	48,000	270,000	20%	4.92	48,000	240,000	12%	(30,000)
005_05	Willow Creek	83	Geyer Willow	980	20	8%	5.66	20,000	110,000	30%	4.31	20,000	86,000	22%	(24,000)
005_05	Willow Creek	84	Geyer Willow	313	20	8%	5.66	6,300	36,000	20%	4.92	6,300	31,000	12%	(5,000)
005_05	Willow Creek	85	Geyer Willow	1456	21	8%	5.66	31,000	180,000	30%	4.31	31,000	130,000	22%	(50,000)
005_05	Willow Creek	86	Geyer Willow	843	21	8%	5.66	18,000	100,000	10%	5.54	18,000	100,000	2%	0
005_05	Willow Creek	87	Geyer Willow	724	22	7%	5.72	16,000	92,000	20%	4.92	16,000	79,000	13%	(13,000)
005_05	Willow Creek	88	Geyer Willow	540	22	7%	5.72	12,000	69,000	30%	4.31	12,000	52,000	23%	(17,000)
005_05	Willow Creek	89	Geyer Willow	3111	23	7%	5.72	72,000	410,000	20%	4.92	72,000	350,000	13%	(60,000)
005_05	Willow Creek	90	Geyer Willow	599	24	7%	5.72	14,000	80,000	30%	4.31	14,000	60,000	23%	(20,000)

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
005_05	Willow Creek	91	Geyer Willow	314	24	7%	5.72	7,500	43,000	20%	4.92	7,500	37,000	13%	(6,000)
005_05	Willow Creek	92	Geyer Willow	321	24	7%	5.72	7,700	44,000	10%	5.54	7,700	43,000	3%	(1,000)
005_05	Willow Creek	93	Geyer Willow	239	24	7%	5.72	5,700	33,000	20%	4.92	5,700	28,000	13%	(5,000)
005_05	Willow Creek	94	Geyer Willow	253	24	7%	5.72	6,100	35,000	10%	5.54	6,100	34,000	3%	(1,000)
005_05	Willow Creek	95	Geyer Willow	1215	24	7%	5.72	29,000	170,000	20%	4.92	29,000	140,000	13%	(30,000)
005_05	Willow Creek	96	Geyer Willow	362	25	6%	5.78	9,100	53,000	30%	4.31	9,100	39,000	24%	(14,000)
005_05	Willow Creek	97	Geyer Willow	767	25	6%	5.78	19,000	110,000	20%	4.92	19,000	93,000	14%	(17,000)
005_05	Willow Creek	98	Geyer Willow	422	25	6%	5.78	11,000	64,000	30%	4.31	11,000	47,000	24%	(17,000)
005_05	Willow Creek	99	Geyer Willow	572	25	6%	5.78	14,000	81,000	20%	4.92	14,000	69,000	14%	(12,000)
			Total Solar Loading						*2,600,000*				*2,200,000*		*-410,000*

Table C-8. Existing and target solar loads for Willow Creek - Mud Creek to Birch Creek (ID17040205SK008_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
008_02	Canyon Creek	3	Geyer Willow	625	1	84%	0.98	600	600	30%	4.31	600	3,000	-54%	2,000
008_02	Canyon Creek	4	Geyer Willow	279	1	84%	0.98	300	300	20%	4.92	300	1,000	-64%	700
008_02	Canyon Creek	5	Geyer Willow	949	1	84%	0.98	900	900	70%	1.85	900	2,000	-14%	1,000
008_02	Canyon Creek	6	Geyer Willow	307	2	55%	2.77	600	2,000	30%	4.31	600	3,000	-25%	1,000
008_02	Canyon Creek	7	Geyer Willow	120	2	55%	2.77	200	600	70%	1.85	200	400	15%	(200)
008_02	Canyon Creek	8	Geyer Willow	471	2	55%	2.77	900	2,000	50%	3.08	900	3,000	-5%	1,000
008_02	Canyon Creek	9	Geyer Willow	625	2	55%	2.77	1,000	3,000	60%	2.46	1,000	2,000	5%	(1,000)
008_02	Canyon Creek	10	Geyer Willow	448	2	55%	2.77	900	2,000	30%	4.31	900	4,000	-25%	2,000
008_02	Twin Creek	2	Grass	143	1	14%	5.29	100	500	10%	5.54	100	600	-4%	100
008_02	Twin Creek	3	Grass	191	1	14%	5.29	200	1,000	50%	3.08	200	600	36%	(400)
008_02	Twin Creek	4	Grass	268	1	14%	5.29	300	2,000	20%	4.92	300	1,000	6%	(1,000)
008_02	Twin Creek	5	Grass	157	1	14%	5.29	200	1,000	50%	3.08	200	600	36%	(400)
008_02	Twin Creek	7	Geyer Willow	308	2	55%	2.77	600	2,000	30%	4.31	600	3,000	-25%	1,000
008_02	Twin Creek	8	Geyer Willow	390	2	55%	2.77	800	2,000	50%	3.08	800	2,000	-5%	0
008_02	Twin Creek	9	Geyer Willow	173	2	55%	2.77	300	800	20%	4.92	300	1,000	-35%	200

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
008_02	Twin Creek	10	Geyer Willow	355	3	41%	3.63	1,000	4,000	60%	2.46	1,000	2,000	19%	(2,000)
008_02	Twin Creek	11	Quaking Aspen	309	3	98%	0.12	900	100	60%	2.46	900	2,000	-38%	2,000
008_02	Willow Creek_Trib 10	6	Grass	751	1	14%	5.29	800	4,000	10%	5.54	800	4,000	-4%	0
008_02	Willow Creek_Trib 10	7	Grass	659	1	14%	5.29	700	4,000	20%	4.92	700	3,000	6%	(1,000)
008_02	Willow Creek_Trib 10	8	Grass	385	2	8%	5.66	800	5,000	10%	5.54	800	4,000	2%	(1,000)
008_02	Willow Creek_Trib 10	9	Geyer Willow	287	2	55%	2.77	600	2,000	30%	4.31	600	3,000	-25%	1,000
008_02	Willow Creek_Trib 10	10	Grass	199	2	8%	5.66	400	2,000	10%	5.54	400	2,000	2%	0
008_02	Willow Creek_Trib 10	11	Geyer Willow	108	2	55%	2.77	200	600	60%	2.46	200	500	5%	(100)
008_02	Willow Creek_Trib 10	12	Grass	362	2	8%	5.66	700	4,000	10%	5.54	700	4,000	2%	0
008_02	Willow Creek_Trib 10	13	Geyer Willow	260	3	41%	3.63	800	3,000	20%	4.92	800	4,000	-21%	1,000
008_02	Willow Creek_Trib 10	14	Grass	257	3	5%	5.84	800	5,000	10%	5.54	800	4,000	5%	(1,000)
008_02	Willow Creek_Trib 10	15	Geyer Willow	470	3	41%	3.63	1,000	4,000	50%	3.08	1,000	3,000	9%	(1,000)
008_02	Willow Creek_Trib 10	16	Geyer Willow	265	3	41%	3.63	800	3,000	30%	4.31	800	3,000	-11%	0
			Total Solar Loading						*61,000*				*66,000*		*3,900*

Table C-9. Existing and target solar loads for Willow Creek - Mud Creek to Birch Creek (ID17040205SK008_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
008_04	Willow Creek	73	Geyer Willow	221	12	13%	5.35	2,700	14,000	20%	4.92	2,700	13,000	7%	(1,000)
008_04	Willow Creek	74	Geyer Willow	632	12	13%	5.35	7,600	41,000	10%	5.54	7,600	42,000	-3%	1,000
008_04	Willow Creek	75	Geyer Willow	358	12	13%	5.35	4,300	23,000	20%	4.92	4,300	21,000	7%	(2,000)
008_04	Willow Creek	76	Geyer Willow	166	12	13%	5.35	2,000	11,000	10%	5.54	2,000	11,000	-3%	0
008_04	Willow Creek	77	Geyer Willow	268	12	13%	5.35	3,200	17,000	10%	5.54	3,200	18,000	-3%	1,000
008_04	Willow Creek	78	Geyer Willow	811	12	13%	5.35	9,700	52,000	20%	4.92	9,700	48,000	7%	(4,000)
008_04	Willow Creek	79	Geyer Willow	309	12	13%	5.35	3,700	20,000	30%	4.31	3,700	16,000	17%	(4,000)
008_04	Willow Creek	80	Geyer Willow	681	12	13%	5.35	8,200	44,000	20%	4.92	8,200	40,000	7%	(4,000)
008_04	Willow Creek	81	Geyer Willow	584	12	13%	5.35	7,000	37,000	10%	5.54	7,000	39,000	-3%	2,000
008_04	Willow Creek	82	Geyer Willow	99	12	13%	5.35	1,200	6,400	10%	5.54	1,200	6,600	-3%	200
008_04	Willow Creek	83	Geyer Willow	829	12	13%	5.35	9,900	53,000	10%	5.54	9,900	55,000	-3%	2,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
008_04	Willow Creek	84	Geyer Willow	423	13	12%	5.41	5,500	30,000	20%	4.92	5,500	27,000	8%	(3,000)
008_04	Willow Creek	85	Geyer Willow	258	13	12%	5.41	3,400	18,000	20%	4.92	3,400	17,000	8%	(1,000)
008_04	Willow Creek	86	Geyer Willow	459	13	12%	5.41	6,000	32,000	30%	4.31	6,000	26,000	18%	(6,000)
008_04	Willow Creek	87	Geyer Willow	1199	13	12%	5.41	16,000	87,000	40%	3.69	16,000	59,000	28%	(28,000)
008_04	Willow Creek	88	Geyer Willow	123	13	12%	5.41	1,600	8,700	20%	4.92	1,600	7,900	8%	(800)
008_04	Willow Creek	89	Geyer Willow	347	13	12%	5.41	4,500	24,000	20%	4.92	4,500	22,000	8%	(2,000)
008_04	Willow Creek	90	Geyer Willow	1294	13	12%	5.41	17,000	92,000	30%	4.31	17,000	73,000	18%	(19,000)
008_04	Willow Creek	91	Geyer Willow	1127	13	12%	5.41	15,000	81,000	30%	4.31	15,000	65,000	18%	(16,000)
008_04	Willow Creek	92	Geyer Willow	500	14	11%	5.47	7,000	38,000	10%	5.54	7,000	39,000	-1%	1,000
008_04	Willow Creek	93	Geyer Willow	128	14	11%	5.47	1,800	9,900	0%	6.15	1,800	11,000	-11%	1,100
008_04	Willow Creek	94	Geyer Willow	462	14	11%	5.47	6,500	36,000	0%	6.15	6,500	40,000	-11%	4,000
008_04	Willow Creek	95	Geyer Willow	580	14	11%	5.47	8,100	44,000	0%	6.15	8,100	50,000	-11%	6,000
008_04	Willow Creek	96	Geyer Willow	403	14	11%	5.47	5,600	31,000	0%	6.15	5,600	34,000	-11%	3,000
008_04	Willow Creek	97	Geyer Willow	1638	14	11%	5.47	23,000	130,000	10%	5.54	23,000	130,000	-1%	0
008_04	Willow Creek	98	Geyer Willow	903	14	11%	5.47	13,000	71,000	0%	6.15	13,000	80,000	-11%	9,000
				Total Solar Loading					*1,100,000*				*990,000*		*-61,000*

Table C-10. Existing and target solar loads for Mud Creek - source to mouth (ID17040205SK009_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
009_02	Mud Creek	11	Grass	725	1	14%	5.29	700	4,000	30%	4.31	700	3,000	16%	(1,000)
009_02	Mud Creek	12	Grass	413	1	14%	5.29	400	2,000	40%	3.69	400	1,000	26%	(1,000)
009_02	Mud Creek	13	Warm Forest	462	1	96%	0.25	500	100	60%	2.46	500	1,000	-36%	900
009_02	Mud Creek	14	Grass	720	1	14%	5.29	700	4,000	10%	5.54	700	4,000	-4%	0
009_02	Mud Creek	15	Grass	490	1	14%	5.29	500	3,000	10%	5.54	500	3,000	-4%	0
009_02	Mud Creek	16	Grass	297	2	8%	5.66	600	3,000	20%	4.92	600	3,000	12%	0
009_02	Mud Creek	17	Grass	644	2	8%	5.66	1,000	6,000	20%	4.92	1,000	5,000	12%	(1,000)
009_02	Mud Creek	18	Grass	701	2	8%	5.66	1,000	6,000	20%	4.92	1,000	5,000	12%	(1,000)
009_02	Mud Creek	19	Geyer Willow	345	2	55%	2.77	700	2,000	20%	4.92	700	3,000	-35%	1,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
009_02	Mud Creek	21	Warm Forest	374	2	95%	0.31	700	200	40%	3.69	700	3,000	-55%	3,000
009_02	Mud Creek	22	Warm Forest	186	2	95%	0.31	400	100	70%	1.85	400	700	-25%	600
009_02	Mud Creek	23	Grass	519	3	5%	5.84	2,000	10,000	10%	5.54	2,000	10,000	5%	0
009_02	Mud Creek	24	Geyer Willow	764	3	41%	3.63	2,000	7,000	70%	1.85	2,000	4,000	29%	(3,000)
009_02	Mud Creek	25	Geyer Willow	610	3	41%	3.63	2,000	7,000	70%	1.85	2,000	4,000	29%	(3,000)
009_02	Mud Creek	26	Geyer Willow	676	3	41%	3.63	2,000	7,000	60%	2.46	2,000	5,000	19%	(2,000)
			Total Solar Loading						*61,000*				*55,000*		*-6,500*

Table C-11. Existing and target solar loads for Sellars Creek - source to mouth (ID17040205SK010_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
010_02	Sellars Creek	6	Warm Forest	344	1	96%	0.25	300	70	40%	3.69	300	1,000	-56%	900
010_02	Sellars Creek	7	Warm Forest	520	1	96%	0.25	500	100	50%	3.08	500	2,000	-46%	2,000
010_02	Sellars Creek	8	Warm Forest	228	1	96%	0.25	200	50	30%	4.31	200	900	-66%	900
010_02	Sellars Creek	9	Warm Forest	504	2	95%	0.31	1,000	300	50%	3.08	1,000	3,000	-45%	3,000
010_02	Sellars Creek	10	Warm Forest	473	2	95%	0.31	900	300	30%	4.31	900	4,000	-65%	4,000
010_02	Sellars Creek	11	Warm Forest	353	2	95%	0.31	700	200	20%	4.92	700	3,000	-75%	3,000
010_02	Sellars Creek	12	Warm Forest	150	2	95%	0.31	300	90	40%	3.69	300	1,000	-55%	900
010_02	Sellars Creek_Trib 02	3	Warm Forest	637	1	96%	0.25	600	100	50%	3.08	600	2,000	-46%	2,000
010_02	Sellars Creek_Trib 02	4	Warm Forest	170	1	96%	0.25	200	50	10%	5.54	200	1,000	-86%	1,000
010_02	Sellars Creek_Trib 02	5	Warm Forest	80	1	96%	0.25	80	20	60%	2.46	80	200	-36%	200
010_02	Sellars Creek_Trib 02	6	Warm Forest	228	1	96%	0.25	200	50	10%	5.54	200	1,000	-86%	1,000
010_02	Sellars Creek_Trib 02	7	Warm Forest	361	1	96%	0.25	400	100	50%	3.08	400	1,000	-46%	900
010_02	Sellars Creek_Trib 02	8	Warm Forest	154	1	96%	0.25	200	50	40%	3.69	200	700	-56%	700
010_02	Sellars Creek_Trib 02	9	Warm Forest	205	1	96%	0.25	200	50	50%	3.08	200	600	-46%	600
010_02	Sellars Creek_Trib 02	10	Warm Forest	347	1	96%	0.25	300	70	10%	5.54	300	2,000	-86%	2,000
010_02	Sellars Creek_Trib 02	11	Warm Forest	144	1	96%	0.25	100	20	40%	3.69	100	400	-56%	400

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
010_02	Sellars Creek_Trib 02	12	Warm Forest	185	1	96%	0.25	200	50	20%	4.92	200	1,000	-76%	1,000
010_02	Sellars Creek_Trib 02	13	Warm Forest	129	1	96%	0.25	100	20	70%	1.85	100	200	-26%	200
010_02	Sellars Creek_Trib 02	14	Geyer Willow	80	1	84%	0.98	80	80	60%	2.46	80	200	-24%	100
010_02	Sellars Creek_Trib 03	4	Warm Forest	1208	1	96%	0.25	1,000	200	60%	2.46	1,000	2,000	-36%	2,000
010_02	Sellars Creek_Trib 03	5	Warm Forest	334	1	96%	0.25	300	70	50%	3.08	300	900	-46%	800
010_02	Sellars Creek_Trib 03	6	Warm Forest	173	1	96%	0.25	200	50	60%	2.46	200	500	-36%	500
010_02	Sellars Creek_Trib 03	7	Warm Forest	153	1	96%	0.25	200	50	50%	3.08	200	600	-46%	600
010_02	Sellars Creek_Trib 03	8	Warm Forest	271	1	96%	0.25	300	70	60%	2.46	300	700	-36%	600
010_02	Sellars Creek_Trib 03	9	Warm Forest	439	1	96%	0.25	400	100	20%	4.92	400	2,000	-76%	2,000
010_02	Sellars Creek_Trib 03	10	Warm Forest	532	1	96%	0.25	500	100	40%	3.69	500	2,000	-56%	2,000
010_02	Sellars Creek_Trib 03	11	Warm Forest	298	1	96%	0.25	300	70	50%	3.08	300	900	-46%	800
010_02	South Fork Sellars Creek	3	Warm Forest	198	1	96%	0.25	200	50	50%	3.08	200	600	-46%	600
010_02	South Fork Sellars Creek	4	Warm Forest	465	1	96%	0.25	500	100	70%	1.85	500	900	-26%	800
010_02	South Fork Sellars Creek	5	Warm Forest	283	1	96%	0.25	300	70	60%	2.46	300	700	-36%	600
010_02	South Fork Sellars Creek	6	Warm Forest	353	1	96%	0.25	400	100	40%	3.69	400	1,000	-56%	900
010_02	South Fork Sellars Creek	7	Warm Forest	395	1	96%	0.25	400	100	20%	4.92	400	2,000	-76%	2,000
010_02	South Fork Sellars Creek	8	Warm Forest	123	1	96%	0.25	100	20	50%	3.08	100	300	-46%	300
010_02	South Fork Sellars Creek	9	Warm Forest	342	1	96%	0.25	300	70	10%	5.54	300	2,000	-86%	2,000
010_02	South Fork Sellars Creek	10	Warm Forest	273	2	95%	0.31	500	200	30%	4.31	500	2,000	-65%	2,000
010_02	South Fork Sellars Creek	11	Warm Forest	250	2	95%	0.31	500	200	20%	4.92	500	2,000	-75%	2,000
010_02	South Fork Sellars Creek	12	Warm Forest	158	2	95%	0.31	300	90	30%	4.31	300	1,000	-65%	900
010_02	South Fork Sellars Creek	13	Warm Forest	248	2	95%	0.31	500	200	20%	4.92	500	2,000	-75%	2,000
010_02	South Fork Sellars Creek	14	Warm Forest	373	2	95%	0.31	700	200	30%	4.31	700	3,000	-65%	3,000
010_02	South Fork Sellars Creek	15	Warm Forest	404	2	95%	0.31	800	200	20%	4.92	800	4,000	-75%	4,000
010_02	South Fork Sellars Creek	16	Warm Forest	416	2	95%	0.31	800	200	50%	3.08	800	2,000	-45%	2,000
010_02	South Fork Sellars Creek	17	Geyer Willow	186	3	41%	3.63	600	2,000	30%	4.31	600	3,000	-11%	1,000
010_02	South Fork Sellars Creek	18	Geyer Willow	159	3	41%	3.63	500	2,000	30%	4.31	500	2,000	-11%	0
010_02	South Fork Sellars Creek	19	Geyer Willow	152	3	41%	3.63	500	2,000	20%	4.92	500	2,000	-21%	0
010_02	South Fork Sellars Creek	20	Geyer Willow	109	3	41%	3.63	300	1,000	40%	3.69	300	1,000	-1%	0
010_02	South Fork Sellars Creek	21	Geyer Willow	263	3	41%	3.63	800	3,000	20%	4.92	800	4,000	-21%	1,000
010_02	South Fork Sellars Creek	22	Geyer Willow	592	3	41%	3.63	2,000	7,000	30%	4.31	2,000	9,000	-11%	2,000
010_02	South Fork Sellars Creek	23	Geyer Willow	258	3	41%	3.63	800	3,000	20%	4.92	800	4,000	-21%	1,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
010_02	South Fork Sellars Creek	24	Geyer Willow	264	3	41%	3.63	800	3,000	30%	4.31	800	3,000	-11%	0
010_02	South Fork Sellars Creek	25	Geyer Willow	162	3	41%	3.63	500	2,000	40%	3.69	500	2,000	-1%	0
			Total Solar Loading						*29,000*				*88,000*		*62,000*

Table C-12. Existing and target solar loads for Sellars Creek - source to mouth (ID17040205SK010_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
010_03	Sellars Creek	13	Geyer Willow	293	3	41%	3.63	900	3,000	50%	3.08	900	3,000	9%	0
010_03	Sellars Creek	14	Geyer Willow	225	3	41%	3.63	700	3,000	50%	3.08	700	2,000	9%	(1,000)
010_03	Sellars Creek	15	Geyer Willow	243	3	41%	3.63	700	3,000	40%	3.69	700	3,000	-1%	0
010_03	Sellars Creek	16	Geyer Willow	163	4	33%	4.12	700	3,000	50%	3.08	700	2,000	17%	(1,000)
010_03	Sellars Creek	17	Geyer Willow	390	4	33%	4.12	2,000	8,000	50%	3.08	2,000	6,000	17%	(2,000)
010_03	Sellars Creek	18	Geyer Willow	362	4	33%	4.12	1,000	4,000	30%	4.31	1,000	4,000	-3%	0
010_03	Sellars Creek	19	Geyer Willow	132	4	33%	4.12	500	2,000	10%	5.54	500	3,000	-23%	1,000
010_03	Sellars Creek	20	Geyer Willow	317	4	33%	4.12	1,000	4,000	30%	4.31	1,000	4,000	-3%	0
010_03	Sellars Creek	21	Geyer Willow	244	4	33%	4.12	1,000	4,000	50%	3.08	1,000	3,000	17%	(1,000)
010_03	Sellars Creek	22	Geyer Willow	209	4	33%	4.12	800	3,000	60%	2.46	800	2,000	27%	(1,000)
010_03	Sellars Creek	23	Geyer Willow	475	4	33%	4.12	2,000	8,000	20%	4.92	2,000	10,000	-13%	2,000
010_03	Sellars Creek	24	Geyer Willow	286	4	33%	4.12	1,000	4,000	50%	3.08	1,000	3,000	17%	(1,000)
010_03	Sellars Creek	25	Geyer Willow	304	4	33%	4.12	1,000	4,000	20%	4.92	1,000	5,000	-13%	1,000
010_03	Sellars Creek	26	Geyer Willow	450	5	28%	4.43	2,000	9,000	50%	3.08	2,000	6,000	22%	(3,000)
010_03	Sellars Creek	27	Geyer Willow	121	5	28%	4.43	600	3,000	10%	5.54	600	3,000	-18%	0
010_03	Sellars Creek	28	Geyer Willow	711	5	28%	4.43	4,000	20,000	30%	4.31	4,000	20,000	2%	0
010_03	Sellars Creek	29	Geyer Willow	500	5	28%	4.43	3,000	10,000	60%	2.46	3,000	7,000	32%	(3,000)
010_03	Sellars Creek	30	Geyer Willow	307	5	28%	4.43	2,000	9,000	10%	5.54	2,000	10,000	-18%	1,000
010_03	Sellars Creek	31	Geyer Willow	298	5	28%	4.43	1,000	4,000	60%	2.46	1,000	2,000	32%	(2,000)
010_03	Sellars Creek	32	Geyer Willow	133	5	28%	4.43	700	3,000	30%	4.31	700	3,000	2%	0
010_03	Sellars Creek	33	Geyer Willow	254	5	28%	4.43	1,000	4,000	10%	5.54	1,000	6,000	-18%	2,000
010_03	Sellars Creek	34	Geyer Willow	237	5	28%	4.43	1,000	4,000	30%	4.31	1,000	4,000	2%	0

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
010_03	Sellars Creek	35	Geyer Willow	159	5	28%	4.43	800	4,000	20%	4.92	800	4,000	-8%	0
			Total Solar Loading						*120,000*				*120,000*		*-8,000*

Table C-13. Existing and target solar loads for Willow Creek - Crane Creek to Mud Creek (ID17040205SK011_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
011_04	Willow Creek	42	Geyer Willow	246	7	21%	4.86	2,000	10,000	10%	5.54	2,000	10,000	-11%	0
011_04	Willow Creek	43	Geyer Willow	120	7	21%	4.86	800	4,000	20%	4.92	800	4,000	-1%	0
011_04	Willow Creek	44	Geyer Willow	371	7	21%	4.86	3,000	10,000	10%	5.54	3,000	20,000	-11%	10,000
011_04	Willow Creek	45	Geyer Willow	173	7	21%	4.86	1,000	5,000	20%	4.92	1,000	5,000	-1%	0
011_04	Willow Creek	46	Geyer Willow	165	7	21%	4.86	1,000	5,000	10%	5.54	1,000	6,000	-11%	1,000
011_04	Willow Creek	47	Geyer Willow	459	7	21%	4.86	3,000	10,000	30%	4.31	3,000	10,000	9%	0
011_04	Willow Creek	48	Geyer Willow	520	7	21%	4.86	4,000	20,000	20%	4.92	4,000	20,000	-1%	0
011_04	Willow Creek	49	Geyer Willow	502	7	21%	4.86	4,000	20,000	10%	5.54	4,000	20,000	-11%	0
011_04	Willow Creek	50	Geyer Willow	493	8	19%	4.98	4,000	20,000	30%	4.31	4,000	20,000	11%	0
011_04	Willow Creek	51	Geyer Willow	358	8	19%	4.98	3,000	10,000	10%	5.54	3,000	20,000	-9%	10,000
011_04	Willow Creek	52	Geyer Willow	340	8	19%	4.98	3,000	10,000	30%	4.31	3,000	10,000	11%	0
011_04	Willow Creek	53	Geyer Willow	183	8	19%	4.98	1,000	5,000	40%	3.69	1,000	4,000	21%	(1,000)
011_04	Willow Creek	54	Geyer Willow	337	8	19%	4.98	3,000	10,000	30%	4.31	3,000	10,000	11%	0
011_04	Willow Creek	55	Geyer Willow	641	8	19%	4.98	5,000	20,000	10%	5.54	5,000	30,000	-9%	10,000
011_04	Willow Creek	56	Geyer Willow	294	8	19%	4.98	2,000	10,000	20%	4.92	2,000	10,000	1%	0
011_04	Willow Creek	57	Geyer Willow	445	9	17%	5.10	4,000	20,000	10%	5.54	4,000	20,000	-7%	0
011_04	Willow Creek	58	Geyer Willow	643	9	17%	5.10	6,000	30,000	20%	4.92	6,000	30,000	3%	0
011_04	Willow Creek	59	Geyer Willow	620	9	17%	5.10	6,000	30,000	30%	4.31	6,000	30,000	13%	0
011_04	Willow Creek	60	Geyer Willow	230	9	17%	5.10	2,000	10,000	20%	4.92	2,000	10,000	3%	0
011_04	Willow Creek	61	Geyer Willow	208	9	17%	5.10	2,000	10,000	30%	4.31	2,000	9,000	13%	(1,000)
011_04	Willow Creek	62	Geyer Willow	117	9	17%	5.10	1,000	5,000	10%	5.54	1,000	6,000	-7%	1,000
011_04	Willow Creek	63	Geyer Willow	189	9	17%	5.10	2,000	10,000	30%	4.31	2,000	9,000	13%	(1,000)
011_04	Willow Creek	64	Geyer Willow	249	9	17%	5.10	2,000	10,000	10%	5.54	2,000	10,000	-7%	0

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
011_04	Willow Creek	65	Geyer Willow	640	10	15%	5.23	6,400	33,000	30%	4.31	6,400	28,000	15%	(5,000)
011_04	Willow Creek	66	Geyer Willow	525	10	15%	5.23	5,300	28,000	20%	4.92	5,300	26,000	5%	(2,000)
011_04	Willow Creek	67	Geyer Willow	354	10	15%	5.23	3,500	18,000	30%	4.31	3,500	15,000	15%	(3,000)
011_04	Willow Creek	68	Geyer Willow	515	10	15%	5.23	5,200	27,000	20%	4.92	5,200	26,000	5%	(1,000)
011_04	Willow Creek	69	Geyer Willow	526	10	15%	5.23	5,300	28,000	10%	5.54	5,300	29,000	-5%	1,000
011_04	Willow Creek	70	Geyer Willow	1295	11	14%	5.29	14,000	74,000	0%	6.15	14,000	86,000	-14%	12,000
011_04	Willow Creek	71	Geyer Willow	306	11	14%	5.29	3,400	18,000	30%	4.31	3,400	15,000	16%	(3,000)
011_04	Willow Creek	72	Geyer Willow	878	11	14%	5.29	9,700	51,000	20%	4.92	9,700	48,000	6%	(3,000)
011_04	Willow Creek	73	Geyer Willow	492	11	14%	5.29	5,400	29,000	30%	4.31	5,400	23,000	16%	(6,000)
			Total Solar Loading						*600,000*				*620,000*		*19,000*

Table C-14. Existing and target solar loads for Mill Creek - source to mouth (ID17040205SK012_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
012_02	Alley Lyons Creek	7	Warm Forest	235	1	96%	0.25	200	50	30%	4.31	200	900	-66%	900
012_02	Alley Lyons Creek	8	Warm Forest	152	1	96%	0.25	200	50	20%	4.92	200	1,000	-76%	1,000
012_02	Alley Lyons Creek	9	Warm Forest	174	1	96%	0.25	200	50	70%	1.85	200	400	-26%	400
012_02	Alley Lyons Creek	10	Warm Forest	210	1	96%	0.25	200	50	40%	3.69	200	700	-56%	700
012_02	Alley Lyons Creek	11	Warm Forest	135	1	96%	0.25	100	20	60%	2.46	100	200	-36%	200
012_02	Alley Lyons Creek	12	Warm Forest	374	1	96%	0.25	400	100	30%	4.31	400	2,000	-66%	2,000
012_02	Alley Lyons Creek	13	Geyer Willow	382	1	84%	0.98	400	400	0%	6.15	400	2,000	-84%	2,000
012_02	Alley Lyons Creek	14	Geyer Willow	101	1	84%	0.98	100	100	30%	4.31	100	400	-54%	300
012_02	Alley Lyons Creek	15	Geyer Willow	294	2	55%	2.77	600	2,000	60%	2.46	600	1,000	5%	(1,000)
012_02	Alley Lyons Creek	16	Geyer Willow	143	2	55%	2.77	300	800	40%	3.69	300	1,000	-15%	200
012_02	Alley Lyons Creek	17	Geyer Willow	109	2	55%	2.77	200	600	50%	3.08	200	600	-5%	0
012_02	Alley Lyons Creek	18	Geyer Willow	420	2	55%	2.77	800	2,000	60%	2.46	800	2,000	5%	0
012_02	Alley Lyons Creek	19	Geyer Willow	310	2	55%	2.77	600	2,000	40%	3.69	600	2,000	-15%	0
012_02	Alley Lyons Creek	20	Geyer Willow	142	2	55%	2.77	300	800	60%	2.46	300	700	5%	(100)
012_02	Alley Lyons Creek	21	Geyer Willow	217	2	55%	2.77	400	1,000	40%	3.69	400	1,000	-15%	0

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
012_02	Alley Lyons Creek	22	Geyer Willow	192	2	55%	2.77	400	1,000	50%	3.08	400	1,000	-5%	0
012_02	Buck Creek	1	Warm Forest	103	1	96%	0.25	100	20	30%	4.31	100	400	-66%	400
012_02	Buck Creek	2	Warm Forest	216	1	96%	0.25	200	50	20%	4.92	200	1,000	-76%	1,000
012_02	Buck Creek	3	Geyer Willow	189	1	84%	0.98	200	200	30%	4.31	200	900	-54%	700
012_02	Buck Creek	3	Warm Forest	189	1	96%	0.25	200	50	30%	4.31	200	900	-66%	900
012_02	Buck Creek	4	Geyer Willow	299	1	84%	0.98	300	300	10%	5.54	300	2,000	-74%	2,000
012_02	Buck Creek	5	Geyer Willow	143	1	84%	0.98	100	100	30%	4.31	100	400	-54%	300
012_02	Buck Creek	6	Geyer Willow	133	1	84%	0.98	100	100	10%	5.54	100	600	-74%	500
012_02	Buck Creek	7	Geyer Willow	86	1	84%	0.98	90	90	40%	3.69	90	300	-44%	200
012_02	Buck Creek	8	Geyer Willow	334	1	84%	0.98	300	300	30%	4.31	300	1,000	-54%	700
012_02	Buck Creek	9	Geyer Willow	271	1	84%	0.98	300	300	60%	2.46	300	700	-24%	400
012_02	Buck Creek	10	Geyer Willow	194	1	84%	0.98	200	200	10%	5.54	200	1,000	-74%	800
012_02	Buck Creek	11	Geyer Willow	207	2	55%	2.77	400	1,000	0%	6.15	400	2,000	-55%	1,000
012_02	Buck Creek	12	Geyer Willow	675	2	55%	2.77	1,000	3,000	40%	3.69	1,000	4,000	-15%	1,000
012_02	Buck Creek	13	Geyer Willow	128	2	55%	2.77	300	800	10%	5.54	300	2,000	-45%	1,000
012_02	Buck Creek	14	Geyer Willow	133	2	55%	2.77	300	800	40%	3.69	300	1,000	-15%	200
012_02	Buck Creek	15	Geyer Willow	284	2	55%	2.77	600	2,000	10%	5.54	600	3,000	-45%	1,000
012_02	Buck Creek	16	Geyer Willow	196	2	55%	2.77	400	1,000	40%	3.69	400	1,000	-15%	0
012_02	Buck Creek	17	Geyer Willow	208	2	55%	2.77	400	1,000	10%	5.54	400	2,000	-45%	1,000
012_02	Buck Creek	18	Geyer Willow	201	2	55%	2.77	400	1,000	40%	3.69	400	1,000	-15%	0
012_02	Buck Creek	19	Geyer Willow	179	2	55%	2.77	400	1,000	60%	2.46	400	1,000	5%	0
012_02	Levi Hawkley Creek	5	Geyer Willow	220	1	84%	0.98	200	200	0%	6.15	200	1,000	-84%	800
012_02	Levi Hawkley Creek	6	Geyer Willow	91	1	84%	0.98	90	90	10%	5.54	90	500	-74%	400
012_02	Levi Hawkley Creek	7	Geyer Willow	288	1	84%	0.98	300	300	0%	6.15	300	2,000	-84%	2,000
012_02	Levi Hawkley Creek	8	Geyer Willow	229	1	84%	0.98	200	200	10%	5.54	200	1,000	-74%	800
012_02	Levi Hawkley Creek	9	Geyer Willow	218	1	84%	0.98	200	200	0%	6.15	200	1,000	-84%	800
012_02	Levi Hawkley Creek	10	Geyer Willow	145	1	84%	0.98	100	100	10%	5.54	100	600	-74%	500
012_02	Levi Hawkley Creek	11	Geyer Willow	151	1	84%	0.98	200	200	50%	3.08	200	600	-34%	400
012_02	Mill Creek	9	Geyer Willow	355	1	84%	0.98	400	400	10%	5.54	400	2,000	-74%	2,000
012_02	Mill Creek	10	Geyer Willow	615	1	84%	0.98	600	600	20%	4.92	600	3,000	-64%	2,000
012_02	Mill Creek	11	Geyer Willow	195	2	55%	2.77	400	1,000	60%	2.46	400	1,000	5%	0
012_02	Mill Creek	12	Geyer Willow	177	2	55%	2.77	400	1,000	0%	6.15	400	2,000	-55%	1,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
012_02	Mill Creek	13	Geyer Willow	235	2	55%	2.77	500	1,000	10%	5.54	500	3,000	-45%	2,000
012_02	Mill Creek	14	Geyer Willow	147	2	55%	2.77	300	800	0%	6.15	300	2,000	-55%	1,000
012_02	Mill Creek	15	Geyer Willow	260	2	55%	2.77	500	1,000	10%	5.54	500	3,000	-45%	2,000
012_02	Mill Creek	16	Geyer Willow	473	3	41%	3.63	1,000	4,000	60%	2.46	1,000	2,000	19%	(2,000)
012_02	Mill Creek	17	Geyer Willow	210	3	41%	3.63	600	2,000	70%	1.85	600	1,000	29%	(1,000)
			Total Solar Loading						*37,000*				*69,000*		*32,000*

Table C-15. Existing and target solar loads for Mill Creek - source to mouth (ID17040205SK012_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
012_03	Mill Creek	18	Geyer Willow	257	3	41%	3.63	800	3,000	50%	3.08	800	2,000	9%	(1,000)
012_03	Mill Creek	19	Geyer Willow	747	3	41%	3.63	2,000	7,000	60%	2.46	2,000	5,000	19%	(2,000)
012_03	Mill Creek	20	Geyer Willow	201	3	41%	3.63	600	2,000	50%	3.08	600	2,000	9%	0
012_03	Mill Creek	21	Geyer Willow	181	3	41%	3.63	500	2,000	60%	2.46	500	1,000	19%	(1,000)
012_03	Mill Creek	22	Geyer Willow	423	3	41%	3.63	1,000	4,000	50%	3.08	1,000	3,000	9%	(1,000)
012_03	Mill Creek	23	Geyer Willow	154	3	41%	3.63	500	2,000	50%	3.08	500	2,000	9%	0
012_03	Mill Creek	24	Geyer Willow	202	4	33%	4.12	800	3,000	10%	5.54	800	4,000	-23%	1,000
012_03	Mill Creek	25	Geyer Willow	219	4	33%	4.12	900	4,000	0%	6.15	900	6,000	-33%	2,000
012_03	Mill Creek	26	Geyer Willow	275	4	33%	4.12	1,000	4,000	40%	3.69	1,000	4,000	7%	0
012_03	Mill Creek	27	Geyer Willow	147	4	33%	4.12	600	2,000	10%	5.54	600	3,000	-23%	1,000
012_03	Mill Creek	28	Geyer Willow	146	4	33%	4.12	600	2,000	60%	2.46	600	1,000	27%	(1,000)
012_03	Mill Creek	29	Geyer Willow	406	4	33%	4.12	2,000	8,000	40%	3.69	2,000	7,000	7%	(1,000)
012_03	Mill Creek	30	Geyer Willow	483	4	33%	4.12	2,000	8,000	30%	4.31	2,000	9,000	-3%	1,000
012_03	Mill Creek	31	Geyer Willow	161	5	28%	4.43	800	4,000	50%	3.08	800	2,000	22%	(2,000)
012_03	Mill Creek	32	Geyer Willow	137	5	28%	4.43	700	3,000	40%	3.69	700	3,000	12%	0
012_03	Mill Creek	33	Geyer Willow	282	5	28%	4.43	1,000	4,000	50%	3.08	1,000	3,000	22%	(1,000)
012_03	Mill Creek	34	Geyer Willow	237	5	28%	4.43	1,000	4,000	40%	3.69	1,000	4,000	12%	0
012_03	Mill Creek	35	Geyer Willow	144	5	28%	4.43	700	3,000	30%	4.31	700	3,000	2%	0
012_03	Mill Creek	36	Geyer Willow	166	5	28%	4.43	800	4,000	10%	5.54	800	4,000	-18%	0

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
012_03	Mill Creek	37	Geyer Willow	153	5	28%	4.43	800	4,000	30%	4.31	800	3,000	2%	(1,000)
012_03	Mill Creek	38	Geyer Willow	194	5	28%	4.43	1,000	4,000	50%	3.08	1,000	3,000	22%	(1,000)
			Total Solar Loading						*81,000*				*74,000*		*-7,000*

Table C-16. Existing and target solar loads for Willow Creek - source to Crane Creek (ID17040205SK013_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
013_02	Deer Creek	11	Geyer Willow	174	1	84%	0.98	200	200	20%	4.92	200	1,000	-64%	800
013_02	Deer Creek	12	Geyer Willow	103	1	84%	0.98	100	100	10%	5.54	100	600	-74%	500
013_02	Deer Creek	13	Geyer Willow	153	1	84%	0.98	200	200	30%	4.31	200	900	-54%	700
013_02	Deer Creek	14	Geyer Willow	428	2	55%	2.77	900	2,000	0%	6.15	900	6,000	-55%	4,000
013_02	Deer Creek	15	Geyer Willow	328	2	55%	2.77	700	2,000	20%	4.92	700	3,000	-35%	1,000
013_02	Deer Creek	16	Geyer Willow	196	2	55%	2.77	400	1,000	0%	6.15	400	2,000	-55%	1,000
013_02	Deer Creek	17	Geyer Willow	142	3	41%	3.63	400	1,000	30%	4.31	400	2,000	-11%	1,000
013_02	Deer Creek	18	Geyer Willow	95	3	41%	3.63	300	1,000	10%	5.54	300	2,000	-31%	1,000
013_02	Deer Creek	19	Geyer Willow	210	3	41%	3.63	600	2,000	60%	2.46	600	1,000	19%	(1,000)
013_02	Deer Creek	20	Geyer Willow	104	3	41%	3.63	300	1,000	20%	4.92	300	1,000	-21%	0
013_02	Pack Saddle Creek	4	Geyer Willow	3044	2	55%	2.77	6,000	20,000	0%	6.15	6,000	40,000	-55%	20,000
013_02	Willow Creek	12	Geyer Willow	503	5	28%	4.43	3,000	10,000	10%	5.54	3,000	20,000	-18%	10,000
013_02	Willow Creek	13	Geyer Willow	255	5	28%	4.43	1,000	4,000	10%	5.54	1,000	6,000	-18%	2,000
013_02	Willow Creek	14	Geyer Willow	261	5	28%	4.43	1,000	4,000	10%	5.54	1,000	6,000	-18%	2,000
013_02	Willow Creek	15	Geyer Willow	551	5	28%	4.43	3,000	10,000	10%	5.54	3,000	20,000	-18%	10,000
013_02	Willow Creek	16	Geyer Willow	69	5	28%	4.43	300	1,000	0%	6.15	300	2,000	-28%	1,000
013_02	Willow Creek	17	Geyer Willow	334	5	28%	4.43	2,000	9,000	0%	6.15	2,000	10,000	-28%	1,000
013_02	Willow Creek	18	Geyer Willow	194	5	28%	4.43	1,000	4,000	40%	3.69	1,000	4,000	12%	0
013_02	Willow Creek	19	Geyer Willow	510	5	28%	4.43	3,000	10,000	0%	6.15	3,000	20,000	-28%	10,000
013_02	Willow Creek	20	Geyer Willow	1022	5	28%	4.43	5,000	20,000	0%	6.15	5,000	30,000	-28%	10,000
013_02	Willow Creek	21	Geyer Willow	177	5	28%	4.43	900	4,000	10%	5.54	900	5,000	-18%	1,000
013_02	Willow Creek	22	Geyer Willow	272	5	28%	4.43	1,000	4,000	0%	6.15	1,000	6,000	-28%	2,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
013_02	Willow Creek	23	Geyer Willow	601	5	28%	4.43	3,000	10,000	0%	6.15	3,000	20,000	-28%	10,000
013_02	Willow Creek	24	Geyer Willow	516	5	28%	4.43	3,000	10,000	0%	6.15	3,000	20,000	-28%	10,000
013_02	Willow Creek_Trib 01	7	Grass	166	1	14%	5.29	200	1,000	10%	5.54	200	1,000	-4%	0
013_02	Willow Creek_Trib 02	1	Grass	236	1	14%	5.29	200	1,000	0%	6.15	200	1,000	-14%	0
			Total Solar Loading						*130,000*				*230,000*		*98,000*

Table C-17. Existing and target solar loads for Willow Creek - source to Crane Creek (ID17040205SK013_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
013_03	Willow Creek	25	Geyer Willow	1721	6	24%	4.67	10,000	50,000	10%	5.54	10,000	60,000	-14%	10,000
013_03	Willow Creek	26	Geyer Willow	194	6	24%	4.67	1,000	5,000	20%	4.92	1,000	5,000	-4%	0
013_03	Willow Creek	27	Geyer Willow	259	6	24%	4.67	2,000	9,000	30%	4.31	2,000	9,000	6%	0
013_03	Willow Creek	28	Geyer Willow	382	6	24%	4.67	2,000	9,000	10%	5.54	2,000	10,000	-14%	1,000
013_03	Willow Creek	29	Geyer Willow	189	6	24%	4.67	1,000	5,000	50%	3.08	1,000	3,000	26%	(2,000)
013_03	Willow Creek	30	Geyer Willow	98	6	24%	4.67	600	3,000	10%	5.54	600	3,000	-14%	0
013_03	Willow Creek	31	Geyer Willow	246	6	24%	4.67	1,000	5,000	0%	6.15	1,000	6,000	-24%	1,000
013_03	Willow Creek	32	Geyer Willow	226	6	24%	4.67	1,000	5,000	30%	4.31	1,000	4,000	6%	(1,000)
013_03	Willow Creek	33	Geyer Willow	297	6	24%	4.67	2,000	9,000	40%	3.69	2,000	7,000	16%	(2,000)
013_03	Willow Creek	34	Geyer Willow	404	6	24%	4.67	2,000	9,000	20%	4.92	2,000	10,000	-4%	1,000
013_03	Willow Creek	35	Geyer Willow	342	6	24%	4.67	2,000	9,000	30%	4.31	2,000	9,000	6%	0
013_03	Willow Creek	36	Geyer Willow	561	6	24%	4.67	3,000	10,000	20%	4.92	3,000	10,000	-4%	0
013_03	Willow Creek	37	Geyer Willow	110	6	24%	4.67	700	3,000	30%	4.31	700	3,000	6%	0
013_03	Willow Creek	38	Geyer Willow	296	6	24%	4.67	2,000	9,000	20%	4.92	2,000	10,000	-4%	1,000
013_03	Willow Creek	39	Geyer Willow	138	6	24%	4.67	800	4,000	0%	6.15	800	5,000	-24%	1,000
013_03	Willow Creek	40	Geyer Willow	260	6	24%	4.67	2,000	9,000	10%	5.54	2,000	10,000	-14%	1,000
013_03	Willow Creek	41	Geyer Willow	218	6	24%	4.67	1,000	5,000	20%	4.92	1,000	5,000	-4%	0
			Total Solar Loading						*160,000*				*170,000*		*11,000*

Table C-18. Existing and target solar load for Grays Lake outlet - Hell Creek to mouth (ID17040205SK016_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
016_04	Grays Lake Outlet	1	Geyer Willow	476	20	8%	5.66	9,500	54,000	40%	3.69	9,500	35,000	32%	(19,000)
016_04	Grays Lake Outlet	2	Geyer Willow	374	20	8%	5.66	7,500	42,000	30%	4.31	7,500	32,000	22%	(10,000)
016_04	Grays Lake Outlet	4	Geyer Willow	289	20	8%	5.66	5,800	33,000	40%	3.69	5,800	21,000	32%	(12,000)
016_04	Grays Lake Outlet	5	Geyer Willow	191	20	8%	5.66	3,800	22,000	50%	3.08	3,800	12,000	42%	(10,000)
016_04	Grays Lake Outlet	6	Geyer Willow	244	20	8%	5.66	4,900	28,000	40%	3.69	4,900	18,000	32%	(10,000)
016_04	Grays Lake Outlet	7	Geyer Willow	224	20	8%	5.66	4,500	25,000	50%	3.08	4,500	14,000	42%	(11,000)
016_04	Grays Lake Outlet	8	Geyer Willow	292	20	8%	5.66	5,800	33,000	40%	3.69	5,800	21,000	32%	(12,000)
016_04	Grays Lake Outlet	9	Geyer Willow	526	20	8%	5.66	11,000	62,000	50%	3.08	11,000	34,000	42%	(28,000)
016_04	Grays Lake Outlet	10	Geyer Willow	582	20	8%	5.66	12,000	68,000	40%	3.69	12,000	44,000	32%	(24,000)
016_04	Grays Lake Outlet	11	Geyer Willow	573	20	8%	5.66	11,000	62,000	50%	3.08	11,000	34,000	42%	(28,000)
016_04	Grays Lake Outlet	12	Geyer Willow	532	20	8%	5.66	11,000	62,000	60%	2.46	11,000	27,000	52%	(35,000)
016_04	Grays Lake Outlet	13	Geyer Willow	393	20	8%	5.66	7,900	45,000	40%	3.69	7,900	29,000	32%	(16,000)
016_04	Grays Lake Outlet	14	Geyer Willow	496	20	8%	5.66	9,900	56,000	50%	3.08	9,900	30,000	42%	(26,000)
016_04	Grays Lake Outlet	15	Geyer Willow	343	20	8%	5.66	6,900	39,000	40%	3.69	6,900	25,000	32%	(14,000)
016_04	Grays Lake Outlet	16	Geyer Willow	287	20	8%	5.66	5,700	32,000	50%	3.08	5,700	18,000	42%	(14,000)
016_04	Grays Lake Outlet	17	Geyer Willow	347	20	8%	5.66	6,900	39,000	40%	3.69	6,900	25,000	32%	(14,000)
016_04	Grays Lake Outlet	18	Geyer Willow	303	20	8%	5.66	6,100	35,000	30%	4.31	6,100	26,000	22%	(9,000)
016_04	Grays Lake Outlet	19	Geyer Willow	206	20	8%	5.66	4,100	23,000	20%	4.92	4,100	20,000	12%	(3,000)
016_04	Grays Lake Outlet	20	Geyer Willow	561	20	8%	5.66	11,000	62,000	40%	3.69	11,000	41,000	32%	(21,000)
016_04	Grays Lake Outlet	21	Geyer Willow	331	20	8%	5.66	6,600	37,000	30%	4.31	6,600	28,000	22%	(9,000)
			Total Solar Loading						*860,000*				*530,000*		*-330,000*

Table C-19. Existing and target solar load for Grays Lake outlet - Home Creek to Hell Creek (ID17040205SK017_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
017_04	Grays Lake Outlet	1	Geyer Willow	269	18	9%	5.60	4,800	27,000	40%	3.69	4,800	18,000	31%	(9,000)
017_04	Grays Lake Outlet	2	Geyer Willow	592	18	9%	5.60	11,000	62,000	40%	3.69	11,000	41,000	31%	(21,000)
017_04	Grays Lake Outlet	3	Geyer Willow	187	18	9%	5.60	3,400	19,000	40%	3.69	3,400	13,000	31%	(6,000)
017_04	Grays Lake Outlet	4	Geyer Willow	204	18	9%	5.60	3,700	21,000	40%	3.69	3,700	14,000	31%	(7,000)
017_04	Grays Lake Outlet	5	Geyer Willow	491	18	9%	5.60	8,800	49,000	40%	3.69	8,800	32,000	31%	(17,000)
017_04	Grays Lake Outlet	6	Geyer Willow	285	18	9%	5.60	5,100	29,000	40%	3.69	5,100	19,000	31%	(10,000)
017_04	Grays Lake Outlet	7	Geyer Willow	167	18	9%	5.60	3,000	17,000	40%	3.69	3,000	11,000	31%	(6,000)
017_04	Grays Lake Outlet	8	Geyer Willow	374	18	9%	5.60	6,700	37,000	40%	3.69	6,700	25,000	31%	(12,000)
017_04	Grays Lake Outlet	9	Geyer Willow	245	18	9%	5.60	4,400	25,000	40%	3.69	4,400	16,000	31%	(9,000)
017_04	Grays Lake Outlet	10	Geyer Willow	121	18	9%	5.60	2,200	12,000	40%	3.69	2,200	8,100	31%	(3,900)
017_04	Grays Lake Outlet	11	Geyer Willow	151	18	9%	5.60	2,700	15,000	40%	3.69	2,700	10,000	31%	(5,000)
017_04	Grays Lake Outlet	12	Geyer Willow	373	18	9%	5.60	6,700	37,000	40%	3.69	6,700	25,000	31%	(12,000)
017_04	Grays Lake Outlet	13	Geyer Willow	914	18	9%	5.60	16,000	90,000	40%	3.69	16,000	59,000	31%	(31,000)
017_04	Grays Lake Outlet	14	Geyer Willow	289	18	9%	5.60	5,200	29,000	40%	3.69	5,200	19,000	31%	(10,000)
017_04	Grays Lake Outlet	15	Geyer Willow	979	18	9%	5.60	18,000	100,000	40%	3.69	18,000	66,000	31%	(34,000)
017_04	Grays Lake Outlet	16	Geyer Willow	579	18	9%	5.60	10,000	56,000	40%	3.69	10,000	37,000	31%	(19,000)
017_04	Grays Lake Outlet	17	Geyer Willow	863	18	9%	5.60	16,000	90,000	40%	3.69	16,000	59,000	31%	(31,000)
017_04	Grays Lake Outlet	18	Geyer Willow	203	19	8%	5.66	3,900	22,000	40%	3.69	3,900	14,000	32%	(8,000)
017_04	Grays Lake Outlet	19	Geyer Willow	761	19	8%	5.66	14,000	79,000	40%	3.69	14,000	52,000	32%	(27,000)
017_04	Grays Lake Outlet	20	Geyer Willow	355	19	8%	5.66	6,700	38,000	30%	4.31	6,700	29,000	22%	(9,000)
017_04	Grays Lake Outlet	21	Geyer Willow	483	19	8%	5.66	9,200	52,000	40%	3.69	9,200	34,000	32%	(18,000)
017_04	Grays Lake Outlet	22	Geyer Willow	320	19	8%	5.66	6,100	35,000	30%	4.31	6,100	26,000	22%	(9,000)
017_04	Grays Lake Outlet	23	Geyer Willow	383	19	8%	5.66	7,300	41,000	40%	3.69	7,300	27,000	32%	(14,000)
017_04	Grays Lake Outlet	24	Geyer Willow	435	19	8%	5.66	8,300	47,000	20%	4.92	8,300	41,000	12%	(6,000)
017_04	Grays Lake Outlet	25	Geyer Willow	223	19	8%	5.66	4,200	24,000	30%	4.31	4,200	18,000	22%	(6,000)
017_04	Grays Lake Outlet	26	Geyer Willow	256	19	8%	5.66	4,900	28,000	50%	3.08	4,900	15,000	42%	(13,000)
017_04	Grays Lake Outlet	27	Geyer Willow	251	19	8%	5.66	4,800	27,000	20%	4.92	4,800	24,000	12%	(3,000)
017_04	Grays Lake Outlet	28	Geyer Willow	394	19	8%	5.66	7,500	42,000	50%	3.08	7,500	23,000	42%	(19,000)
017_04	Grays Lake Outlet	29	Geyer Willow	517	19	8%	5.66	9,800	55,000	40%	3.69	9,800	36,000	32%	(19,000)
017_04	Grays Lake Outlet	30	Geyer Willow	704	19	8%	5.66	13,000	74,000	50%	3.08	13,000	40,000	42%	(34,000)
017_04	Grays Lake Outlet	31	Geyer Willow	248	19	8%	5.66	4,700	27,000	40%	3.69	4,700	17,000	32%	(10,000)

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
017_04	Grays Lake Outlet	32	Geyer Willow	133	19	8%	5.66	2,500	14,000	30%	4.31	2,500	11,000	22%	(3,000)
017_04	Grays Lake Outlet	33	Geyer Willow	344	19	8%	5.66	6,500	37,000	40%	3.69	6,500	24,000	32%	(13,000)
017_04	Grays Lake Outlet	34	Geyer Willow	272	19	8%	5.66	5,200	29,000	50%	3.08	5,200	16,000	42%	(13,000)
017_04	Grays Lake Outlet	35	Geyer Willow	235	19	8%	5.66	4,500	25,000	30%	4.31	4,500	19,000	22%	(6,000)
017_04	Grays Lake Outlet	36	Geyer Willow	265	19	8%	5.66	5,000	28,000	40%	3.69	5,000	18,000	32%	(10,000)
			Total Solar Loading						*1,400,000*				*960,000*		*-480,000*

Table C-20. Existing and target solar load for Homer Creek - source to mouth (ID17040205SK018_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
018_02	Chicken Creek	8	Geyer Willow	217	1	84%	0.98	200	200	10%	5.54	200	1,000	-74%	800
018_02	Chicken Creek	9	Geyer Willow	571	1	84%	0.98	600	600	30%	4.31	600	3,000	-54%	2,000
018_02	Chicken Creek	10	Geyer Willow	180	1	84%	0.98	200	200	10%	5.54	200	1,000	-74%	800
018_02	Chicken Creek	11	Geyer Willow	169	2	55%	2.77	300	800	30%	4.31	300	1,000	-25%	200
018_02	Chicken Creek	12	Geyer Willow	94	2	55%	2.77	200	600	0%	6.15	200	1,000	-55%	400
018_02	Chicken Creek	13	Geyer Willow	541	2	55%	2.77	1,000	3,000	30%	4.31	1,000	4,000	-25%	1,000
018_02	Chicken Creek	14	Geyer Willow	618	3	41%	3.63	2,000	7,000	20%	4.92	2,000	10,000	-21%	3,000
018_02	Chicken Creek	15	Geyer Willow	311	3	41%	3.63	900	3,000	10%	5.54	900	5,000	-31%	2,000
018_02	Chicken Creek	16	Geyer Willow	247	3	41%	3.63	700	3,000	0%	6.15	700	4,000	-41%	1,000
018_02	Chicken Creek	17	Geyer Willow	140	3	41%	3.63	400	1,000	10%	5.54	400	2,000	-31%	1,000
018_02	Homer Creek	9	Geyer Willow	175	1	84%	0.98	200	200	0%	6.15	200	1,000	-84%	800
018_02	Homer Creek	10	Geyer Willow	553	1	84%	0.98	600	600	10%	5.54	600	3,000	-74%	2,000
018_02	Homer Creek	11	Geyer Willow	598	2	55%	2.77	1,000	3,000	0%	6.15	1,000	6,000	-55%	3,000
018_02	Homer Creek	12	Geyer Willow	434	2	55%	2.77	900	2,000	10%	5.54	900	5,000	-45%	3,000
018_02	Homer Creek_Trib 02	5	Geyer Willow	649	1	84%	0.98	600	600	20%	4.92	600	3,000	-64%	2,000
018_02	Homer Creek_Trib 02	6	Geyer Willow	341	1	84%	0.98	300	300	30%	4.31	300	1,000	-54%	700
018_02	Homer Creek_Trib 02	7	Geyer Willow	168	1	84%	0.98	200	200	20%	4.92	200	1,000	-64%	800
018_02	Homer Creek_Trib 02	8	Geyer Willow	199	1	84%	0.98	200	200	10%	5.54	200	1,000	-74%	800
018_02	Homer Creek_Trib 02	9	Geyer Willow	156	1	84%	0.98	200	200	30%	4.31	200	900	-54%	700

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
018_02	Homer Creek_Trib 02	10	Geyer Willow	374	1	84%	0.98	400	400	0%	6.15	400	2,000	-84%	2,000
018_02	Homer Creek_Trib 02	11	Geyer Willow	1299	1	84%	0.98	1,000	1,000	0%	6.15	1,000	6,000	-84%	5,000
018_02	Homer Creek_Trib 02	12	Geyer Willow	654	1	84%	0.98	700	700	10%	5.54	700	4,000	-74%	3,000
018_02	Homer Creek_Trib 02a	7	Geyer Willow	510	1	84%	0.98	500	500	0%	6.15	500	3,000	-84%	3,000
018_02	Homer Creek_Trib 03	4	Geyer Willow	283	1	84%	0.98	300	300	10%	5.54	300	2,000	-74%	2,000
018_02	Homer Creek_Trib 03	5	Geyer Willow	206	1	84%	0.98	200	200	20%	4.92	200	1,000	-64%	800
018_02	Homer Creek_Trib 03	6	Geyer Willow	392	1	84%	0.98	400	400	10%	5.54	400	2,000	-74%	2,000
018_02	Homer Creek_Trib 03	7	Geyer Willow	281	1	84%	0.98	300	300	20%	4.92	300	1,000	-64%	700
018_02	Homer Creek_Trib 03	8	Geyer Willow	119	1	84%	0.98	100	100	30%	4.31	100	400	-54%	300
018_02	Homer Creek_Trib 03	9	Geyer Willow	96	1	84%	0.98	100	100	10%	5.54	100	600	-74%	500
018_02	Homer Creek_Trib 03	9	Geyer Willow	308	1	84%	0.98	300	300	20%	4.92	300	1,000	-64%	700
018_02	Homer Creek_Trib 03	10	Geyer Willow	1321	2	55%	2.77	3,000	8,000	0%	6.15	3,000	20,000	-55%	10,000
018_02	Homer Creek_Trib 04	8	Geyer Willow	1403	1	84%	0.98	1,000	1,000	0%	6.15	1,000	6,000	-84%	5,000
018_02	Homer Creek_Trib 11	6	Geyer Willow	1761	1	84%	0.98	2,000	2,000	10%	5.54	2,000	10,000	-74%	8,000
018_02	Homer Creek_Trib 11	7	Geyer Willow	405	1	84%	0.98	400	400	0%	6.15	400	2,000	-84%	2,000
018_02	Homer Creek_Trib 11	8	Geyer Willow	620	1	84%	0.98	600	600	10%	5.54	600	3,000	-74%	2,000
			Total Solar Loading						*43,000*				*120,000*		*73,000*

Table C-21. Existing and target solar load for Homer Creek - source to mouth (ID17040205SK018_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
018_03	Homer Creek	13	Geyer Willow	1121	2	55%	2.77	2,000	6,000	10%	5.54	2,000	10,000	-45%	4,000
018_03	Homer Creek	14	Geyer Willow	286	2	55%	2.77	600	2,000	0%	6.15	600	4,000	-55%	2,000
018_03	Homer Creek	15	Geyer Willow	390	2	55%	2.77	800	2,000	10%	5.54	800	4,000	-45%	2,000
018_03	Homer Creek	16	Geyer Willow	544	2	55%	2.77	1,000	3,000	0%	6.15	1,000	6,000	-55%	3,000
018_03	Homer Creek	17	Geyer Willow	955	2	55%	2.77	2,000	6,000	0%	6.15	2,000	10,000	-55%	4,000
018_03	Homer Creek	18	Geyer Willow	1449	3	41%	3.63	4,000	10,000	0%	6.15	4,000	20,000	-41%	10,000
018_03	Homer Creek	19	Geyer Willow	1298	3	41%	3.63	4,000	10,000	0%	6.15	4,000	20,000	-41%	10,000
018_03	Homer Creek	20	Geyer Willow	1990	3	41%	3.63	6,000	20,000	0%	6.15	6,000	40,000	-41%	20,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
018_03	Homer Creek	21	Geyer Willow	561	4	33%	4.12	2,000	8,000	0%	6.15	2,000	10,000	-33%	2,000
018_03	Homer Creek	22	Geyer Willow	136	4	33%	4.12	500	2,000	0%	6.15	500	3,000	-33%	1,000
018_03	Homer Creek	23	Geyer Willow	756	4	33%	4.12	3,000	10,000	0%	6.15	3,000	20,000	-33%	10,000
018_03	Homer Creek	24	Geyer Willow	1649	4	33%	4.12	7,000	30,000	0%	6.15	7,000	40,000	-33%	10,000
018_03	Homer Creek	25	Geyer Willow	265	4	33%	4.12	1,000	4,000	0%	6.15	1,000	6,000	-33%	2,000
018_03	Homer Creek	26	Geyer Willow	829	4	33%	4.12	3,000	10,000	0%	6.15	3,000	20,000	-33%	10,000
018_03	Homer Creek	27	Geyer Willow	1108	5	28%	4.43	6,000	30,000	0%	6.15	6,000	40,000	-28%	10,000
018_03	Homer Creek	28	Geyer Willow	423	5	28%	4.43	2,000	9,000	10%	5.54	2,000	10,000	-18%	1,000
018_03	Homer Creek	29	Geyer Willow	428	5	28%	4.43	2,000	9,000	20%	4.92	2,000	10,000	-8%	1,000
018_03	Homer Creek	30	Geyer Willow	251	5	28%	4.43	1,000	4,000	10%	5.54	1,000	6,000	-18%	2,000
018_03	Homer Creek	31	Geyer Willow	339	5	28%	4.43	2,000	9,000	10%	5.54	2,000	10,000	-18%	1,000
018_03	Homer Creek	32	Geyer Willow	426	5	28%	4.43	2,000	9,000	20%	4.92	2,000	10,000	-8%	1,000
018_03	Homer Creek	33	Geyer Willow	223	5	28%	4.43	1,000	4,000	10%	5.54	1,000	6,000	-18%	2,000
018_03	Homer Creek	34	Geyer Willow	113	5	28%	4.43	600	3,000	10%	5.54	600	3,000	-18%	0
018_03	Homer Creek	35	Geyer Willow	242	5	28%	4.43	1,000	4,000	20%	4.92	1,000	5,000	-8%	1,000
018_03	Homer Creek	36	Geyer Willow	228	5	28%	4.43	1,000	4,000	30%	4.31	1,000	4,000	2%	0
018_03	Homer Creek	37	Geyer Willow	413	5	28%	4.43	2,000	9,000	30%	4.31	2,000	9,000	2%	0
018_03	Homer Creek	38	Geyer Willow	565	6	24%	4.67	3,000	10,000	40%	3.69	3,000	10,000	16%	0
018_03	Homer Creek	39	Geyer Willow	605	6	24%	4.67	4,000	20,000	50%	3.08	4,000	10,000	26%	(10,000)
018_03	Homer Creek	40	Geyer Willow	192	6	24%	4.67	1,000	5,000	20%	4.92	1,000	5,000	-4%	0
018_03	Homer Creek	41	Geyer Willow	95	6	24%	4.67	600	3,000	20%	4.92	600	3,000	-4%	0
018_03	Homer Creek	42	Geyer Willow	588	6	24%	4.67	4,000	20,000	30%	4.31	4,000	20,000	6%	0
018_03	Homer Creek	43	Geyer Willow	291	6	24%	4.67	2,000	9,000	40%	3.69	2,000	7,000	16%	(2,000)
018_03	Homer Creek	44	Geyer Willow	402	6	24%	4.67	2,000	9,000	20%	4.92	2,000	10,000	-4%	1,000
018_03	Homer Creek	45	Geyer Willow	220	6	24%	4.67	1,000	5,000	30%	4.31	1,000	4,000	6%	(1,000)
018_03	Homer Creek	46	Geyer Willow	230	6	24%	4.67	1,000	5,000	30%	4.31	1,000	4,000	6%	(1,000)
018_03	Homer Creek	47	Geyer Willow	267	6	24%	4.67	2,000	9,000	40%	3.69	2,000	7,000	16%	(2,000)
018_03	Homer Creek	48	Geyer Willow	153	6	24%	4.67	900	4,000	30%	4.31	900	4,000	6%	0
018_03	Homer Creek	49	Geyer Willow	611	6	24%	4.67	4,000	20,000	40%	3.69	4,000	10,000	16%	(10,000)
018_03	Homer Creek	50	Geyer Willow	757	7	21%	4.86	5,000	20,000	30%	4.31	5,000	20,000	9%	0
018_03	Homer Creek	51	Geyer Willow	875	7	21%	4.86	6,000	30,000	30%	4.31	6,000	30,000	9%	0
018_03	Homer Creek	52	Geyer Willow	246	7	21%	4.86	2,000	10,000	40%	3.69	2,000	7,000	19%	(3,000)

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
018_03	Homer Creek	53	Geyer Willow	551	7	21%	4.86	4,000	20,000	20%	4.92	4,000	20,000	-1%	0
018_03	Homer Creek	54	Geyer Willow	557	7	21%	4.86	4,000	20,000	30%	4.31	4,000	20,000	9%	0
018_03	Homer Creek	55	Geyer Willow	415	7	21%	4.86	3,000	10,000	30%	4.31	3,000	10,000	9%	0
018_03	Homer Creek	56	Geyer Willow	264	7	21%	4.86	2,000	10,000	40%	3.69	2,000	7,000	19%	(3,000)
018_03	Homer Creek	57	Geyer Willow	154	7	21%	4.86	1,000	5,000	30%	4.31	1,000	4,000	9%	(1,000)
018_03	Homer Creek	58	Geyer Willow	147	8	19%	4.98	1,000	5,000	10%	5.54	1,000	6,000	-9%	1,000
018_03	Homer Creek	59	Geyer Willow	253	8	19%	4.98	2,000	10,000	30%	4.31	2,000	9,000	11%	(1,000)
018_03	Homer Creek	60	Geyer Willow	320	8	19%	4.98	3,000	10,000	40%	3.69	3,000	10,000	21%	0
018_03	Homer Creek	61	Geyer Willow	578	8	19%	4.98	5,000	20,000	30%	4.31	5,000	20,000	11%	0
018_03	Homer Creek	62	Geyer Willow	95	8	19%	4.98	800	4,000	30%	4.31	800	3,000	11%	(1,000)
018_03	Homer Creek	63	Geyer Willow	719	8	19%	4.98	6,000	30,000	40%	3.69	6,000	20,000	21%	(10,000)
018_03	Homer Creek	64	Geyer Willow	178	8	19%	4.98	1,000	5,000	30%	4.31	1,000	4,000	11%	(1,000)
018_03	Homer Creek	65	Geyer Willow	642	8	19%	4.98	5,000	20,000	50%	3.08	5,000	20,000	31%	0
018_03	Homer Creek	66	Geyer Willow	285	8	19%	4.98	2,000	10,000	30%	4.31	2,000	9,000	11%	(1,000)
			Total Solar Loading						*580,000*				*640,000*		*64,000*

Table C-22. Existing and target solar load for Grays Lake outlet - Brockman Creek to Homer Creek (ID17040205SK019_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
019_04	Grays Lake Outlet	1	Geyer Willow	2103	16	10%	5.54	34,000	190,000	10%	5.54	34,000	190,000	0%	0
019_04	Grays Lake Outlet	2	Geyer Willow	980	16	10%	5.54	16,000	89,000	10%	5.54	16,000	89,000	0%	0
019_04	Grays Lake Outlet	3	Geyer Willow	134	16	10%	5.54	2,100	12,000	10%	5.54	2,100	12,000	0%	0
019_04	Grays Lake Outlet	4	Geyer Willow	636	16	10%	5.54	10,000	55,000	0%	6.15	10,000	62,000	-10%	7,000
019_04	Grays Lake Outlet	5	Geyer Willow	446	16	10%	5.54	7,100	39,000	10%	5.54	7,100	39,000	0%	0
019_04	Grays Lake Outlet	6	Geyer Willow	546	16	10%	5.54	8,700	48,000	10%	5.54	8,700	48,000	0%	0
019_04	Grays Lake Outlet	7	Geyer Willow	413	16	10%	5.54	6,600	37,000	0%	6.15	6,600	41,000	-10%	4,000
019_04	Grays Lake Outlet	8	Geyer Willow	1744	16	10%	5.54	28,000	150,000	10%	5.54	28,000	150,000	0%	0
019_04	Grays Lake Outlet	9	Geyer Willow	227	16	10%	5.54	3,600	20,000	10%	5.54	3,600	20,000	0%	0
019_04	Grays Lake Outlet	10	Geyer Willow	223	16	10%	5.54	3,600	20,000	10%	5.54	3,600	20,000	0%	0

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
019_04	Grays Lake Outlet	11	Geyer Willow	217	16	10%	5.54	3,500	19,000	10%	5.54	3,500	19,000	0%	0
019_04	Grays Lake Outlet	12	Geyer Willow	2086	16	10%	5.54	33,000	180,000	10%	5.54	33,000	180,000	0%	0
019_04	Grays Lake Outlet	13	Geyer Willow	868	16	10%	5.54	14,000	77,000	10%	5.54	14,000	77,000	0%	0
019_04	Grays Lake Outlet	14	Geyer Willow	426	17	9%	5.60	7,200	40,000	10%	5.54	7,200	40,000	1%	0
019_04	Grays Lake Outlet	15	Geyer Willow	2478	17	9%	5.60	42,000	240,000	10%	5.54	42,000	230,000	1%	(10,000)
019_04	Grays Lake Outlet	16	Geyer Willow	4195	17	9%	5.60	71,000	400,000	20%	4.92	71,000	350,000	11%	(50,000)
019_04	Grays Lake Outlet	17	Geyer Willow	839	17	9%	5.60	14,000	78,000	20%	4.92	14,000	69,000	11%	(9,000)
019_04	Grays Lake Outlet	18	Geyer Willow	216	17	9%	5.60	3,700	21,000	20%	4.92	3,700	18,000	11%	(3,000)
019_04	Grays Lake Outlet	19	Geyer Willow	188	17	9%	5.60	3,200	18,000	30%	4.31	3,200	14,000	21%	(4,000)
019_04	Grays Lake Outlet	20	Geyer Willow	912	17	9%	5.60	16,000	90,000	30%	4.31	16,000	69,000	21%	(21,000)
			Total Solar Loading						*1,800,000*				*1,700,000*		*-86,000*

Table C-23. Existing and target solar load for Grays Lake outlet - Grays Lake to Brockman Creek (ID17040205SK020_04).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
020_04	Grays Lake Outlet	1	Geyer Willow	127	14	11%	5.47	1,800	9,900	10%	5.54	1,800	10,000	-1%	100
020_04	Grays Lake Outlet	2	Geyer Willow	3862	14	11%	5.47	54,000	300,000	10%	5.54	54,000	300,000	-1%	0
020_04	Grays Lake Outlet	3	Geyer Willow	1502	14	11%	5.47	21,000	110,000	10%	5.54	21,000	120,000	-1%	10,000
020_04	Grays Lake Outlet	4	Geyer Willow	2616	14	11%	5.47	37,000	200,000	10%	5.54	37,000	200,000	-1%	0
020_04	Grays Lake Outlet	5	Geyer Willow	833	14	11%	5.47	12,000	66,000	0%	6.15	12,000	74,000	-11%	8,000
020_04	Grays Lake Outlet	6	Geyer Willow	542	14	11%	5.47	7,600	42,000	10%	5.54	7,600	42,000	-1%	0
020_04	Grays Lake Outlet	7	Geyer Willow	370	14	11%	5.47	5,200	28,000	0%	6.15	5,200	32,000	-11%	4,000
020_04	Grays Lake Outlet	8	Geyer Willow	795	14	11%	5.47	11,000	60,000	10%	5.54	11,000	61,000	-1%	1,000
020_04	Grays Lake Outlet	9	Geyer Willow	328	14	11%	5.47	4,600	25,000	0%	6.15	4,600	28,000	-11%	3,000
020_04	Grays Lake Outlet	10	Geyer Willow	2685	14	11%	5.47	38,000	210,000	10%	5.54	38,000	210,000	-1%	0
020_04	Grays Lake Outlet	11	Geyer Willow	418	14	11%	5.47	5,900	32,000	0%	6.15	5,900	36,000	-11%	4,000
020_04	Grays Lake Outlet	12	Geyer Willow	780	14	11%	5.47	11,000	60,000	10%	5.54	11,000	61,000	-1%	1,000
020_04	Grays Lake Outlet	13	Geyer Willow	703	14	11%	5.47	9,800	54,000	20%	4.92	9,800	48,000	9%	(6,000)
020_04	Grays Lake Outlet	14	Geyer Willow	756	14	11%	5.47	11,000	60,000	0%	6.15	11,000	68,000	-11%	8,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
020_04	Grays Lake Outlet	15	Geyer Willow	1592	14	11%	5.47	22,000	120,000	10%	5.54	22,000	120,000	-1%	0
020_04	Grays Lake Outlet	16	Geyer Willow	743	14	11%	5.47	10,000	55,000	0%	6.15	10,000	62,000	-11%	7,000
			Total Solar Loading						*1,400,000*				*1,500,000*		*40,000*

Table C-24. Existing and target solar load for Grays Lake - 1st- and 2nd- order tributaries (ID17040205SK021_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
021_02	Bridge Creek	8	Geyer Willow	501	1	84%	0.98	500	500	50%	3.08	500	2,000	-34%	2,000
021_02	Bridge Creek	9	Geyer Willow	496	1	84%	0.98	500	500	60%	2.46	500	1,000	-24%	500
021_02	Bridge Creek	10	Geyer Willow	113	1	84%	0.98	100	100	40%	3.69	100	400	-44%	300
021_02	Bridge Creek	11	Warm Forest	212	1	96%	0.25	200	50	40%	3.69	200	700	-56%	700
021_02	Bridge Creek	12	Geyer Willow	378	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
021_02	Bridge Creek	13	Grass	792	2	8%	5.66	2,000	10,000	20%	4.92	2,000	10,000	12%	0
021_02	Bridge Creek	14	Grass	1515	2	8%	5.66	3,000	20,000	20%	4.92	3,000	10,000	12%	(10,000)
021_02	Bridge Creek	15	Grass	1474	3	5%	5.84	4,000	20,000	20%	4.92	4,000	20,000	15%	0
021_02	Clark Creek	7	Grass	220	1	14%	5.29	200	1,000	30%	4.31	200	900	16%	(100)
021_02	Clark Creek	8	Geyer Willow	383	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
021_02	Clark Creek	9	Geyer Willow	420	1	84%	0.98	400	400	10%	5.54	400	2,000	-74%	2,000
021_02	Clark Creek	10	Geyer Willow	408	1	84%	0.98	400	400	60%	2.46	400	1,000	-24%	600
021_02	Clark Creek	11	Geyer Willow	1212	2	55%	2.77	2,000	6,000	50%	3.08	2,000	6,000	-5%	0
021_02	Clark Creek	12	Grass	257	2	8%	5.66	500	3,000	0%	6.15	500	3,000	-8%	0
021_02	Clark Creek	13	Grass	793	3	5%	5.84	2,000	10,000	10%	5.54	2,000	10,000	5%	0
021_02	Clark Creek	14	Grass	419	3	5%	5.84	1,000	6,000	10%	5.54	1,000	6,000	5%	0
021_02	Clark Creek	15	Grass	839	3	5%	5.84	3,000	20,000	10%	5.54	3,000	20,000	5%	0
021_02	Eagle Creek	11	Warm Forest	1517	1	96%	0.25	2,000	500	60%	2.46	2,000	5,000	-36%	5,000
021_02	Eagle Creek	12	Warm Forest	600	2	95%	0.31	1,000	300	60%	2.46	1,000	2,000	-35%	2,000
021_02	Eagle Creek	13	Warm Forest	228	2	95%	0.31	500	200	40%	3.69	500	2,000	-55%	2,000
021_02	Eagle Creek	14	Geyer Willow	1028	3	41%	3.63	3,000	10,000	50%	3.08	3,000	9,000	9%	(1,000)

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
021_02	Eagle Creek	15	Geyer Willow	531	3	41%	3.63	2,000	7,000	50%	3.08	2,000	6,000	9%	(1,000)
021_02	Eagle Creek	16	Geyer Willow	935	4	33%	4.12	4,000	20,000	30%	4.31	4,000	20,000	-3%	0
021_02	Eagle Creek	17	Geyer Willow	269	4	33%	4.12	1,000	4,000	20%	4.92	1,000	5,000	-13%	1,000
021_02	Eagle Creek_Trib 02	1	Warm Forest	672	1	96%	0.25	700	200	70%	1.85	700	1,000	-26%	800
021_02	Eagle Creek_Trib 02	2	Warm Forest	1451	1	96%	0.25	1,000	200	70%	1.85	1,000	2,000	-26%	2,000
021_02	Eagle Creek_Trib 02	3	Warm Forest	412	1	96%	0.25	400	100	80%	1.23	400	500	-16%	400
021_02	Eagle Creek_Trib 02	4	Grass	353	1	14%	5.29	400	2,000	30%	4.31	400	2,000	16%	0
021_02	Grays Lake_Trib 1	2	Grass	494	1	14%	5.29	500	3,000	30%	4.31	500	2,000	16%	(1,000)
021_02	Grays Lake_Trib 1	3	Grass	918	2	8%	5.66	2,000	10,000	10%	5.54	2,000	10,000	2%	0
021_02	Grays Lake_Trib 1	5	Grass	619	2	8%	5.66	1,000	6,000	10%	5.54	1,000	6,000	2%	0
021_02	Grays Lake_Trib 1	6	Grass	2165	3	5%	5.84	6,000	40,000	50%	3.08	6,000	20,000	45%	(20,000)
021_02	Grays Lake_Trib 10	6	Geyer Willow	462	1	84%	0.98	500	500	50%	3.08	500	2,000	-34%	2,000
021_02	Grays Lake_Trib 10	7	Geyer Willow	615	1	84%	0.98	600	600	20%	4.92	600	3,000	-64%	2,000
021_02	Grays Lake_Trib 10	8	Grass	1638	2	8%	5.66	3,000	20,000	20%	4.92	3,000	10,000	12%	(10,000)
021_02	Grays Lake_Trib 12	5	Geyer Willow	428	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
021_02	Grays Lake_Trib 12	6	Grass	496	1	14%	5.29	500	3,000	30%	4.31	500	2,000	16%	(1,000)
021_02	Grays Lake_Trib 12	7	Grass	908	1	14%	5.29	900	5,000	10%	5.54	900	5,000	-4%	0
021_02	Grays Lake_Trib 12	8	Grass	624	2	8%	5.66	1,000	6,000	10%	5.54	1,000	6,000	2%	0
021_02	Grays Lake_Trib 12	9	Grass	359	2	8%	5.66	700	4,000	10%	5.54	700	4,000	2%	0
021_02	Grays Lake_Trib 13	7	Grass	1181	2	8%	5.66	2,000	10,000	10%	5.54	2,000	10,000	2%	0
021_02	Grays Lake_Trib 13	8	Grass	1177	3	5%	5.84	4,000	20,000	10%	5.54	4,000	20,000	5%	0
021_02	Harrison Creek	6	Geyer Willow	727	1	84%	0.98	700	700	60%	2.46	700	2,000	-24%	1,000
021_02	Harrison Creek	7	Geyer Willow	500	1	84%	0.98	500	500	70%	1.85	500	900	-14%	400
021_02	Harrison Creek	8	Grass	454	2	8%	5.66	900	5,000	20%	4.92	900	4,000	12%	(1,000)
021_02	Harrison Creek	9	Grass	939	2	8%	5.66	2,000	10,000	20%	4.92	2,000	10,000	12%	0
021_02	North Fork Eagle Creek	1	Cool Forest	338	1	70%	1.85	300	600	40%	3.69	300	1,000	-30%	400
021_02	North Fork Eagle Creek	2	Cool Forest	653	1	70%	1.85	700	1,000	50%	3.08	700	2,000	-20%	1,000
021_02	North Fork Eagle Creek	3	Warm Forest	1691	1	96%	0.25	2,000	500	70%	1.85	2,000	4,000	-26%	4,000
021_02	North Fork Eagle Creek	4	Warm Forest	1571	2	95%	0.31	3,000	900	70%	1.85	3,000	6,000	-25%	5,000
021_02	North Fork Eagle Creek	5	Warm Forest	1020	2	95%	0.31	2,000	600	60%	2.46	2,000	5,000	-35%	4,000
021_02	North Fork Eagle Creek	6	Quaking Aspen	399	3	98%	0.12	1,000	100	60%	2.46	1,000	2,000	-38%	2,000
021_02	North Fork Eagle Creek	7	Quaking Aspen	572	3	98%	0.12	2,000	200	50%	3.08	2,000	6,000	-48%	6,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
021_02	North Fork Eagle Creek	8	Quaking Aspen	657	3	98%	0.12	2,000	200	20%	4.92	2,000	10,000	-78%	10,000
021_02	North Fork Eagle Creek	9	Geyer Willow	245	3	41%	3.63	700	3,000	30%	4.31	700	3,000	-11%	0
021_02	Willow Creek	3	Warm Forest	962	1	96%	0.25	1,000	200	60%	2.46	1,000	2,000	-36%	2,000
021_02	Willow Creek	4	Warm Forest	347	1	96%	0.25	300	70	50%	3.08	300	900	-46%	800
021_02	Willow Creek	5	Warm Forest	1121	2	95%	0.31	2,000	600	40%	3.69	2,000	7,000	-55%	6,000
021_02	Willow Creek	6	Geyer Willow	267	2	55%	2.77	500	1,000	20%	4.92	500	2,000	-35%	1,000
021_02	Willow Creek	7	Geyer Willow	517	2	55%	2.77	1,000	3,000	30%	4.31	1,000	4,000	-25%	1,000
021_02	Willow Creek	8	Geyer Willow	493	3	41%	3.63	1,000	4,000	30%	4.31	1,000	4,000	-11%	0
021_02	Willow Creek	10	Geyer Willow	89	3	41%	3.63	300	1,000	20%	4.92	300	1,000	-21%	0
021_02	Willow Creek	11	Geyer Willow	874	3	41%	3.63	3,000	10,000	30%	4.31	3,000	10,000	-11%	0
021_02	Willow Creek	12	Grass	423	3	5%	5.84	1,000	6,000	20%	4.92	1,000	5,000	15%	(1,000)
			Total Solar Loading						*320,000*				*340,000*		*24,000*

Table C-25. Existing and target solar load for Brockman Creek - Corral Creek to mouth (ID17040205SK024_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
024_02	Shirley Creek	7	Geyer Willow	239	2	55%	2.77	500	1,000	10%	5.54	500	3,000	-45%	2,000
024_02	Shirley Creek	8	Geyer Willow	181	2	55%	2.77	400	1,000	20%	4.92	400	2,000	-35%	1,000
024_02	Shirley Creek	9	Geyer Willow	344	2	55%	2.77	700	2,000	40%	3.69	700	3,000	-15%	1,000
024_02	Shirley Creek	10	Geyer Willow	224	2	55%	2.77	400	1,000	50%	3.08	400	1,000	-5%	0
024_02	Shirley Creek	11	Geyer Willow	131	2	55%	2.77	300	800	30%	4.31	300	1,000	-25%	200
024_02	Shirley Creek	12	Geyer Willow	133	2	55%	2.77	300	800	10%	5.54	300	2,000	-45%	1,000
024_02	Shirley Creek	13	Geyer Willow	217	2	55%	2.77	400	1,000	30%	4.31	400	2,000	-25%	1,000
024_02	Shirley Creek	14	Geyer Willow	215	2	55%	2.77	400	1,000	0%	6.15	400	2,000	-55%	1,000
024_02	Shirley Creek	15	Geyer Willow	97	2	55%	2.77	200	600	0%	6.15	200	1,000	-55%	400
024_02	Shirley Creek	16	Geyer Willow	227	2	55%	2.77	500	1,000	30%	4.31	500	2,000	-25%	1,000
024_02	Shirley Creek	17	Geyer Willow	224	3	41%	3.63	700	3,000	40%	3.69	700	3,000	-1%	0
024_02	Shirley Creek	18	Geyer Willow	175	3	41%	3.63	500	2,000	50%	3.08	500	2,000	9%	0
024_02	Shirley Creek	19	Geyer Willow	97	3	41%	3.63	300	1,000	10%	5.54	300	2,000	-31%	1,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
024_02	Shirley Creek	20	Geyer Willow	502	3	41%	3.63	2,000	7,000	50%	3.08	2,000	6,000	9%	(1,000)
024_02	Shirley Creek	21	Geyer Willow	222	3	41%	3.63	700	3,000	10%	5.54	700	4,000	-31%	1,000
024_02	Shirley Creek	22	Geyer Willow	228	3	41%	3.63	700	3,000	20%	4.92	700	3,000	-21%	0
024_02	Shirley Creek	23	Geyer Willow	186	3	41%	3.63	600	2,000	0%	6.15	600	4,000	-41%	2,000
024_02	Shirley Creek	24	Geyer Willow	192	3	41%	3.63	600	2,000	30%	4.31	600	3,000	-11%	1,000
024_02	Shirley Creek	25	Geyer Willow	116	3	41%	3.63	300	1,000	10%	5.54	300	2,000	-31%	1,000
024_02	Shirley Creek	26	Geyer Willow	824	4	33%	4.12	3,000	10,000	0%	6.15	3,000	20,000	-33%	10,000
024_02	Shirley Creek	27	Geyer Willow	107	4	33%	4.12	400	2,000	20%	4.92	400	2,000	-13%	0
024_02	Shirley Creek	28	Geyer Willow	316	4	33%	4.12	1,000	4,000	30%	4.31	1,000	4,000	-3%	0
024_02	Shirley Creek	29	Geyer Willow	277	4	33%	4.12	1,000	4,000	10%	5.54	1,000	6,000	-23%	2,000
024_02	Shirley Creek	30	Geyer Willow	151	4	33%	4.12	600	2,000	40%	3.69	600	2,000	7%	0
024_02	Shirley Creek	31	Geyer Willow	214	4	33%	4.12	900	4,000	50%	3.08	900	3,000	17%	(1,000)
024_02	Shirley Creek	32	Geyer Willow	417	4	33%	4.12	2,000	8,000	30%	4.31	2,000	9,000	-3%	1,000
			Total Solar Loading						*68,000*				*94,000*		*26,000*

Table C-26. Existing and target solar load for Brockman Creek - Corral Creek to mouth (ID17040205SK024_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
024_03	Brockman Creek	20	Geyer Willow	283	4	33%	4.12	1,000	4,000	30%	4.31	1,000	4,000	-3%	0
024_03	Brockman Creek	21	Geyer Willow	755	4	33%	4.12	3,000	10,000	40%	3.69	3,000	10,000	7%	0
024_03	Brockman Creek	22	Geyer Willow	343	4	33%	4.12	1,000	4,000	40%	3.69	1,000	4,000	7%	0
024_03	Brockman Creek	23	Geyer Willow	696	4	33%	4.12	3,000	10,000	20%	4.92	3,000	10,000	-13%	0
024_03	Brockman Creek	24	Geyer Willow	608	5	28%	4.43	3,000	10,000	30%	4.31	3,000	10,000	2%	0
024_03	Brockman Creek	25	Geyer Willow	218	5	28%	4.43	1,000	4,000	20%	4.92	1,000	5,000	-8%	1,000
024_03	Brockman Creek	26	Geyer Willow	90	5	28%	4.43	500	2,000	20%	4.92	500	2,000	-8%	0
024_03	Brockman Creek	27	Geyer Willow	316	5	28%	4.43	2,000	9,000	30%	4.31	2,000	9,000	2%	0
024_03	Brockman Creek	28	Geyer Willow	415	5	28%	4.43	2,000	9,000	60%	2.46	2,000	5,000	32%	(4,000)
024_03	Brockman Creek	29	Geyer Willow	294	5	28%	4.43	1,000	4,000	50%	3.08	1,000	3,000	22%	(1,000)
024_03	Brockman Creek	30	Geyer Willow	627	5	28%	4.43	3,000	10,000	40%	3.69	3,000	10,000	12%	0

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
024_03	Brockman Creek	31	Geyer Willow	128	6	24%	4.67	800	4,000	50%	3.08	800	2,000	26%	(2,000)
024_03	Brockman Creek	32	Geyer Willow	160	6	24%	4.67	1,000	5,000	50%	3.08	1,000	3,000	26%	(2,000)
024_03	Brockman Creek	33	Geyer Willow	185	6	24%	4.67	1,000	5,000	60%	2.46	1,000	2,000	36%	(3,000)
024_03	Brockman Creek	34	Geyer Willow	617	6	24%	4.67	4,000	20,000	40%	3.69	4,000	10,000	16%	(10,000)
024_03	Brockman Creek	35	Geyer Willow	441	6	24%	4.67	3,000	10,000	50%	3.08	3,000	9,000	26%	(1,000)
024_03	Brockman Creek	36	Geyer Willow	638	6	24%	4.67	4,000	20,000	40%	3.69	4,000	10,000	16%	(10,000)
024_03	Brockman Creek	37	Geyer Willow	130	6	24%	4.67	800	4,000	50%	3.08	800	2,000	26%	(2,000)
024_03	Brockman Creek	38	Geyer Willow	119	6	24%	4.67	700	3,000	40%	3.69	700	3,000	16%	0
024_03	Brockman Creek	39	Geyer Willow	231	7	21%	4.86	2,000	10,000	30%	4.31	2,000	9,000	9%	(1,000)
024_03	Brockman Creek	40	Geyer Willow	166	7	21%	4.86	1,000	5,000	10%	5.54	1,000	6,000	-11%	1,000
024_03	Brockman Creek	41	Geyer Willow	192	7	21%	4.86	1,000	5,000	20%	4.92	1,000	5,000	-1%	0
024_03	Brockman Creek	42	Geyer Willow	261	7	21%	4.86	2,000	10,000	10%	5.54	2,000	10,000	-11%	0
024_03	Brockman Creek	43	Geyer Willow	183	7	21%	4.86	1,000	5,000	20%	4.92	1,000	5,000	-1%	0
024_03	Brockman Creek	44	Geyer Willow	126	7	21%	4.86	900	4,000	30%	4.31	900	4,000	9%	0
024_03	Brockman Creek	45	Geyer Willow	312	7	21%	4.86	2,000	10,000	20%	4.92	2,000	10,000	-1%	0
024_03	Brockman Creek	46	Geyer Willow	366	7	21%	4.86	3,000	10,000	10%	5.54	3,000	20,000	-11%	10,000
024_03	Brockman Creek	47	Geyer Willow	221	7	21%	4.86	2,000	10,000	30%	4.31	2,000	9,000	9%	(1,000)
024_03	Brockman Creek	48	Geyer Willow	125	7	21%	4.86	900	4,000	10%	5.54	900	5,000	-11%	1,000
024_03	Brockman Creek	49	Geyer Willow	412	7	21%	4.86	3,000	10,000	60%	2.46	3,000	7,000	39%	(3,000)
024_03	Brockman Creek	50	Geyer Willow	552	8	19%	4.98	4,000	20,000	20%	4.92	4,000	20,000	1%	0
024_03	Brockman Creek	51	Geyer Willow	97	8	19%	4.98	800	4,000	10%	5.54	800	4,000	-9%	0
024_03	Brockman Creek	52	Geyer Willow	344	8	19%	4.98	3,000	10,000	40%	3.69	3,000	10,000	21%	0
024_03	Brockman Creek	53	Geyer Willow	278	8	19%	4.98	2,000	10,000	30%	4.31	2,000	9,000	11%	(1,000)
024_03	Brockman Creek	54	Geyer Willow	318	8	19%	4.98	3,000	10,000	40%	3.69	3,000	10,000	21%	0
024_03	Brockman Creek	55	Geyer Willow	817	8	19%	4.98	7,000	30,000	30%	4.31	7,000	30,000	11%	0
			Total Solar Loading						*310,000*				*290,000*		*-28,000*

Table C-27. Existing and target solar load Brockman Creek - source to Corral Creek (ID17040205SK025_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
025_02	Brockman Creek	6	Geyer Willow	251	2	55%	2.77	500	1,000	40%	3.69	500	2,000	-15%	1,000
025_02	Brockman Creek	7	Geyer Willow	232	2	55%	2.77	500	1,000	40%	3.69	500	2,000	-15%	1,000
025_02	Brockman Creek	8	Geyer Willow	248	2	55%	2.77	500	1,000	30%	4.31	500	2,000	-25%	1,000
025_02	Brockman Creek	9	Geyer Willow	923	2	55%	2.77	2,000	6,000	30%	4.31	2,000	9,000	-25%	3,000
025_02	Brockman Creek	10	Geyer Willow	365	2	55%	2.77	700	2,000	20%	4.92	700	3,000	-35%	1,000
025_02	Brockman Creek	11	Geyer Willow	794	2	55%	2.77	2,000	6,000	20%	4.92	2,000	10,000	-35%	4,000
025_02	Brockman Creek	12	Geyer Willow	193	3	41%	3.63	600	2,000	40%	3.69	600	2,000	-1%	0
025_02	Brockman Creek	13	Geyer Willow	590	3	41%	3.63	2,000	7,000	20%	4.92	2,000	10,000	-21%	3,000
025_02	Brockman Creek	14	Geyer Willow	457	3	41%	3.63	1,000	4,000	20%	4.92	1,000	5,000	-21%	1,000
025_02	Brockman Creek	15	Geyer Willow	440	3	41%	3.63	1,000	4,000	30%	4.31	1,000	4,000	-11%	0
025_02	Brockman Creek	16	Geyer Willow	670	3	41%	3.63	2,000	7,000	20%	4.92	2,000	10,000	-21%	3,000
025_02	Brockman Creek	17	Geyer Willow	387	3	41%	3.63	1,000	4,000	40%	3.69	1,000	4,000	-1%	0
025_02	Brockman Creek_Trib 01	8	Warm Forest	1032	1	96%	0.25	1,000	200	30%	4.31	1,000	4,000	-66%	4,000
025_02	Brockman Creek_Trib 05	5	Warm Forest	740	1	96%	0.25	700	200	60%	2.46	700	2,000	-36%	2,000
025_02	Brockman Creek_Trib 05	6	Geyer Willow	499	1	84%	0.98	500	500	50%	3.08	500	2,000	-34%	2,000
			Total Solar Loading						*46,000*				*71,000*		*26,000*

Table C-28. Existing and target solar load for Brockman Creek - source to Corral Creek (ID17040205SK025_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
025_03	Brockman Creek	18	Geyer Willow	278	4	33%	4.12	1,000	4,000	40%	3.69	1,000	4,000	7%	0
025_03	Brockman Creek	19	Geyer Willow	260	4	33%	4.12	1,000	4,000	20%	4.92	1,000	5,000	-13%	1,000
			Total Solar Loading						*8,000*				*9,000*		*1,000*

Table C-29. Existing and target solar load for Corral Creek - source to mouth (ID17040205SK026_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
026_02	Corral Creek	9	Warm Forest	515	1	96%	0.25	500	100	60%	2.46	500	1,000	-36%	900
026_02	Corral Creek	10	Warm Forest	231	1	96%	0.25	200	50	50%	3.08	200	600	-46%	600
026_02	Corral Creek	11	Warm Forest	146	1	96%	0.25	100	20	10%	5.54	100	600	-86%	600
026_02	Corral Creek	12	Warm Forest	479	1	96%	0.25	500	100	60%	2.46	500	1,000	-36%	900
026_02	Corral Creek	13	Warm Forest	271	1	96%	0.25	300	70	50%	3.08	300	900	-46%	800
026_02	Corral Creek	14	Warm Forest	543	2	95%	0.31	1,000	300	60%	2.46	1,000	2,000	-35%	2,000
026_02	Corral Creek	15	Warm Forest	436	2	95%	0.31	900	300	60%	2.46	900	2,000	-35%	2,000
026_02	Corral Creek	16	Warm Forest	718	2	95%	0.31	1,000	300	50%	3.08	1,000	3,000	-45%	3,000
026_02	Corral Creek	17	Geyer Willow	633	3	41%	3.63	2,000	7,000	60%	2.46	2,000	5,000	19%	(2,000)
026_02	Corral Creek	18	Geyer Willow	334	3	41%	3.63	1,000	4,000	60%	2.46	1,000	2,000	19%	(2,000)
026_02	Corral Creek	19	Geyer Willow	197	3	41%	3.63	600	2,000	30%	4.31	600	3,000	-11%	1,000
026_02	Corral Creek	20	Geyer Willow	439	3	41%	3.63	1,000	4,000	20%	4.92	1,000	5,000	-21%	1,000
			Total Solar Loading						*18,000*				*26,000*		*8,800*

Table C-30. Existing and target solar load for Sawmill Creek - source to mouth (ID17040205SK027_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
027_02	Sawmill Creek	7	Geyer Willow	184	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
027_02	Sawmill Creek	8	Geyer Willow	277	1	84%	0.98	300	300	50%	3.08	300	900	-34%	600
027_02	Sawmill Creek	9	Geyer Willow	226	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
027_02	Sawmill Creek	10	Geyer Willow	310	1	84%	0.98	300	300	50%	3.08	300	900	-34%	600
027_02	Sawmill Creek	11	Geyer Willow	241	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
027_02	Sawmill Creek	12	Geyer Willow	113	1	84%	0.98	100	100	40%	3.69	100	400	-44%	300
027_02	Sawmill Creek	13	Geyer Willow	1123	2	55%	2.77	2,000	6,000	50%	3.08	2,000	6,000	-5%	0
027_02	Sawmill Creek	14	Geyer Willow	261	2	55%	2.77	500	1,000	60%	2.46	500	1,000	5%	0
027_02	Sawmill Creek_Trib 01	4	Warm Forest	212	2	95%	0.31	400	100	60%	2.46	400	1,000	-35%	900
027_02	Sawmill Creek_Trib 01	5	Warm Forest	165	3	92%	0.49	500	200	20%	4.92	500	2,000	-72%	2,000
027_02	Sawmill Creek_Trib 01	6	Warm Forest	204	3	92%	0.49	600	300	10%	5.54	600	3,000	-82%	3,000

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
027_02	Sawmill Creek_Trib 01	7	Warm Forest	391	3	92%	0.49	1,000	500	60%	2.46	1,000	2,000	-32%	2,000
027_02	Sawmill Creek_Trib 01	8	Warm Forest	268	3	92%	0.49	800	400	40%	3.69	800	3,000	-52%	3,000
027_02	Sawmill Creek_Trib 01	9	Warm Forest	234	3	92%	0.49	700	300	50%	3.08	700	2,000	-42%	2,000
027_02	Sawmill Creek_Trib 01	10	Warm Forest	132	3	92%	0.49	400	200	40%	3.69	400	1,000	-52%	800
027_02	Sawmill Creek_Trib 01	11	Geyer Willow	338	3	41%	3.63	1,000	4,000	60%	2.46	1,000	2,000	19%	(2,000)
			Total Solar Loading						*14,000*				*27,000*		*15,000*

Table C-31. Existing and target solar load for Lava Creek - source to mouth (ID17040205SK028_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
028_02	Lava Creek	1	Warm Forest	515	1	96%	0.25	500	100	30%	4.31	500	2,000	-66%	2,000
028_02	Lava Creek	2	Geyer Willow	281	1	84%	0.98	300	300	40%	3.69	300	1,000	-44%	700
028_02	Lava Creek	3	Geyer Willow	395	2	55%	2.77	800	2,000	50%	3.08	800	2,000	-5%	0
028_02	Lava Creek	4	Geyer Willow	116	2	55%	2.77	200	600	50%	3.08	200	600	-5%	0
028_02	Lava Creek	5	Warm Forest	938	3	92%	0.49	3,000	1,000	60%	2.46	3,000	7,000	-32%	6,000
028_02	Lava Creek	6	Warm Forest	351	4	87%	0.80	1,000	800	60%	2.46	1,000	2,000	-27%	1,000
028_02	Lava Creek_Trib 02	7	Geyer Willow	226	2	55%	2.77	500	1,000	40%	3.69	500	2,000	-15%	1,000
028_02	Lava Creek_Trib 02	8	Warm Forest	245	2	95%	0.31	500	200	40%	3.69	500	2,000	-55%	2,000
028_02	North Fork Lava Creek	5	Warm Forest	94	1	96%	0.25	90	20	40%	3.69	90	300	-56%	300
028_02	North Fork Lava Creek	6	Warm Forest	487	1	96%	0.25	500	100	50%	3.08	500	2,000	-46%	2,000
028_02	North Fork Lava Creek	7	Geyer Willow	392	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
028_02	North Fork Lava Creek	8	Geyer Willow	584	2	55%	2.77	1,000	3,000	30%	4.31	1,000	4,000	-25%	1,000
028_02	North Fork Lava Creek	9	Geyer Willow	688	2	55%	2.77	1,000	3,000	50%	3.08	1,000	3,000	-5%	0
028_02	North Fork Lava Creek_Trib 01	2	Warm Forest	204	1	96%	0.25	200	50	70%	1.85	200	400	-26%	400
028_02	North Fork Lava Creek_Trib 01	3	Warm Forest	772	1	96%	0.25	800	200	60%	2.46	800	2,000	-36%	2,000
028_02	North Fork Lava Creek_Trib 01	4	Warm Forest	387	1	96%	0.25	400	100	70%	1.85	400	700	-26%	600
028_02	North Fork Lava Creek_Trib 01	5	Warm Forest	174	1	96%	0.25	200	50	60%	2.46	200	500	-36%	500
028_02	South Fork Lava Creek	3	Warm Forest	317	1	96%	0.25	300	70	60%	2.46	300	700	-36%	600
			Total Solar Loading						*13,000*				*33,000*		*21,000*

Table C-32. Existing and target solar load for Lava Creek - source to mouth (ID17040205SK028_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
028_03	Lava Creek	7	Geyer Willow	200	4	33%	4.12	800	3,000	40%	3.69	800	3,000	7%	0
028_03	Lava Creek	8	Geyer Willow	209	4	33%	4.12	800	3,000	30%	4.31	800	3,000	-3%	0
028_03	Lava Creek	9	Geyer Willow	69	4	33%	4.12	300	1,000	20%	4.92	300	1,000	-13%	0
028_03	Lava Creek	10	Geyer Willow	143	4	33%	4.12	600	2,000	20%	4.92	600	3,000	-13%	1,000
028_03	Lava Creek	11	Geyer Willow	295	4	33%	4.12	1,000	4,000	10%	5.54	1,000	6,000	-23%	2,000
028_03	Lava Creek	12	Geyer Willow	276	4	33%	4.12	1,000	4,000	20%	4.92	1,000	5,000	-13%	1,000
028_03	Lava Creek	13	Geyer Willow	246	4	33%	4.12	1,000	4,000	30%	4.31	1,000	4,000	-3%	0
028_03	Lava Creek	14	Geyer Willow	166	4	33%	4.12	700	3,000	20%	4.92	700	3,000	-13%	0
028_03	Lava Creek	15	Geyer Willow	243	4	33%	4.12	1,000	4,000	40%	3.69	1,000	4,000	7%	0
028_03	Lava Creek	16	Geyer Willow	285	4	33%	4.12	1,000	4,000	30%	4.31	1,000	4,000	-3%	0
028_03	Lava Creek	17	Geyer Willow	201	4	33%	4.12	800	3,000	20%	4.92	800	4,000	-13%	1,000
028_03	Lava Creek	18	Geyer Willow	295	4	33%	4.12	1,000	4,000	40%	3.69	1,000	4,000	7%	0
028_03	Lava Creek	19	Geyer Willow	269	4	33%	4.12	1,000	4,000	40%	3.69	1,000	4,000	7%	0
028_03	Lava Creek	20	Geyer Willow	494	4	33%	4.12	2,000	8,000	30%	4.31	2,000	9,000	-3%	1,000
028_03	Lava Creek	21	Geyer Willow	185	4	33%	4.12	700	3,000	40%	3.69	700	3,000	7%	0
028_03	Lava Creek	22	Geyer Willow	653	4	33%	4.12	3,000	10,000	30%	4.31	3,000	10,000	-3%	0
028_03	Lava Creek	23	Geyer Willow	897	4	33%	4.12	4,000	20,000	10%	5.54	4,000	20,000	-23%	0
			Total Solar Loading						*84,000*				*90,000*		*6,000*

Table C-33. Existing and target solar load for Hell Creek - source to mouth (ID17040205SK029_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m²/day)	Segment Area (m²)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
029_02	Beaver Creek	4	Warm Forest	315	1	96%	0.25	300	70	40%	3.69	300	1,000	-56%	900
029_02	Beaver Creek	5	Warm Forest	204	1	96%	0.25	200	50	40%	3.69	200	700	-56%	700
029_02	Beaver Creek	6	Warm Forest	388	1	96%	0.25	400	100	40%	3.69	400	1,000	-56%	900
029_02	Beaver Creek	7	Geyer Willow	304	1	84%	0.98	300	300	40%	3.69	300	1,000	-44%	700
029_02	Dan Creek	7	Geyer Willow	727	1	84%	0.98	700	700	50%	3.08	700	2,000	-34%	1,000
029_02	Dan Creek	8	Geyer Willow	234	1	84%	0.98	200	200	60%	2.46	200	500	-24%	300
029_02	Dan Creek	9	Geyer Willow	375	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
029_02	Dan Creek	10	Geyer Willow	229	1	84%	0.98	200	200	50%	3.08	200	600	-34%	400
029_02	Dan Creek	11	Geyer Willow	476	2	55%	2.77	1,000	3,000	60%	2.46	1,000	2,000	5%	(1,000)
029_02	Dan Creek	12	Geyer Willow	135	2	55%	2.77	300	800	60%	2.46	300	700	5%	(100)
029_02	Dan Creek	13	Geyer Willow	285	2	55%	2.77	600	2,000	30%	4.31	600	3,000	-25%	1,000
029_02	Dan Creek	14	Geyer Willow	244	2	55%	2.77	500	1,000	60%	2.46	500	1,000	5%	0
029_02	Dan Creek	15	Geyer Willow	390	2	55%	2.77	800	2,000	50%	3.08	800	2,000	-5%	0
029_02	Dan Creek	16	Geyer Willow	576	2	55%	2.77	1,000	3,000	50%	3.08	1,000	3,000	-5%	0
029_02	Dan Creek	17	Geyer Willow	280	3	41%	3.63	800	3,000	30%	4.31	800	3,000	-11%	0
029_02	Dan Creek	18	Geyer Willow	359	3	41%	3.63	1,000	4,000	40%	3.69	1,000	4,000	-1%	0
029_02	Dan Creek	19	Geyer Willow	393	3	41%	3.63	1,000	4,000	50%	3.08	1,000	3,000	9%	(1,000)
029_02	Hell Creek	7	Geyer Willow	243	1	84%	0.98	200	200	50%	3.08	200	600	-34%	400
029_02	Hell Creek	8	Geyer Willow	172	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
029_02	Hell Creek	9	Geyer Willow	230	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
029_02	Hell Creek	10	Geyer Willow	376	2	55%	2.77	800	2,000	30%	4.31	800	3,000	-25%	1,000
029_02	Hell Creek	11	Geyer Willow	493	2	55%	2.77	1,000	3,000	50%	3.08	1,000	3,000	-5%	0
029_02	Hell Creek	12	Geyer Willow	328	3	41%	3.63	1,000	4,000	60%	2.46	1,000	2,000	19%	(2,000)
029_02	Hell Creek	13	Geyer Willow	182	3	41%	3.63	500	2,000	20%	4.92	500	2,000	-21%	0
029_02	Hell Creek_Trib 02	16	Geyer Willow	254	1	84%	0.98	300	300	60%	2.46	300	700	-24%	400
029_02	Hell Creek_Trib 02	17	Geyer Willow	366	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
029_02	Hell Creek_Trib 02	18	Geyer Willow	199	1	84%	0.98	200	200	50%	3.08	200	600	-34%	400
029_02	Hell Creek_Trib 02	19	Geyer Willow	221	1	84%	0.98	200	200	50%	3.08	200	600	-34%	400
029_02	Hell Creek_Trib 11	10	Geyer Willow	465	1	84%	0.98	500	500	20%	4.92	500	2,000	-64%	2,000
029_02	Hell Creek_Trib 11	11	Geyer Willow	506	2	55%	2.77	1,000	3,000	40%	3.69	1,000	4,000	-15%	1,000
			Total Solar Loading						*41,000*				*50,000*		*9,600*

Table C-34. Existing and target solar load for Hell Creek - source to mouth (ID17040205SK029_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
029_03	Hell Creek	1	Geyer Willow	161	4	33%	4.12	600	2,000	70%	1.85	600	1,000	37%	(1,000)
029_03	Hell Creek	2	Geyer Willow	349	4	33%	4.12	1,000	4,000	60%	2.46	1,000	2,000	27%	(2,000)
029_03	Hell Creek	3	Geyer Willow	416	4	33%	4.12	2,000	8,000	60%	2.46	2,000	5,000	27%	(3,000)
029_03	Hell Creek	4	Geyer Willow	481	4	33%	4.12	2,000	8,000	70%	1.85	2,000	4,000	37%	(4,000)
029_03	Hell Creek	5	Geyer Willow	534	4	33%	4.12	2,000	8,000	60%	2.46	2,000	5,000	27%	(3,000)
029_03	Hell Creek	6	Geyer Willow	370	4	33%	4.12	1,000	4,000	50%	3.08	1,000	3,000	17%	(1,000)
029_03	Hell Creek	7	Geyer Willow	275	4	33%	4.12	1,000	4,000	50%	3.08	1,000	3,000	17%	(1,000)
029_03	Hell Creek	8	Geyer Willow	597	4	33%	4.12	2,000	8,000	60%	2.46	2,000	5,000	27%	(3,000)
029_03	Hell Creek	9	Geyer Willow	473	4	33%	4.12	2,000	8,000	60%	2.46	2,000	5,000	27%	(3,000)
029_03	Hell Creek	10	Geyer Willow	398	4	33%	4.12	2,000	8,000	70%	1.85	2,000	4,000	37%	(4,000)
029_03	Hell Creek	11	Geyer Willow	430	4	33%	4.12	2,000	8,000	50%	3.08	2,000	6,000	17%	(2,000)
029_03	Hell Creek	12	Geyer Willow	241	5	28%	4.43	1,000	4,000	60%	2.46	1,000	2,000	32%	(2,000)
029_03	Hell Creek	13	Geyer Willow	302	5	28%	4.43	2,000	9,000	60%	2.46	2,000	5,000	32%	(4,000)
029_03	Hell Creek	14	Geyer Willow	490	5	28%	4.43	2,000	9,000	70%	1.85	2,000	4,000	42%	(5,000)
029_03	Hell Creek	15	Geyer Willow	659	5	28%	4.43	3,000	10,000	70%	1.85	3,000	6,000	42%	(4,000)
029_03	Hell Creek	16	Geyer Willow	644	5	28%	4.43	3,000	10,000	60%	2.46	3,000	7,000	32%	(3,000)
029_03	Hell Creek	17	Geyer Willow	324	5	28%	4.43	2,000	9,000	50%	3.08	2,000	6,000	22%	(3,000)
029_03	Hell Creek	18	Geyer Willow	670	5	28%	4.43	3,000	10,000	60%	2.46	3,000	7,000	32%	(3,000)
029_03	Hell Creek	19	Geyer Willow	404	5	28%	4.43	2,000	9,000	70%	1.85	2,000	4,000	42%	(5,000)
029_03	Hell Creek	20	Geyer Willow	1159	5	28%	4.43	6,000	30,000	50%	3.08	6,000	20,000	22%	(10,000)
029_03	Hell Creek	21	Geyer Willow	912	6	24%	4.67	5,000	20,000	40%	3.69	5,000	20,000	16%	0
029_03	Hell Creek	22	Geyer Willow	743	6	24%	4.67	4,000	20,000	50%	3.08	4,000	10,000	26%	(10,000)
029_03	Hell Creek	23	Geyer Willow	33	6	24%	4.67	200	900	60%	2.46	200	500	36%	(400)
029_03	Hell Creek	24	Geyer Willow	434	6	24%	4.67	3,000	10,000	60%	2.46	3,000	7,000	36%	(3,000)
029_03	Hell Creek	25	Geyer Willow	763	6	24%	4.67	5,000	20,000	50%	3.08	5,000	20,000	26%	0
029_03	Hell Creek	26	Geyer Willow	1161	6	24%	4.67	7,000	30,000	70%	1.85	7,000	10,000	46%	(20,000)
029_03	Hell Creek	27	Geyer Willow	1364	7	21%	4.86	10,000	50,000	60%	2.46	10,000	20,000	39%	(30,000)
029_03	Hell Creek	28	Geyer Willow	794	7	21%	4.86	6,000	30,000	60%	2.46	6,000	10,000	39%	(20,000)
029_03	Hell Creek	29	Geyer Willow	783	7	21%	4.86	5,000	20,000	60%	2.46	5,000	10,000	39%	(10,000)
029_03	Hell Creek	30	Geyer Willow	1025	7	21%	4.86	7,000	30,000	60%	2.46	7,000	20,000	39%	(10,000)
			Total Solar Loading						*400,000*				*230,000*		*-170,000*

Table C-35. Existing and target solar load for Bulls Fork - source to mouth (ID17040205SK030_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
030_02	Bulls Fork	1	Quaking Aspen	247	1	99%	0.06	200	10	70%	1.85	200	400	-29%	400
030_02	Bulls Fork	2	Quaking Aspen	365	1	99%	0.06	400	20	50%	3.08	400	1,000	-49%	1,000
030_02	Bulls Fork	3	Quaking Aspen	442	1	99%	0.06	400	20	60%	2.46	400	1,000	-39%	1,000
030_02	Bulls Fork	4	Quaking Aspen	563	1	99%	0.06	600	40	40%	3.69	600	2,000	-59%	2,000
030_02	Bulls Fork	5	Quaking Aspen	333	1	99%	0.06	300	20	70%	1.85	300	600	-29%	600
030_02	Bulls Fork	6	Quaking Aspen	227	1	99%	0.06	200	10	50%	3.08	200	600	-49%	600
030_02	Bulls Fork	7	Quaking Aspen	182	1	99%	0.06	200	10	70%	1.85	200	400	-29%	400
030_02	Bulls Fork	8	Quaking Aspen	542	2	99%	0.06	1,000	60	20%	4.92	1,000	5,000	-79%	5,000
030_02	Bulls Fork	9	Quaking Aspen	407	2	99%	0.06	800	50	30%	4.31	800	3,000	-69%	3,000
030_02	Bulls Fork	11	Geyer Willow	229	2	55%	2.77	500	1,000	30%	4.31	500	2,000	-25%	1,000
030_02	Bulls Fork	13	Geyer Willow	202	2	55%	2.77	400	1,000	30%	4.31	400	2,000	-25%	1,000
030_02	Bulls Fork	14	Geyer Willow	261	2	55%	2.77	500	1,000	40%	3.69	500	2,000	-15%	1,000
030_02	Bulls Fork	15	Geyer Willow	192	2	55%	2.77	400	1,000	20%	4.92	400	2,000	-35%	1,000
030_02	Bulls Fork	16	Quaking Aspen	264	2	99%	0.06	500	30	50%	3.08	500	2,000	-49%	2,000
030_02	Bulls Fork	17	Geyer Willow	345	3	41%	3.63	1,000	4,000	50%	3.08	1,000	3,000	9%	(1,000)
030_02	Bulls Fork	18	Geyer Willow	559	3	41%	3.63	2,000	7,000	50%	3.08	2,000	6,000	9%	(1,000)
030_02	Bulls Fork	20	Geyer Willow	577	3	41%	3.63	2,000	7,000	30%	4.31	2,000	9,000	-11%	2,000
030_02	Bulls Fork	21	Geyer Willow	712	3	41%	3.63	2,000	7,000	50%	3.08	2,000	6,000	9%	(1,000)
030_02	Bulls Fork	22	Geyer Willow	905	4	33%	4.12	4,000	20,000	40%	3.69	4,000	10,000	7%	(10,000)
030_02	Bulls Fork	23	Geyer Willow	777	4	33%	4.12	3,000	10,000	40%	3.69	3,000	10,000	7%	0
030_02	Bulls Fork	24	Geyer Willow	797	4	33%	4.12	3,000	10,000	30%	4.31	3,000	10,000	-3%	0
030_02	Bulls Fork	25	Geyer Willow	1196	4	33%	4.12	5,000	20,000	30%	4.31	5,000	20,000	-3%	0
030_02	Bulls Fork	26	Geyer Willow	448	4	33%	4.12	2,000	8,000	50%	3.08	2,000	6,000	17%	(2,000)
030_02	Bulls Fork	27	Geyer Willow	758	5	28%	4.43	4,000	20,000	40%	3.69	4,000	10,000	12%	(10,000)
030_02	Bulls Fork	28	Geyer Willow	804	5	28%	4.43	4,000	20,000	20%	4.92	4,000	20,000	-8%	0
030_02	Bulls Fork	29	Geyer Willow	384	5	28%	4.43	2,000	9,000	20%	4.92	2,000	10,000	-8%	1,000
030_02	Bulls Fork	30	Geyer Willow	260	5	28%	4.43	1,000	4,000	30%	4.31	1,000	4,000	2%	0
030_02	Bulls Fork	31	Geyer Willow	784	5	28%	4.43	4,000	20,000	20%	4.92	4,000	20,000	-8%	0
030_02	Bulls Fork	32	Geyer Willow	992	5	28%	4.43	5,000	20,000	30%	4.31	5,000	20,000	2%	0
			Total Solar Loading						*190,000*				*190,000*		*-2,000*

Table C-36. Existing and target solar load for Tex Creek - source to mouth (ID17040205SK031_02).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
031_02	Big Dry Hollow	4	Warm Forest	526	1	96%	0.25	500	100	80%	1.23	500	600	-16%	500
031_02	Big Dry Hollow	5	Warm Forest	313	1	96%	0.25	300	70	80%	1.23	300	400	-16%	300
031_02	Big Dry Hollow	6	Warm Forest	568	1	96%	0.25	600	100	30%	4.31	600	3,000	-66%	3,000
031_02	Big Dry Hollow	7	Warm Forest	368	1	96%	0.25	400	100	60%	2.46	400	1,000	-36%	900
031_02	Big Dry Hollow	8	Geyer Willow	1007	1	84%	0.98	1,000	1,000	40%	3.69	1,000	4,000	-44%	3,000
031_02	Indian Fork	5	Geyer Willow	106	1	84%	0.98	100	100	60%	2.46	100	200	-24%	100
031_02	Indian Fork	6	Geyer Willow	190	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
031_02	Indian Fork	7	Geyer Willow	145	1	84%	0.98	100	100	60%	2.46	100	200	-24%	100
031_02	Indian Fork	8	Geyer Willow	499	1	84%	0.98	500	500	40%	3.69	500	2,000	-44%	2,000
031_02	Indian Fork	9	Geyer Willow	186	1	84%	0.98	200	200	30%	4.31	200	900	-54%	700
031_02	Indian Fork	10	Geyer Willow	353	1	84%	0.98	400	400	60%	2.46	400	1,000	-24%	600
031_02	Indian Fork	11	Geyer Willow	277	1	84%	0.98	300	300	40%	3.69	300	1,000	-44%	700
031_02	Indian Fork	12	Geyer Willow	418	2	55%	2.77	800	2,000	60%	2.46	800	2,000	5%	0
031_02	Indian Fork	13	Geyer Willow	106	2	55%	2.77	200	600	40%	3.69	200	700	-15%	100
031_02	Indian Fork	14	Geyer Willow	281	2	55%	2.77	600	2,000	60%	2.46	600	1,000	5%	(1,000)
031_02	Indian Fork	15	Geyer Willow	878	2	55%	2.77	2,000	6,000	60%	2.46	2,000	5,000	5%	(1,000)
031_02	Indian Fork	16	Geyer Willow	657	3	41%	3.63	2,000	7,000	40%	3.69	2,000	7,000	-1%	0
031_02	Indian Fork	17	Geyer Willow	403	3	41%	3.63	1,000	4,000	30%	4.31	1,000	4,000	-11%	0
031_02	Indian Fork	18	Geyer Willow	287	3	41%	3.63	900	3,000	20%	4.92	900	4,000	-21%	1,000
031_02	Indian Fork	19	Geyer Willow	353	3	41%	3.63	1,000	4,000	30%	4.31	1,000	4,000	-11%	0
031_02	Indian Fork	20	Geyer Willow	292	4	33%	4.12	1,000	4,000	20%	4.92	1,000	5,000	-13%	1,000
031_02	Indian Fork	21	Geyer Willow	361	4	33%	4.12	1,000	4,000	10%	5.54	1,000	6,000	-23%	2,000
031_02	Indian Fork	22	Geyer Willow	541	4	33%	4.12	2,000	8,000	10%	5.54	2,000	10,000	-23%	2,000
031_02	Indian Fork	23	Geyer Willow	525	4	33%	4.12	2,000	8,000	20%	4.92	2,000	10,000	-13%	2,000
031_02	Indian Fork	24	Geyer Willow	440	4	33%	4.12	2,000	8,000	50%	3.08	2,000	6,000	17%	(2,000)
031_02	Peterson Creek	20	Geyer Willow	185	1	84%	0.98	200	200	30%	4.31	200	900	-54%	700
031_02	Peterson Creek	21	Geyer Willow	180	1	84%	0.98	200	200	10%	5.54	200	1,000	-74%	800
031_02	Peterson Creek	22	Geyer Willow	155	1	84%	0.98	200	200	40%	3.69	200	700	-44%	500
031_02	Peterson Creek	23	Geyer Willow	213	2	55%	2.77	400	1,000	0%	6.15	400	2,000	-55%	1,000
031_02	Peterson Creek	24	Geyer Willow	192	2	55%	2.77	400	1,000	10%	5.54	400	2,000	-45%	1,000
031_02	Pipe Creek	13	Geyer Willow	89	1	84%	0.98	90	90	20%	4.92	90	400	-64%	300

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
031_02	Pipe Creek	14	Geyer Willow	87	1	84%	0.98	90	90	0%	6.15	90	600	-84%	500
031_02	Pipe Creek	15	Geyer Willow	168	1	84%	0.98	200	200	20%	4.92	200	1,000	-64%	800
031_02	Pipe Creek	16	Geyer Willow	805	1	84%	0.98	800	800	40%	3.69	800	3,000	-44%	2,000
031_02	Pipe Creek	17	Geyer Willow	281	2	55%	2.77	600	2,000	20%	4.92	600	3,000	-35%	1,000
031_02	Pipe Creek	18	Geyer Willow	400	2	55%	2.77	800	2,000	40%	3.69	800	3,000	-15%	1,000
031_02	Pipe Creek	19	Geyer Willow	174	2	55%	2.77	300	800	20%	4.92	300	1,000	-35%	200
031_02	Tex Creek	3	Warm Forest	199	2	95%	0.31	400	100	70%	1.85	400	700	-25%	600
031_02	Tex Creek	4	Warm Forest	350	2	95%	0.31	700	200	80%	1.23	700	900	-15%	700
031_02	Tex Creek	5	Warm Forest	247	2	95%	0.31	500	200	70%	1.85	500	900	-25%	700
031_02	Tex Creek	6	Warm Forest	249	2	95%	0.31	500	200	90%	0.62	500	300	-5%	100
031_02	Tex Creek	7	Warm Forest	255	2	95%	0.31	500	200	70%	1.85	500	900	-25%	700
031_02	Tex Creek	8	Warm Forest	982	2	95%	0.31	2,000	600	80%	1.23	2,000	2,000	-15%	1,000
031_02	Tex Creek	9	Geyer Willow	116	2	55%	2.77	200	600	40%	3.69	200	700	-15%	100
031_02	Tex Creek	10	Geyer Willow	231	2	55%	2.77	500	1,000	30%	4.31	500	2,000	-25%	1,000
031_02	Tex Creek	11	Geyer Willow	161	2	55%	2.77	300	800	20%	4.92	300	1,000	-35%	200
031_02	Tex Creek	12	Geyer Willow	587	2	55%	2.77	1,000	3,000	40%	3.69	1,000	4,000	-15%	1,000
031_02	Tex Creek	13	Geyer Willow	444	3	41%	3.63	1,000	4,000	20%	4.92	1,000	5,000	-21%	1,000
031_02	Tex Creek	14	Geyer Willow	157	3	41%	3.63	500	2,000	10%	5.54	500	3,000	-31%	1,000
031_02	Tex Creek	15	Geyer Willow	319	3	41%	3.63	1,000	4,000	10%	5.54	1,000	6,000	-31%	2,000
031_02	Tex Creek_Trib 02	8	Geyer Willow	99	1	84%	0.98	100	100	60%	2.46	100	200	-24%	100
031_02	Tex Creek_Trib 02	9	Geyer Willow	411	1	84%	0.98	400	400	40%	3.69	400	1,000	-44%	600
031_02	Tex Creek_Trib 04	7	Geyer Willow	316	1	84%	0.98	300	300	50%	3.08	300	900	-34%	600
031_02	Tex Creek_Trib 04	8	Geyer Willow	455	1	84%	0.98	500	500	10%	5.54	500	3,000	-74%	3,000
031_02	Tex Creek_Trib 04	9	Geyer Willow	169	2	55%	2.77	300	800	20%	4.92	300	1,000	-35%	200
031_02	Tex Creek_Trib 04	10	Geyer Willow	241	2	55%	2.77	500	1,000	60%	2.46	500	1,000	5%	0
031_02	Tex Creek_Trib 04	11	Geyer Willow	275	2	55%	2.77	600	2,000	20%	4.92	600	3,000	-35%	1,000
			Total Solar Loading						*94,000*				*140,000*		*42,000*

Table C-37. Existing and target solar load for Tex Creek - source to mouth (ID17040205SK031_03).

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
031_03	Tex Creek	16	Geyer Willow	185	3	41%	3.63	600	2,000	40%	3.69	600	2,000	-1%	0
031_03	Tex Creek	17	Geyer Willow	402	3	41%	3.63	1,000	4,000	30%	4.31	1,000	4,000	-11%	0
031_03	Tex Creek	18	Geyer Willow	257	3	41%	3.63	800	3,000	40%	3.69	800	3,000	-1%	0
031_03	Tex Creek	19	Geyer Willow	526	3	41%	3.63	2,000	7,000	20%	4.92	2,000	10,000	-21%	3,000
031_03	Tex Creek	20	Geyer Willow	488	3	41%	3.63	1,000	4,000	50%	3.08	1,000	3,000	9%	(1,000)
031_03	Tex Creek	21	Geyer Willow	186	3	41%	3.63	600	2,000	40%	3.69	600	2,000	-1%	0
031_03	Tex Creek	22	Geyer Willow	859	4	33%	4.12	3,000	10,000	30%	4.31	3,000	10,000	-3%	0
031_03	Tex Creek	23	Geyer Willow	471	4	33%	4.12	2,000	8,000	20%	4.92	2,000	10,000	-13%	2,000
031_03	Tex Creek	24	Geyer Willow	649	4	33%	4.12	3,000	10,000	20%	4.92	3,000	10,000	-13%	0
031_03	Tex Creek	25	Geyer Willow	404	4	33%	4.12	2,000	8,000	30%	4.31	2,000	9,000	-3%	1,000
031_03	Tex Creek	26	Geyer Willow	506	4	33%	4.12	2,000	8,000	40%	3.69	2,000	7,000	7%	(1,000)
031_03	Tex Creek	27	Geyer Willow	225	4	33%	4.12	900	4,000	30%	4.31	900	4,000	-3%	0
031_03	Tex Creek	28	Geyer Willow	125	5	28%	4.43	600	3,000	40%	3.69	600	2,000	12%	(1,000)
031_03	Tex Creek	29	Geyer Willow	159	5	28%	4.43	800	4,000	50%	3.08	800	2,000	22%	(2,000)
031_03	Tex Creek	30	Geyer Willow	123	5	28%	4.43	600	3,000	30%	4.31	600	3,000	2%	0
031_03	Tex Creek	31	Geyer Willow	309	5	28%	4.43	2,000	9,000	50%	3.08	2,000	6,000	22%	(3,000)
031_03	Tex Creek	32	Geyer Willow	210	5	28%	4.43	1,000	4,000	30%	4.31	1,000	4,000	2%	0
031_03	Tex Creek	33	Geyer Willow	589	5	28%	4.43	3,000	10,000	30%	4.31	3,000	10,000	2%	0
031_03	Tex Creek	34	Geyer Willow	275	5	28%	4.43	1,000	4,000	60%	2.46	1,000	2,000	32%	(2,000)
031_03	Tex Creek	35	Geyer Willow	296	5	28%	4.43	1,000	4,000	50%	3.08	1,000	3,000	22%	(1,000)
031_03	Tex Creek	36	Geyer Willow	630	5	28%	4.43	3,000	10,000	40%	3.69	3,000	10,000	12%	0
031_03	Tex Creek	37	Geyer Willow	353	5	28%	4.43	2,000	9,000	40%	3.69	2,000	7,000	12%	(2,000)
031_03	Tex Creek	38	Geyer Willow	344	6	24%	4.67	2,000	9,000	30%	4.31	2,000	9,000	6%	0
031_03	Tex Creek	39	Geyer Willow	281	6	24%	4.67	2,000	9,000	40%	3.69	2,000	7,000	16%	(2,000)
031_03	Tex Creek	40	Geyer Willow	203	6	24%	4.67	1,000	5,000	30%	4.31	1,000	4,000	6%	(1,000)
031_03	Tex Creek	41	Geyer Willow	186	6	24%	4.67	1,000	5,000	50%	3.08	1,000	3,000	26%	(2,000)
031_03	Tex Creek	42	Geyer Willow	486	6	24%	4.67	3,000	10,000	50%	3.08	3,000	9,000	26%	(1,000)
031_03	Tex Creek	43	Geyer Willow	380	6	24%	4.67	2,000	9,000	30%	4.31	2,000	9,000	6%	0
031_03	Tex Creek	44	Geyer Willow	215	6	24%	4.67	1,000	5,000	40%	3.69	1,000	4,000	16%	(1,000)
031_03	Tex Creek	45	Geyer Willow	324	6	24%	4.67	2,000	9,000	30%	4.31	2,000	9,000	6%	0
031_03	Tex Creek	46	Geyer Willow	898	7	21%	4.86	6,000	30,000	50%	3.08	6,000	20,000	29%	(10,000)

	Stream Segment Details					Target Shade				Existing Shade				Solar Load Summary	
AU	Stream Name	Segment Number	Vegetation Type	Length (m)	Segment Width (m)	Shade Value	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Shade Level	Solar Radiation (kWh/m^2/day)	Segment Area (m^2)	Solar Load (kWh/day)	Lack of Shade	Excess Load (kWh/day)
031_03	Tex Creek	47	Geyer Willow	420	7	21%	4.86	3,000	10,000	40%	3.69	3,000	10,000	19%	0
031_03	Tex Creek	48	Geyer Willow	325	7	21%	4.86	2,000	10,000	50%	3.08	2,000	6,000	29%	(4,000)
031_03	Tex Creek	49	Geyer Willow	163	7	21%	4.86	1,000	5,000	30%	4.31	1,000	4,000	9%	(1,000)
031_03	Tex Creek	50	Geyer Willow	941	7	21%	4.86	7,000	30,000	40%	3.69	7,000	30,000	19%	0
031_03	Tex Creek	51	Geyer Willow	317	7	21%	4.86	2,000	10,000	30%	4.31	2,000	9,000	9%	(1,000)
031_03	Tex Creek	52	Geyer Willow	548	7	21%	4.86	4,000	20,000	60%	2.46	4,000	10,000	39%	(10,000)
			Total Solar Loading						*310,000*				*270,000*		*-40,000*

Willow Creek Subbasin SEI Data Sheets

Table C-37. SEI calculation worksheet for Rock Creek ID17040205SK005_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Rock Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK005_02	***Upstream N***	43.378910
Segment Inventoried:	Elkington prop. Below Bone Rd.	***W***	-111.797800
Total Reach:	2451 feet	***Downstream N***	43.385190
Date Collected:	22-Sep-14	***W***	-111.796740
Field Crew:	J Heaton, J Fales	**Notes:**	
Data Reduced By:			

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalw eg Length (LBB) (stream flow path distance)	2451.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	6003	ft	Total Reach
Estimated Distance inventoried	4902.00	ft	"
Total Erosive Bank Length	3268.00	ft	"
Percent Erosive Bank	66.7	%	"
Eroding Area (AE)	2604.80	ft^2	"
Lateral Recession Rate (RLR)	0.06		"
Bank Erosion (E)	6.64	tons/year	"
Total Bank Erosion Rate (ER)	14.31	tons/mile/year	Reach and Segment
Total Bank Erosion	16.27	tons/year	"

Recession Rate Calculations

Factor	Field Stability Score	Erosion Severity Reduction
Bank Erosion Evidence (0 to 3)	2.5	2.5
Bank Stability Condition (0 to 3)	0.5	0.5
Bank Cover/Vegetation(0 to 3)	0.5	0.5
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	1.5	1.5
In-Channel Deposition (-1 to 1)	-1	-1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	5	5
Lateral Recession Rate (RLR) (ft/yr)	**0.06**	**0.06**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	781.44	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	1.99	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	4.29	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	4.88	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
14.3	**16.3**	**4.3**	**4.9**	YES	**2**

Percent Erosion Reduction (%)	**73**
Total Erosion Reduction (tons/yr)	**13**

Table C-38. SEI calculation worksheet for Twin Creek ID17040205SK008_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Twin Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK008_02	***Upstream N***	43.301860
Segment Inventoried:	Downstream of Bone Road	***W***	-111.781140
Total Reach:	870 ft	***Downstream N***	46.304050
Date Collected:	22-Sep-14	***W***	-111.780420
Field Crew:	J Heaton, J Fales	**Notes:**	
Data Reduced By:			

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	870.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	5056	ft	Total Reach
Estimated Distance inventoried	1740.00	ft	"
Total Erosive Bank Length	0.00	ft	"
Percent Erosive Bank	0.0	%	"
Eroding Area (AE)	0.00	ft^2	"
Lateral Recession Rate (RLR)	0.0275		"
Bank Erosion (E)	0.00	tons/year	"
Total Bank Erosion Rate (ER)	0.00	tons/mile/year	Reach and Segment
Total Bank Erosion	0.00	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0	0.5
Bank Stability Condition (0 to 3)	0.25	0.5
Bank Cover/Vegetation(0 to 3)	0.25	1
Lateral Channel Stability (0 to 3)	0.25	0.5
Channel Bottom Stability (0 to 2)	1	0.5
In-Channel Deposition (-1 to 1)	0	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	1.75	4
Lateral Recession Rate (RLR) (ft/yr)	**0.0275**	**0.05**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	0.00	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.00	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	0.00	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	0.00	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
0.0	**0.0**	**0.0**	**0.0**	**No**	**0**

Percent Erosion Reduction (%)	**0**
Total Erosion Reduction (tons/yr)	**0**

Table C-39. SEI calculation worksheet for Mud Creek ID17040205SK009_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Mud Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK009_02	***Upstream N***	43.288640
Segment Inventoried:	on state land off Blackfoot Res. Rd.	***W***	-111.820140
Total Reach:	1375 feet	***Downstream N***	43.286830
Date Collected:	22-Sep-14	***W***	-111.816920
Field Crew:	J Heaton, J Fales	**Notes:**	Stream lacks power to move sediment downstream except in exteme flow conditions ~ 25 year flood.
Data Reduced By:			

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1375.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	9400	ft	Total Reach
Estimated Distance inventoried	2750.00	ft	"
Total Erosive Bank Length	257.00	ft	"
Percent Erosive Bank	9.3	%	"
Eroding Area (AE)	188.40	ft^2	"
Lateral Recession Rate (RLR)	0.0375		"
Bank Erosion (E)	0.30	tons/year	"
Total Bank Erosion Rate (ER)	1.15	tons/mile/year	Reach and Segment
Total Bank Erosion	2.05	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.5	0.5
Bank Stability Condition (0 to 3)	0.5	0.5
Bank Cover/Vegetation(0 to 3)	0.25	0.25
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	0.5	0.5
In-Channel Deposition (-1 to 1)	0	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	2.75	2.75
Lateral Recession Rate (RLR) (ft/yr)	**0.0375**	**0.0375**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	403.19	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.64	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	2.47	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	4.39	tons/year	Total Reach

Summary of Loads

Current Load		Load Capacity			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
1.2	**2.1**	**2.5**	**4.4**	**No**	**0**

Percent Erosion Reduction (%)	**-114**
Total Erosion Reduction (tons/yr)	**-2**

Table C-40. SEI calculation worksheet for Sellars Creek ID17040205SK010_03.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Sellars Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK010_03	**Upstream N**	43.262190
Segment Inventoried:		**W**	-111.834530
Total Reach:		**Downstream N**	43.260800
Date Collected:	31-Aug-16	**W**	-111.834740
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Grazed and trampled, runs along road
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1051.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	17907	ft	Total Reach
Estimated Distance inventoried	2102.00	ft	"
Total Erosive Bank Length	747.00	ft	"
Percent Erosive Bank	35.5	%	"
Eroding Area (AE)	1035.00	ft^2	"
Lateral Recession Rate (RLR)	0.325		"
Bank Erosion (E)	14.30	tons/year	"
Total Bank Erosion Rate (ER)	71.82	tons/mile/year	Reach and Segment
Total Bank Erosion	243.58	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2.5	1.5
Bank Stability Condition (0 to 3)	2.5	1
Bank Cover/Vegetation(0 to 3)	2	1
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	1.5	1
In-Channel Deposition (-1 to 1)	1	0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	10.5	6
Lateral Recession Rate (RLR) (ft/yr)	**0.325**	**0.09**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	582.48	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	2.23	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	11.19	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	37.96	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
71.8	**243.6**	**11.2**	**38.0**	**YES**	**4**

Percent Erosion Reduction (%)	**85**
Total Erosion Reduction (tons/yr)	**209**

Table C-41. SEI calculation worksheet for Willow Creek—Crane Creek to Mud Creek ID17040205SK011_04.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Willow Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK011_04	**Upstream N**	43.246960
Segment Inventoried:		**W**	-111.755060
Total Reach:		**Downstream N**	43.248780
Date Collected:	31-Aug-16	**W**	-111.753300
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Beaver ponds in reach creating undercut banks, few eroding banks
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1100.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	18923	ft	Total Reach
Estimated Distance inventoried	2200.00	ft	"
Total Erosive Bank Length	186.00	ft	"
Percent Erosive Bank	8.5	%	"
Eroding Area (AE)	219.00	ft^2	"
Lateral Recession Rate (RLR)	0.025		"
Bank Erosion (E)	0.23	tons/year	"
Total Bank Erosion Rate (ER)	1.12	tons/mile/year	Reach and Segment
Total Bank Erosion	4.00	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.5	0.5
Bank Stability Condition (0 to 3)	0.5	0.5
Bank Cover/Vegetation(0 to 3)	0.5	0
Lateral Channel Stability (0 to 3)	0.5	0.5
Channel Bottom Stability (0 to 2)	0.5	0.5
In-Channel Deposition (-1 to 1)	-1	-0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	1.5	1.5
Lateral Recession Rate (RLR) (ft/yr)	**0.025**	**0.025**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	518.06	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.55	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	2.64	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	9.47	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
1.1	**4.0**	**2.6**	**9.5**	**No**	**1**

Percent Erosion Reduction (%)	**-91**
Total Erosion Reduction (tons/yr)	**-5**

Table C-42. SEI calculation worksheet for Mill Creek ID17040205SK012_03.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Mill Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK012_03	**Upstream N**	43.217260
Segment Inventoried:		**W**	-111.799620
Total Reach:		**Downstream N**	43.217090
Date Collected:	31-Aug-16	**W**	-111.797290
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Grazed and trampled
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1010.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	4715	ft	Total Reach
Estimated Distance inventoried	2020.00	ft	"
Total Erosive Bank Length	706.00	ft	"
Percent Erosive Bank	35.0	%	"
Eroding Area (AE)	706.00	ft^2	"
Lateral Recession Rate (RLR)	0.12		"
Bank Erosion (E)	3.60	tons/year	"
Total Bank Erosion Rate (ER)	18.82	tons/mile/year	Reach and Segment
Total Bank Erosion	16.81	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	1	1
Bank Stability Condition (0 to 3)	1	0.5
Bank Cover/Vegetation(0 to 3)	1	1
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	2	1.5
In-Channel Deposition (-1 to 1)	1	0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	7	5.5
Lateral Recession Rate (RLR) (ft/yr)	**0.12**	**0.075**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	404.00	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	1.29	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	6.73	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	6.01	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
18.8	**16.8**	**6.7**	**6.0**	**YES**	**1**

Percent Erosion Reduction (%)	**65**
Total Erosion Reduction (tons/yr)	**11**

Table C-43. SEI calculation worksheet for Homer Creek ID17040205SK018_03.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Homer Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK018_03	**Upstream N**	43.201390
Segment Inventoried:		**W**	-111.637570
Total Reach:		**Downstream N**	43.202870
Date Collected:	31-Aug-16	**W**	-111.638680
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Heavily Grazed and trampled, water has little to no flow, algal blooms and glossy coat on water
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	740.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	20100	ft	Total Reach
Estimated Distance inventoried	1480.00	ft	"
Total Erosive Bank Length	1480.00	ft	"
Percent Erosive Bank	100.0	%	"
Eroding Area (AE)	2220.00	ft^2	"
Lateral Recession Rate (RLR)	0.325		"
Bank Erosion (E)	30.66	tons/year	"
Total Bank Erosion Rate (ER)	218.79	tons/mile/year	Reach and Segment
Total Bank Erosion	832.89	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2.5	1
Bank Stability Condition (0 to 3)	2	1
Bank Cover/Vegetation(0 to 3)	2	1
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	2	1
In-Channel Deposition (-1 to 1)	1	0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	10.5	5.5
Lateral Recession Rate (RLR) (ft/yr)	**0.325**	**0.075**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	444.00	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	1.42	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	10.10	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	38.44	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
218.8	**832.9**	**10.1**	**38.4**	**YES**	**4**

Percent Erosion Reduction (%)	**95**
Total Erosion Reduction (tons/yr)	**798**

Table C-44. SEI calculation worksheet for Grays Lake outlet ID17040205SK019_04.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Gray's Lake Outlet	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK019_04	***Upstream N***	43.259930
Segment Inventoried:	upstream of Horse Cr. rd	***W***	-111.638440
Total Reach:	2165 feet	***Downstream N***	43.265170
Date Collected:	22-Sep-14	***W***	-111.639810
Field Crew:	J Heaton, J Fales	**Notes:**	
Data Reduced By:			

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	1	Single Bank	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	2165.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	12000	ft	Total Reach
Estimated Distance inventoried	2165.00	ft	"
Total Erosive Bank Length	96.00	ft	"
Percent Erosive Bank	4.4	%	"
Eroding Area (AE)	244.40	ft^2	"
Lateral Recession Rate (RLR)	0.05		"
Bank Erosion (E)	0.52	tons/year	"
Total Bank Erosion Rate (ER)	1.27	tons/mile/year	Reach and Segment
Total Bank Erosion	2.88	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.5	0.5
Bank Stability Condition (0 to 3)	0.5	0.5
Bank Cover/Vegetation(0 to 3)	1	1
Lateral Channel Stability (0 to 3)	0.5	0.5
Channel Bottom Stability (0 to 2)	0.5	0.5
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	4	4
Lateral Recession Rate (RLR) (ft/yr)	**0.05**	**0.05**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	1102.35	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	2.34	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	5.71	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	12.98	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
1.3	**2.9**	**5.7**	**13.0**	**No**	**0**

Percent Erosion Reduction (%)	**-351**
Total Erosion Reduction (tons/yr)	**-10**

Table C-45. SEI worksheet calculation for North Fork Eagle Creek ID17040205SK021_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	North Fork Eagle Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK021_02	***Upstream N***	43.068330
Segment Inventoried:	off FR119	***W***	-111.345390
Total Reach:	1412 feet	***Downstream N***	43.065830
Date Collected:	23-Sep-14	***W***	-111.348510
Field Crew:	J Heaton, J Fales	**Notes:**	Very little bank erosion evident, less as you proceed upstream.
Data Reduced By:			

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1412.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	80	lb/ft^3	Total Reach
Length of Similar Stream	5350	ft	Total Reach
Estimated Distance inventoried	2824.00	ft	"
Total Erosive Bank Length	125.80	ft	"
Percent Erosive Bank	4.5	%	"
Eroding Area (AE)	117.60	ft^2	"
Lateral Recession Rate (RLR)	0.0175		"
Bank Erosion (E)	0.08	tons/year	"
Total Bank Erosion Rate (ER)	0.31	tons/mile/year	Reach and Segment
Total Bank Erosion	0.31	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.25	0.25
Bank Stability Condition (0 to 3)	0.25	0.25
Bank Cover/Vegetation(0 to 3)	0	0
Lateral Channel Stability (0 to 3)	0.5	0.5
Channel Bottom Stability (0 to 2)	0.25	0.25
In-Channel Deposition (-1 to 1)	-0.5	-0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	0.75	0.75
Lateral Recession Rate (RLR) (ft/yr)	**0.0175**	**0.0175**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	527.98	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.37	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	1.38	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	1.40	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
0.3	**0.3**	**1.4**	**1.4**	**No**	**0**

Percent Erosion Reduction (%)	**-349**
Total Erosion Reduction (tons/yr)	**-1**

Table C-46. SEI calculation worksheet for Brockman Creek ID17040205SK024_03.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Brockman Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK024_03	**Upstream N**	43.214540
Segment Inventoried:	Upstream of Dan Creek Road	**W**	-111.490040
Total Reach:	2693 ft	**Downstream N**	43.212330
Date Collected:	19-Sep-17	**W**	-111.493340
Field Crew:	C. Castle and A. Olsen	**Notes:**	
Data Reduced By:	C. Sandow		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	2693.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	70	lb/ft^3	Total Reach
Length of Similar Stream	17276	ft	Total Reach
Estimated Distance inventoried	5386.00	ft	"
Total Erosive Bank Length	23.51	ft	"
Percent Erosive Bank	0.4	%	"
Eroding Area (AE)	336.93	ft^2	"
Lateral Recession Rate (RLR)	0.12		"
Bank Erosion (E)	1.42	tons/year	"
Total Bank Erosion Rate (ER)	2.77	tons/mile/year	Reach and Segment
Total Bank Erosion	9.08	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2.25	2
Bank Stability Condition (0 to 3)	1.25	1
Bank Cover/Vegetation(0 to 3)	1.5	1
Lateral Channel Stability (0 to 3)	1.5	1
Channel Bottom Stability (0 to 2)	0.25	1
In-Channel Deposition (-1 to 1)	0.25	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	7	6
Lateral Recession Rate (RLR) (ft/yr)	**0.12**	**0.09**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	15437.64	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	48.63	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	95.34	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	311.96	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
2.8	**9.1**	**95.3**	**312.0**	**No**	**0**

Percent Erosion Reduction (%)	**-3336**
Total Erosion Reduction (tons/yr)	**-303**

Table C-47. SEI calculation worksheet for Corral Creek ID17040205SK026_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Corral Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK026_02	**Upstream N**	43.240900
Segment Inventoried:	Approximately 0.75 miles upstream of Brockman	**W**	-111.456790
Total Reach:	2246 ft	**Downstream N**	43.265730
Date Collected:	19-Sep-17	**W**	-111.453290
Field Crew:	G. Lehotsky and C. Sandow	**Notes:**	
Data Reduced By:	C. Sandow		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	2246.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	29694	ft	Total Reach
Estimated Distance inventoried	4492.00	ft	"
Total Erosive Bank Length	6.89	ft	"
Percent Erosive Bank	0.2	%	"
Eroding Area (AE)	139.68	ft^2	"
Lateral Recession Rate (RLR)	0.035		"
Bank Erosion (E)	0.21	tons/year	"
Total Bank Erosion Rate (ER)	0.49	tons/mile/year	Reach and Segment
Total Bank Erosion	2.75	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	1.5	1.5
Bank Stability Condition (0 to 3)	0.25	1
Bank Cover/Vegetation(0 to 3)	0.25	1.5
Lateral Channel Stability (0 to 3)	0	1
Channel Bottom Stability (0 to 2)	0	1
In-Channel Deposition (-1 to 1)	0.5	0
Total = Slight (0-4); Moderate (4-8); Severe (>8)	2.5	6
Lateral Recession Rate (RLR) (ft/yr)	**0.035**	**0.09**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	18212.81	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	69.66	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	163.77	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	921.02	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
0.5	**2.7**	**163.8**	**921.0**	**No**	**0**

Percent Erosion Reduction (%)	**-33429**
Total Erosion Reduction (tons/yr)	**-918**

Table C-48. SEI calculation worksheet for Lava Creek ID17040205SK028_03.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Lava Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK028_03	**Upstream N**	43.258510
Segment Inventoried:	Upstream of Dan Creek Rd Culvert	**W**	-111.573360
Total Reach:	520 ft	**Downstream N**	43.257630
Date Collected:	11-Jul-16	**W**	-111.573910
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Heavily Grazed and trampled
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	520.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	11930	ft	Total Reach
Estimated Distance inventoried	1040.00	ft	"
Total Erosive Bank Length	540.00	ft	"
Percent Erosive Bank	51.9	%	"
Eroding Area (AE)	699.00	ft^2	"
Lateral Recession Rate (RLR)	0.325		"
Bank Erosion (E)	9.65	tons/year	"
Total Bank Erosion Rate (ER)	98.03	tons/mile/year	Reach and Segment
Total Bank Erosion	221.51	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2.5	1.5
Bank Stability Condition (0 to 3)	2	1.5
Bank Cover/Vegetation(0 to 3)	1.25	1
Lateral Channel Stability (0 to 3)	2.25	2
Channel Bottom Stability (0 to 2)	1.5	1
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	10.5	8
Lateral Recession Rate (RLR) (ft/yr)	**0.325**	**0.15**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	269.24	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	1.72	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	17.43	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	39.38	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
98.0	**221.5**	**17.4**	**39.4**	**YES**	**4**

Percent Erosion Reduction (%)	**83**
Total Erosion Reduction (tons/yr)	**186**

Table C-49. SEI calculation worksheet for Hell Creek ID17040205SK029_03.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Hell Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK029_03	**Upstream N**	43.329640
Segment Inventoried:	Downstream of new culvert located 1.1 miles	**W**	-111.681240
Total Reach:	217 ft	**Downstream N**	43.329360
Date Collected:	11-Jul-16	**W**	-111.681760
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Downcut, likely from undersized culvert upstream. More stable as gradient increases w/ exposed
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	217.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	23680	ft	Total Reach
Estimated Distance inventoried	434.00	ft	"
Total Erosive Bank Length	270.00	ft	"
Percent Erosive Bank	62.2	%	"
Eroding Area (AE)	303.00	ft^2	"
Lateral Recession Rate (RLR)	0.1525		"
Bank Erosion (E)	1.96	tons/year	"
Total Bank Erosion Rate (ER)	47.78	tons/mile/year	Reach and Segment
Total Bank Erosion	214.30	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2	1.5
Bank Stability Condition (0 to 3)	1.5	1
Bank Cover/Vegetation(0 to 3)	1.5	1
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	1.25	1
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	8.25	6.5
Lateral Recession Rate (RLR) (ft/yr)	**0.1525**	**0.105**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	97.41	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.43	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	10.58	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	47.43	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
47.8	**214.3**	**10.6**	**47.4**	**YES**	**5**

Percent Erosion Reduction (%)	**78**
Total Erosion Reduction (tons/yr)	**172**

Table C-50. SEI calculation worksheet for Bulls Fork ID17040205SK030_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Bulls Fork Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK030_02	***Upstream N***	43.390990
Segment Inventoried:	dow nstream of rd crossing	***W***	-111.654360
Total Reach:	1608 feet	***Downstream N***	43.394920
Date Collected:	23-Sep-14	***W***	-111.656260
Field Crew:	J Heaton, J Fales	**Notes:**	
Data Reduced By:			

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalw eg Length (LBB) (stream flow path distance)	1608.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	10000	ft	Total Reach
Estimated Distance inventoried	3216.00	ft	"
Total Erosive Bank Length	528.00	ft	"
Percent Erosive Bank	16.4	%	"
Eroding Area (AE)	383.80	ft^2	"
Lateral Recession Rate (RLR)	0.0475		"
Bank Erosion (E)	0.77	tons/year	"
Total Bank Erosion Rate (ER)	2.54	tons/mile/year	Reach and Segment
Total Bank Erosion	4.82	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.75	0.75
Bank Stability Condition (0 to 3)	0.5	0.5
Bank Cover/Vegetation(0 to 3)	0.5	0.5
Lateral Channel Stability (0 to 3)	0.5	0.5
Channel Bottom Stability (0 to 2)	1	1
In-Channel Deposition (-1 to 1)	0.5	0.5
Total = Slight (0-4); Moderate (4-8); Severe (>8)	3.75	3.75
Lateral Recession Rate (RLR) (ft/yr)	**0.0475**	**0.0475**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	467.54	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	0.94	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	3.10	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	5.87	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
2.5	**4.8**	**3.1**	**5.9**	**No**	**0**

Percent Erosion Reduction (%)	**-22**
Total Erosion Reduction (tons/yr)	**-1**

Table C-51. SEI calculation worksheet for Tex Creek ID17040205SK030_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Tex Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK031_03	**Upstream N**	43.433250
Segment Inventoried:	Upstream of Meadow Creek Rd. crossing	**W**	-111.705950
Total Reach:	1320 ft	**Downstream N**	43.433080
Date Collected:	11-Jul-16	**W**	-111.709890
Field Crew:	Jason Fales, Chase Cusack	**Notes:**	Channel influenced by culvert, road, animal access, and grazing
Data Reduced By:	Chase Cusack		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1320.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	10890	ft	Total Reach
Estimated Distance inventoried	2640.00	ft	"
Total Erosive Bank Length	2400.00	ft	"
Percent Erosive Bank	90.9	%	"
Eroding Area (AE)	4980.00	ft^2	"
Lateral Recession Rate (RLR)	0.325		"
Bank Erosion (E)	68.79	tons/year	"
Total Bank Erosion Rate (ER)	275.15	tons/mile/year	Reach and Segment
Total Bank Erosion	567.49	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	2.5	1.5
Bank Stability Condition (0 to 3)	2	1.5
Bank Cover/Vegetation(0 to 3)	2	1.5
Lateral Channel Stability (0 to 3)	1	1
Channel Bottom Stability (0 to 2)	2	1.5
In-Channel Deposition (-1 to 1)	1	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	10.5	8
Lateral Recession Rate (RLR) (ft/yr)	**0.325**	**0.15**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	1095.60	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	6.98	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	27.94	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	57.62	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
275.1	**567.5**	**27.9**	**57.6**	**YES**	**6**

Percent Erosion Reduction (%)	**90**
Total Erosion Reduction (tons/yr)	**516**

Table C-52. SEI calculation worksheet for Meadow Creek ID17040205SK032_02.

STREAMBANK EROSION INVENTORY CALCULATION WORKSHEET

Stream:	Meadow Creek	**Stream Segment Location (DD)**	
Assessment Unit:	ID17040205SK032_02 and ID17040205SK032_03	**Upstream N**	43.512790
Segment Inventoried:	Approximately 0.12 miles upstream of Deep Creek	**W**	-111.690410
Total Reach:	1795 ft	**Downstream N**	43.516170
Date Collected:	20-Sep-17	**W**	-111.690820
Field Crew:	C. Castle, A. Olsen, A. Lugar	**Notes:**	
Data Reduced By:	C. Sandow		

Current Load Streambank Erosion Calculations		Unit	Area Applied
Right, left or both bank measurements	2	Both Banks	Inventoried Segment
Inventory/Thalweg Length (LBB) (stream flow path distance)	1795.00	ft	Inventoried Segment
TMDL Margin of Safety	10	%	Total Reach
Bulk Density (BD)	85	lb/ft^3	Total Reach
Length of Similar Stream	60530	ft	Total Reach
Estimated Distance inventoried	3590.00	ft	"
Total Erosive Bank Length	5.24	ft	"
Percent Erosive Bank	0.1	%	"
Eroding Area (AE)	28.36	ft^2	"
Lateral Recession Rate (RLR)	0.02		"
Bank Erosion (E)	0.02	tons/year	"
Total Bank Erosion Rate (ER)	0.07	tons/mile/year	Reach and Segment
Total Bank Erosion	0.81	tons/year	"

Recession Rate Calculations		
Factor	**Field Stability Score**	**Erosion Severity Reduction**
Bank Erosion Evidence (0 to 3)	0.25	0.5
Bank Stability Condition (0 to 3)	0.25	0.5
Bank Cover/Vegetation(0 to 3)	0	0
Lateral Channel Stability (0 to 3)	0.25	1
Channel Bottom Stability (0 to 2)	0.25	1
In-Channel Deposition (-1 to 1)	0	1
Total = Slight (0-4); Moderate (4-8); Severe (>8)	1	4
Lateral Recession Rate (RLR) (ft/yr)	**0.02**	**0.05**

Load Capacity Streambank Erosion Calculations for Total Reach		Unit	Area Applied
Eroding Area at Load Capacity (AE)	3886.18	ft^2	Inventoried Segment
Bank Erosion at Load Capacity (E)	8.26	tons/year	"
Total Bank Erosion Rate at Load Capacity (ER)	24.29	tons/mile/year	Reach and Segment
Total Bank Erosion at Load Capacity for Reach	278.48	tons/year	Total Reach

Summary of Loads					
Current Load		**Load Capacity**			
Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Total Bank Erosion Rate (tons/mile/yr)	Total Bank Erosion (tons/yr)	Load Reduction Required?	Margin of Safety (tons/yr)
0.1	**0.8**	**24.3**	**278.5**	**No**	**0**

Percent Erosion Reduction (%)	**-34156**
Total Erosion Reduction (tons/yr)	**-278**

Willow Creek McNeil Sediment Core Data

Table C-53. McNeil sediment core data for Willow Creek—Birch Creek to Bulls Fork ID17040205SK005_04.

Stream:	Willow Creek					
Date (mm/dd/yyyy):	8/18/2014					
Site Description:						
Lat/Lon:	43.39852 N / -111.79283 W					
Lat/Lon accuracy:		meters				
Datum:	WGS 84					
Samping Event ID	ID17040205SK005_04					
Personnel:	J Fales, J Heaton, T Saffle					
Rosgen Channel:	C					
Habitat Unit						
Reach Gradient (%):						
Geology (Q, G, V, or S):						
Target Species:						
Flow (cfs):						
Surrounding Land Use:	Range					
Sample number		1	2	3		
Ocular est. % surface fines						
Sieve size		(mL)	(mL)	(mL)		
63 mm (2.5")		300	85	210		
25 mm (1.0")		2000	3170	1380		
12.5 mm (0.5")		820	490	620		
6.34 mm (0.25")		560	600	400		
1.0 - 0.25" Subtotal		3380	4260	2400		
4.75 mm (0.187")		180	200	65		
2.36 mm (0.0937")		480	580	220		
850 µm (0.0331")		470	565	230		
212 µm (0.0083")		65	240	160		
106 µm (0.0041")						
75 µm (0.0029")						
53 µm (0.0021")		155	170	90		
Bottom pan (< 53 µm)						
< 0.25" Subtotal		1350	1755	765		
Sample total w/o 2.5" particles		4730	6015	3165	Mean	STDDEV
% fines w/o 2.5" particles		0.285412262	0.291770574	0.241706161	0.272963	0.022254
Sample total w/ 2.5" particles		5030	6100	3375	Mean	STDDEV
% fines w/ 2.5" particles		0.268389662	0.287704918	0.226666667	0.26092	0.025472

Table C-54. McNeil sediment core data for Shirley Creek ID17040205SK024_02.

Stream:	Shirley Creek 024_02 (Willow)					
Date (mm/dd/yyyy):	7.8.2020					
Site Description:						
Lat/Lon:	43.19774, -111.50090					
Lat/Lon accuracy:		meters				
Datum:						
Samping Event ID	ID17040205SK024_02					
Personnel:	A. Bell, G. Lehotsky					
Rosgen Channel:						
Habitat Unit						
Reach Gradient (%):	2%					
Geology (Q, G, V, or S):						
Target Species:	Resident Species					
Flow (cfs):	8					
Surrounding Land Use:	Grazing					
Sample number		1	2	3		
Ocular est. % surface fines						
Sieve size		(mL)	(mL)	(mL)		
63 mm (2.5")		0	340	0		
25 mm (1.0")		2050	1920	800		
12.5 mm (0.5")		800	560	1500		
6.34 mm (0.25")		540	510	890		
1.0 - 0.25" Subtotal		3390	2990	3190		
4.75 mm (0.187")		180	120	190		
2.36 mm (0.0937")		320	360	120		
850 µm (0.0331")		380	360	260		
212 µm (0.0083")		305	260	360		
106 µm (0.0041")						
75 µm (0.0029")						
53 µm (0.0021")		140	75	60		
Bottom pan (< 53 µm)						
< 0.25" Subtotal		1325	1175	990		
Sample total w/o 2.5" particles		4715	4165	4180	Mean	STDDEV
% fines w/o 2.5" particles		0.281018028	0.282112845	0.236842105	0.266658	0.021088
Sample total w/ 2.5" particles		4715	4505	4180	Mean	STDDEV
% fines w/ 2.5" particles		0.281018028	0.26082131	0.236842105	0.25956	0.018057

Appendix D. Managing Storm Water

Municipal Separate Storm Sewer Systems

Polluted storm water runoff is commonly transported through municipal separate storm sewer systems (MS4s), from which it is often discharged untreated into local water bodies. An MS4, according to 40 CFR 122.26(b)(8), is a conveyance or system of conveyances that meets the following criteria:

- Owned by a state, city, town, village, or other public entity that discharges to waters of the US
- Designed or used to collect or convey storm water (including storm drains, pipes, ditches, etc.)
- Not a combined sewer
- Not part of a publicly owned treatment works (sewage treatment plant)

To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a National Pollutant Discharge Elimination System (NPDES) permit from the United States Environmental Protection Agency (EPA), implement a comprehensive municipal storm water management program (SWMP), and use best management practices (BMPs) to control pollutants in storm water discharges to the maximum extent practicable.

Industrial Storm Water Requirements

Storm water runoff picks up industrial pollutants and typically discharges them into nearby water bodies directly or indirectly via storm sewer systems. When facility practices allow exposure of industrial materials to storm water, runoff from industrial areas can contain toxic pollutants (e.g., heavy metals and organic chemicals) and other pollutants such as trash, debris, and oil and grease. This increased flow and pollutant load can impair water bodies, degrade biological habitats, pollute drinking water sources, and cause flooding and hydrologic changes, such as channel erosion, to the receiving water body.

Multi-Sector General Permit and Storm Water Pollution Prevention Plans

In Idaho, if an industrial facility discharges industrial storm water into waters of the US, the facility must be permitted under EPA's most recent Multi-Sector General Permit (MSGP). To obtain an MSGP, the facility must prepare a storm water pollution prevention plan (SWPPP) before submitting a notice of intent for permit coverage. The SWPPP must document the site description, design, and installation of control measures; describe monitoring procedures; and summarize potential pollutant sources. A copy of the SWPPP must be kept on site in a format that is accessible to workers and inspectors and be updated to reflect changes in site conditions, personnel, and storm water infrastructure.

Industrial Facilities Discharging to Impaired Water Bodies

Any facility that discharges to an impaired water body must monitor all pollutants for which the water body is impaired and for which a standard analytical method exists (40 CFR136).

Also, because different industrial activities have sector-specific types of material that may be exposed to storm water, EPA grouped the different regulated industries into 29 sectors, based on their typical activities. Part 8 of EPA's MSGP details the storm water management practices and monitoring that are required for the different industrial sectors. DEQ anticipates including specific requirements for impaired waters as a condition of the 401 certification. The MSGP will detail the specific monitoring requirements.

TMDL Industrial Storm Water Requirements

When a stream is on Idaho's § 303(d) list and has a TMDL developed, DEQ may incorporate a wasteload allocation for industrial storm water activities under the MSGP. However, most load analyses developed in the past have not identified sector-specific numeric wasteload allocations for industrial storm water activities. Industrial storm water activities are considered in compliance with provisions of the TMDL if operators obtain an MSGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The next MSGP will have specific monitoring requirements that must be followed.

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 municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites.

Construction General Permit (CGP) and Storm Water Pollution Prevention Plans

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 CGP from EPA after developing a site-specific SWPPP. The SWPPP must provide for the erosion, sediment, and pollution controls they intend to use; inspection of the controls periodically; and maintenance of BMPs throughout the life of the project. Operators are required to keep a current copy of their SWPPP on site or at an easily accessible location.

TMDL Construction Storm Water 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 storm water activities. Most loads developed in the past did not have a numeric wasteload allocation for construction storm water activities. Construction storm water activities are considered in compliance with provisions of the TMDL if operators obtain a CGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The CGP has monitoring requirements that must be followed.

Postconstruction Storm Water Management

Many communities throughout Idaho are currently developing rules for postconstruction storm water management. Sediment is usually the main pollutant of concern in construction site storm water. DEQ's *Catalog of Storm Water Best Management Practices for Idaho Cities and Counties* (DEQ 2005b) should be used to select the proper suite of BMPs for the specific site, soils, climate, and project phasing in order to sufficiently meet the standards and requirements of the CGP to protect water quality. Where local ordinances have more stringent and site-specific standards, those are applicable.

Appendix E. Public Participation and Public Comments

An update on the Willow Creek subbasin TMDL and 5-year review was delivered to the Upper Snake Basin Advisory Group (BAG) on October 11, 2023. The Upper Snake BAG was notified of the intent to complete a final submittal to EPA and post for public comments on October 2, 2024. The public comment period was conducted in 2024.

[Public comments and DEQ responses to be inserted following public comment period.]

Appendix F. Distribution List

[To be inserted following public comment period.]