RECLAMATION

Managing Water in the West

Biological Assessment on the Future Operation and Maintenance of the Rogue River Basin Project and Effects on Essential Fish Habitat under the Magnuson-Stevens Act

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office, Yakima, Washington
Pacific Northwest Regional Office, Boise, Idaho

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U.S. Department of the Interior

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Mission of the Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Subsequent to Reclamation's submission of the Final *Biological Assessment on the Future Operation and Maintenance of the Rogue River Basin Project and Effects on Essential Fish Habitat under the Magnuson-Stevens Act* to NOAA Fisheries, errors were identified. This version reflects the corrected information.

Acronyms and Abbreviations

BA	Biological Assessment
BiOp	Biological opinion
BLM	Bureau of Land Management
BRT	Biological Review Team
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
Districts	Talent, Medford, and Rogue River Valley Irrigation Districts
DO	dissolved oxygen
EFH	essential fish habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
HUC	hydrologic unit code
IFIM	Instream Flow Incremental Methodology
IP	Intrinsic Potential
LWD	large woody debris
MID	Medford Irrigation District
Model	Emigrant and Bear creeks Daily Operations Model
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NOAA Fisheries	NOAA's National Marine Fisheries Service

O&M	operation and maintenance
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PCE	primary constituent element
PFMC	Pacific Fisheries Management Council
PHABSIM	Physical Habitat Simulation
Project	Rogue River Basin Project, Talent Division
RBFATT	Rogue Basin Fish Access Technical Team
Reclamation	U.S. Bureau of Reclamation
RM	river mile
RPA	reasonable and prudent alternative
RRVID	Rogue River Valley Irrigation District
RVCOG	Rogue Valley Council of Governments
SONCC	Southern Oregon/Northern California Chinook
TID	Talent Irrigation District
TMDL	Total Maximum Daily Loads
URR	upper Rogue River
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WISE	Water for Irrigation, Streams, Economy
WUA	weighted useable area

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Chapter 1 INTRODUCTION

1.1 Purpose

The U.S. Bureau of Reclamation (Reclamation) is consulting with the National Marine Fisheries Service (NOAA Fisheries) pursuant to Section 7 (a) (2) of the Endangered Species Act (ESA). This Biological Assessment (BA) describes and analyzes the future effects of the operation and maintenance (O&M) of the Rogue River Basin Project, Talent Division (Project) on anadromous ESA-listed species and those species' designated critical habitats. This document also addresses effects on essential fish habitat (EFH) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996.

This BA details the effects of proposed future Project O&M on the Southern Oregon Northern California Coast (SONCC) evolutionarily significant unit (ESU) of coho salmon (*Oncorhynchus kisutch*) including designated critical habitat. This document also analyzes the effects of future Project O&M on EFH for Chinook salmon (*Oncorhynchus tshawytscha*). This BA supplants Reclamation's 2009 BA for the future O&M of the Project (Reclamation 2009b).

1.2 How to use this Document

This document is intended to convey information needed to facilitate interagency consultation on ESA-listed species and designated critical habitat, and on species and EFH protected under the MSA. The information is organized and presented as follows:

Chapter 1, "Introduction," provides important background and contextual information including a consultation history and brief descriptions of the proposed action, action area, listed species and designated critical habitat in the action area, and the analytical approach taken in developing the proposed action and analyzing effects.

Chapter 2, "Proposed Action," includes detailed descriptions of the water management facilities of the Project and their proposed O&M. The proposed action also includes a number of conservation actions; these generally involve proposed modifications to existing facilities and operations for the benefit of listed species and designated critical habitat, and also include proposed activities aimed at conserving water, improving instream habitat, and restoring stream-side riparian areas. Actions which are interdependent or interrelated to the proposed action are also described in this section.

Chapter 3, “Environmental Baseline,” provides a “snapshot” of the current status of affected species and current habitat conditions, including current hydrologic conditions resulting, in part, from ongoing operation of project facilities; it also describes the causative factors (both adverse and beneficial) leading to current species and habitat conditions and indicating potential trends. The environmental baseline assists the consulting agencies in determining the effects of the proposed action on listed species and designated critical habitat.

Chapter 4, “Effects of the Action,” provides an analysis of the anticipated impacts of the proposed action on hydrologic characteristics, listed species, and designated critical habitat, together with the effects of other activities that are interrelated to or interdependent with the proposed action.

Chapter 5, “Cumulative Effects,” provides information regarding water conservation efforts, fish passage improvements, demographic and land use changes, climate change, and other factors or actions considered “reasonably certain to occur” which may contribute to cumulative effects on listed species and critical habitat within the action area.

Chapter 6, “Essential Fish Habitat Assessment,” provides an analysis of the impacts of Reclamation’s proposed action on affected EFH.

Chapter 7, “Bibliography,” provides a list of references used in preparing the BA.

1.3 Proposed Action

The Project is located near the cities of Medford and Ashland in Southwest Oregon in two tributary basins to the Rogue River, Bear Creek and Little Butte Creek, and the tributaries of Jenny Creek in the Klamath basin. Originally a network of privately owned facilities, Congress authorized an expanded and improved Project to serve multiple purposes including irrigation, flood control, fish and wildlife, and recreation in 1954. The proposed action consists primarily of the future O&M of federally owned water collection, storage, conveyance, diversion, and delivery facilities that comprise the Project. Predominantly, the Project collects water from the headwaters of South Fork Little Butte Creek for storage in Hyatt, Howard Prairie, and Emigrant reservoirs, where the water awaits delivery to and within the Bear Creek watershed via canals on Ashland, Emigrant, and Bear creeks.

The Project serves to provide an adequate supply of water to approximately 35,000 acres of irrigated cropland. The Talent, Medford, and Rogue River Valley Irrigation Districts (collectively “the Districts”) deliver water to end users and are responsible for the O&M of Project facilities. Historically, Project operations have been governed by the terms of repayment contracts between Reclamation and each of the three Districts, and by flood control rules set by the U.S. Army Corps of Engineers (Corps). Since 2009, operations have included minimum operational releases as identified in Reclamation's 2009 BA (Reclamation 2009b). This BA proposes to add an expanded instream flow program, revised ramping rate controls, modification of Project facilities to improve fish passage, instream habitat restoration, and riparian zone management activities to the proposed action.

1.4 Action Area

The "action area" for this consultation includes all areas affected, directly or indirectly, by the proposed future O&M of the Project. In the Rogue River basin, this includes portions of the Bear Creek watershed, the South Fork Little Butte Creek watershed, the Little Butte Creek watershed downstream of the confluence of North and South Forks of Little Butte Creek, and the mainstem Rogue River from the confluence of Bear Creek to the Pacific Ocean. In the Klamath River basin, this includes portions of the Jenny Creek and Beaver Creek watersheds and the mainstem Klamath River from Iron Gate Reservoir to the Pacific Ocean. The downstream extent of the action area is based on the hydrologic influence of the Project on flows within the Rogue and Klamath rivers. The relative influence of the Project on total flows, water quality, and related parameters diminishes greatly as the Rogue and Klamath rivers approach the Pacific Ocean; effects to water quantity and quality are considered to be essentially undetectable outside of Bear Creek in the Rogue River basin and below the Siead Valley in the Klamath basin.

1.5 Consultation History

1.5.1 Previous Consultations

Reclamation has informally consulted with NOAA Fisheries since 2000 under Section 7 of the ESA on several projects and programs undertaken in the Project area. Reclamation evaluated some of these actions under the National Environmental Policy Act (NEPA) environmental compliance requirements using the respective NEPA documents to identify the effects of the action on ESA-proposed or listed species. Accordingly, the ESA effects analysis was included in environmental assessment documents followed by Findings of No Significant Impacts (Table 1-1).

Table 1-1. Previous Reclamation ESA Section 7 consultations in the Project action area.

Project Name (NEPA Document)	Listed Species	Consultation Results	USFWS/NOAA Fisheries Determination
J. Herbert Stone Constructed Wetlands Demonstration Project, J. Herbert Stone Nursery, Oregon (FONSI/FEA July 1999)	SONCC coho salmon, peregrine falcon, bald eagle, northern spotted owl	No Effect	Concurrence by USFWS and NOAA Fisheries, 2000
Agate Reservoir Resource Management Plan, Oregon (FONSI/FEA September 2000)	SONCC coho salmon, vernal pool fairy shrimp, peregrine falcon, bald eagle, northern spotted owl	May Affect, Not Likely to Adversely Affect	Concurrence by USFWS and NOAA Fisheries, 2000
Continued Operation and Maintenance of the Rogue River Basin Project (BA August 2003)	Multiple including SONCC coho salmon and designated critical habitat	May Affect, Likely to Adversely Affect	No jeopardy from U.S. Fish and Wildlife Service; continuing consultation with NOAA Fisheries

Reclamation also consulted informally with NOAA Fisheries in 2009 on a short-term gate closure at Emigrant Dam to allow for a valve inspection. As a result, a plan was developed to protect SONCC coho salmon during such a closure.

1.5.2 History of the Current Consultation

Reclamation completed its initial BA for the continued O&M of the Project in August 2003 (Reclamation 2003). The following month Reclamation and NOAA Fisheries initiated formal consultation. The BA concluded the continued O&M was likely to adversely affect the SONCC coho salmon, likely to adversely affect designated SONCC coho salmon critical habitat, and likely to adversely affect EFH for coho salmon and Chinook salmon (Reclamation 2003).

In March of 2006, NOAA Fisheries provided Reclamation a draft biological opinion (BiOp) (NOAA Fisheries 2006), which reflected NOAA Fisheries preliminary conclusion that the continued O&M of the Project, as proposed was likely to jeopardize SONCC coho salmon, and adversely modify that species' designated critical habitat. The draft BiOp included a proposed reasonable and prudent alternative (RPA) which would have required, among other elements, that Reclamation provide instream flow to augment available fish habitat; NOAA Fisheries based these proposed instream flow requirements on a 1972 Oregon Department of Fish and Wildlife (ODFW) study. Reclamation evaluated the 1972 study and concluded that it did not provide an adequate scientific basis for the proposed instream flows, and that better information was available or reasonably obtainable (NOAA Fisheries 2006).

To better analyze the effects of the project on streamflows and on SONCC coho, Reclamation developed a Physical Habitat Simulation (PHABSIM) model for the Bear and Little Butte creeks (Sutton 2007a). In July of 2007, Reclamation and NOAA Fisheries agreed to amend the 2003 BA (Reclamation 2003) to incorporate and address new hydrologic and habitat information based on the PHABSIM model. Reclamation submitted a supplemental BA to NOAA Fisheries in January 2009 (Reclamation 2009a).

In the interim, Oregon Wild filed suit against Reclamation and NOAA Fisheries to compel the agencies to complete the ongoing consultation for the Project. Reclamation and NOAA Fisheries entered into a settlement agreement which set a timeline for the consultation. Reclamation was to provide NOAA Fisheries a new BA by October 16, 2009, and NOAA Fisheries would provide Reclamation a final BiOp by March 1, 2010.

Reclamation submitted a new BA to NOAA Fisheries in October 2009 (Reclamation 2009b). The 2009 BA provided an analysis based on a 2009 hydrologic model of the Project using the recently developed daily time-step, Hydromet dataset, and the 2007 PHABSIM habitat model. The proposed action in the 2009 BA was a modified version of the 2003 proposed action, altered to include several elements from the 2006 draft BiOp's (NOAA Fisheries 2006) RPA including a minimum streamflow component. In December 2010, NOAA Fisheries provided Reclamation with a draft BiOp (NOAA Fisheries 2010a) which concluded that continued O&M of the Project as proposed in the 2009 BA was likely to jeopardize SONCC coho and adversely modify that species critical habitat; NOAA Fisheries accordingly provided a draft RPA. Reclamation provided comments to NOAA Fisheries in February and March 2010.

On May 5, 2011, Reclamation, NOAA Fisheries, and the Districts met to discuss technical issues regarding the 2010 draft BiOp. Among these issues was NOAA Fisheries' use of the combined 2003 BA (Reclamation 2003) and 2010 Oregon Water Resources Department (OWRD) streamflow data to determine project hydrology. After this meeting, NOAA Fisheries and Reclamation agreed to perform the requisite effects analysis using the daily time-step, Hydromet data. To do so, Reclamation set out to develop a new hydrologic model capable of utilizing the most current dataset.

On May 27, 2011, NOAA Fisheries provided Reclamation with a revised draft of the BiOp (NOAA Fisheries 2011a). While the analysis and conclusion of the BiOp generally mirrored that of the 2010 draft BiOp (NOAA Fisheries 2010a), NOAA Fisheries outlined a different framework for a proposed RPA in which Reclamation could provide habitat augmentation through a combination of different methods, including instream flow, instream habitat rehabilitation, and riparian zone restoration. On July 22, 2011, Reclamation, NOAA Fisheries, and the Districts met to outline a process for defining an alternative operational scenario and develop a schedule to complete required technical work products for the consultation.

1.6 Listed Species & Designated Critical Habitat in the Action Area

SONCC coho salmon is the listed species that falls under the jurisdiction of NOAA Fisheries that occurs in the action area. Critical habitat for this species was designated in 1999 and is also present in the action area.

Chapter 2. PROPOSED ACTION

The Project is located in the Bear Creek and Little Butte Creek watersheds of the Rogue River basin in Southwest Oregon, near the cities of Medford and Ashland; and in the Jenny Creek watershed of the Klamath River basin. The O&M of the Project includes: 1) the collection, storage, and delivery of water for irrigation, municipal and industrial purposes; 2) flood control; 3) the operation of recreational facilities at Emigrant, Hyatt, and Howard Prairie reservoirs; and 4) the management of Project facilities for the benefit of fish and wildlife. This section describes these operations in greater detail, and specifies a series of proposed conservation actions to minimize the adverse effects of the Project on SONCC coho and that species' critical habitat and to promote species recovery. These actions include: 1) minimum instream flow requirements on the operation of Project facilities; 2) the implementation of ramping rates on Project facilities; 3) water conservation activities; 4) instream habitat restoration actions; and 5) riparian zone restoration.

2.1 Water Management Facilities and Operations

The Project was authorized by Congress in 1954 to rehabilitate, improve, and develop facilities needed to provide water to irrigate 35,000 acres of cropland in the Bear and Little Butte Creek basins. These lands are situated among the Talent, Medford, and Rogue River Valley (RRVID) irrigation districts. The Talent Irrigation District (TID) consists of approximately 15,500 irrigable acres, the Medford Irrigation District (MID) has a water supply for 11,500 acres, and RRVID has a water supply for 8,300 acres. Each district has a long-term repayment contract with Reclamation for the use of storage water and the use of Project facilities.

Supplemental water for MID and RRVID is also diverted through the Project facilities. MID diverts its supplemental water at Phoenix Diversion Dam, and RRVID diverts its share from a reconstructed Jackson Street Diversion Dam in Medford, Oregon. In addition to water for irrigation, TID also provides limited municipal and industrial water service. Reclamation provides electric power from the 16,000-kilowatt hydroelectric Green Springs Powerplant, and Emigrant Dam is operated for flood control purposes. Jackson County manages lands and facilities at Agate Reservoir, Emigrant Lake, and Howard Prairie Lake for recreational use.

Figure 2-1 illustrates and Table 2-1 describes the facilities and general operations of the Project, broken down by water collection and storage facilities and conveyance facilities. For clarity, descriptions of these facilities are divided between the South Fork Little Butte Creek and Bear Creek area, and the Antelope Creek area. A more detailed explanation of the facilities, including privately owned facilities, and O&M activities is provided in the *Rogue River Basin Project Talent Division, Oregon, Facilities and Operations* report (Vinsonhaler 2002).

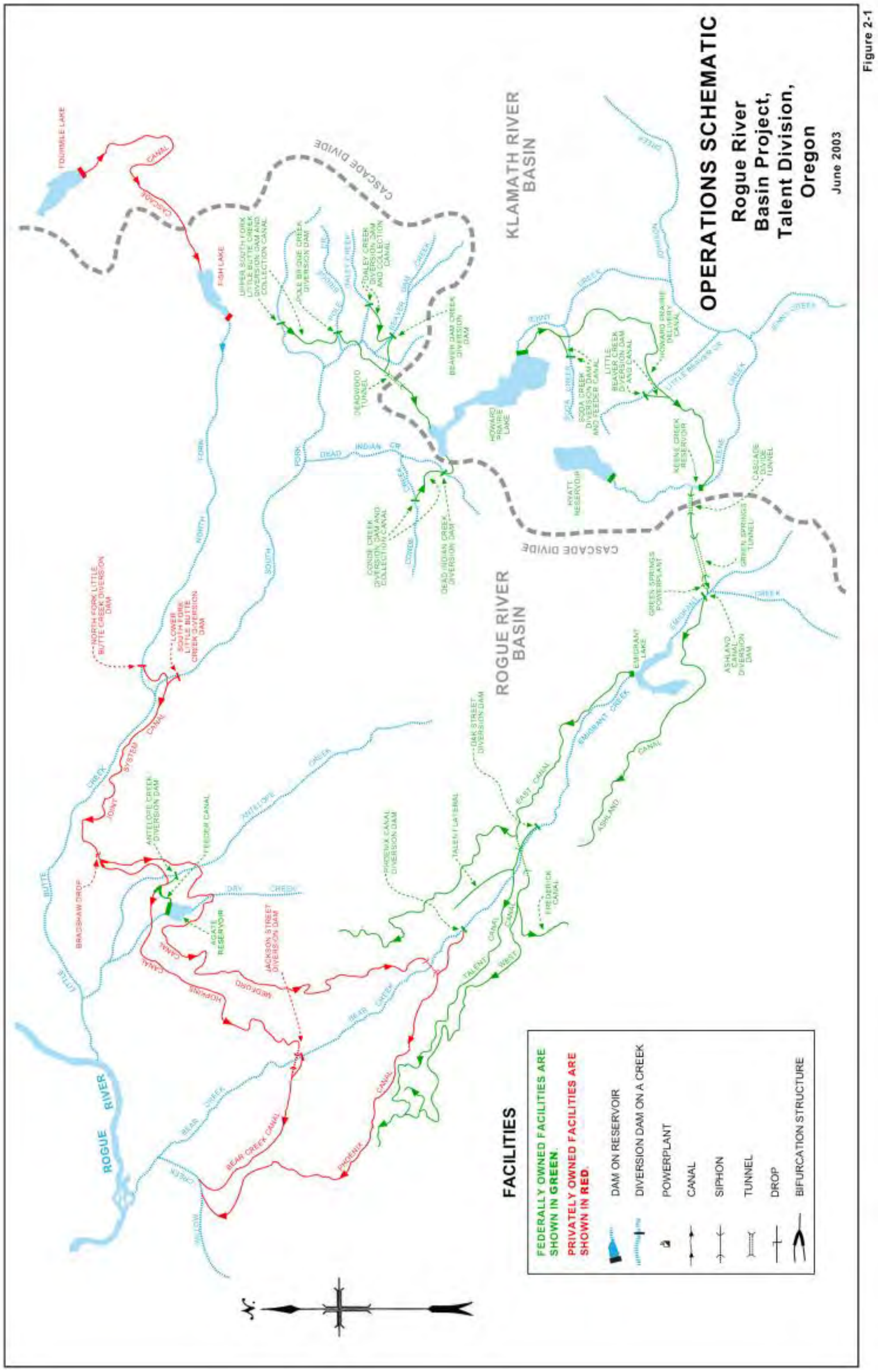


Figure 2-1. Water collection and storage facilities for the Project.

Table 2-1. Project facilities, ownership, and storage rights.

Facility	Facility Ownership	Location (Basin)	Original Construction/ Reclamation Rehabilitation	Storage/Water Right	O&M Responsibility
Agate Dam and Reservoir	Reclamation	Dry Creek (Rogue)	Reclamation constructed in 1966	RRVID	RRVID
Howard Prairie Dam and Lake	Reclamation	Jenny Creek (Klamath)	Reclamation constructed in 1958	Reclamation	TID
Hyatt Dam and Reservoir	Reclamation	Keene Creek (Klamath)	TID built in 1922, Reclamation rehabilitated in 1961	TID	TID
Keene Creek Dam and Reservoir	Reclamation	Keene Creek (Klamath)	Reclamation constructed in 1959	Reclamation & TID	TID
Green Springs Powerplant	Reclamation	Emigrant Creek (Rogue)	Reclamation constructed in 1960	Reclamation & TID	Reclamation
Emigrant Dam and Lake	Reclamation	Emigrant Creek (Rogue)	TID built in 1924, Reclamation rebuilt in 1961	Reclamation & TID	TID
Upper South Fork Little Butte Creek Diversion Dam and Collection Canal	Reclamation	South Fork Little Butte Creek (Rogue)	Reclamation constructed in 1960	Reclamation	TID
Pole Bridge Creek Diversion Dam	Reclamation	Pole Bridge Creek (Rogue)	Reclamation constructed in 1960	TID assigned to Reclamation	TID
Daley Creek Diversion Dam and Collection Canal	Reclamation	Daley Creek (Rogue)	Reclamation constructed in 1960	TID assigned to Reclamation	TID
Beaver Dam Creek Diversion Dam	Reclamation	Beaver Dam Creek (Rogue)	Reclamation constructed in 1960	TID assigned to Reclamation	TID
Conde Creek Diversion Dam and Collection Canal	Reclamation	Conde Creek (Rogue)	Reclamation constructed in 1958	TID assigned to Reclamation	TID
Dead Indian Creek Diversion Dam	Reclamation	Dead Indian Creek (Rogue)	Reclamation constructed in 1958	TID assigned to Reclamation	TID

Facility	Facility Ownership	Location (Basin)	Original Construction/ Reclamation Rehabilitation	Storage/Water Right	O&M Responsibility
Soda Creek Diversion Dam and Feeder Canal	Reclamation	Soda Creek (Klamath)	Reclamation constructed in 1959	Reclamation	TID
Little Beaver Creek Diversion Dam and Delivery Canal	Reclamation	Little Beaver Creek (Klamath)	Reclamation constructed in 1959	Reclamation	TID
Antelope Creek Diversion Dam and Feeder Canal	Reclamation	Antelope Creek (Rogue)	Reclamation constructed in 1966, fish screen & passage added in 1998	RRVID	RRVID
Agate Reservoir Feeder Canal	Reclamation	Dry Creek (Rogue)	Reclamation constructed in 1966	RRVID	RRVID
Ashland Canal Diversion Dam	Reclamation	Emigrant Creek (Rogue)	Reclamation relocated original works and rebuilt in 1959	TID & Reclamation	TID
Ashland Creek Diversion	Reclamation	Ashland Creek (Rogue)	TID constructed in 1924	TID	TID
Oak Street Diversion	Reclamation	Bear Creek (Rogue)	Reclamation constructed in 1961, fish screen & passage added in 1997	TID & Reclamation	TID
Phoenix Canal Diversion and Feeder Canal	Reclamation	Bear Creek (Rogue)	originally built about 1900, Reclamation rehabilitated in 1960, fish screens & passage added in 1998	MID	MID
Jackson Street Diversion and Feeder Canal	RRVID	Bear Creek (Rogue)	originally built about 1910, removed and replaced in an upstream location in 1998, fish screen & passage added in 1999	RRVID	RRVID

Facility	Facility Ownership	Location (Basin)	Original Construction/ Reclamation Rehabilitation	Storage/Water Right	O&M Responsibility
Deadwood Tunnel	Reclamation	South Fork Little Butte Creek (Rogue)	Reclamation constructed 1956-1958	Combination	TID
Howard Prairie Delivery Canal	Reclamation	Jenny Creek watershed (Klamath)	Reclamation constructed 1956-1959	Combination	TID
Cascade Divide Tunnel	Reclamation	(Cascade Divide)	Reclamation constructed 1958-1959	Combination	TID
Green Springs Tunnel	Reclamation	(Rogue)	Reclamation constructed 1957-1959	Combination	TID
Ashland Canal	Reclamation	Emigrant Creek (Rogue)	constructed in 1923	Combination	TID
East Canal	Reclamation	Emigrant Creek (Rogue)	constructed in 1925	Combination	TID
West Canal	Reclamation	Bear Creek (Rogue)	constructed in 1925	Combination	TID
Talent Canal	Reclamation	Bear Creek (Rogue)	constructed prior to 1925	Combination	TID
Phoenix Canal	MID	Bear Creek (Rogue)	constructed in 1960	MID	MID
Jackson Street Diversion Canal	RRVID	Bear Creek (Rogue)	constructed in 1906	RRVID	RRVID
Hopkins Canal	RRVID	(Rogue)	constructed prior to 1910	RRVID	RRVID

2.2 Operational Overview

A primary purpose of the Project is to deliver irrigation water to the Districts consistent with the terms of their repayment contracts and within the limits of their water rights. To provide a general understanding of the water operations for this Project, a short summary is given in this section that covers a typical year.

Depending on the water right, irrigation season begins on average April 15 and ends October 15; however, most water rights held by the Districts allow the flexibility to extend the season to October 31 if weather conditions permit. As irrigation water needs decrease at the end of the irrigation season, the diversions to canals and discharges from the dams are reduced which requires a down-ramp process. With the end of irrigation season and full down-ramp period, the regulating gates of each reservoir are closed to a level sufficient to satisfy instream flow requirements and the canal headgates are closed. During the winter, streamflows are diverted, collected, and stored to refill the Project storage reservoirs. This involves diverting water from the South Fork Little Butte Creek systems and routing it into Howard Prairie Reservoir for storage and transport through the Howard Prairie Delivery Canal to operate the Green Springs Powerplant. Discharges from the Green Springs Powerplant are re-regulated and stored in Emigrant Reservoir for the future delivery during irrigation season. Streamflows from the Jenny Creek tributaries are also collected, with some of the water going into storage in Hyatt Reservoir and some being routed through the Green Springs Powerplant to Emigrant Reservoir. Storage season operations routinely involve reservoir adjustments and operations to meet flood control rule curves and surcharge space requirements as well as meeting hydropower demands for the Green Springs Powerplant. While the reservoir regulating gates and canal headgates are shut, routine maintenance on the storage and conveyance system occurs.

When the Project reservoirs reach a certain level and irrigation season approaches, the diversions are managed in a manner to keep an even flow into the reservoirs, maintain the maximum pool possible for the delivery season, and allow adequate carry-over for future deliveries. In an average water year, delivery of storage water from Emigrant Dam to Emigrant Creek begins in May. Prior to the release of storage water, users receive water from natural streamflow, as allowed by their water rights, which are administered by the Districts, from various diversion structures throughout the basin. Typically, these streamflow rights are the Districts' primary and senior rights and as they diminish, irrigation requirements are supplemented by the releases from the storage reservoirs. Once the water is released from Emigrant Dam, it travels downstream from Emigrant Creek to Bear Creek where it can be diverted at multiple locations.

At times, there is variability in Bear Creek flows. This is due in part to the natural diurnal flow cycle of the stream and precipitation events, and is compounded by both Project and non-Project water diversions, return flows, and municipal influences (i.e., wastewater and stormwater discharges; municipal hydropower withdrawals). There are a large number of non-Project users in the Bear Creek basin whose water rights are senior to the Districts and the Project. The Bear Creek Watershed Assessment (RVCOG 2001) reports that there are over 1,200 recorded water rights in the Bear Creek watershed and that private irrigators hold rights to about 105 cubic feet per second (cfs) of natural flow in Bear Creek and its tributaries. Non-Project water users are not required to notify the Districts or the Jackson County Watermaster about diversion schedules. As long as they do not exceed the terms of their water right, they can divert completely independently of the Districts. At times this can prove challenging for the District managers when non-Project diverters go on and off quickly, altering the amount of streamflow in Bear Creek.

2.3 Upper South Fork Little Butte Creek Area and Bear Creek Area

The Upper South Fork Little Butte Creek area and Bear Creek area include the following facilities:

- Water collection and storage facilities
    - Water collection facilities on the headwaters of South Fork Little Butte Creek and its tributaries in the Rogue River basin which collect and move water from the Rogue River basin for storage in Klamath River basin.
    - Water collection facilities on Jenny Creek tributaries in Klamath River basin.
    - Water storage facilities on Jenny Creek tributaries in Klamath River basin.
    - Water storage facilities on Emigrant Creek in Rogue River basin.
- Water conveyance facilities
    - Water conveyance facilities which move water from the Rogue River basin to the Klamath River basin.
    - Water conveyance facilities which move water from the Klamath River basin to the Rogue River basin.
    - Diversion dams on Bear Creek which divert water into canals.
- Powerplant facilities
    - Green Springs Powerplant.

2.3.1 Water Collection Facilities

A portion of the South Fork Little Butte Creek streamflows in the Rogue River basin is diverted near its headwaters by the upper South Fork Diversion Dam into the South Fork Collection Canal. From there, the canal extends about 4 miles to a point where flows from Pole Bridge Creek are intercepted. At about canal mile 7.4, the South Fork Collection Canal is joined by the Daley Creek Collection Canal which collects runoff from Daley Creek and Beaver Dam Creek. At canal mile 8.6, the South Fork Collection Canal, with a capacity of 130 cfs, enters Deadwood Tunnel which conveys the collected runoff from the west side of Cascade Divide to the east side. This water is then discharged into the natural channel of Grizzly Creek that flows into Howard Prairie Reservoir in the Klamath River basin.

Water from two other headwater tributaries of South Fork Little Butte Creek is also moved from the Rogue River basin to the Klamath River basin. The flow of Conde Creek is diverted at Conde Creek Diversion Dam into the Conde Creek Canal, which terminates at Dead Indian Creek. The combined flow of Conde and Dead Indian creeks is then diverted into the 86-cfs-capacity Dead Indian Creek Canal, which crosses Cascade Divide and discharges into Howard Prairie Reservoir in the Klamath River basin.

These water collection facilities are operated and maintained by TID. The facilities can operate year round, but most creek diversions usually occur during the winter and spring months until the needs of downstream senior natural flow rights in the Little Butte Creek drainage take precedent.

The average amount of water transferred for water years 1961 to 1999 and from water years 2001 to 2011 was about 14,800 acre-feet. Table 2-2 provides the volume and timing of average monthly diversions of the South Fork Little Butte Creek transbasin transfers for water years 1961 to 1999; Table 2-3 shows the same data for water years 2001 to 2011. Although the volume of transfers has not changed over time, the timing has shifted to transfer more water later in the spring, March through May rather than October through February.

Table 2-2. Average monthly South Fork Little Butte Creek[1] transbasin water transfer, Rogue River Basin Project (in acre-feet) for water years 1961 to 1999.

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
246	572	1,415	1,541	1,592	2,209	2,936	3,033	998	264	52	46

[1] Average of the sum of measured flow for the South Fork Little Butte Creek Collection Canal near Pinehurst (USGS:1433940) and Dead Indian Canal near Pinehurst (USGS:14340400).

Table 2-3. Average monthly South Fork Little Butte Creek[1] transbasin water transfer, Rogue River Basin Project (in acre-feet) for water years 2001 to 2011.

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89	249	680	1,211	1,240	2,613	4,277	3,147	867	153	44	55

[1] Average of the sum of measured flow for the South Fork Little Butte Cr. Collection Canal, OR (Hydromet:SLBO QJ) and Dead Indian Collection Canal nr. Pinehurst, OR (Hydromet:DICO QJ).

2.3.2 Water Storage Facilities

The Project storage facilities include Howard Prairie Dam and Reservoir (Lake), Hyatt Dam and Reservoir, Keene Creek Dam and Reservoir, and Emigrant Dam and Reservoir (Lake). TID operates and maintains the water storage facilities. Contracts between Reclamation and TID, MID, and RRVID provide for these reservoirs to be operated as a pooled system with a total active capacity of 115,000 acre-feet. These contracts allocate the pooled storage as follows:

- 8,500 acre-feet (7.4 percent) is preferred capacity assigned to TID. The first annual inflow to the system is assigned to this preferred capacity.
- The residual capacity of 106,500 acre-feet (92.6 percent) is considered as new capacity and is assigned as follows:
    - 4,000 acre-feet (3.8 percent) to RRVID
    - 8,000 acre-feet (7.5 percent) to MID
    - 94,500 acre-feet (81.3 percent) to TID

Each irrigation district has the right to carry its stored water over from one year to the next year as long as the stored water does not exceed its assigned reservoir space. In addition to the irrigation storage, each reservoir has established surcharge space based on Reclamation requirements and Safety of Dam procedures. Surcharge space is temporary reservoir capacity provided for use in passing floods. This space can be used during emergencies or extreme conditions on the reservoir or the river basin.

Howard Prairie Dam and Lake

Howard Prairie Dam and Lake (total capacity 62,100-acre-feet; active capacity 60,600 acre-feet) are located on Jenny Creek. The priority for filling Howard Prairie Lake is to collect runoff from the Jenny Creek watershed, then supplement the runoff with transbasin transfers from the South Fork Little Butte Creek Collection System. The filling of Howard Prairie Lake can occur at any time and at any rate. There is no formalized flood control operation for the dam.

Howard Prairie Lake provides water for irrigation purposes in the Bear Creek drainage of Rogue River basin and for hydroelectric generation at Green Springs Powerplant. Releases from Howard Prairie Dam can be made at any time into the 18.7-mile-long Howard Prairie Delivery Canal, which terminates at Keene Creek Reservoir. Storage releases are usually maintained at the maximum 53 to 55 cfs carrying capacity of Howard Prairie Delivery Canal throughout the year except as modified by downstream runoff intercepted by the canal en route to Keene Creek Reservoir. Flows from Soda and Little Beaver creeks are diverted into Howard Prairie Delivery Canal.

Hyatt Dam and Reservoir

Located in the Klamath River basin, Hyatt Dam and Reservoir (total capacity 16,200 acre-feet; active capacity 16,200 acre-feet) store runoff from the Keene Creek watershed, a tributary of Jenny Creek. Hyatt Reservoir is operated by TID to supplement irrigation water and hydroelectric generation demands not met from Howard Prairie Lake. Hyatt Reservoir releases flow down Keene Creek a few miles to Keene Creek Reservoir.

Hyatt Reservoir can be filled at any time and at any rate. Although no formalized flood control operations exist, prudent efforts are made to maintain some flood control capability. The goal at Hyatt Reservoir is to operate in the top half (8,000 acre-feet) of the reservoir. This allows 8,000 acre-feet of stored water to be carried over to the next year and provides reasonable assurance that Hyatt Reservoir will refill.

Keene Creek Dam and Reservoir

Keene Creek Dam and Reservoir (total capacity 370 acre-feet; active capacity 260 acre-feet) receives water from Howard Prairie Lake via the Howard Prairie Delivery Canal and from Hyatt Reservoir releases into Keene Creek. The dam creates an impoundment used to regulate flows to the Green Springs Powerplant for various generating modes.

Emigrant Dam and Lake

Emigrant Dam and Lake (total capacity 40,500 acre-feet; active capacity 39,000 acre-feet) sits on Emigrant Creek. Emigrant Lake is the lowermost storage facility in this system and gets its water supply from several sources:

- Water is transferred by South Fork Little Butte Creek Collection System from the Rogue River basin to the Klamath River basin and released from Howard Prairie Lake.
- Runoff from Keene Creek (a Jenny Creek tributary in the Klamath River basin) is impounded in and released from Hyatt Reservoir.
- Runoff from various Jenny Creek tributaries in Klamath River basin is intercepted by Howard Prairie Delivery Canal en route to Keene Creek Reservoir.
- Emigrant Creek natural inflows.

Emigrant Dam and Reservoir are operated by TID to provide irrigation water in the Bear Creek drainage and for flood control. Releases are made into Emigrant Creek or directly into TID's East Canal.

Water can be impounded in the flood control reserved space only when inflow from Emigrant Creek is greater than 600 cfs or flow in Bear Creek at the Medford gage (Reclamation: MFDO; USGS: 14357500) is forecasted to be greater than 3,000 cfs. Any flood control reserved space filled under the foregoing conditions must be evacuated as soon as possible. Flood control of Emigrant Dam is described further in Section 2.3.2.

The lake reaches its highest level after April 1. It is drawn down during the irrigation season and reaches its lowest level in mid-October. Prior to 2009, the outlet gates at Emigrant Dam were typically completely closed at the end of the irrigation season after a down-ramp process, to accommodate refilling the lake. Under this proposed action, releases from Emigrant Lake will be made if required by the flood control management plan or if required by the instream flow regime identified later in Section 2.6.1. Tributaries, and for a time irrigation return flows, provide additional flow in the mainstem of Bear Creek

Project irrigation demands can often be met during the spring months with natural flow from tributaries downstream from Emigrant Dam and irrigation surface and subsurface return flows. When irrigation demands can no longer be fully met from these sources, storage water is released from Emigrant Lake to meet demands of the Districts. Stored water is called for by MID and RRVID from TID, who operates Emigrant Dam and Reservoir. The released stored water is assessed against the respective irrigation district's stored water supply.

Emigrant Creek flows about 4.5 miles downstream from Emigrant Dam to the confluence of Neil Creek at river mile (RM) 24.8 where Bear Creek begins. From this point Bear Creek, continues an additional 24.8 miles to its confluence with the Rogue River.

Short-term Operational Considerations

There are operational considerations at the Emigrant Dam facility, primarily when releasing flows below 10 cfs. The regulating gates for Emigrant Dam were not originally designed to provide fine adjustments for low operational releases. As the regulating gates are closed or minimally opened to release water, cavitation may occur, causing damage to the gate surfaces over time. Nonetheless, in the short term the minimum instream flows proposed in Section 2.6.1 can be provided. Additional analysis is needed to collect the necessary data for accurate improvement designs. A 2009 preliminary report supports the flow capability described above through a filler valve and identifies the potential for damage to the regulating gates from low flow releases. Design work on the needed gate modification is currently scheduled to begin in fiscal year 2013. Reclamation will coordinate with the TID to ensure that the required data collection and engineering designs for regulating gate modifications are sufficient to provide both low flow water delivery for minimum target flow compliance as well as protection of facility infrastructure as low flow releases are made from Emigrant Dam.

Flood Control

Section 7 of the Flood Control Act of 1944 gives the Corps flood control authority over Emigrant Dam. Flood control rule curves were developed by the Corps, with input from Reclamation, in a manner that balances flood protection with assuring a viable irrigation water supply. The flood control rule curve prescribes the amount of reservoir space needed to reduce the downstream flood potential during the October through April period. Rule curves are developed using historic runoff volumes, reservoir storage potential, and downstream flow restrictions.

The rule curve for Emigrant Reservoir requires 20,000 acre-feet of space to be reserved for flood regulation from October through December (Figure 2-2). This storage space is sufficient to control all floods of record including the historical floods of 1861 and 1890. After January 1, the reservoir can begin filling by 18,500 acre-feet on a gradual straight-line basis until April 1, when 1,500 acre-feet of space is required. This gradual reduction in flood control storage space coincides with the decrease in storm activity as the season progresses and balances the need to refill the Project for irrigation supply. The final 1,500 acre-feet of space can be refilled on a straight-line basis during April.

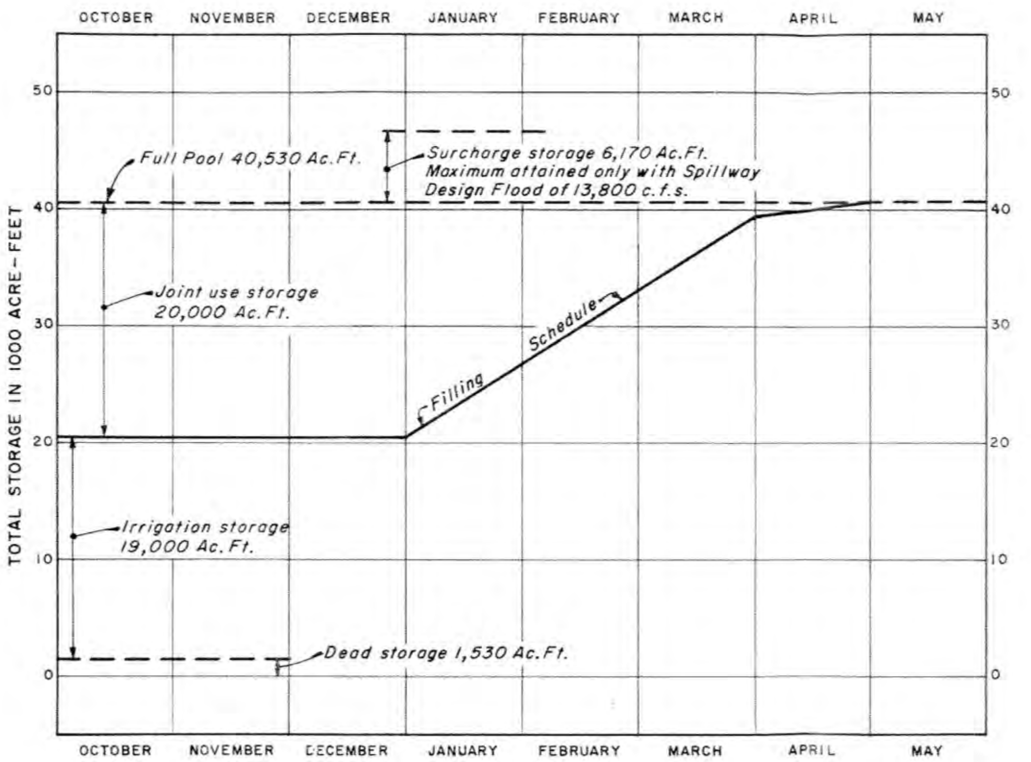


Figure 2-2. Flood control rule curve for Emigrant Dam (Corps 1965).

During the flood season, assuring sufficient flood control space for downstream protection takes precedence. Reservoir releases during the October through April period are guided by the rule curve space requirements. Releases are adjusted as needed to allow Emigrant Reservoir to fill to the space requirement dictated by the rule curve (i.e., "follow the curve") and refill at a controlled rate. Inflows are sometimes too low to allow the reservoir to follow the curve, even with minimum discharges. During flood events, the reservoir stores flood water and fills above the rule curve requirements. Higher releases are made after the flood event to lower the reservoir down to the rule curve space requirements. Floodwater can be evacuated rapidly or more gradually if flood space is not immediately needed. The rate of reservoir drawdown is coordinated between Reclamation and the Corps.

2.3.3 Water Conveyance Facilities

The water conveyance facilities which move water from the Klamath River basin through the Cascade Divide to the Rogue River basin consist of the Howard Prairie Delivery Canal, Keene Creek Reservoir, and Green Springs Powerplant and appurtenant works. These facilities transfer water 1) collected from the headwaters of South Fork Little Butte drainage and moved from the west side of Cascade Divide to the east side for storage in Howard

Prairie Lake and 2) Jenny Creek tributary runoff impounded by Howard Prairie and Hyatt Dams as well as downstream runoff intercepted en route to the Rogue River basin.

Howard Prairie Delivery Canal

The 18.7-mile-long Howard Prairie Delivery Canal extends from the outlet of Howard Prairie Dam to Keene Creek Reservoir. Operated by TID, the canal has the ability to convey 53 to 55 cfs, its maximum carrying capacity, to meet irrigation needs for stored water in Emigrant Lake and to facilitate hydroelectric generation at the Green Springs Powerplant.

The extent of releases from Howard Prairie Lake depends upon the flows of Soda Creek and Little Beaver Creek, which are intercepted en route by the Howard Prairie Delivery Canal, as well as discharges from Hyatt Reservoir. Hyatt Reservoir elevation and discharge, Soda Creek and Little Beaver Creek flows, and Howard Prairie Lake storage are monitored through the Hydromet system. When the Howard Prairie Delivery Canal is close to capacity due to Soda Creek and Little Beaver Creek inflows, releases from Howard Prairie Lake are curtailed. Peak inflows are about 11 cfs from Soda Creek and about 24 cfs from Little Beaver Creek.

During water years 1961 to 2000, an annual average volume of about 24,000 acre-feet of runoff (Table 2-4) from the Jenny Creek drainage was moved from the east side to the west side of the Cascade Divide through the Green Springs Powerplant and appurtenant works. From water years 2003 to 2011, the annual average volume was about 24,400 acre-feet (Table 2-5). Table 2-4 and Table 2-5 provide an estimate of the monthly volume and timing of average annual diversion from Jenny Creek to the Rogue River basin. The monthly volumes were estimated because a monthly distribution of natural or unregulated flow is not readily available since the natural flow is captured by Howard Prairie and Hyatt reservoirs. Monthly estimates of diversions are complicated by the reservoirs because of losses due to evaporation, seepage, and spill, and the fact that Howard Prairie inflows include Rogue River drainage diversions. Due to these factors, the average annual volume was distributed by month based on the monthly natural 50 percent exceedance flow on Jenny Creek above Johnson Creek as estimated by OWRD (2004)[1].

Table 2-4. Estimate of average monthly Jenny Creek[1] transbasin water transfer, Rogue River Basin Project (in acre-feet) for water years 1961 to 2000.

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
238	330	1,014	1,598	3,579	6,171	6,988	2,629	724	358	227	220

[1] Annual average (sum of months) based on observed and estimated flow and reservoir content at Howard Prairie Lake, Hyatt Reservoir, Green Springs Powerplant, South Fork Little Butte Creek Collection Canal Near Pinehurst (USGS 14339499), and Dead Indian Collection Canal near Pinehurst (USGS:14340400). Monthly distribution patterned by natural 50 percent exceedance distribution on Jenny Creek (OWRD 2004). See the Draft Technical Memorandum, Jenny Creek contributions to the Rogue basin, March 1, 2001, in Appendix B of Vinsonhaler 2002.

Table 2-5. Estimate of average monthly Jenny Creek[1] transbasin water transfer, Rogue River Basin Project (in acre-feet) for water years 2003 to 2011.

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
242	335	1,030	1,622	3,633	6,264	7,094	2,669	735	363	231	223

[1] Annual average (sum of months) based on observed and estimated flow and reservoir content at Howard Prairie Lake, Hyatt Reservoir, Green Springs Powerplant, South Fork Little Butte Creek Collection Canal Near Pinehurst (Hydromet: SLBO), and Dead Indian Collection Canal near Pinehurst (Hydromet:DICO). Monthly distribution patterned by natural 50 percent exceedance distribution on Jenny Creek (OWRD 2004). See the Draft Technical Memorandum, Jenny Creek contributions to the Rogue basin, March 1, 2001, in Appendix B of Vinsonhaler 2002.

Green Springs Powerplant and Appurtenant Works

Water released from Keene Creek Reservoir flows through the Green Springs Powerplant and appurtenant works and is discharged into Emigrant Creek upstream of Emigrant Lake. The 16-megawatt powerplant and appurtenant works are operated by Reclamation. The power produced at the powerplant is provided to Bonneville Power Administration at the switchyard.

The Green Springs Powerplant normally operates daily during the irrigation season and on an abbreviated schedule during the non-irrigation season. If Keene Creek Reservoir receives higher than normal flows, then the Green Springs Powerplant is operated accordingly. When water bypasses the powerplant, it travels through a control structure to Schoolhouse Creek, Tyler Creek, and Emigrant Creek.

When total storage in Howard Prairie Lake is less than 20,000 acre-feet, the operation for higher power generation is modified. This is done by reducing the continuous flow into Keene Creek Reservoir to 30 cfs or the amount of available unregulated runoff, whichever is greater.

The average annual transbasin transfer through Green Springs Powerplant and appurtenant works for water years 1962 to 1999 amounted to 39,500 acre-feet. This was comprised of 15,500 acre-feet moved from the Rogue River basin via South Fork Little Butte Creek Collection Canal to Howard Prairie Lake (Table 2-2 and Table 2-3) plus 24,000 acre-feet of Jenny Creek drainage runoff (Table 2-4 and Table 2-5).

Major Rogue Diversion Dams and Conveyance Facilities

The major water diversion dams and conveyance facilities, which carry water within the Rogue River basin and convey the water to points of use include:

- Ashland Canal Diversion Dam, on Emigrant Creek at 33.7 miles above the mouth of Bear Creek, about 100 feet downstream from the Green Springs Powerplant discharge; diverts up to 48 cfs into the Ashland Canal on the west side of the creek.

- The 132-cfs capacity East Canal receives water directly from Emigrant Dam at 29.3 miles above the mouth of Bear Creek, and the 39-cfs capacity West Canal bifurcates off the East Canal at canal mile 11.0.

- Oak Street Diversion Dam at RM 21.59 diverts up to 65 cfs into the Talent Canal which begins on the east side of Bear Creek.

- Phoenix Canal Diversion Dam at RM 16.8 delivers water into the Phoenix Canal with a maximum of 102 cfs on the west side of Bear Creek. The Phoenix Canal also receives up to 49 cfs from the Little Butte Creek drainage by siphon from the Medford Canal. The maximum capacity of the Phoenix Canal at the junction is 75 to 85 cfs.

- Jackson Street Diversion Dam, a non-Federal facility, at RM 9.5 diverts into a short canal on the west side that connects with the 50-cfs capacity Hopkins Canal (a non-Federal facility) before it crosses Bear Creek by siphon. The Hopkins Canal also carries water from the Little Butte Creek drainage.

Table 2-6 shows annual diversions in Bear Creek drainage by the Districts for water years 1990 through 1999, and Table 2-7 shows the same data for water years 2001 to 2011. For the first ten years, the average annual diversion during the irrigation season by the Districts was 70,000 acre-feet, and the last eleven years was 65,000 acre-feet.

Table 2-6. Annual MID, TID, and RRVIC diversions in Bear Creek subbasin for water years 1990 to 1999 (in acre-feet) (Vinsonhaler 2002).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Upstream from Emigrant Reservoir										
Ashland Canal	10,300	7,600	6,300	6,200	8,300	6,100	8,100	9,400	7,100	6,900
Directly from Emigrant Reservoir										
East Canal	36,700	29,500	26,200	28,700	32,700	29,300[1]	34,600	33,100	38,700	39,700
Downstream from Emigrant Reservoir Diverted From Bear Creek										

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Talent Canal	8,300[2]	13,800	8,800	12,500	11,200	14,000	13,500	14,000	13,500	15,500
Phoenix Canal	13,000	14,900	4,800[3]	11,200	7,000	11,700	10,100	9,800	10,600[3]	14,500
Hopkins Canal[4]	4,100	4,200	5,200	6,700	8,600	7,900	8,200	8,900	7,900	6,800
Total	72,600	70,000	50,900	65,500	67,800	69,000	74,500	76,700	72,200	80,900

[1] Partial data for June 1995 and significant missing data for July 1995 but data estimated.

[2] Missing data for May and June 1990.

[3] Partial data for June and July 1992 and missing data for May 1998.

[4] Accounts only for water diverted from Bear Creek through the Jackson Street Diversion Dam, a non-Federal facility.

Table 2-7. Annual MID, TID, and RRVID diversions in Bear Creek subbasin for water years 2001 to 2011 (in acre-feet) (Hydromet).

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Upstream from Emigrant Reservoir											
Ashland Canal	6,500	6,200	6,900	7,200	6,300	6,500	6,800	6,800	7,800	7,400	7,600
Directly from Emigrant Reservoir											
East Canal	29,800	30,300	29,300	31,700	27,100	30,900	33,400	32,900	34,600	27,700	27,600
Downstream from Emigrant Reservoir Diverted From Bear Creek											
Talent Canal	9,200	9,100	10,900	10,500	9,000	10,000	10,500	10,200	10,400	9,200	8,900
Phoenix Canal	8,500	8,100	9,300	9,000	10,800	11,000	12,100	13,000	12,800	9,900	9,800
Hopkins Canal[3]	8,700	8,600	5,000[1]	9,100[2]	8,300	7,400	8,900	7,700	7,300	7,000	6,900
Total	62,800	62,300	61,400	67,600[2]	61,500	65,700	71,700	70,600	73,000	61,300	60,900

[1] Partial data for April and May 2003.

[2] Partial data for May 2004.

[3] Accounts only for water diverted from Bear Creek through the Jackson Street Diversion Dam, a non-Federal facility.

2.4 Antelope Creek/Dry Creek Areas

The Antelope Creek/Dry Creek areas include the following facilities:

- Water Collection and Storage Facilities:
  - Water collection facility on Antelope Creek.
  - Storage regulating facility on Dry Creek.

- Water Conveyance Facilities:
  - Antelope Feeder Canal.
  - Agate Feeder Canal.

2.4.1 Water Collection Facilities

Antelope Creek Diversion Dam at RM 7.0 of Antelope Creek diverts up to 50 cfs into a connector canal extending about 0.1 mile to the Hopkins Canal. Flows in the connector canal are combined with the Hopkins Canal flows until they reach a bifurcation structure where the flows from Antelope Creek are diverted to Agate Reservoir. An estimated 1,400 acre-feet is diverted annually from Antelope Creek.

From November through March, a minimum flow of 1 cfs must pass downstream from Antelope Creek Diversion Dam for streamflow maintenance while Project diversions are being made. From April through October, 2 cfs or the natural streamflow, whichever is less, must be bypassed for streamflow maintenance and senior water rights. The stream is often dry at the diversion dam in the summer months and no diversions are made.

2.4.2 Water Storage Facility

Agate Dam and Reservoir, located on Dry Creek in the Rogue River basin stores and re-regulates water from Antelope Creek, natural flows of Dry Creek, and water conveyed from the North and South Forks of Little Butte Creek. Agate Dam and Reservoir has a total capacity of 4,780 acre-feet and an active capacity of 4,670 acre-feet. The dam and reservoir are operated by RRVID as a storage and re-regulating facility.

Water can be stored in Agate Reservoir at any time and rate consistent with downstream rights. There is no flood control operation, as the reservoir is kept as full as possible. Water released from Agate Dam into Dry Creek flows a short distance downstream where it is diverted into the Hopkins Canal for irrigation uses on RRVID lands on both the east and west sides of Bear Creek. Dry Creek flows into Antelope Creek below Agate Dam, which flows into Little Butte Creek at RM 3.2, downstream from Eagle Point.

Releases from Agate Reservoir of 1 cfs for streamflow maintenance in Dry Creek are made when the inflow is equal to or greater than that amount. If inflow is less than 1 cfs, then the inflow amount is released for streamflow maintenance. These releases are made through a 6-inch bypass line in the outlet works.

2.5 Maintenance

With the exception of Green Springs Powerplant, the Districts have the responsibility for maintenance of all Project facilities.

2.5.1 Inspection

All Project facilities are subject to on-going inspection programs. Dams identified as a high risk to downstream populations in the event of a failure are examined every 3 years and an underwater inspection by divers of the outlet works and spillway stilling basins is typically conducted every 6 years. Diversion and delivery facilities and dams characterized as low risk are examined at least every 6 years.

Such inspections may prevent Reclamation or the Districts from fully satisfying the instream flow targets identified below Emigrant Dam. Reclamation anticipates that routine inspections may result in reductions in flows to no lower than 2 cfs for no longer than 48 hours. Reclamation will strive to coordinate these inspection activities with NOAA Fisheries to minimize the impact on listed fish.

The Green Springs Powerplant penstock intake is periodically examined by divers. Flow through the penstock shut down to conduct this examination.

2.5.2 Routine Maintenance

The Districts maintain the transferred works of the Project. Routine maintenance is performed in accordance with state and Federal laws. If possible, most maintenance is completed during the non-irrigation season. At times, it may be necessary to work within the stream channel, but an effort is made to minimize this work. Extraordinary maintenance is consulted on separately.

Fish screens and passage facilities are maintained according to various operating criteria appropriate for their design. Fish screens are removed every year by RRVID and the headgates closed as a precaution against damage from high runoff. TID and MID do not remove their screens annually (unless they need maintenance) since their facilities are isolated from the creek channel by control gages which are closed in the off season.

The maintenance program may include, but is not limited to, the following activities:

- Repair eroded concrete.
- Recoat or replace corroded metalwork.
- Repair cavitation damage to control gates.
- Remove sediment, rock, and debris from intake and outlet works.
- Stabilize embankments.

- Reshape canals.
- Replace riprap.
- Remove trees and debris.
- Repair structures at creek crossings.
- Maintain access roads and right-of-way fencing.
- Control noxious and aquatic weeds.

2.5.3 Green Springs Powerplant

Reclamation maintains the reserved works of the Green Springs powerplant and its appurtenant facilities including the Tyler Creek bypass channel. Routine maintenance is done in accordance with state and Federal laws. Maintenance is performed on several items which include, but are not limited to:

- Turbine, generator, and transformer
- Outlet works
- Intake and tunnel

2.6 Conservation Actions

2.6.1 Instream Flows

To increase the amount of available coho salmon habitat in Bear, Emigrant, and South Fork Little Butte creeks, Reclamation will institute an instream flow regime to guide the operations of Emigrant Dam, Oak Street Diversion Dam, Phoenix Diversion Dam, and the South Fork Little Butte Creek collection facilities consistent with the targets presented in Table 2-8. Instream flow targets are established according the total reservoir storage method of determining water year type, with greater instream flow targets during water year types associated with higher unregulated flow conditions. Reclamation will monitor instream flows at the Hydromet gage immediately downstream of each relevant facility. Instream flow targets guide the operations of Project facilities; as such, instream flow targets do not apply when a facility is not operating. Adjustments to facility operations pursuant to this instream flow regime are dependent on operational limitations of each facility and are described in greater detail below. The 7-day daily average flow value leading up to a particular date will be calculated at 12:01 a.m. the following day.

Table 2-8. Instream flow targets for Emigrant Dam, downstream of Oak Street Diversion, downstream of Phoenix Diversion, and downstream of South Fork Little Butte Creek Collection Facilities. Both a 7-day daily average and 3-hour minimum flow value are specified for gages downstream of Oak Street and Phoenix Diversions.

	EMI Emigrant Dam			BASO Oak Street Diversion		BCTO Phoenix Diversion		GILO S.F. Little Butte Cr. Collection Facilities	
	3 hour minimum (cfs)			7 day daily average (cfs) /3 hour minimum (cfs)				7 day daily average (cfs)	
System State	Wet	Avg	Dry	Wet & Avg	Dry	Wet & Avg	Dry	Wet & Avg	Dry
Oct	6	3	2	8/5	3/2	12/8	8/5	10	8
Nov	10	6	2	No Operations				15	10
Dec	12	10	2					20	15
Jan	**12**	10	2					25	15
Feb	12	10	2					25	20
Mar	12	10	2					55	25
Apr	12	9	2	30/20	25/15	40/20	30/15	75	40
May	10	9	2	30/20	25/15	20/10	20/10	60	40
Jun	6	3	2	20/15	15/8	12/6	10/5	25	15
Jul	6	3	2	12/10	5/3	10/5	8/5	15	10
Aug	6	3	2	6/4	3/2	8/5	5/3	12	8
Sep	6	3	2	6/4	3/2	8/4	5/3	10	8

Emigrant Dam

Emigrant Dam outlets directly into Emigrant Creek and affects the availability of coho habitat in Emigrant Creek downstream from Bounds Pond. Releases from Emigrant Dam can also affect habitat availability in the mainstem of Bear Creek, but the proportion of total flow attributable to Emigrant Dam releases is less as additional tributary inflows increase total flows downstream. To adjust operations under this instream flow regime, the TID will release water from Emigrant Dam to meet the instream flow targets specified for the EMI gage in Table 2-8.

South Fork Little Butte Creek

The South Fork Little Butte Creek Collection facilities divert water from the Little Butte Creek watershed for storage in the Howard Prairie Reservoir in the Klamath basin. These diversions can affect the availability of coho habitat in South Fork Little Butte Creek. To adjust operations under this instream flow regime, the TID will reduce cumulative diversions of water from South Fork Little Butte Creek and its tributaries to avoid causing flow reductions below the targets specified in Table 2-8. At times there may not be sufficient natural flow in South Fork Little Butte Creek to satisfy the instream flow targets presented in Table 2-8. In addition, TID may continue to divert 2 to 3 cfs when needed to prevent snow or ice buildup from impairing operational capacity of the canals and diversion facilities. Reclamation will coordinate with TID to minimize the frequency of these diversions at these facilities.

Oak Street and Phoenix Diversion Dams

Diversion of water via the Oak Street and Phoenix diversion dams during the irrigation season can affect the availability of coho habitat in Bear Creek. To adjust irrigation season operations under this instream flow regime TID will adjust Project operations to avoid causing reductions in the 7-day average flow below targets specified in Table 2-8. The flow targets specified in Table 2-8 are monitored as a 7-day average because private diversion activity renders more detailed management of Bear Creek impracticable. During the storage season, Reclamation will bypass all natural flow at these facilities.

At times, flows in Bear Creek can rapidly and unexpectedly decline to very low levels. This is most likely attributable to the combined and uncoordinated withdrawals of water by private water users. To avoid increasing the frequency of very low flow events, the irrigation district operating the diversion facility will adjust operations of Oak Street and Phoenix diversion dams so as not to cause a 3-consecutive-hour low flow event below the targets specified in Table 2-8.

Monitoring and Reporting

Reclamation will continue to monitor streamflow in Bear, Emigrant, and Little Butte creeks. If instream flows should fall below the targets specified in Table 2-8, Reclamation will, within 12 hours of the event, provide NOAA Fisheries with a report containing a record of flows for all gages in the affected stream(s) and canal(s); and a record of associated operational changes. In this report, Reclamation will provide data for the prior 72 hours for instream flow targets measured as a 3-hour minimum, and 10 days for instream flow targets measured as a 7-day average. Following transmittal of such report, Reclamation will coordinate with NOAA Fisheries in identifying steps to return flows to target levels and assessing the impact, if any, of the low flow event on listed fish. Reclamation will also provide an annual report detailing compliance measures by February 15 of each year. Reclamation and the Districts will continue to coordinate with NOAA Fisheries regarding appropriate and reasonable measures to improve the implementation of this instream flow regime.

Occasional deficits in instream flows may occur due to the physical limitations of Project facilities, mechanical failures, natural events that prevent normal operation, or emergency repairs or maintenance. Reclamation will strive to minimize occurrences when deficits in instream flow may occur and communicate with NOAA Fisheries as soon as possible to determine the appropriate course of action if an instream target is not met.

How Reclamation Developed these Instream Flow Targets

To develop this instream flow targets, Reclamation, in coordination with the NOAA Fisheries and the Districts, used a variant of the instream flow incremental methodology (IFIM) (USGS 1995). Under this method, Reclamation used the 2011 MODSIM model of the Project to estimate daily streamflows under several minimum flow scenarios (Appendix A). Reclamation also modeled a without Reclamation scenario which simulates streamflows without the operation of Reclamation facilities. Using a flow duration analysis, Reclamation determined the representative streamflow values for high (20 percent exceedance), median (50 percent exceedance), and low (80 percent exceedance) flow conditions, evaluated monthly. These representative streamflow values were used to estimate the availability of coho microhabitat for spawning/incubation, winter rearing, and summer rearing life stages using a habitat model called PHABSIM (Sutton 2007a). Reclamation then compared habitat availability under each condition for each instream flow scenario to the corresponding conditions under the without Reclamation scenario to estimate the habitat effects of the Project for each scenario. For a complete explanation of these methods, see Chapter 4.

To evaluate each scenario, Reclamation considered what benefits of additional flow-related habitat would have on SONCC coho productivity, the benefits of alternative means of habitat quantity and quality improvement, and the impact of each scenario on the ability of the Project to meet irrigation water demand. To estimate the benefit of habitat to productivity, Reclamation performed a life cycle analysis of coho habitat (Appendix B). The evaluation of alternative methodologies utilized the large wood installation habitat enhancement methodology developed by GeoEngineers (Appendix C). Impact of maintaining the minimum instream flows on reservoir storage was evaluated using the 2011 MODSIM model of the Project.

The result of this evaluation generally indicated that winter and summer rearing habitat limited coho productivity, and that there was adequate spawning habitat for both the current and recovered coho populations. Therefore, the instream flows presented here attempt to maximize the useable area of winter and summer rearing habitat under Project operations. It is important to note that the flow targets identified in the proposed action are minimum flow targets. Often the routine operation of the Project results in flows greater than the identified minimum.

In developing these instream flow targets, Reclamation considered several alternatives, including minimum flow targets identified in NOAA Fisheries May draft BiOp. Reclamation declined to adopt these flows for two reasons. First, the flows were not based on the best available science at the time they were considered by Reclamation. NOAA Fisheries developed these flows using data from Reclamation's 2003 monthly time step model of the Project. The development of a daily time step model for the Project rendered these data ill suited to the development of instream flow targets because they only estimated monthly average flow. Monthly flow targets can mask intra-monthly variations in habitat (NRC 2008). Further, much of the data in the 2003 model was simulated, providing spatial resolution that was less than optimal for reliably modeling habitat impacts. Second, the flows identified in the RPA appeared to compromise the ability of the Project to provide an adequate supply of water for irrigation, fish and wildlife, and recreational purposes.

To determine the appropriate time scale for an instream flow target, Reclamation considered the ability of the Districts to manage water deliveries against both natural and unnatural hydrologic variability. At the South Fork Little Butte Creek canals, Reclamation used a 7-day moving average because of a time delay between operational changes and a response at the GILO gage several miles downstream, the difficulty in accessing and adjusting the South Fork Little Butte Creek Collection facilities, the infrequency of operational modifications, and a low likelihood of critically low flows.

At Phoenix and Oak Street diversions, the 7-day moving average instream flow target seeks to stabilize habitat availability in light of the potential for significant impacts of private diversion activity on streamflow in Bear Creek. Reclamation identified a 3-hour instream flow target to reduce the risk that District operations may cause an extreme low flow event. Reclamation set these 3-hour targets by selecting the greater of one-half the weekly target or the weekly target less one standard deviation. This approach assured instream flow targets addressed baseline flow variability each month while preventing unacceptable deviations from the 7-day average value.

Reclamation identified instream flow targets for median and low water year conditions for the South Fork Little Butte Creek collection facilities (GILO), Oaks Street Diversion (BASO), and Phoenix Diversion (BCTO). Reclamation also identified an instream flow target for wet system states for Emigrant Creek below Emigrant Dam in Table 2-8. This target is specified because the releases from Emigrant dam have a direct relationship to flows in Emigrant Creek, and the target flow targets are low enough at all times that differences in operations can affect the availability of coho habitat.

Determination of System State

The instream flow targets identified above differ between wet, average, and dry hydrologic system states. For the Project, Reclamation estimates system state using a total reservoir storage method (Appendix D). Under the total reservoir storage method, Reclamation compares the sum of the daily storage values of Howard Prairie, Hyatt, and Emigrant reservoirs to historic values at similar times during the year. Where storage is within 15,000 acre-feet of average total storage, the system is in an average hydrologic state. Wet and dry hydrologic states are those values greater than 15,000 acre-feet above or below the average.

Figure 2-3, identifies the system state thresholds using daily storage values from 1992 to 2010 (updated to 2010 from GeoEngineers 2008). By referencing the storage curve on a daily basis, the instream flow targets can be adjusted to reflect the current state of the system (see Appendix D for a more detailed explanation of this methodology).

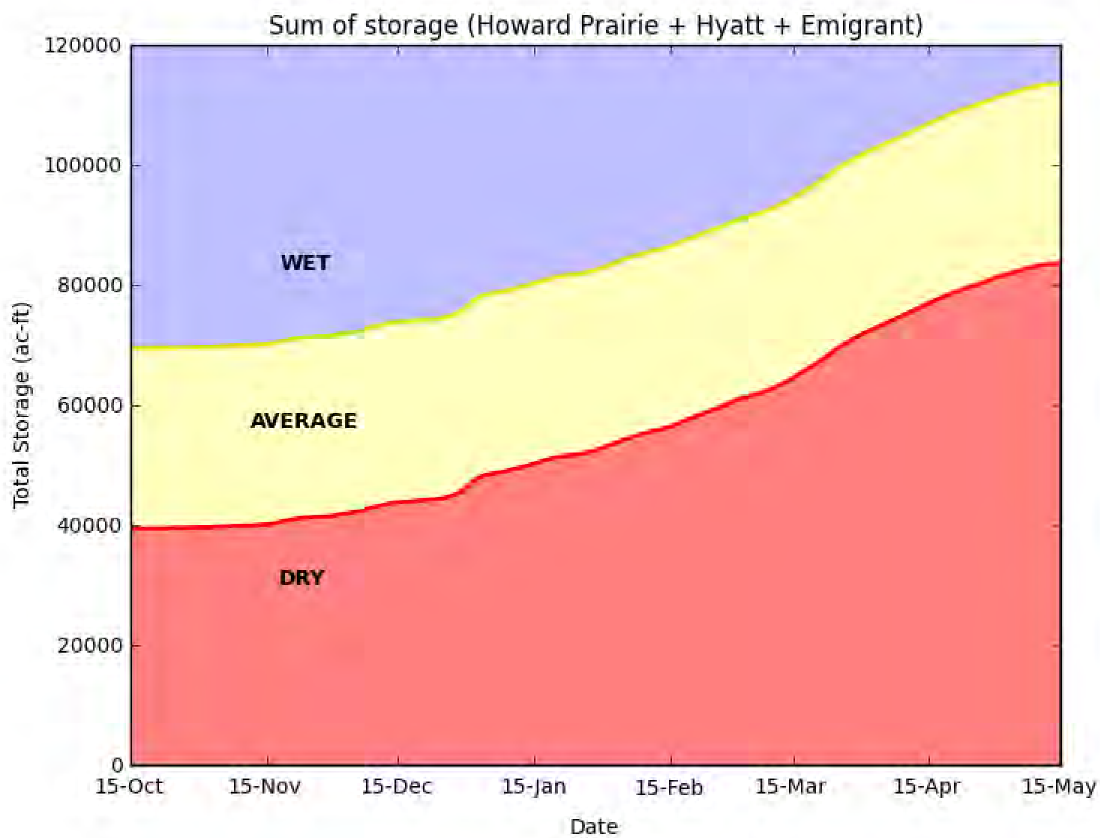


Figure 2-3. Plot of wet, average, and dry storage curves and resulting storage zones (Appendix D).

Reclamation selected a total reservoir storage methodology because it is a reasonable indicator of hydrologic conditions (Appendix D), provides an unambiguous indicator of system state, and is reasonably representative of actual hydrologic conditions. Reclamation considered other methodologies to determine hydrologic state, including the use of snow pack and precipitation forecasts, but concluded the total reservoir storage method was best suited for application to an instream flow regime. In the Rogue River basin, high degrees of variability in precipitation and snowmelt from November through April limit the utility of forecast based methods to provide a meaningful estimate of hydrologic state on a day-to-day basis (Appendix D). This rendered forecast based methods ill suited for this instream flow program because system state would need to be reliably assessed on a periodic basis. Reclamation also considered the effect of irrigation water demand and instream flows on reservoir storage. Over time, Reclamation anticipates irrigation water demand will remain consistent with historic practices captured within the reservoir storage curve. While instream flows can affect system state in a manner not captured in the reservoir storage curve, Reclamation anticipates the minimum instream flows of this proposed action will have a minimal impact on system state.

2.6.2 Ramping Rates

Ramping rates limit rapid fluctuations in streamflow, which may injure aquatic life below dams or diversions structures. This section provides a ramping rate protocol to control both storage season and irrigation season operations. This protocol will supersede the previously agree-to ramping protocol with ODFW (Appendix C in Reclamation 2009b).

Storage Season

Streamflow fluctuations in Emigrant Creek are due to the management of Emigrant Dam for both water storage and flood control activities and can have adverse effects on fish below Emigrant Dam. While scope of water storage activities is within the discretion of Reclamation, flood control activities are non-discretionary and set by the Corps flood control rule curve (Figure 2-2). Further, a ramping rate protocol for Oak Street or Phoenix Diversion canals is not identified because they do not function during the storage season. Under the proposed action, Reclamation will institute a ramping rate protocol for both water storage and flood control related releases from Emigrant Dam as follows:

- When adjusting flow releases from Emigrant Reservoir during non-flood rule conditions, flows will not increase (up ramp) more than 100 percent nor decrease (down ramp) more than 50 percent from the previous 24-hour period.

- When Emigrant Reservoir is under a flood rule condition between October 1 and May 1, as established and required by the Flood Control Storage Schedule, releases will be determined by the details of that rule and schedule, per a mandate from the Secretary of the Army in 1969. The Flood Control Storage Schedule is designed to minimize flood potential in the communities downstream of Emigrant Reservoir by maintaining a required surcharge in Emigrant. To maintain the required surcharge in Emigrant during periods of heavy runoff, the Districts may need to up ramp or down ramp releases from Emigrant that exceed the provisions established for non-flood control periods. If at all feasible, and in recognition of the Project effects on fish, efforts will be made to maintain the 50 percent down-ramping protocol even during periods of flood control.

Irrigation Season

During the irrigation season, rapid fluctuations in streamflow may adversely impact coho salmon and other aquatic life below Emigrant Dam, Oak Street Diversion, and Phoenix Diversion. To minimize these effects, Reclamation will establish a ramping protocol at Project facilities to minimize the potential for a gain or reduction in water surface elevation greater than 2 inches per hour in Emigrant or Bear creeks as a result of direct Project action.

Project impacts on up and down ramping in Emigrant Creek will be managed based on flow releases from Emigrant Reservoir and as measured at the EMI Hydromet station. Project impacts on down ramping in Bear Creek downstream of the Oak Street Diversion will be managed based on diversion rates into the Talent Canal and measured at the BASO Hydromet station. Project impacts on down ramping in Bear Creek downstream of the Phoenix Diversion will be managed based on diversion rates into the Phoenix Canal and measured at the BCTO Hydromet station. The 2-inch threshold in water surface elevation decrease was determined through an analysis of the rating curves at EMI, BASO, and BCTO, which are presented in Appendix E.

The proposed ramping protocol considers critical flows in each affected stream reach. Critical flows were determined by Reclamation to define the low flow threshold condition at which down ramping may have the greatest impact on weighted useable area (WUA), which may result in fish stranding. Table 2-9 presents Reclamation's proposed critical flow volumes for the gages of interest. Flows above the defined critical flow rates in each stream are large enough to withstand a more rapid ramping condition.

Table 2-9. Critical flow values for EMI, BASO, and GILO.

Hydromet station	Critical Flow (cfs)
EMI	10
BASO	20
BCTO	20
GILO	40

Emigrant Reservoir

Up Ramping

It is generally recognized that up ramping impacts fish resources much less than down ramping. Nonetheless, when not under a flood rule condition, up ramping from Emigrant Reservoir during the irrigation season will be managed to minimize potential increases of water surface elevation of more than 2 inches per hour at EMI, according to the following schedule:

- When flows at EMI are between 2 and 6 cfs, flow increases from Emigrant will not exceed 8 cfs per hour.
- When flows at EMI are between 6 and 20 cfs, flow increases from Emigrant will not exceed 10 cfs per hour
- When flows at EMI are between 20 and 40 cfs, flow increases from Emigrant will not exceed 15 cfs per hour.
- When flows at EMI are between 40 and 100 cfs, flow increases from Emigrant will not exceed 20 cfs per hour.
- When flows are greater than 100 cfs at EMI, flow increases from Emigrant will not exceed 30 cfs per hour.

The ramping schedule described above is based on an up-ramping analysis of the rating curve at EMI and on average, for the flow ranges identified, maintains a water surface increase of less than 2 inches per hour.

Down Ramping

- Down ramping rates from Emigrant Reservoir will be managed to not exceed 50 percent of the previous 24-hour average.
- When flows at EMI drop at or below the critical flow of 10 cfs, down ramping will be limited to a maximum change of 5 cfs per hour to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at EMI and the corresponding reach.

Oak Street Diversion Dam

- Prior to increasing diversion flow rates at Oak Street, the District Manager will first consult the Hydromet gage at BASO to determine the current instream flow volume.
- When streamflow at BASO falls at or below the critical flow of 20 cfs, increases of diversion flow rates at the Oak Street Diversion will be limited to a maximum change of 5 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BASO and the corresponding reach.
- When streamflow at BASO is between 20 and 70 cfs, increases in diversion flow rates at Oak Street Diversion will be limited to a maximum change of 10 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BASO and the corresponding reach.

- When streamflow at BASO exceeds 70 cfs, increases in diversion flow rates at Oak Street Diversion will be limited to a maximum change of 20 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BASO and the corresponding reach

Phoenix Canal and Diversion Dam

- Prior to increasing diversion flow rates at Phoenix, the District Manager will first consult the Hydromet gage at BCTO to determine the current instream flow volume.

- When streamflow at BCTO falls at or below the critical flow of 20 cfs, increases in diversion flow rates at the Phoenix Diversion will be limited to a maximum change of 5 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BCTO and the corresponding reach.

- When streamflow at BCTO is between 20 and 80 cfs, increases in diversion flow rates at Phoenix Diversion will be limited to a maximum change of 10 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BCTO and the corresponding reach.

When streamflow at BCTO exceeds 80 cfs, increases in diversion flow rates at Phoenix Diversion will be limited to a maximum change of 20 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BCTO and the corresponding reach.

2.6.3 Fish Passage Modifications

Oak Street Diversion

The fishway on the Oak Street Diversion has been identified as potentially impeding upstream passage of adult SONCC coho salmon to the upper reaches of Bear Creek and its tributaries. The current fishway was modified in 1998 by Reclamation to meet the 1997 fish protection design criteria of State and Federal fishery agencies. Since the modification, the difficulties associated with fish passage include:

- Sediment buildup in and around the ladder exit.
- Debris obstructing the orifice to the uppermost pool.
- High velocity jet in the fish passage orifice.
- Water surface elevation differences between the uppermost pool and ladder exit, further exacerbating passage between the trashracks.
- Adjustments to attraction flows needed to improve passage conditions.

The Oak Street Diversion was initially added to the Rogue Basin Fish Access Technical Team (RBFATT) list in 2003, but it was moved to a lower priority later that same year because it was a federally owned site. The primary responsibility of RBFATT is to enhance fish passage at non-Federal sites. There were numerous meetings and communications with multiple local agencies and Federal agencies, including Reclamation, regarding the issues at Oak Street Diversion through the summer of 2007. The discussions involved feedback on various types of fish passage improvements to meet NOAA Fisheries current fish passage design criteria while addressing maintenance and aesthetic concerns.

Reclamation has been requested to continue working on the Oak Street Diversion project as the owner of the diversion dam. The proposed action includes improvement of the fish passage structure to resolve the existing passage issues in accordance with current NOAA Fisheries fish passage criteria. At this time, Reclamation is preparing the final engineering design specifications for this fish passage structure. It is Reclamation’s intent to complete the proposed fish passage improvements at this facility by the fall of 2015. This is considered a reasonably attainable timeframe for implementation based on Reclamation ESA program needs and priorities and assuming a continuation of historical funding levels.

Reclamation has consulted with NOAA Fisheries fish passage experts through this process to ensure compliance with current criteria. O&M requirements also have been considered and addressed to ensure that modifications are compatible with the Districts’ current schedule and cost structure.

Following completion of other necessary compliance and permitting requirements, Reclamation would begin construction and associated activities. Since designs for the site have not been completed, the following discussion assumes that construction would be similar to other fish passage improvements in small streams (e.g., installation of the fish ladder and fish screen in the South Fork of Little Butte Creek in 2003 and the North Fork of Little Butte Creek fish ladder constructed in 2004).

When construction commences, a cofferdam would be constructed to isolate Bear Creek from the construction area near the existing fish ladder. This would allow removal of all or part of the original ladder and construction of the modified section of ladder or replacement with a new fishway to be completed “in the dry.” This would prevent contamination of the creek from concrete, silt, welding slag, sandblasting abrasive, or other contaminants, and prevent physical harm to aquatic life. Upon completion of construction tasks, the cofferdam would be removed.

All construction work would be accomplished during the ODFW-established in-water work period of June 15 to September 15 for Bear Creek (ODFW 2008). Work is estimated to take from 3 to 4 weeks for modification to the existing ladder structure and between 5 to 7 weeks for replacement with a new fishway (McGowan 2008).

At this site, a gravel parking area exists on the left side of the creek and a gravel O&M road exists on the right side of the creek, including a small area of riparian vegetation. Less than an acre of riparian habitat in the project area would be affected by construction-related activities.

Ashland Creek Diversion

The Ashland Creek Diversion is a Reclamation facility that diverts water for TID from Ashland Creek through an underground pipeline that connects to Bear Creek. The water is then diverted at the Oak Street Diversion to the TID Canal. This structure has been identified as an upstream passage impediment for juvenile fish passage to the upper reaches of Ashland Creek by RBFATT (2007).

The existing head gate structure is absent any fish screen. ODFW recommended a fish screen to protect juveniles at this location as the 18-inch underground pipe is non-passable for juveniles and the exit of the pipeline can be plugged by debris. Additionally, juveniles that do travel through the head gate structure and pipeline can get stranded in the shoulder of the ditch along Oak Street.

As with the Oak Street Diversion, RBFATT moved Ashland Creek Diversion to a low priority because it is a federally owned facility. It has been requested by local organizations and parties to address the fish barrier issues at Ashland Creek Diversion. This has been included in the proposed action to address potential improvements for fish passage and to ensure implementation resolves the existing issues in accordance with current NOAA Fisheries fish passage criteria.

Both juvenile and adult coho salmon passage problems would be corrected as part of the proposed action as designs and ultimate construction actions will improve juvenile fish passage survival by installing a NOAA Fisheries -conforming screen and fish passage design and operation improvements for adult passage at the Ashland Creek Diversion Dam.

At this time, Reclamation has prepared a final pre-design technical memorandum and will be preparing the final engineering design specifications for this fish passage structure. It is Reclamation's intent to complete the proposed fish passage improvements at this facility by the fall of 2015. This is considered a reasonably attainable timeframe for implementation based on Reclamation ESA program needs and priorities and assuming a continuation of historical funding levels. Reclamation would consult with NOAA Fisheries fish passage experts through this process to ensure compliance with current criteria. Following other necessary compliance and permitting requirements, Reclamation would begin construction and associated activities. Construction steps would be similar to those outlined for Oak Street; however, access to this site is more difficult so some additional disturbance to riparian habitat may be needed to gain access to the site.

Reclamation and TID are attempting to coordinate and fund water conservation projects in the Bear Creek system that would allow for the complete removal of the Ashland Creek Diversion Dam altogether. See Section 2.6.6 Water Conservation for additional information on options and benefits of complete dam removal. However, the complete removal of this diversion dam is not certain to occur but would provide additional benefits than providing fish passage around the dam itself. However, if dam removal cannot be negotiated through water conservation efforts, Reclamation will commit to providing fish passage improvements according to the methods described above (fish passage and screening installation actions).

2.6.4 Instream Habitat Rehabilitation

To improve the quality and quantity of coho habitat, Reclamation will design and install sufficient pieces of large wood to increase WUA of winter rearing habitat within the Bear Creek and Little Butte Creek watersheds as presented in Table 2-10. Within one year of a final BiOp, Reclamation will submit to NOAA Fisheries an instream habitat rehabilitation plan identifying the locations and amounts of large wood to be installed, the anticipated habitat uplift from those installations, a prioritized schedule of installation, and a description of monitoring and reporting requirements under the plan. It is Reclamation's intent to implement 70 percent of this plan by 2017 and 100 percent by 2020, contingent on availability of funding. This is considered a reasonably attainable timeframe for implementation based on Reclamation ESA program needs and priorities and assuming a continuation of historical funding levels.

Table 2-10. Instream habitat improvement targets for Emigrant, Bear, and South Fork Little Butte creeks.

	Increase in Habitat (ft^2 WUA)		
Location	Median Flow (50 percent exceedance)	Low Flow (20 percent exceedance)	Targeted Life Stage
Emigrant Creek/Neil Creek	7,100	15,700	Winter rearing habitat
Bear Creek/Ashland Creek	8,600	3,000	Winter rearing habitat
Bear Creek below BASO	5,100	No uplift required	Summer rearing habitat
South Fork Little Butte Creek	6,500	No uplift required	Winter rearing habitat

The objective of the instream habitat plan is to create sufficient physical habitat quantity and quality to promote increased coho salmon productivity in the Bear Creek and Little Butte Creek watersheds by improving the quantity and quality of instream habitat. Stream channel complexity has been listed as a limiting factor for coho salmon production in the Bear Creek and Little Butte Creek watersheds (ODFW 2008). Placement of large woody debris (LWD) is an established method to improve the quantity, quality, and productivity of coho habitat. For these reasons, Reclamation anticipates a combination of instream flows and instream habitat restoration will provide greater benefits to coho productivity than implementation of instream flows alone.

The total habitat uplift identified in this proposed action is the sum of habitat uplift needs for each project affected stream reach. To calculate the reach specific habitat uplift need, Reclamation identified the greater of 1) the difference between the proposed action and 90 percent without Project WUA habitat under median flow conditions; and 2) the difference between the proposed action and 80 percent without Project WUA under low flow conditions for winter and summer rearing habitat. Because quantities of spawning and incubation habitat do not limit coho productivity (Appendix B), Reclamation does not seek to address effects to spawning and incubation habitat as part of this plan. Improvements in winter rearing habitat will persist throughout the year, providing additional uplift for the summer rearing life stage.

Reclamation is reasonably certain large wood installations can provide the anticipated increase in useable rearing habitat. To test this conclusion, the effect of different types of large wood installations were modeled for low and median flow conditions during months when adverse effects of the Project were greatest. The potential increase in useable rearing habitat attributable to a large wood structure ranged from 800 to 1200 ft^2 per structure depending on flow and structure type (Appendix C). Using this method, it is estimated the installation of approximately11 to 18 large wood structures could provide the proposed increase in useable rearing habitat within Emigrant Creek

The ultimate implementation of instream habitat restoration is dependent on the cooperation of private landowners and the availability of Congressionally appropriated funds. Reclamation has evaluated the size and scope of this activity and does not believe the cooperation of willing landowners will be a substantial impediment to accomplishing the goals of this Project. For fiscal year 2012, Congress has appropriated $250,000 for initial implementation of this plan. Based on preliminary cost estimates, Reclamation believes additional work can be implemented assuming a continuation of historical funding levels.

2.6.5 Riparian Zone Restoration

Reclamation proposes to implement riparian zone restoration actions along 3 miles of streambank within the Bear Creek watershed to enhance water quality conditions for coho salmon. Riparian zone conditions in Bear Creek are currently degraded, contributing high summer water temperatures in Bear Creek. The objective of the riparian zone management plan is to improve the utility of existing habitat by improving riparian zone conditions in select areas the Bear Creek and Little Butte Creek watersheds.

Within one year of the BiOp, Reclamation will submit to NOAA Fisheries a riparian zone management plan. Proposed management actions will focus on vegetation plantings along Emigrant, Neil, and Bear creeks in areas above and below the Oak Street Diversion Dam near Ashland. Areas selected for vegetation plantings will be coordinated through willing landowners and will focus on stream zones where vegetation growth can provide shade, food resources, and eventual stream structural elements to the stream channel. The Riparian Zone Management Plan will describe the proposed planting schedule, amount, timing, and composition of vegetation proposed for planting. This Riparian Management Plan will be developed in cooperation with NOAA Fisheries and consultants to ensure that the water quality enhancement objectives of any riparian zone planting actions provide short- and long-term benefits to aquatic habitat in general and coho salmon in particular. It is Reclamation's intent that elements of the Riparian Management Plan will be phased in over the period of 2012 to 2017, contingent on availability of funding. This is considered a reasonably attainable timeframe for implementation based on Reclamation ESA program needs and priorities and assuming a continuation of historical funding levels.

The ultimate implementation of Riparian Zone Restoration Plan is dependent on the cooperation of private landowners and the availability of congressionally appropriated funds. Reclamation has evaluated the size and scope of this activity and does not believe the cooperation of willing landowners will be a substantial impediment to accomplishing the goals of this activity. Reclamation has also performed a preliminary cost estimate of this activity and believes it can be implemented assuming a continuation of historical funding levels.

2.6.6 Water Conservation

The Districts have undertaken numerous water conservation, system efficiency improvement, and fish habitat protection projects since 1996 (Appendix F). Those efforts have included piping irrigation laterals, installation of measurement devices, installation of fish passage and screening devices on Bear Creek and several tributary diversions, and improved instrumentation and automation of canal diversions. These system efficiency improvement projects will continue to be implemented in the future and will result in additional water conservation savings for the Districts.

Reclamation and the Districts are proposing to continue this water conservation strategy over the next 10-year period. This section of the new proposed action describes some of the actions that are currently proposed for completion within the next 5-year period by a cooperative effort of the Districts and Reclamation. These projects define a water conservation target in acre-feet of water savings within a 5-year timeframe, which is the maximum length of time that we can predict with relative certainty that these conservation projects can occur. The projects that are proposed to occur during this time period were selected for their water conservation benefits but also because they provide ancillary benefits to streamflow and aquatic habitat in the Bear Creek drainage.

The Districts are currently developing several water conservation projects with the technical and financial support of Reclamation. Several of these projects have been sufficiently planned and designed so that water saving benefits from their implementation can be quantified with a reasonable degree of accuracy. In addition, these projects have been prioritized for funding according to cost benefit ratios and can be implemented within a 5-year timeframe. For example, in 2010 the Districts completed a System Optimization Review, which evaluated potential operation efficiency improvements and assessed opportunities for water conservation within water delivery systems operated by the Districts within the Project. The System Optimization Review report provided a comprehensive description of measures that could be used to improve the existing water delivery systems and evaluated the costs and water saving estimates associated with those improvements. The ultimate goal of the System Optimization Review study was to identify and prioritize water conservation projects that provide the greatest benefits to the system and ultimately, the watershed.

Other programs such as the Water for Irrigation, Streams, Economy (WISE) Project have been in the development stage in the Rogue River basin for several years. These programs also use a holistic and collaborative watershed approach to water conservation in the Rogue River basin. The WISE Project will continue to identify water conservation opportunities and funding sources to implement those identified projects in the future. These projects will be considered jointly by Reclamation and the Districts as to the cost benefit of implementation.

Since the completion of the 2010 System Optimization Review study, the Districts have conducted additional work to identify water conservation measures that incorporate a more holistic approach to water conservation and management. The Districts, in cooperation with HDR Engineering have further refined and expanded on water conservation projects that were initially identified in the System Optimization Review study and have provided feasibility level design in preparation for planned implementation in the near future.

Payne Creek Project and Removal of Ashland Diversion Dam

An example of this holistic approach to water conservation is the Payne Creek project. This project involves East Main Canal and lateral piping components that prevent seepage, spill, and evaporation losses at the end of the East Main Canal delivery system for the TID. Water conservation from this project will save enough water to allow for the removal of the diversion facility on Ashland Creek, an important tributary to Bear Creek in the City of Ashland.

Reclamation previously committed to providing fish passage at the Ashland Creek Diversion Dam in the 2009 BA (Reclamation 2009b). Reclamation had committed to implement this fish passage improvement project by 2013. NOAA Fisheries evaluated the construction of fish passage facilities at this structure in the May 2011 draft BiOp and concluded that this fish passage project would benefit coho salmon habitat if implemented (NOAA Fisheries 2011a). Although Reclamation remains committed to providing fish passage at this structure, the introduction of the Payne Creek project by TID provided a new opportunity for fish passage via complete removal of the diversion dam rather than providing fish passage through a traditional ladder or roughened channel as proposed in the 2009 BA (Reclamation 2009b). In addition to the complete removal of the Ashland Diversion Dam, implementation of the Payne Creek project would also provide for additional instream flow enhancement that was not considered in Reclamation's initial plan to provide fish passage at this structure.

Reclamation and TID propose to implement components of the Payne Creek project in phases over the next 5-year period as funding is made available through Federal and non-federal sources. The initial phases of the Payne Creek project will consist of piping large sections of the East Main Canal that have the largest water conservation savings. Other irrigation diversion canals and laterals will follow and will provide further conservation savings. In total, approximately 1,800 acre-feet of potential water conservation savings have been estimated through these main canal and lateral piping components. When sufficient amounts of water have been conserved through piping components, the Ashland Diversion Dam will be completely removed. To compensate for the loss of water diversions at Ashland Creek, TID would make commensurate water releases at Emigrant Dam to meet delivery demands of the Talent Canal at the Oak Street Diversion.

It will likely take at least 2 years to complete enough of the piping components to allow for the removal of the Ashland Creek Diversion Dam. It is anticipated that it will likely require 3 years before the Ashland Diversion Dam can be removed by Reclamation. As a result, the Ashland Diversion Dam will not be scheduled for removal until the year 2015 or 2016. This will result in a 2 year delay in Reclamation's commitment to provide fish passage at Ashland Diversion Dam. However, the ability to completely remove the diversion dam and secure instream flow in Ashland Creek is considered to be a significantly better option than the previously planned construction of fish passage around the dam and continuing to divert water out of Ashland Creek. Reclamation and TID believe the benefits that would accrue to Ashland Creek from dam removal justify the 2-year delay in project implementation at this site.

Reclamation and TID plan to cost share to complete this project as quickly as possible. It is anticipated that the project can be completed by 2016 if sufficient funds can be secured. Reclamation and TID have identified and are committing significant financial resources to this project to help achieve both water conservation and ecosystem restoration goals. The likelihood of success for achieving fishery benefits will be increased by targeting the highest priority components within the Payne Creek project that have the greatest amount of water conservation benefits first to allow for the removal of the Ashland Diversion at the earliest possible time.

2.7 Interrelated and Interdependent Actions

Effects from interrelated and interdependent actions are considered along with effects from the proposed action itself in making the overall determination of effects on ESA-listed species or critical habitat affected by the proposed action. An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. Interrelated or interdependent activities are measured against the proposed action.

The Hopkins Canal, Jackson Street Diversion Canal, Phoenix Canal, and Jackson Street Diversion Dam and Feeder Canal are privately-owned facilities; their operations are considered interrelated and interdependent due to the co-mingling of water delivered under Federal and private water rights. These facilities could be operated to deliver non-Federal water in the absence of the proposed action.

Other private facilities within the Project including Cascade Canal, Fish Lake, and Fourmile Reservoir are not considered interrelated or interdependent because these facilities 1) do not depend on the proposed action for their justification, and 2) have independent utility from the proposed action.

Chapter 3 Environmental Baseline

The environmental baseline describes the impacts of past and ongoing human and natural factors leading to the current status of the species and its critical habitat within the action area, providing a "snapshot" of the relevant species' present health and habitat. This includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 ESA consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.2). The environmental baseline assists both the action agency and NOAA Fisheries in determining the effects of the proposed action on listed species and critical habitat and whether the proposed action will jeopardize the listed species or adversely modify or destroy its critical habitat.

3.1 Fisheries

3.1.1 Current Range-wide Status of the SONCC Coho Salmon

All actions and effects included in the environmental baseline have led to the current status of SONCC coho salmon in the Rogue River basin. When the SONCC ESU was listed as threatened in 1997, long-standing human induced actions combined with natural environmental variability were believed to be major factors causing decline (62 FR 24588). Human-caused factors date back to the earliest arrivals of European settlers in the 18th Century. The first impacts were associated with beaver trapping activities and subsequently with mining, forestry, and agriculture (NOAA Fisheries 2012). The combination of both anthropogenic stressors and natural variability in marine and freshwater environmental conditions essentially impacted all phases of the fishes' life cycle in this ESU, diminishing its population numbers steadily over time. Historically, coho salmon abundance within this region was estimated from 150,000 to 400,000 native fish (62 FR 24588). In 1997, abundance was estimated to be less that 30,000 naturally reproducing coho salmon, and a vast majority of those (roughly 20,000) were considered to be non-native fish (62 FR 24588).

Since the 1997 listing, status reviews have been completed in 2005 and 2011. Data analyzed by the Biological Review Team (BRT) as part of the 2005 status did not reveal a marked change in the abundance or distribution of coho salmon (Good et al. 2005). The BRT concluded that the 2001 broodyear appeared to be one of the strongest of the last decade, following a number of relatively weak years. In the 2011 review, researchers observed that coho abundance had decreased for many SONCC coho populations since the 2005 status review (NOAA Fisheries 2011b). Available coded wire tag data of hatchery fish revealed low marine survival for the 2004 to 2006 broodyears. While this marine survival data helps identify a contributing factor for the recent low abundance data, there is not corresponding data for freshwater conditions.

Throughout the SONCC coho ESU, habitat destruction, over-utilization for commercial purposes, inadequacy of existing regulatory mechanisms for habitat and harvest management, long-term climate trends, and artificial propagation where identified listing factors and summarized at the time of listing (62 FR 24588). Stream habitat degradation from road building, logging, livestock grazing, mining, irrigation diversion, urbanization, wetlands removal, beaver trapping, channelization projects, and point and non-point source water pollution impact coho salmon survival in freshwater. Overall, the Rogue River basin, its tributaries, and riparian areas are in relatively poor condition with respect to fish habitat conditions (USFS and BLM 1997).

SONCC coho salmon, along with the region's other salmon and steelhead species, historically supported major commercial and sport fisheries. Overfishing of coho salmon was sanctioned from the mid-1970s to the mid-1990s during a time when poor ocean conditions resulted in poor salmon growth and survival; consequently, overharvesting contributed heavily to the decline in coho salmon populations. In 1996, coho-directed commercial fishing was banned off the California's coast. In 2008 and 2009, all salmon fisheries south of Cape Falcon, Oregon were closed, bringing the exploitation rate down from approximately 6 percent to 1 to 3 percent (NOAA Fisheries 2011b). In 1994, recreational harvest of SONCC coho was banned, with the exception of a recent mark-selective recreational coho salmon fishery in the Rogue River and Oregon Coastal waters. The Pacific Fisheries Management Council (PFMC) estimated that 3.3 percent of coho accidentally caught in this mark-selective fishery would die after release (PFMC 2007 in NOAA Fisheries 2011b).

Hatchery and fishery management plus regulatory practices prior to the listing often worked against preservation of wild coho salmon populations (62 FR 24588). In addition to hatchery-related problems identified as listing factors at the time of listing (genetic impacts, disease transmission, predation, and competition), the combination of hatchery programs and harvest policies caused wild coho populations to decline. Coho salmon fisheries during the mid-1970s to the mid-1990s consisted of a meager wild fish component mixed with a much more abundant, artificially-produced hatchery population of coho salmon. The greater numbers of hatchery fish within these fisheries could not be distinguished from fish produced in nature. This allowed for excessive harvest on declining wild fish stocks. In 1988, this problem was addressed when Oregon hatcheries began clipping the adipose fin of all released juvenile coho salmon (Jacobs et al. 2000) and ODFW began restricting harvest of wild fish.

Fluctuating ocean conditions, in particular the Pacific Decadal Oscillation, produced alternating periods of good and poor ocean productivity and environmental conditions that affected the survival of anadromous salmonids (62 FR 24588). Ocean conditions and cold, nutrient-rich upwelling currents stimulate and enhance phytoplankton and zooplankton production which directly benefit prey animals that coho salmon feed upon. Numerous El Niño climate occurrences in recent decades have depressed upwelling currents, resulting in reduced coho salmon growth rates and survival. El Niño-Southern Oscillation events are superimposed over the longer-term Pacific Decadal Oscillation to affect ocean productivity. Droughts and flooding over time added to the adverse impacts to naturally occurring anadromous fish runs and caused most wild Pacific Coast coho salmon populations to be listed or considered for listing under the ESA.

NOAA Fisheries 2011 status review identified new threats to the SONCC coho salmon ESU since the 1997 listing. These threats included the invasive plant species reed canary grass (*Phalaris arundinacea*) and long-term climate change. Reed canary grass is present throughout southern Oregon and northern California and negatively impacts coho by inhibiting native riparian growth, choking stream channels, and increasing sedimentation. The 2011 status review also concluded from new information available since the time of listing that climate change poses a new threat to the long-term viability and recovery of salmon. This ESU may be at particular risk since it is near the southern end of the species' distribution and many populations occupy degraded streams that have water temperatures near the upper limits of thermal tolerance for the species (NOAA Fisheries 2011b).

3.1.2 Current Status of Upper Rogue River Subbasin Independent Population

The Project lies within the upper Rogue River (URR) subbasin of the SONCC coho salmon ESU (Figure 3-1). The URR subbasin population is part of Interior Rogue diversity strata of the SONCC coho ESU and has been identified as a functionally independent population (Williams et al. 2008). A functionally independent population has a high likelihood to persist over a 100-year time scale and "whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations" (Williams et al. 2006; McElhany et al. 2000). The Draft SONCC coho salmon recovery plan (NOAA Fisheries 2012) identifies that 16,100 spawners in the URR population are required for ESU viability.

Streams inhabited by SONCC coho salmon and influenced by Project operations include Little Butte Creek and Bear Creek watersheds (Figure 3-2). Multiple reviews have been conducted to evaluate the status of the SONCC ESU coho salmon and specifically for the URR coho salmon population. For the purposes of the environmental baseline, each relevant report is summarized below to identify the range of analysis that has been completed.

The West Coast Coho Salmon BRT conducted an analysis of the SONCC coho salmon (BRT 2003) utilizing a risk-matrix method reflective of the four major criteria identified in the NOAA Fisheries Viable Salmonid Population document (McElhany et al. 2007). The four criteria are abundance, growth rate/productivity, spatial structure, and diversity. The BRT concluded that positive upward trends in mean spawner abundance in the Rogue River reflect the effects of reduced harvest rather than improved freshwater conditions and productivity since trends in pre-harvest recruits are flat. The overall risk assessment by the BRT concluded the SONCC ESU coho salmon are likely to become endangered based on extinction risk determinations listed in Table 3-1.

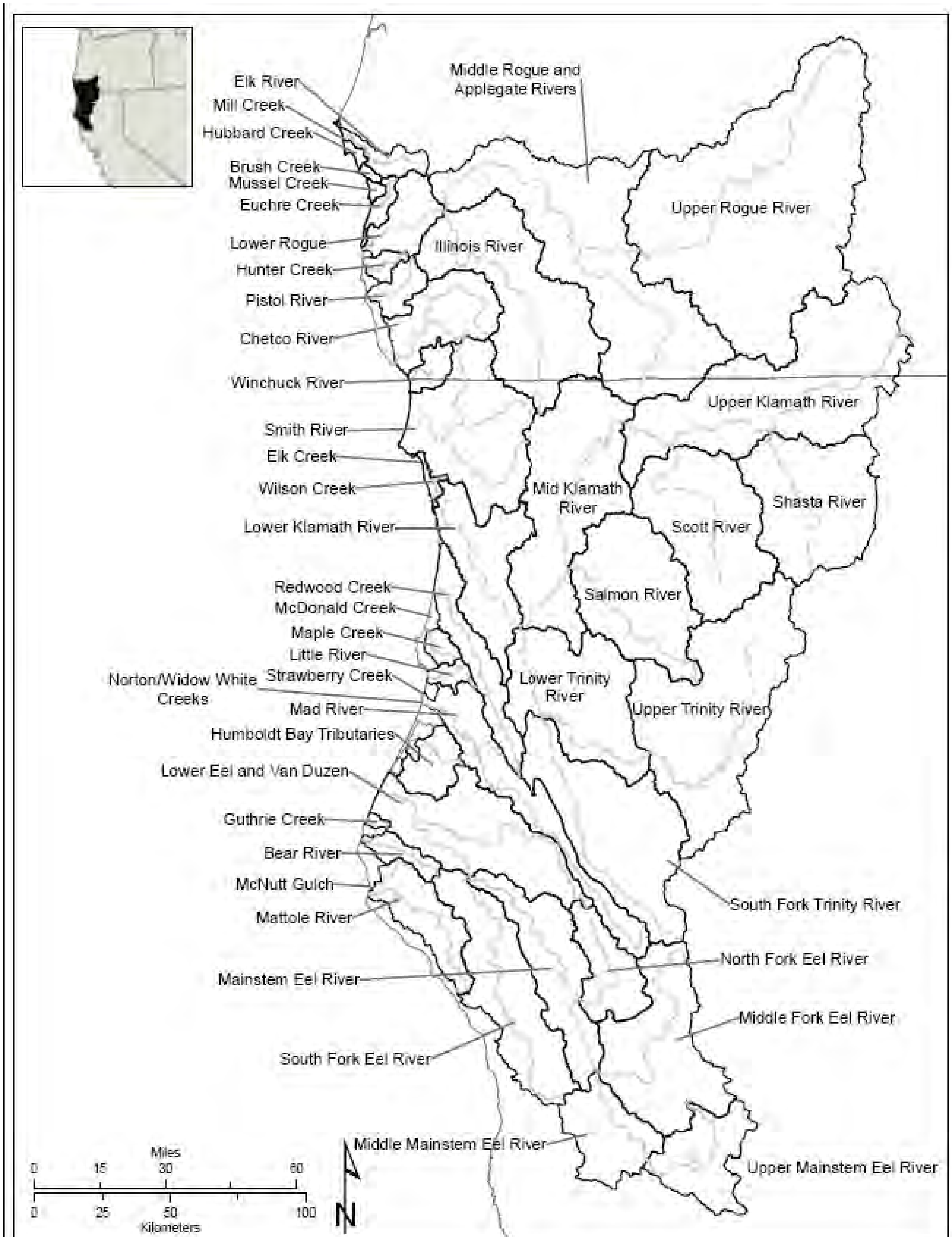


Figure 3-1. SONCC coho salmon ESU and historic population structure distribution (Williams et al. 2006).

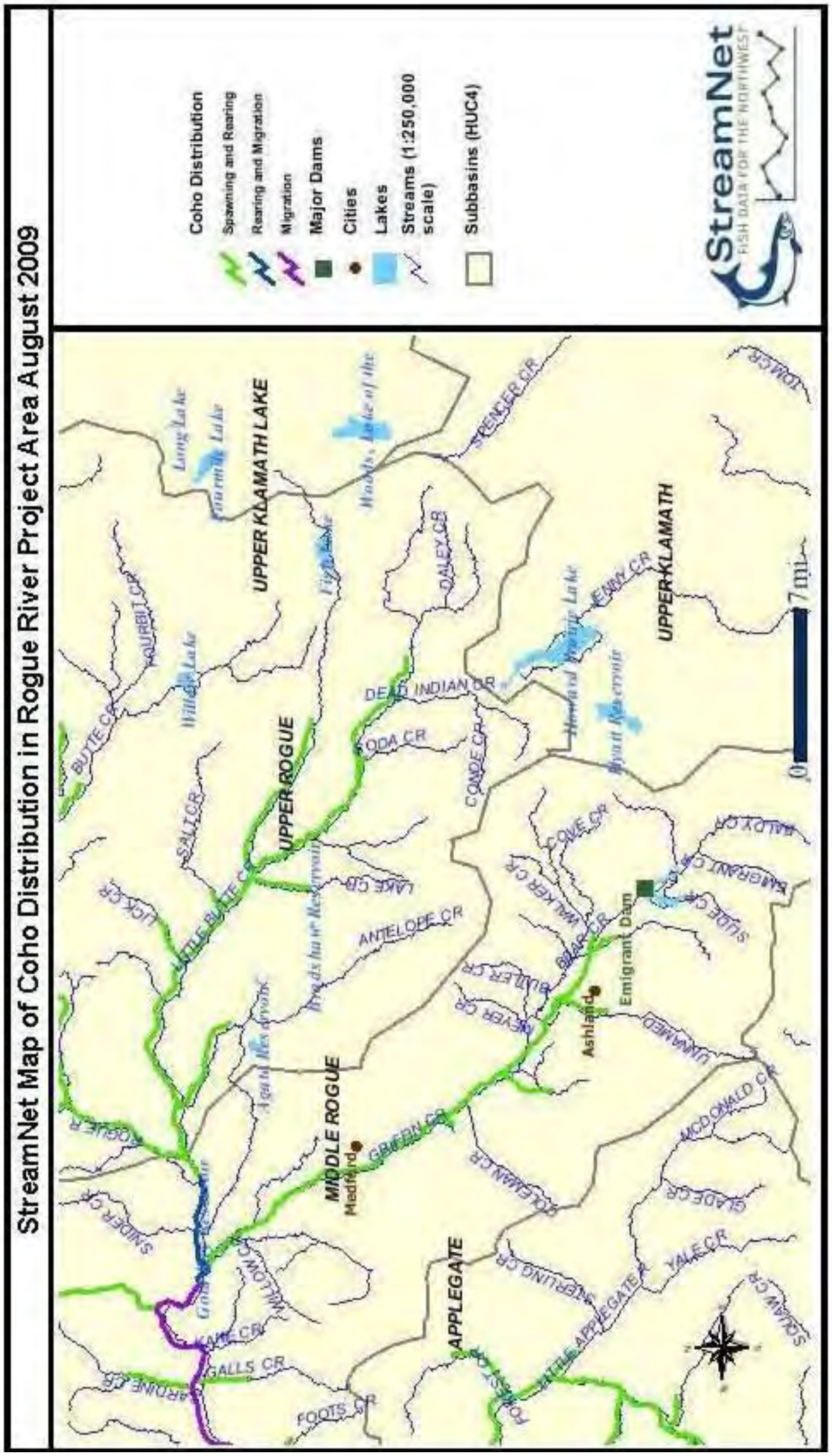


Figure 3-2. Distribution of coho salmon in Little Butte Creek and Bear Creek watersheds (streamnet.org, August 7, 2009).

Good et al. (2005) recognized that the Rogue River stock had an average increase in spawners over the last several years despite two low years (1998 and 1999), and that proposed hatchery reforms were expected to have a positive effect in the Rogue River basin. Yet, the BRT concluded that the new data does not contradict conclusions reached previously by the 2003 BRT Viable Salmonid Population analysis that the SONCC ESU is likely to become endangered in the foreseeable future. The BRT also indicated that the recent data (1995 to 2002) does not suggest any marked change, either positive or negative, in the abundance or distribution of coho salmon within the SONCC ESU (Good et al. 2005). Risk factors identified in previous status reviews that continue to be of concern to the BRT include severe declines from historical run sizes, the apparent frequency of local extinctions, long-term trends that are apparently moving downward, and degraded freshwater habitat and its associated reduction in carrying capacity.

Table 3-1. List of BRT (2003) SONCC ESU Viable Salmonid Population analysis criterion and extinction risk determination.

Criterion	Extinction Risk Determination
Abundance	Moderate
Growth rate/productivity	Moderate
Spatial Structure and Connectivity	Low
Diversity	Low

In 2005, the Oregon Native Fish Status Report was conducted by ODFW. It concluded that the Rogue River coho salmon Species Management Unit was not at risk, an area that includes the URR population. ODFW did not use the Viable Salmonid Population analysis framework established by NOAA Fisheries, but used criteria and data that consisted of:

- Existing Populations – annual seining surveys near Huntley Park near the mouth of the Rogue River, upstream of Gold Beach.
- Habitat Use Distribution – percentage of accessible miles.
- Abundance – Huntley Park seine mark-recapture estimates adjusted to account for harvest of hatchery and wild fish above the park since 1980.
- Productivity - Huntley Park seine mark-recapture estimates less harvest of wild fish above the park since 1994.

- Reproductive Independence – ratio of hatchery to naturally-produced spawners estimated during stratified random spawning surveys.
- Hybridization – not an issue for Rogue coho salmon.

In their report, ODFW considered all six interim criteria to be "Not at Risk" for the Rogue coho salmon Species Management Unit (ODFW 2005).

A viability assessment of the SONCC coho salmon in the URR population was recently completed by GeoEngineers on behalf of the Districts (GeoEngineers 2008a). It utilized the NOAA Fisheries Technical Review Team framework and criteria to conduct the analysis for determination of the extinction risk (Williams et al. 2008). The report concluded that the URR population is currently at a low risk of extinction based on the viability assessment as the population trends have significantly increased in abundance over the last four generations. The risk of extinction would remain at a low risk in the foreseeable future due to substantially reduced harvest levels which would remain low because of State and Federal regulations. Additionally, the report suggests that there is a strong indication of a resilient population that has the ability to recover from extended periods of lower abundance as related to poor ocean conditions based on the abundance trends for the past 65 years. The criteria and extinction risk determinations from the viability assessment are listed in Table 3-2.

Table 3-2. List of GeoEngineers (2008a) viability assessment of the URR coho salmon population criteria and extinction risk determination.

Criterion	Extinction Risk Determination
Effective Population Size	Low
Population Size Per Generation	Low
Population Decline	Low
Catastrophe, rate and effect	Low
Spatial Structure and Diversity	Moderate
Hatchery Influence	Low

The most current framework utilized for assessing viability is the *Framework for Assessing Viability of Threatened Coho Salmon in the Southern Oregon/Northern California Coast Evolutionarily Significant Unit* (Williams et al. 2008). This report does not assess the viability for the SONCC coho salmon for each subbasin, but provides the framework and tools for practitioners such as GeoEngineers (2008a). The report provides an example for determining the extinction risk of the URR population for each of the criteria and the overall extinction risk. Both reports utilized the same Gold Ray Dam data set for their analysis

(Table 3-3). The extinction risk for the URR population unit example is listed in Table 3-4 with the overall extinction risk identified as moderate since the framework and approach classify a population's overall risk factor based on the highest risk determination in any category (Williams et al. 2008).

Researchers did not evaluate extinction risk on the population level during their 2011 status review. At this time, researchers noted that two extensive time series for coho abundance data in the Rogue River basin showed recent negative trends, though neither was statistically significant (NOAA Fisheries 2012). Taken together, the multiples reviews indicate that the range of extinction risk for the URR population of SONCC coho salmon is low to moderate.

Table 3-3. Number of wild, hatchery, and total coho salmon counted at Gold Ray Dam, 1942 to 2007 (compiled from GeoEngineer 2008a).

Year	Number of Wild Coho Salmon	Number of Hatchery Coho Salmon	Total Coho Salmon
1942	4,608	0	4,608
1943	3,290	0	3,290
1944	3,230	0	3,230
1945	1,907	0	1,907
1946	3,840	0	3,840
1947	5,340	0	5,340
1948	1,764	0	1,764
1949	9,440	0	9,440
1950	2,007	0	2,007
1951	2,738	0	2,738
1952	320	0	320
1953	1,453	0	1,453
1954	2,138	0	2,138
1955	480	0	480
1956	421	0	421
1957	1,075	0	1,075
1958	732	0	732
1959	371	0	371
1960	1,851	0	1,851
1961	232	0	232
1962	457	0	457
1963	3,831	0	3,831
1964	168	0	168
1965	482	0	482
1966	178	0	178
1967	89	0	89

Year	Number of Wild Coho Salmon	Number of Hatchery Coho Salmon	Total Coho Salmon
1968	149	0	149
1969	530	0	530
1970	160	0	160
1971	181	0	181
1972	185	0	185
1973	193	0	193
1974	146	0	146
1975	154	0	154
1976	44	0	44
1977	52	464	516
1978	240	511	751
1979	236	1,505	1,741
1980	1,608	3,919	5,527
1981	3,055	3,670	6,725
1982	591	79	670
1983	796	697	1,493
1984	2,203	1,033	3,236
1985	411	759	1,170
1986	591	3,481	4,072
1987	1,537	3,858	5,395
1988	3,545	3,337	6,882
1989	253	1,148	1,401
1990	331	366	697
1991	699	1,863	2,562
1992	1,770	2,236	4,006
1993	1,106	2,380	3,486
1994	3,244	7,455	10,699
1995	2,570	10,948	13,518
1996	2,572	11,027	13,599
1997	4,587	11,163	15,750
1998	1,325	4,717	6,042
1999	1,417	6,305	7,722
2000	15,460	13,331	28,791
2001	12,577	20,385	32,962
2002	11,335	22,819	34,154
2003	6,644	10,535	17,179
2004	11,918	9,784	21,702
2005	6,901	7,731	14,632

Year	Number of Wild Coho Salmon	Number of Hatchery Coho Salmon	Total Coho Salmon
2006	4,866	6,502	11,368
2007	4,524	4,211	8,735

Table 3-4. Williams et al. (2008) report identified the extinction risk determination for the URR population example.

Criterion	Extinction Risk Determination
Effective Population Size	Low
Population Size Per Generation	Low
Population Decline	Low
Catastrophe, rate and effect	Low
Spawner Density	Moderate
Hatchery Influence	Moderate

Recently, three major dams that impeded fish passage on the Rogue River were removed: Gold Hill Dam (2008), Savage Rapids Dam (2009), and Gold Ray Dam (2010). In the ESA consultations completed for the removal of these dams, NOAA Fisheries projected that these projects would improve fish production in the URR. Williams et al. (2008) extinction risk evaluation was completed prior to the removal of these dams, and does not address benefits from dam removal. Although sufficient time has not passed to identify increases in adult returns to the Bear Creek or Little Butte Creek watersheds as a result of dam removals, they will likely have a substantial influence on adult returns in the near future. Monitoring is underway and is necessary to determine how returning adults distribute in the URR basin in response to dam removal.

Current Status of Bear Creek Subpopulation

While historically Bear Creek is believed to have contained high quality intrinsic potential coho habitat, high water temperatures and habitat degradation currently limit coho use of these areas (NOAA Fisheries 2012). Additionally, past surveys suggest that historically Bear Creek was not used extensively by spawning coho. Just prior to initiation of the Project, the U.S. Fish and Wildlife Service (USFWS) conducted spawning surveys for anadromous fish in the Rogue River basin (USFWS circa 1955). These surveys included coho salmon spawning surveys in Bear Creek. Surveys in 1949 to 1950, 1951 to 1952, 1953 to 1954, and 1954 to 1955 did not identify any coho salmon redds in the stream reaches surveyed along Bear Creek. No survey results were reported for 1950 to 1951. Based on their spawning surveys, USFWS reported that Bear Creek did not support coho salmon and identified it as a steelhead-only system. Based on the survey reports, it does not appear that the surveys were conducted in a manner that would definitively demonstrate that there was absolutely no use of Bear Creek or its tributaries by coho salmon in those years. On the other hand, the surveys were conducted by trained observers who identified spawning coho salmon in many other stream reaches in the URR basin and who appeared to be familiar with the basin. It seems unlikely that those conducting those spawning surveys simply missed large numbers of spawning coho salmon in Bear Creek. Rather it appears that prior to the advent of the Federal project, coho salmon were not using Bear Creek in large numbers.

More recent survey work investigated juvenile presence in Bear Creek. No juvenile coho salmon were observed during summer sampling conducted between 1998 and 2004 (NOAA Fisheries 2012). It was hypothesized that high water temperatures and habitat degradation may preclude juvenile coho occupancy during this period. However, there are observations of juvenile coho presence earlier in the spring, when water temperatures are lower. Between 2001 and 2006, ODFW installed a rotary screw trap in Bear Creek near its confluence with the Rogue River to collect salmon and steelhead smolts (Vogt 2001). This was installed each year in March and remained in place until June when flows become too low for effective operation. Trapping in Bear Creek resulted in coho salmon smolt production estimates of 100 in 2001; 2,194 in 2002; and 197 in 2003 (Doino 2006). No coho salmon smolts were captured in 2004 or 2005 in Bear Creek. In 2006, ODFW captured 212 coho salmon smolts in Bear Creek near Phoenix for an estimated outmigrant total of 1,843 (ODFW database). ODFW estimates that coho salmon production is approximately 3.7 coho salmon smolts per mile of habitat in the Bear Creek mainstem (Vogt 2004).

Similarly, coho use does not appear to be extensive in tributaries to Bear Creek. In a preliminary study conducted, the smolt production for the Bear Creek watershed is primarily located in the tributary streams of Bear Creek such as Neil and Ashland creeks and the upper reaches of the mainstem Bear Creek. Smolt production in this watershed is limited by summer habitat (Nickelson 2008). The StreamNet map (Figure 3-2) illustrates that coho salmon are not present in Emigrant Creek. An occasional live coho salmon or adult carcass may be found although few data sets exist to evaluate abundance and distribution patterns of coho salmon in the Bear Creek watershed through time. For instance, only one juvenile coho salmon was captured in 1997 and 1998 during Reclamation's summer electrofishing surveys in six sections of mainstem Bear Creek and six tributary reaches (Broderick 2000). Some limited evidence of past coho salmon spawning is noted in Ashland, Neil, and Wagner creeks as indicated on the coho salmon distribution map in Figure 3-1. Summer steelhead and fall Chinook salmon are more abundant and spawning is regularly documented.

Current Status of Little Butte Creek Subpopulation

The Little Butte Creek watershed provides some of the best coho salmon production in the Rogue River basin. Approximately 50 to 75 percent of the coho salmon smolt production for the URR coho salmon population occurs in the Little Butte Creek watershed (Vogt 2004; GeoEngineers 2008b). Several stream reaches within the Little Butte Creek watershed, similar to other Rogue River basin coho salmon streams, were sampled annually under the ODFW Coastal Salmonid Inventory Project to assess wild coho salmon spawning. Sampling occurred in the North Fork, South Fork, Soda Creek, Lake Creek, and Dead Indian Creek drainages of Little Butte Creek. Sampling surveys were done each year during the November to January spawning period (Jacobs et al. 2000). The purpose of these surveys was to gather data to help estimate Rogue River basin-wide escapement and correlate the incidence of spawning with habitat conditions and smolt production. The Little Butte Creek watershed contains some of the better spawning returns in the entire Rogue River basin and, from 1996 to 2000, this stream averaged 15 coho salmon spawners per mile (ODFW 2001a). This represents the highest average density of coho salmon spawners of all Rogue River basin areas sampled.

The Little Butte Creek reaches surveyed each year were randomly selected so the full range of spawning habitat is represented (ODFW 2001b). Once started, surveys were repeated in the select reaches about every 10 days regardless of streamflow conditions. The primary objective was to count spawning coho salmon. Redds were also visually counted and spawned-out carcasses were tallied.

This survey approach does not yield a precise estimate of spawner escapement to the stream because only randomly selected stream reaches were inventoried and observations were dependent on water clarity and flow levels; however, over a period of years, the method provides a relative and valuable indication of coho salmon spawning. Spawning surveys completed by ODFW in the URR tributaries indicate that coho salmon primarily enter tributaries in November, which is consistent with timing of most passage at Gold Ray Dam (Table 3-5). Cumulatively over the 8-year period, 45 adult coho salmon were observed in Little Butte Creek during these surveys.

Table 3-5. First and last dates coho salmon observed during spawning surveys conducted by ODFW, 1996-2004. Data provided by Briana Sounheim, Corvallis Research Office, September 2007 to Rich Piaskowski, GeoEngineers, Inc.

Watershed	n	First Date	Last Date
Big Butte Creek	12	11/3	2/15
Evans Creek	75	11/14	2/2
Little Butte Creek	45	11/25	2/1
Mainstream Tributaries	44	11/26	2/15

A cooperative ODFW, Bureau of Land Management (BLM), and U.S. Forest Service (USFS) coho salmon and steelhead smolt trapping project that began in March 1998 validates that Little Butte Creek is an important producer of wild coho salmon. Trapping has been conducted on six URR basin streams, including Big Butte Creek, Little Butte Creek (action area stream), West Fork Evans Creek, Slate Creek, South Fork Big Butte Creek, and Little Applegate River. The objectives of this project are to:

- Estimate coho salmon and steelhead smolt production in the sampled streams.
- Determine smolt migration timing.
- Determine the size of migrating smolts (Jacobs et al. 2000).

For the cooperative study, an irrigation diversion canal near Eagle Point fitted with a rotary fish screen, bypass pipe, and collection trap was used to capture downstream migrating smolts on Little Butte Creek. Rotary screw traps were also used at other stream trapping locations. The sampling period ran from March 1 to June 30, if streamflow permitted. The traps were checked daily and fish were identified to species and life stage, enumerated, and measured. To estimate trapping efficiency, a subsample of coho salmon over 2.4 inches was marked with a caudal fin clip, transported back upstream, and released. Trapping efficiency estimates derived from the proportion of marked fish that were recaptured were used to estimate overall coho salmon smolt abundance in the stream. In 2004, coho salmon smolts abundance in Little Butte Creek was estimated to be 18,383 (Table 3-6). Aside from the 1998 trapping season, Little Butte Creek has consistently produced the highest number of coho salmon smolts per mile of habitat each year of this ODFW study (Figure 3-3).

Coho salmon smolt outmigration trap results that include Little Butte Creek are summarized in Figure 3-4 through Figure 3-6 for 1999, 2000, and 2004, respectively. Peak emigration in Little Butte Creek occurs in early May according to the figures.

Table 3-6. 2004 coho salmon smolt trap efficiencies and population estimates for each trip site (Vogt 2004).

Stream	Dates Trapped	Number of Days Trapped	Number of Coho Captured	Number of Coho Marked	Number of Coho Recaptured	Trapping Efficiency	Population Estimate	95 Percent Confidence Interval
Little Butte	3/1 – 6/23	115	5,423	1,995	589	30 %	18,383	17,045 – 19,721
Bear Creek	3/1 – 6/16	106*	0	0	0	NA	NA	NA
West Evans	3/1 – 5/13	74	1,172	943	147	16 %	7,513	6,293 – 8,733
Elk Creek	3/1 – 6/12	103*	1,862	1,460	524	36 %	5,187	4,784 – 5,590
L Applegate	3/1 – 6/23	113*	0	0	0	NA	NA	NA
Slate	3/1 – 5/13	74	185	183	16	9 %	2,126	794 – 3,458

*Trap disabled one or more days by high flows/debris.

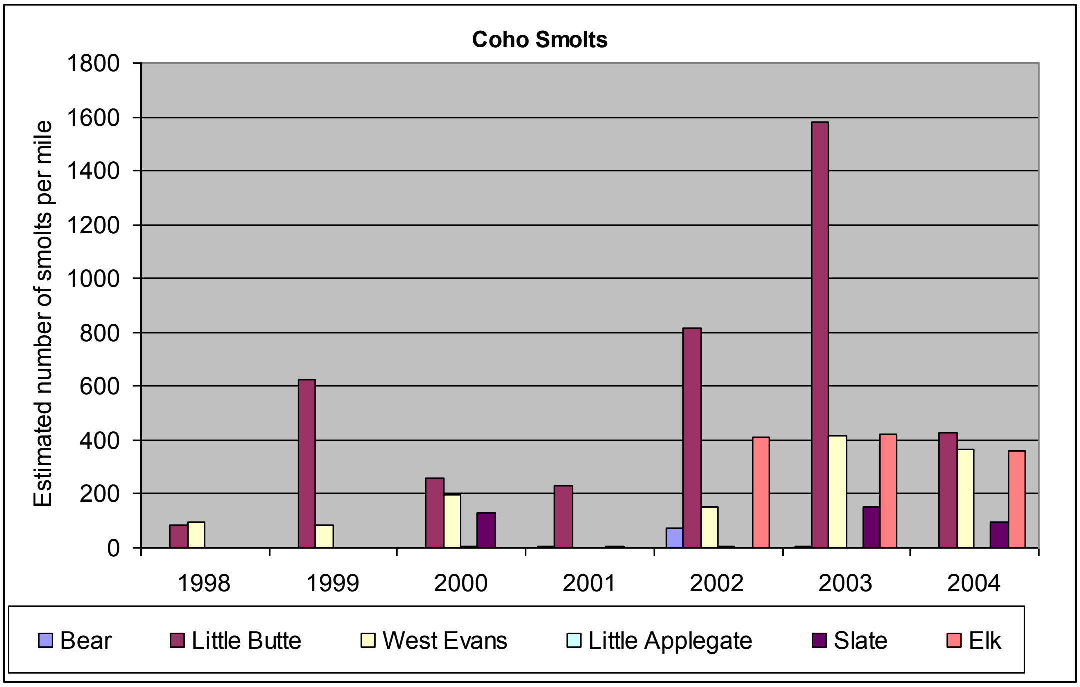


Figure 3-3. Annual estimated numbers of coho salmon smolt per mile from various creeks in the URR basin, 1998-2004. (Vogt 2004)

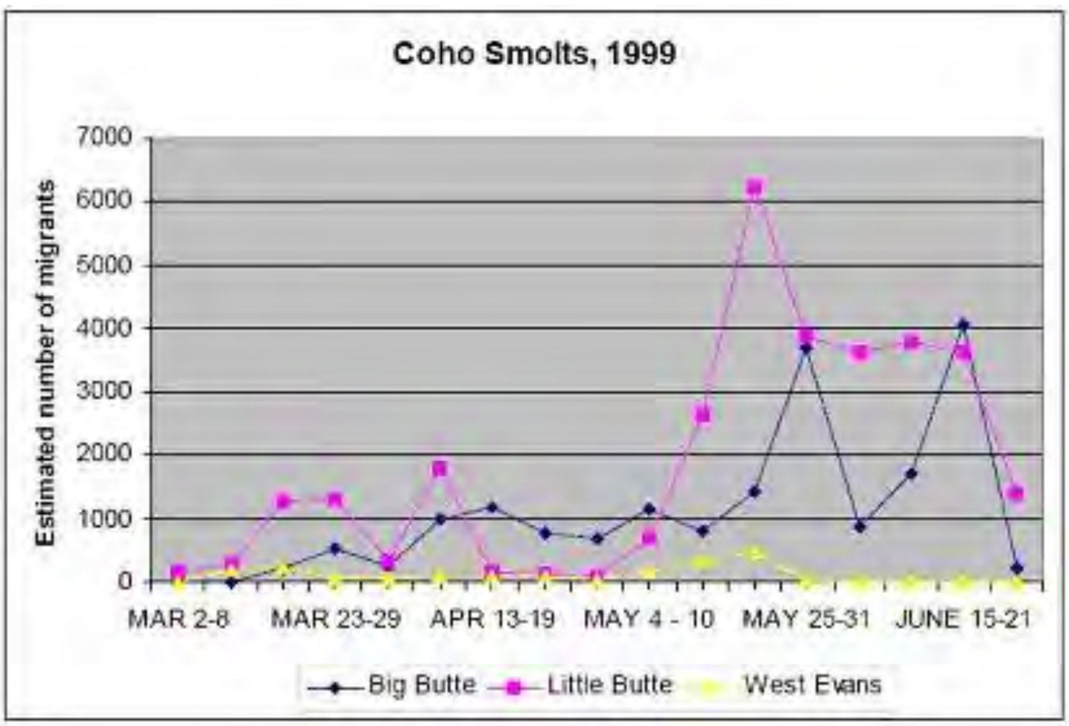


Figure 3-4. Estimated number of coho salmon smolts out-migrating weekly from various creeks in the URR basin, 1999 (Vogt 1999).

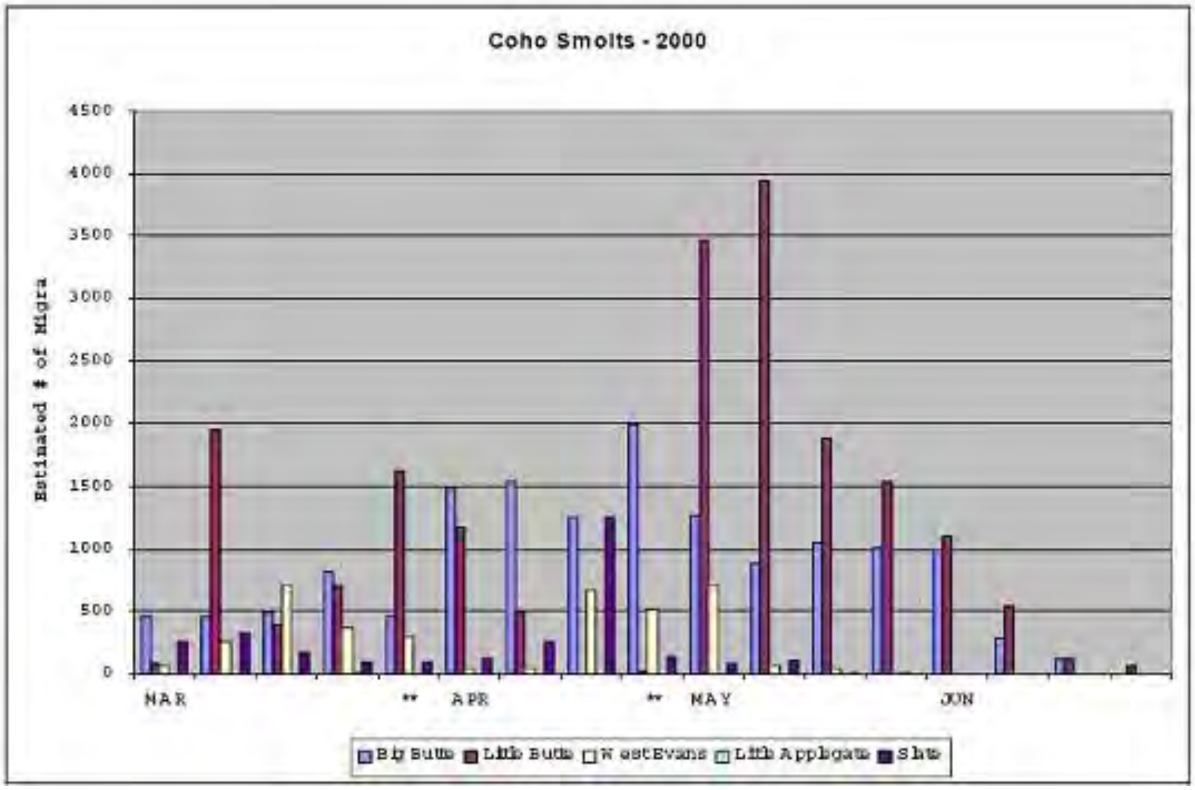


Figure 3-5. Estimated number of coho salmon smolts out-migrating weekly from various creeks in the URR basin, 2000 (Vogt 2000).

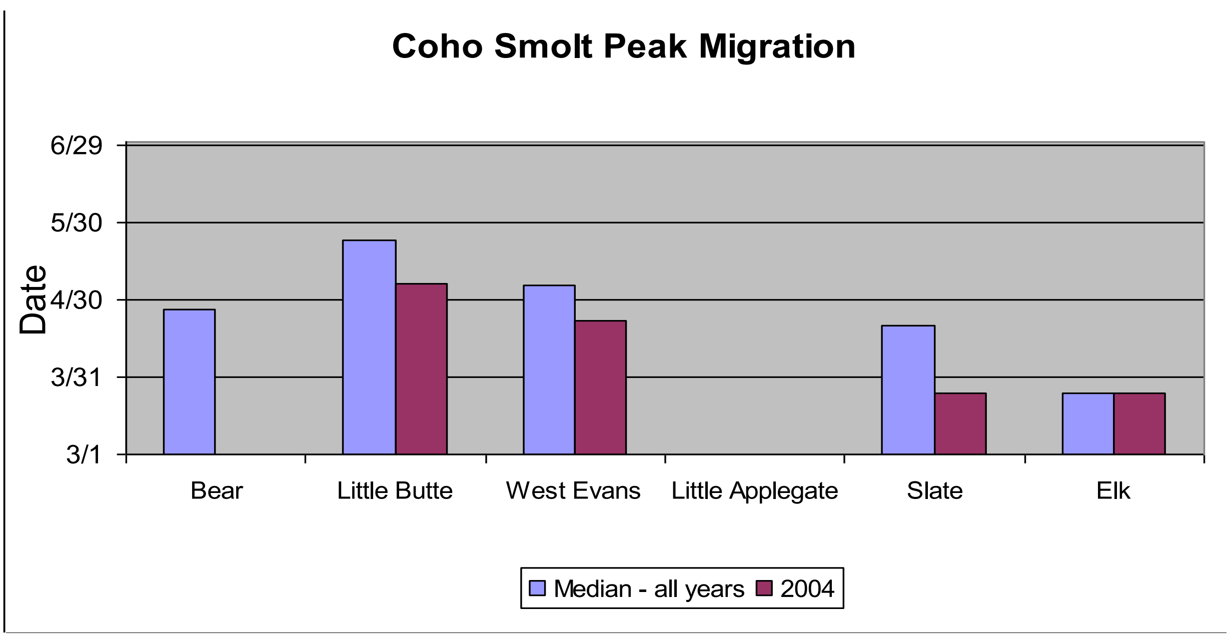


Figure 3-6. Estimated number of coho salmon smolts out-migrating weekly from various creeks in the URR basin, 2004 (Vogt 2004).

Fish surveys were conducted by Reclamation during mid-to-late summer in 1997 and 1998 to supplement ODFW data on salmon and trout distribution and relative abundance in Bear Creek and Little Butte Creek drainages (Broderick 2000). During the survey, two coho salmon juveniles were captured in Little Butte Creek at the Brownsboro Bridge site. In 2006, Reclamation observed juvenile coho salmon in a pool located at the selected PHABSIM study site on South Fork Little Butte Creek where a coho salmon redd had been flagged during a January 2005 spawning survey (Sutton 2007a).

Current Status of Klamath Basin Subpopulation

Anadromous salmonids in the Klamath River are restricted to the mainstem Klamath River and tributaries below Iron Gate Dam. Jenny Creek is located upstream of Iron Gate Dam and is not accessible to coho salmon. No passage facilities exist at Iron Gate or Copco dams, which are owned and operated by PacifiCorp.

Coho salmon still occur in the Klamath River and its tributaries below Iron Gate Dam (CH2M Hill 1985; Hassler et al. 1991). Between Seiad Valley and Iron Gate Dam, coho salmon populations are believed to occur in Bogus Creek, Shasta River, Humbug Creek, Empire Creek, Beaver Creek, Horse Creek, and Scott River (NMFS 1999). Between Orleans and Seiad Valley, coho salmon populations are believed to occur in Seiad Creek, Grider Creek, Thompson Creek, Indian Creek, Elk Creek, Clear Creek, Dillon Creek (suspected), and Salmon River (NMFS 1999). Finally, between Orleans and Klamath (mouth of the river), coho salmon populations are believed to occur in Camp Creek, Red Cap Creek, Trinity River, Turwar Creek, Blue Creek, Tectah Creek, and Pine Creek (NMFS 1999). It is estimated that the Shasta River presently maintains approximately 38 miles of coho salmon habitat, which is below predevelopment levels (INSE 1999). Available data suggests that existing coho salmon habitat in the Scott River now constitutes approximately 88 miles of the river (INSE 1999).

Unscreened or ineffectively screened diversions are common in the Shasta and Scott Rivers, resulting in substantial entrainment and fish stranding. Downstream migrants are also trapped in pools or side channels when streamflows drop sharply during early summer and soon die from high temperatures, lack of food, or predation. Some portions of streams often become entirely dewatered due to diversions. Coho salmon juveniles are very susceptible to diversions because they need to spend at least one full summer in the stream.

Coho Salmon Abundance in the Klamath River Basin

Limited information exists regarding present coho salmon abundance in the Klamath River basin. Adult counts in a few Klamath River tributaries and juvenile trapping on the Klamath River mainstem and tributaries provide valuable information on the presence of coho salmon in specific areas during key time periods which gives an indication of the low abundance and the status of coho salmon populations in the Klamath River basin. However, they are less valuable for determining population status or trends (NOAA Fisheries 2001).

Adult Data

Within the SONCC coho ESU, the longest time series at the population scale is in the Shasta River. Recent adult coho salmon abundance information, summarized in Table 3-7 and Figure 3-7 (NOAA Fisheries 2007, NOAA Fisheries 2011b), shows a significant negative trend for the Shasta River Population. In the Shasta and Scott Rivers, data suggest the 2004 adult returning brood year class was the strongest in recent years, while the 2005 and 2006 brood year class abundances were extremely depressed. Available data for the Shasta River 2008 to 2010 brood years indicates extremely depressed numbers in these years as well.

Table 3-7. Klamath River basin adult coho salmon abundance information, 2002-2006 (NOAA Fisheries 2007).

Year	Yurok Tribal Harvest[1]	Trinity River Weir[2]	Scott River Live Fish or Redd Counts[1]	Shasta River Video Weir[1]	Bogus Creek Fish Counting Facility[1]	Iron Gate Hatchery Returns
2002	486	14,307	17[3]	86	n/a	1,193
2003	343	25,651	8[3]	187	n/a	1,317
2004	1,540	35,209	1,577[3]	373	414	1,495
2005	n/a	28,267	23[4]	69	114	1,384
2006		20,162	7[4]	45	35	332

[1] Annual effort not consistent between years (Yurok Tribal Fisheries Department).
[2] Estimated escapement abundance extrapolated from weir observations (CDFG).
[3] Live fish counts.
[4] Redd counts.

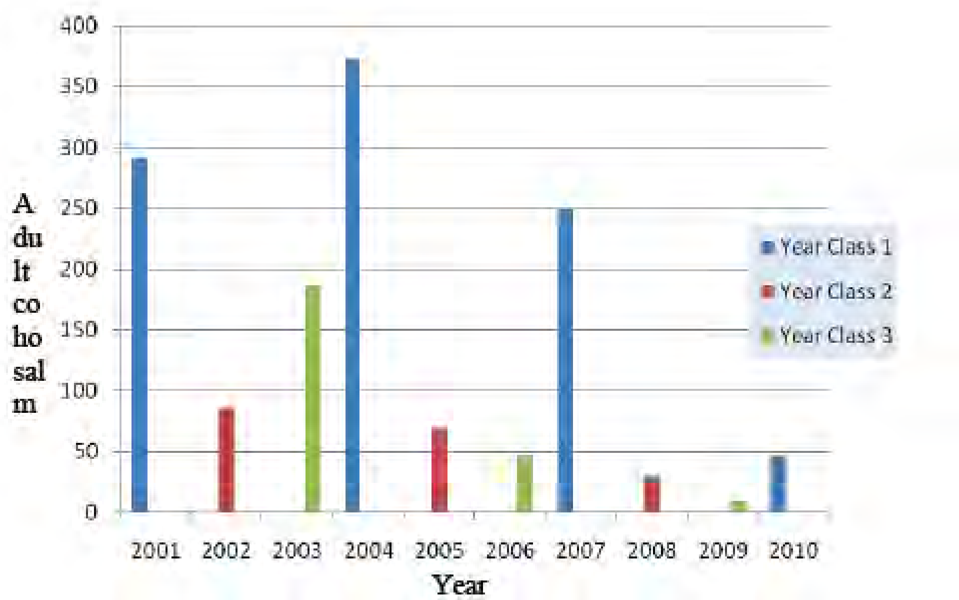


Figure 3-7. Video weir estimates of adult coho salmon abundance in the Shasta River independent population, 2001-2010 (graph presented in NOAA Fisheries 2011b status review, composed of data from M. Knechtle, CDFG).

On average in the Trinity River, over 90 percent of coho salmon spawning between Willow Creek and Lewiston Dam are of hatchery origin (NOAA Fisheries 2007). Estimates of naturally-produced coho salmon are only available since the 1997 return year, after the hatcheries started marking 100 percent of the hatchery coho salmon. The results of counting for the 1997 to 1998, 1998 to 1999, and 1999 to 2000 seasons yielded an estimated 198, 1,001, and 491, respectively, naturally produced adult coho salmon (CDFG 2000). Coho salmon were first observed at the Trinity River weir during the week of September 10 during the 1999 to 2000 trapping season (CDFG 2000). Data from 1997 through 2005 indicate coho salmon runs have generally been higher than average during recent years, although wild fish continue to represent a very small portion of the overall run (NOAA Fisheries 2007).

Low numbers of adult coho salmon redds have been observed in the Iron Gate Dam to Indian Creek reach of the mainstem Klamath River (Table 3-8). These documented cases of mainstem coho salmon spawning indicate that the proportion of mainstem spawners may represent a small percentage of the annual adult coho salmon spawning population (NOAA Fisheries 2007).

Table 3-8. Mainstem Klamath River coho salmon redds observed during fall/winter surveys from Iron Gate Dam to Indian Creek (Magneson and Gough 2006; Slezak 2009).

Year	Number of Redds
2001	21
2002	6
2003	7
2004	6
2005	6

Juvenile Data

Smolt data suggests that Klamath basin coho salmon recruitment is very low and abundance of out-migrating young-of-the-year and smolt coho salmon is correlated to the abundance of their parent brood year class (NOAA Fisheries 2007). Juvenile traps, operated by USFWS on the Klamath River mainstem at Big Bar (RM 48), were used to estimate indices of smolt production. Based on counts from these traps between 1991 and 2000, the annual average number of wild coho salmon smolts was estimated at only 548 individuals (range 137 to 1,268) (USFWS 2000). For the same period, an average output of 2,975 wild coho salmon smolts (range 565 to 5,084) was estimated for the Trinity River at Willow Creek, within the Trinity subbasin (USFWS 2000). The incomplete trapping record provides limited information in terms of temporal trends, but it is still a useful indicator of the extremely small size of coho salmon populations in the Klamath River basin.

The USFWS operates downstream juvenile migrant traps on the mainstem Klamath River at Big Bar (RM 48). The incomplete trapping record provides limited information in terms of abundance or trends, but indicates the presence of coho salmon at different life stages during certain times of the year (NOAA Fisheries 2001). Indices of abundance are calculated from actual numbers trapped. In 2001, coho salmon smolts trapped at Big Bar between April 9 and July 22 resulted in an actual total count of 23 fish, 14 of which were considered wild (USFWS 2001). Trapping was discontinued after July 22 because of heavy algal loading in the traps.

A 1997 USFWS report and 2001 mainstem trap data (CDFG unpublished data) showed that young-of-the-year coho salmon were emerging from the Shasta and Scott rivers, where they were probably spawned, into the mainstem of the lower Klamath River between March and August. Considering the low numbers of coho salmon fry that have been reported from these subbasins, it is unlikely that these fish were displaced downstream because of competitive interactions with other juveniles of their own species. Instead, the most likely explanation for their summer movement is that declining water quality and quantity in the lower-order tributaries force these young fish to seek refuge elsewhere. Thus, they ended up in the river's mainstem earlier than in other river systems. This exploratory behavior and movement in search for adequate nursery habitat has been well documented, especially before the onset of winter (Sandercock 1991). Recent thermal refugia studies on the mainstem Klamath River have documented the persistence of small numbers of coho salmon young-of-the-year near select tributary confluences during the summer (Sutton et al. 2004; Sutton 2007b; Sutton 2009).

Hatchery Programs

The Klamath and Trinity basin coho salmon runs are now composed largely of hatchery fish, although there may still be wild fish remaining in some tributaries. Because of the predominance of hatchery stocks in the Klamath River basin, stock transfers (use of spawn from coho salmon outside the Klamath River basin) in the Trinity and Iron Gate Hatcheries may have had a substantial impact on natural populations in the basin. Artificial propagation can substantially affect the genetic integrity of natural salmon populations in several ways. First, stock transfers that result in interbreeding of hatchery and natural fish can lead to loss of fitness (survivability) in local populations and loss of diversity among populations (Weitkamp et al. 1995). Second, the hatchery salmon may change the mortality profile of the populations, leading to genetic change relative to wild populations that is not beneficial to the naturally reproducing fish. Third, hatchery fish may interfere with natural spawning and production by competing with natural fish for territory or mates. The presence of large numbers of hatchery juveniles or adults may also alter the selective regime faced by natural fish.

Fish Harvest

Commercial fishing for salmon in the Klamath River had major impacts on populations as early as 1900. Commercial and recreational ocean troll fisheries, tribal subsistence fisheries, and in-river recreational fisheries have impacted salmon, including coho salmon, throughout the Twentieth Century. Over-fishing was considered one of the greatest threats facing the Klamath River coho salmon populations in the past; however, these harvest rates probably would not have been as serious if spawning and rearing habitat had not been reduced and degraded. Sport and commercial fishing restrictions ranging from severe curtailment to complete closure in recent years may be providing an increase in adult coho salmon survival. The tribal harvest in the Klamath has been relatively small in the last five years and likely has not had a measurable effect on coho salmon populations (NOAA Fisheries 2001).

3.1.3 Current Conservation Efforts

In the Rogue River basin, there have been numerous water conservation activities adopted by the local irrigation districts and various groups such as the Oregon Watershed Enhancement Board, the Rogue Valley Council of Governments (RVCOG), and the Bear Creek Watershed Council. The Project components have a long history of use and record of upgrades. As this infrastructure continues to age, additional upgrades are and will be needed to maintain proper function.

Conservation Grants

For the past several years, the Districts have applied for grants and expended their own funds to implement conservation actions such as lining and piping canals to minimize seepage and evaporation, utilizing technology such as ArcGIS to develop a comprehensive inventory of conservation activities, and conducting large-scale conservation projects such as the Larson Creek Pipeline and Fish Passage Project where Reclamation was the sponsor agency. A detailed listing of all the Districts' improvement projects was compiled and presented in GeoEngineers (2004). Additionally, a system optimization review grant (Water 2025 Grant) to identify the priority areas within the Project to improve water efficiencies have been awarded to TID and includes MID and RRVID. Through the water conservation process, the Districts address fish passage and fish screen issues when they are present in the location of conservation activity.

Table 3-9 lists potential conservation activities the Districts have suggested and the estimated water savings that may be accomplished through conservation grants received or instream leasing discussed in a following section.

Table 3-9. Potential water conservation activities with estimated annual water savings.

Project Description	Estimated Annual Water Savings (in acre-feet)
Temporarily lease idle lands that have been quit-claimed or land donated back to Districts.	600-1,674
Pump facility moving RRVID's supply from Rogue River with stored water in Lost Creek Reservoir in exchange for release of RRVID annual average Project yield down Bear Creek.	1,000
Exchange McDonald Creek (Little Applegate water) for Project water to be applied to TID lands.	3,000 - 4,000
Exchange water identified by Bear Creek Watershed Council's instream committee for instream lease with TID water delivered into Neil Creek or an added pressure line from Ashland Canal.	300 - 600
Exchange Reclamation/City of Talent Water in Howard Prairie with TID water released from Emigrant Reservoir.	600
Total	**5,500 - 7,874**

WISE Project

Released in February 2001, the *Bear Creek/Little Butte Creek Water Management Study Appraisal Report* documented the analysis that Reclamation conducted from 1997 through 2000 regarding water supply and water conservation opportunities in the Rogue River basin project area. The release of this report coincided with a local effort, called the Irrigation Point of Diversion, which was focused on actions that could be taken to improve streamflows in Little Butte Creek. Reclamation began meeting with the Irrigation Point of Diversion group to explain the interconnectedness of the irrigation storage and distribution system among the Districts. These discussions led the Irrigation Point of Diversion group to expand its efforts to an analysis of water management/water conservation measures that could be implemented in the Bear Creek/Little Butte Creek basins. Eventually, the name of the study effort was changed to WISE.

In 2003, Reclamation and 16 State and local entities signed a Memorandum of Understanding agreeing to work cooperatively on the WISE project. Reclamation continues to participate regularly in this effort. Significant contributions include technical assistance in developing alternatives and undertaking hydrologic modeling, assisting in the development of the Scope of Work that was issued as part of the Request for Proposal for consulting services to undertake the necessary technical studies, serving on the selection team for the consulting services, reviewing technical products developed by the consultant (HDR Associates), and collaborating with the consultant on the hydrologic modeling effort.

Reclamation received authority in 2008 to conduct a feasibility-level study to investigate alternative solutions for improving irrigation reliability, effectiveness, and efficiency for the Districts and streamflow conditions for salmon and steelhead (P.L. 110-229). Though no funding was included in the authorization, funds have been requested for the WISE Feasibility Study to be utilized for coordination with project partners, review of consultants' products, and initiation of the NEPA activities for fiscal year 2010.

In addition, the WISE project sponsors obtained funds from various sources to undertake specific project tasks. Federal grants from the Environmental Protection Agency (EPA) and BLM and funds from the State of Oregon are being used for the preparation and implementation of a public outreach and marketing plan. These funds are also used to initiate the technical studies required for the feasibility study and environmental impact statement. The partners plan to obtain funds from other sources to complete the technical studies. Reclamation continues to participate in regular meetings and related activities.

Instream Leasing

The instream leasing program offered by OWRD provides a voluntary way for water users to aid the restoration and protection of streamflows. The purpose of instream leasing is to preserve water rights that may be forfeited from non-use and improve environmental conditions, such as flow for fish and wildlife, scenic value, and water quality (http://www.oregon.gov/OWRD/mgmt_leases.shtml).

The Districts participate in the instream leasing program. In recent years, the Districts have applied for and received approval from Reclamation to transfer a specified quantity, usually measured in acre-feet, of Project water for an instream lease during the irrigation season. The Districts have had instream leases in the action area since 1996. For example, TID requested the transfer of 242 acre-feet of Project water to Bear Creek for the 2008 irrigation season (April 1 through October 31) which translated to approximately 0.5 cfs of flow in Bear Creek during the irrigation season (information from Reclamation Categorical Exclusion Checklist dated June 30, 2008). In 2009, two instream leases were requested by TID.

Reclamation supports the lease of water rights for instream flows although the improvement from the leases has not been quantified and no such studies have been conducted. The term of the instream lease may range from 1 to 5 years. The applications from the Districts are typically restricted to one irrigation season with no long-term commitment. Typically, the leases from each irrigation season have provided increases in instream flow of 0.5 to 1.0 cfs. In 2009, leased water was protected to the mouth of the tributary from which the lease occurred, either Bear Creek or Little Butte Creek. Overall, Reclamation identifies the instream leases as a positive step to improve environmental conditions.

Other Conservation Efforts

Other activities in the area include routine water quality monitoring by RVCOG, comprehensive watershed assessments by Oregon Watershed Enhancement Board and the Bear Creek Watershed Council, and habitat improvement projects by the Bear Creek Watershed Council (http://www.rvcog.org; http://www.bearcreek-watershed.org). These activities would continue in the Bear Creek and Little Butte Creek watersheds to help protect natural resources important on multiple levels. Reclamation plans to be an active participant.

The Districts are also quite active in a wide array of conservation and stream enhancement efforts in the action area. Appendix F presents a compilation of projects completed by the Districts as an example of the common stewardship objectives these Districts share.

3.2 Hydrology

This section describes current hydrologic conditions in the Bear Creek and Little Butte Creek watersheds of the Rogue River basin, and the Jenny Creek watershed in the Klamath River basin. There have been no major operational changes in the current hydrologic conditions. An overview of the Project operations is located in Chapter 2 with further details in the *Rogue River Basin Project Talent Division – Oregon, Facilities and Operations Report* (Vinsonhaler 2002).

The hydrology in the Project area is monitored through a series of gaging stations that provide real-time provisional data available through Reclamation's Hydromet system. The stations also provide an instrument platform for the collection of additional parameters, such as temperature. Data collection in the Project area is a valuable tool for the primary purpose of real-time management and operation of Reclamation's facilities. Table 3-10 and Table 3-11 provide the locations and descriptions for the monitoring sites and Figure 3-8 is a map of the locations.

Table 3-10.List of multi-parameter monitoring stations and location descriptions in the Project area identified in Figure 3-7.

Reclamation Maintained Hydromet Stations	
Station Identifier	**Location Description**
AGA	Agate Dam and Reservoir near Medford
ANTO	Antelope Creek and Diversion at Dam
BASO	Bear Creek below Ashland Creek at Ashland
BCSO	Beaver Creek and Beaver Siphon at Howard Prairie Delivery Canal
BCTO	Bear Creek below Phoenix Canal Diversion near Talent
CACO	Cascade Canal near Fish Lake

Reclamation Maintained Hydromet Stations	
Station Identifier	**Location Description**
DICO	Dead Indian Collection Canal near Pinehurst
EGSO	Emigrant Creek above Green Springs Power Plant
EMI	Emigrant Dam and Lake near Ashland
GSPO	Green Springs Power Plant
HPCO	Howard Prairie Delivery Canal at Keene Creek Dam
HPD	Howard Prairie Dam and Lake
HPWO	Howard Prairie Dam Weather Station
HYA	Hyatt Dam and Reservoir
MFDO	Bear Creek at Medford
SDCO	Soda Creek at Howard Prairie Delivery Canal
SLBO	South Fork Little Butte Creek Collection Canal
Local District or OWRD Maintained Stations (with Reclamation GOES data processing support)	
ACAO	Ashland Creek Mouth near Ashland
ASLO	Ashland Lateral near Ashland
BCAO	Bear Creek above Ashland
BCCO	Bear Creek Canal at Medford
BCMO	Bear Creek at Mouth near Central Point
BJBO	Bear Creek at Jackson St. Bridge, Medford
EPTO	Antelope Creek near Eagle Point
FIS	Fish Lake near Ashland
FOR	Fourmile Lake near Ashland
FSHO	North Fork Little Butte Creek below Fish Lake
GCCO	Griffin Creek near mouth
GILO	South Fork Little Butte Creek at Gilkey Ranch
JCCO	Jackson Creek mouth at Central Point
JCTO	Joint System Canal below Junction near Lakecreek
LBCO	Little Butte Creek at Lakecreek
LBEO	Little Butte Creek below Eagle Point
NCDO	Neil Creek mouth near Ashland at airport
NFBO	North Fork Little Butte Creek Canal near Pinehurst
NFLO	North Fork Little Butte Creek at Hwy 140
PHXO	Phoenix Canal Diversion at Talent
RRVO/MIDO	RRVID and MID Canals at Bradshaw Drop
SFBO	South Fork Little Butte Creek Canal near Pinehurst
SFLO	South Fork Little Butte Creek at Mouth
TALO	Talent Lateral at Oak St Diversion
WCTO	Wagner Creek mouth at Talent

Table 3-11. List of temperature monitoring stations and location descriptions identified in Figure 3–7 in the Project area.

Reclamation Temperature Monitoring Sites		
Site Reference Number	**Stream Name**	**Location Description**
1	Emigrant Creek	Below Green Springs Power Plant
2	Emigrant Creek	Above Confluence with Neil Creek
3	Bear Creek	Above Oak Street Diversion
4	Bear Creek	Between existing BJBO and BCMO Hydromet Stations, below Medford
5	East Canal	Southeast of Butler Creek Crossing
6	Gaerky Creek	Above confluence with Bear Creek
7	Butler Creek	Above confluence with Bear Creek
8	Jeffery Creek	Above confluence with Bear Creek
9	Anderson Creek	Above confluence with Bear Creek
10	Coleman Creek	Above confluence with Bear Creek
11	Willow Creek	Above confluence with Bear Creek
12	Little Butte Creek	Below confluence with Antelope Creek
13	South Fork Little Butte Creek	Above confluence with Little Butte Creek upstream to Natural Falls

The tables and figures below are based on data from 2001 through 2011 to maintain consistency with the period of record used in the hydrologic model described in Section 4.3. Hydrologic conditions, irrigation practice,s and flood control releases described during this time are reasonably representative of conditions during the broader life of the Project, with the exception of instream flows provided from 2009 to 2011 (Appendix A). A full description of project operations is provided in Chapter 2.

The Hydromet stations at the various sites are independent in the respect one station does not rely on another station to generate data. In addition, each station has a margin of error associated with it primarily due to design criteria, channel composition, calibration frequency, and maintenance standards. For example, a station in a river channel is subject to conditions that will affect the measurements like a piece of woody debris located in the proximity or a sediment build-up both of which may affect the precision of data. There is maintenance and calibration on the Hydromet stations regularly that will identify and address issues affecting streamflow measurement such as the examples described.

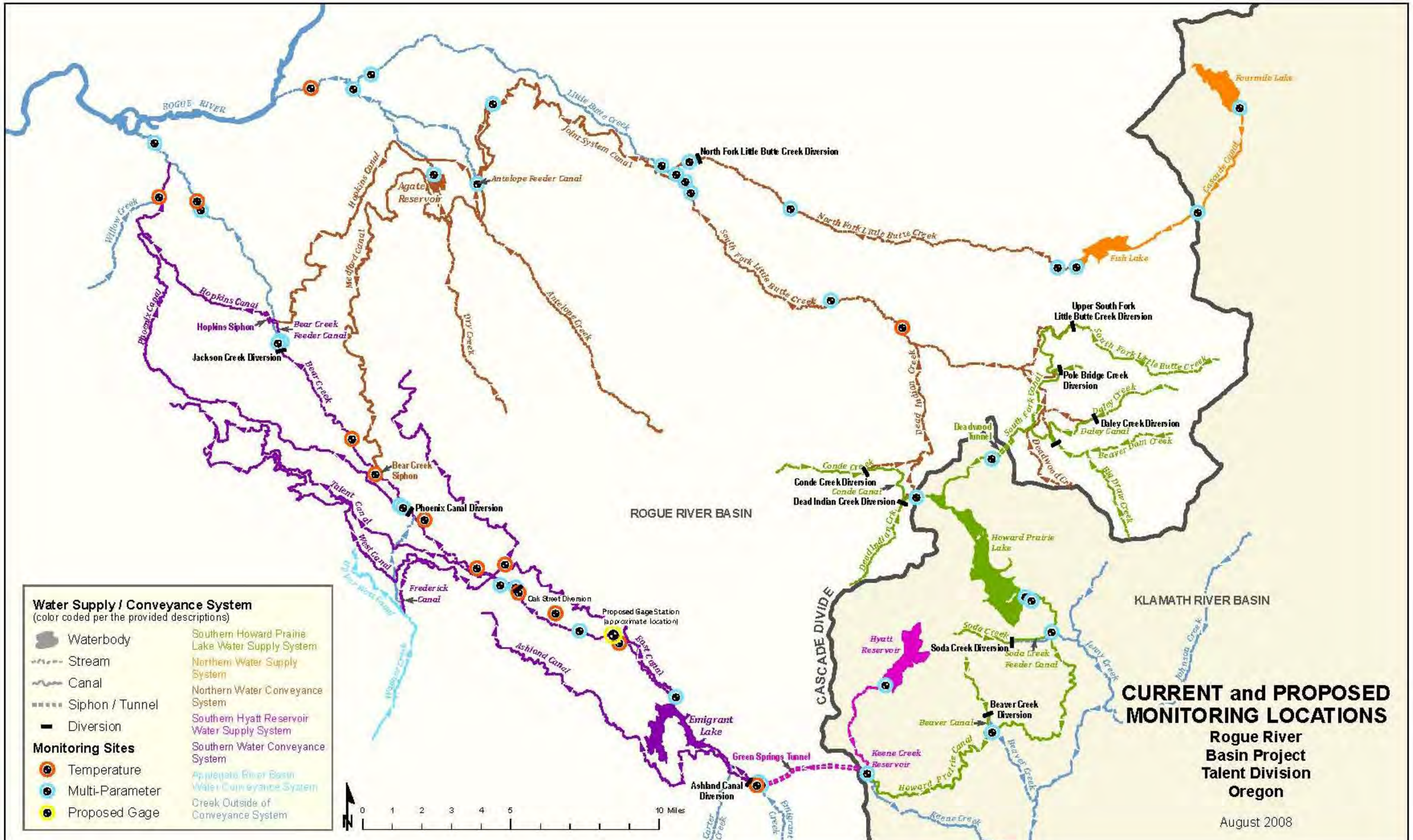


Figure 3-8. Rogue River basin's project current and proposed monitoring locations.

Bear Creek Watershed Hydrology

Bear Creek is a large tributary of the Rogue River. The Bear Creek watershed encompasses approximately 253,440 acres, or 396 square miles, in the URR subbasin of the Rogue River basin. The valley was formed by alluvial deposition from the surrounding areas. The headwaters of Bear Creek include such streams as Emigrant Creek, Tyler Creek, Soda Creek, and Schoolhouse Creek that occur above Emigrant Reservoir within the Emigrant Creek drainage. Approximately 950 linear stream miles create the Bear Creek watershed drainage; of that, 272 miles are within the agriculture zone of the watershed (RVCOG 2001).

The entire Bear Creek watershed lies within Jackson County which has a population of about 200,000 people (PSU 2008). Most of the county's population resides in the communities of Ashland, Talent, Phoenix, Medford, and Central Point. These communities border the banks of Bear Creek and are the most densely populated and intensely cultivated area in the Rogue River basin (ODEQ 2001).

Land use within the Bear Creek basin consists of private timber (31 percent), publicly-owned forest (20 percent), agriculture (39 percent), urban areas (7 percent), and mining and other uses (2 percent) (RVCOG 1995). Approximately 21 percent of the Bear Creek channel is considered confined, reducing floodplain connectivity to adjacent areas (RVCOG 2001). Bear Creek exceeds the Oregon Department of Environmental Quality (ODEQ) turbidity standards during high flow or storm events that occur several times per year (RVCOG 2001). Stream hydrology in the mainstem of Bear Creek is influenced by seasonal fluctuations in precipitation, irrigation withdrawals, and water releases from Emigrant Dam. In recent years, ODFW and the Districts have worked together to try to stabilize water levels during the summer.

There are multiple gages in the Bear Creek watershed as shown in Figure 3-8 and Table 3-10. Available recorded data collected at six Hydromet stations on Emigrant Creek and Bear Creek from March 31, 2001 to August 28, 2011 are presented in Figure 3-9. This period of record was used to maintain consistency with the hydrologic model described in Appendix A. Figure 3-9 provides a representation of three different flow conditions: high (top dotted line), median (thick black line), and low (bottom dotted line). A flow duration analysis was performed at each gage using daily data by month. The values shown for each gage in Figure 3-9 are the 20, 50, and 80 percent flow exceedance at that location by month, they define the high, median, and low flow condition, respectively.

EGSO (Emigrant Creek above Green Springs Powerplant) is the uppermost gage station that records the natural flow occurring in Emigrant Creek, above the transbasin diversion site from the Klamath basin, and into Emigrant Reservoir. Hydromet data collection for this gage began in December 2002. EGSO provides a reference point to the naturally occurring streamflow in Emigrant Creek above Reclamation's influence. Figure 3-9 indicates the majority of streamflow occurs from December to June while in the late summer and fall months, the natural flow approaches zero or is extremely low until precipitation events or snowmelt increase the natural flow through the winter and spring.

A few hundred feet below Emigrant Dam, data is collected at the EMI gage. Emigrant Creek inputs are primarily dependent upon releases from the dam. As shown in Figure 3-9, the streamflow pattern in Emigrant Creek shows higher seasonal discharge for irrigation releases and lower discharge while the reservoir is filling (i.e., mid-October to mid-April). Spikes in discharge during the winter or early spring are generally created by storm events in the area or forced outflow increases to comply with the flood control rule curve from October 1 to May 1.

The gaging station BCAO (Bear Creek above Ashland) is located above Ashland and began collecting data in July 2005. BCAO is below the confluence of Emigrant Creek and Bear Creek but above the Oak Street Diversion. There are also tributaries above BCAO whose flows are captured at this station. From the limited data, the hydrology reflects a pattern similar to that at EMI, higher flows in the summer with lower flows during the winter except when there is a storm event or flood control release.

Data was collected from BASO located on Bear Creek below Ashland Creek at Ashland, OR and MFDO located on Bear Creek at Medford, OR. These stations have been in operation for several years before March 2001 and provide good data. The flow conditions in Figure 3-9 demonstrate lower flows in the winter and increased flows in the spring due to precipitation events and runoff, the flows then decrease through the summer and fall. Flow decreases from BASO to MFDO in the irrigation season as most irrigation withdrawals occur upstream of MFDO.

The gaging station BCMO is located at the mouth of Bear Creek and began collecting data in July 2005. The streamflow follows a similar pattern as described for BASO and MFDO; low in the winter, increasing in the spring, and decreasing in the summer and fall. There are other factors to those identified above for BASO and MFDO as potential causes for the spikes in streamflows including the non-Project water users that start and stop water diversions. Non-project water users are not required to provide communication with the Project managers about their use of water as long as it is within their right. There are also transbasin diversions from the Antelope Creek and Little Butte Creek watersheds that increase flow in this reach.

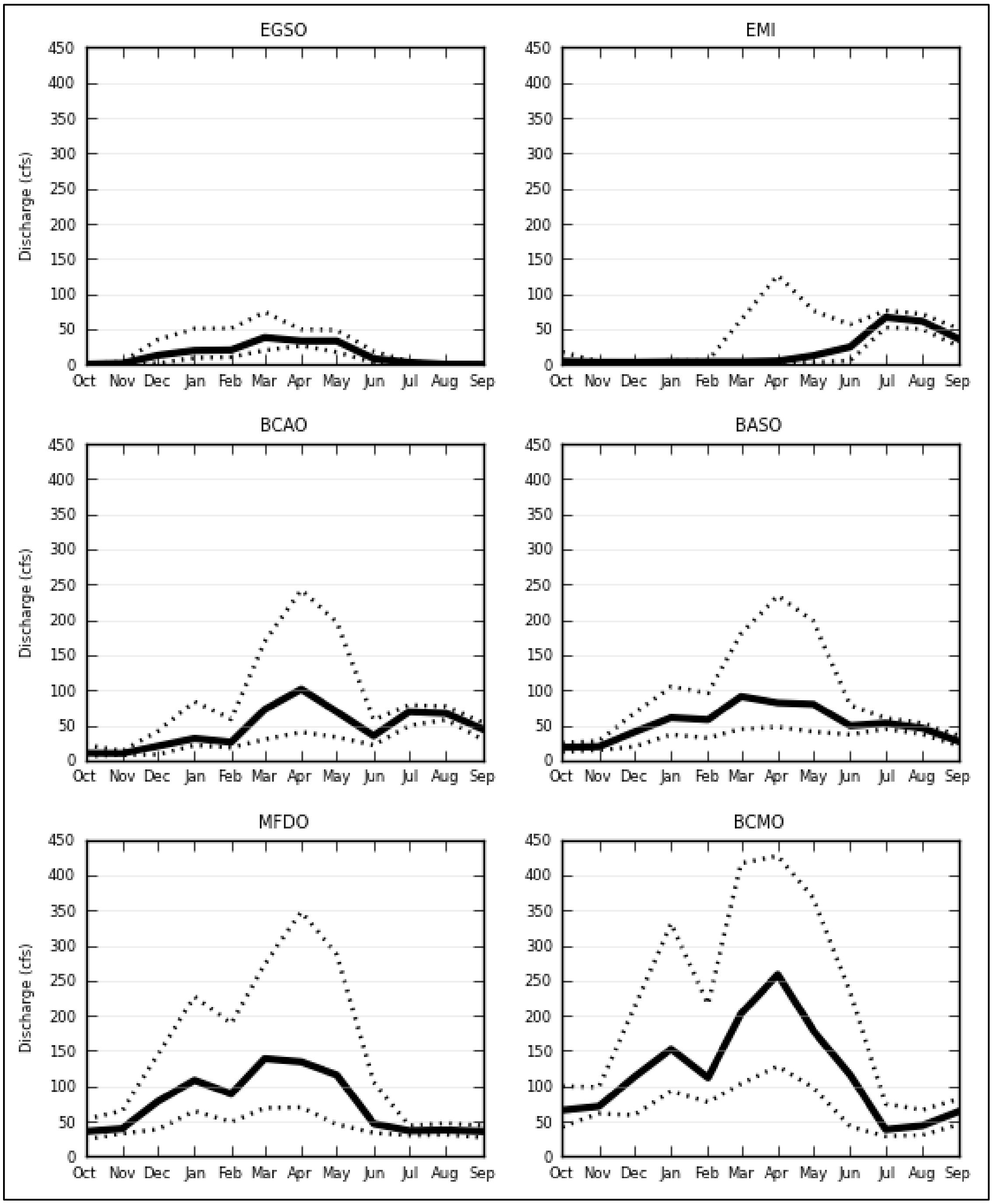


Figure 3-9. Flow duration analysis of measured streamflow at Hydromet stations EGSO, EMI, BCAO, BASO, MFDO, and BCMO located on Emigrant Creek and Bear Creek. The monthly values were generated from a daily flow duration analyses by month. The dotted lines represent the low to high flow condition, and the black line is the median. The high, median, and low flow curves are the 20, 50, and 80 percent exceedance values, respectively. Note: the length of record for each gage may differ, see site description above.

Little Butte Creek Watershed

The Little Butte Creek watershed covers approximately 238,598 acres. The BLM and USFS manage approximately 114,600 acres of Federal land in the watershed. The majority (50 percent) of the land is privately owned. Little Butte Creek watershed is comprised of the mainstem Little Butte Creek and the tributaries, North Fork Little Butte Creek, South Fork Little Butte Creek, Antelope Creek, Dry Creek, Lost Creek, Lake Creek, and Dead Indian Creek.

Available recorded data collected at six Hydromet stations in the Little Butte Creek watershed from March 31, 2001 to August 28, 2011 are presented in Figure 3-10. On the North Fork of Little Butte Creek, there are two gages: North Fork Little Butte Creek below Fish Lake (FSHO) and North Fork Little Butte Creek at Highway 140 (NFLO). Data is available for FSHO beginning in January 2001 which lies below Fish Lake Dam, a non-Project facility, and above any irrigation diversions. The pattern of streamflow in Figure 3-10 suggests seasonal discharge from the dam is clearly represented by low winter flows and higher summer flows to meet irrigation demand. Data is available for NFLO beginning in July 2003 that also depicts higher winter flows and lower summer flows, with greater fluctuation in irrigation releases.

The South Fork of Little Butte Creek has two gages: South Fork Little Butte Creek at Gilkey, OR (GILO) and South Fork Little Butte Creek at the mouth (SFLO). Data is available for GILO beginning in March 2005 (Figure 3-10). It is located in the upper reach of the South Fork and there are two project diversions upstream. The canal and irrigation system is complex in this area as water is diverted out of the South Fork of Little Butte Creek to Howard Prairie Reservoir. Project diversions occur generally from December to June while the reservoirs are storing water and discontinue during the irrigation season or summer months although non-project diversions above the gage continue. Data at SFLO is available beginning March 2005 with some data gaps between 2005 and 2007 due to poor measuring conditions and control problems. SFLO is located just above the confluence of the North and South forks of Little Butte Creek, just below the Lower South Fork Little Butte Creek Diversion Dam, a non-Project facility.

Little Butte Creek below the confluence of the North and South forks also has two gages: Little Butte Creek at Lakecreek (LBCO) and Little Butte Creek below Eagle Point (LBEO). Data is available at LBCO beginning in May 2002. Like SFLO, LBCO is below the South Fork Little Butte Creek Diversion Dam which identifies a seasonal pattern of increased flow from November to May, reflective of precipitation and spring runoff, and decreased flow from June to October (Figure 3-10). It appears that the irrigation releases from Fish and Fourmile reservoirs are removed from the Little Butte Creek watershed between NFLO and LBCO, since the June to September flow at LBCO is less than that at NFLO.

Data is available at LBEO beginning in February 2006 and is further downstream on Little Butte Creek above the confluence with Antelope Creek. It follows the same pattern observed at LBCO, increased flow in the winter and spring and decreased flow in the summer and fall.

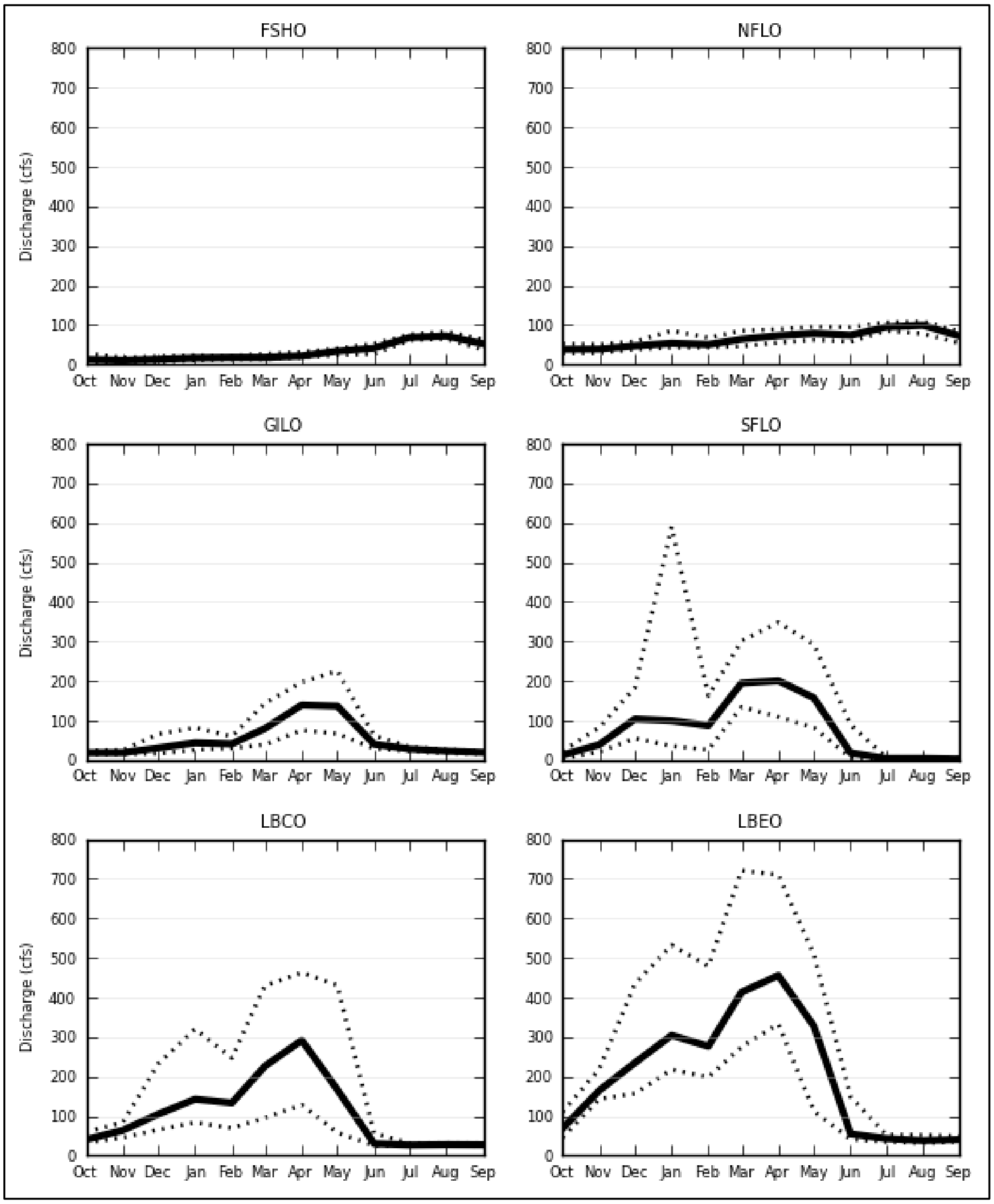


Figure 3-10. Flow duration analysis of measured streamflow at Hydromet stations FSHO, NFLO, GILO, SFLO, LBCO, and LBEO located in the Little Butte Creek watershed. The monthly values were generated from a daily flow duration analyses by month. The dotted lines represent the low to high flow condition, and the black line is the median. The high, median, and low flow curves are the 20, 50, and 80 percent exceedance values, respectively. Note: the length of record for each gage may differ, see site description above.

Antelope Creek Watershed

Three gaging stations have been in operation on Antelope Creek during the last several years; however, the period of record for some of these stations is relatively short. Figure 3-11 shows data from the three stations. Currently, only the Antelope Creek station near Eagle Point (EPTO) is providing reliable streamflow measurements for Antelope Creek, data collection began in May 2006. Since EPTO is located below the confluence of Antelope Creek and Dry Creek which is below Agate Dam and diversions on Antelope Creek, the data collected reflects streamflow from the releases from Agate Dam, Antelope Creek, and any other local gains that occur. Streamflow measurements at the Antelope Creek Diversion Dam (ANTO) began in January 2004 and are not currently reliable, but past records show good correspondence with flows measured at ANTO and those recorded downstream at EPTO, with high flows in the winter and spring and low flows in the summer. Long periods of no streamflow are recorded at ANTO in the summer and, based on actual observations, these are accurate.

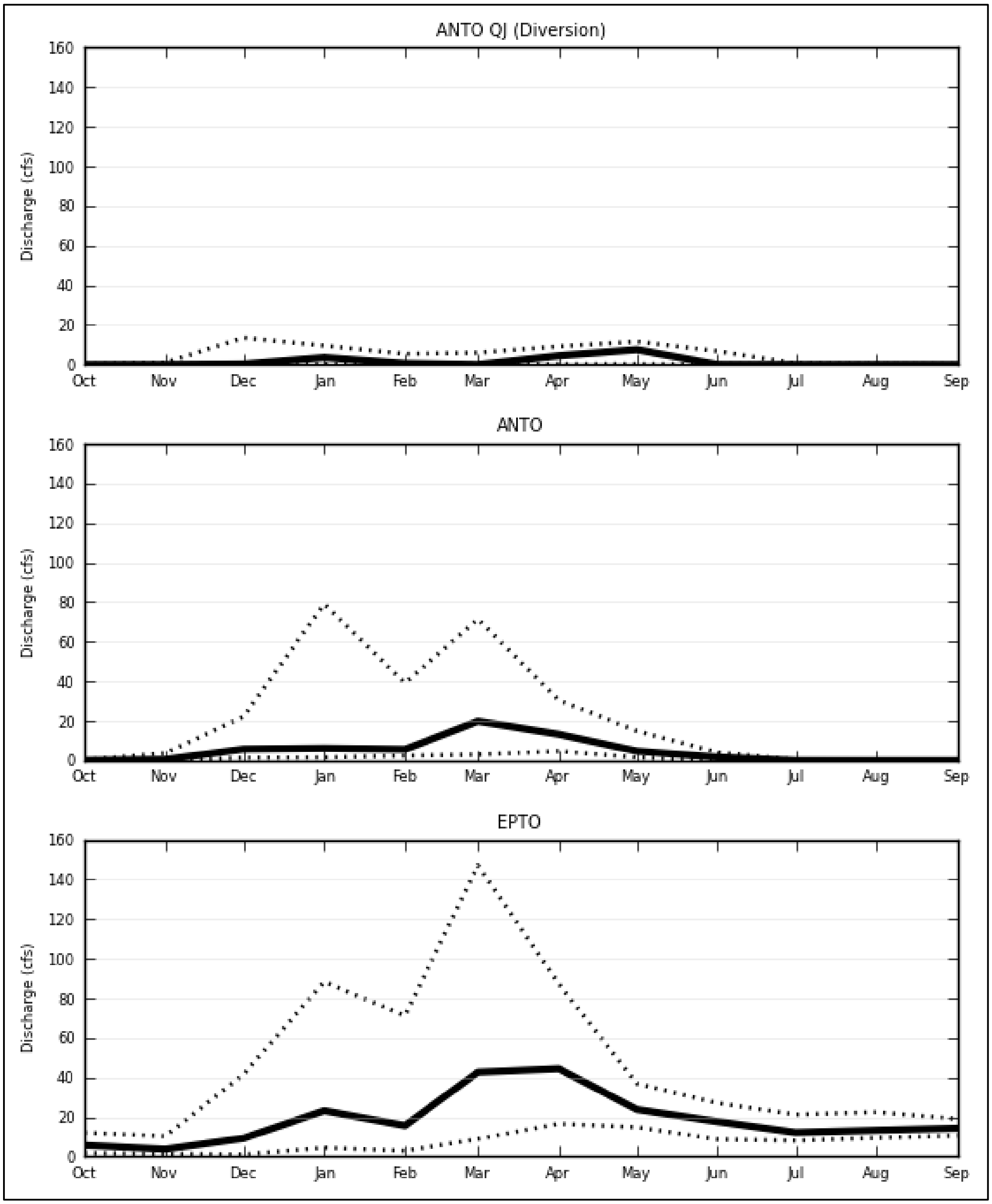


Figure 3-11. Flow duration analysis of measured streamflow at Hydromet stations ANTO and EPTO located on Antelope Creek. The monthly values were generated from a daily flow duration analyses by month. The dotted lines represent the low to high flow condition, and the black line is the median. The high, median, and low flow curves are the 20, 50, and 80 percent exceedance values, respectively. Note: the length of record for each gage may differ, see site description above.

3.2.1 Klamath River Basin

The Klamath River basin covers approximately 12,100 square miles in southern Oregon and northern California. There are four creeks within the Project area which are affected by Project water management: Jenny Creek, Soda Creek, Keene Creek, and Little Beaver Creek. Of those four creeks, Jenny Creek could be considered the main tributary in the reach as it receives water from Soda Creek, Keene Creek, Little Beaver Creek, and Johnson Creek. The hydrology of these creeks is primarily dependent on the release and diversion of water which is determined by the time of year.

As described in Chapter 2, water is transferred from the Rogue River basin to storage facilities in the Klamath River basin, and then transferred back to the Rogue River basin. Runoff in the Jenny Creek basin is also captured, stored, and routed to the Rogue River basin. There are approximately 24,000 acre-feet transferred from the Klamath River basin to the Rogue River basin. Although no flow duration analysis is shown for these creeks, the type of system is similar to most irrigation water management systems with low flows in the winter months and higher flows in the spring and summer months. Additional information regarding the Klamath basin hydrology can be found in the Klamath Project BA (Reclamation 2008).

The Hydromet stations at the various sites are independent in the respect one station does not rely on another station to generate data. In addition, each station has a margin of error associated with it primarily due to design criteria, channel composition, calibration frequency, and staging standard. For example, a station in a river channel is subject to conditions that will affect the measurements like a piece of woody debris located in the proximity or a sediment build-up both of which may affect the precision of data. There is maintenance and calibration on the Hydromet stations regularly that will identify issues affecting streamflow measurement such as the examples described.

3.3 Habitat Conditions

There are a total of 110 streams and approximately 1,000 miles in the entire Rogue River basin considered to be coho salmon habitat, but only 18 stream reaches totaling 170.9 miles within Rogue River basin were designated as coho salmon core areas in the Southwest Oregon Salmon Restoration Initiative report (Prevost et al. 1997). About 17 percent of Rogue River basin coho salmon streams are considered high value coho salmon core habitat.

3.3.1 Bear Creek Watershed

Aquatic habitat conditions in the environmental baseline are documented through habitat surveys, water quality sampling, and flow data collected within the Bear Creek watershed (Table 3-12). ODFW conducted habitat surveys in six reaches of the mainstem of Bear Creek in 1990. More recent habitat-typing was conducted by Reclamation (Sutton 2007b). In addition to these habitat surveys, temperature and other water quality surveys have been conducted (GeoEngineers 2004). Overall, Bear Creek provides relatively poor habitat for coho salmon (NOAA Fisheries 2007). Despite poor habitat conditions in the Bear Creek subbasin, some coho salmon spawning and rearing habitat occurs in approximately 30 miles of streams in this basin and accessible habitat in the basin has been designated as critical habitat for SONCC coho salmon (Vogt 2004). Beneficial actions have also occurred within the watershed and have included instream and riparian habitat enhancements, fish passage improvements, upland restoration, and road improvements.

Table 3-12. Summaries from ODFW, USFS Level II, and Reclamation stream habitat surveys.

Stream	Reach	Survey Date	Total pools (%)	Riffles (%)	Glides (%)	Other (%)	Avg Gradient (%)	Width/Depth Ratio	Substrate percent wetted area				
									Sand (%)	Grav (%)	Cob (%)	Boul (%)	Bed (%)
Reclamation stream segments (Sutton 2007)													
Bear Creek	Avg	2006-2007	17	37	47		1	27	21	31	17	4	14
Emigrant Creek	Mouth to Emigrant Dam	8/17/06	16	39	45			20	13	26	17	3	18
Little Butte Creek	Avg	8/17/06	25	29	46		0	39	7	36	23	1	18
S. Fk. Little Butte Creek	Mouth to natural falls	8/17/06	7	25	68	<1	1.7	19	5	28	62	3	0
Antelope Creek	Avg (mouth to diversion)	2006	32	35	33		1	31	12	37	21	9	11
Neil Creek	Mouth to Tolman Creek	6/13/06	19	40	41	<2	0.7	15	53	14	15	3	0
Oregon Dept Fish and Wildlife													
Bear Creek[a]	Avg (Reaches 1-6)	6/27/1990	29	6	63	3	0		22	33	25	4	17
Antelope Creek[b]	Avg (Reaches 1-6)	4/91	22	37	28	12	1	13	8	33	48	5	6
Little Butte Creek[b]	Avg (Reaches 1-3)	6/94	39	24	15	21	2	53	3	34	17	5	12
S Fk Little Butte Creek[b]	Avg (Reaches 1-11)	7&8/94	24	19	4	52	3	36	7	32	28	15	4
S Fk Little Butte Creek[c]		6/2/1969	86										
U.S. Forest Service Level II Surveys													
Neil Creek[d]	Avg (Reaches 1-6)	8/30/2002	30	66		8	3	17					
Neil Creek[c]	Avg (Reaches 1-3)	8/20/1990	4	86	7		14	5			SUB	DOM	
Neil Creek[c]		1969-1970	15				7						
S Fk Little Butte Creek[b]	Avg (Reaches 1-6)	8/1990	9	66	23	0	6	10					
	Avg (Reaches 1-6)	9/6/97	24	76		0	4	23					
S Fk Little Butte Creek[c]		1969-1970	10	86		14	4-5						

Sources:
[a] Dambacher et al. (1992)
[b] Talabere (1994)
[c] GeoEngineers, Inc. (2004)
[d] Siskiyou Research Group (2002)
DOM – Dominant Substrate Type
SUB – Sub Dominant Substrate Type

Examination of Table 3-12 shows some general similarities between habitat conditions of each Reclamation instream flow study site and stream habitat conditions at large. For example, the gradient in Bear Creek is between about 0 and 1 percent at each stream reach measured by Reclamation in 2006 and by ODFW in 1990. Also, there is general agreement of a higher percentage of glides than riffles or pools in Bear Creek; however, it should be noted that many of the differences in habitat parameters among various habitat surveys are the result of different objectives, methodologies, and flow conditions at the time of the surveys. For example, ODFW reports substrate types as a percentage of wetted area, while the USFS reports only dominant and subdominant substrate types. Reclamation's substrate results were summarized as percentages of each substrate type from cells among all transects at each site. Also, ODFW and USFS surveys contain entire stream segments, including channelized areas, whereas Reclamation surveys focused on untreated habitat reaches. Finally, stream morphology in Bear Creek was likely affected by the flooding that occurred in December 2005; thus, habitat conditions recorded by Reclamation in the spring and summer of 2006 and fall of 2007 were likely different than before the flood.

Water Quality

Water quality impairment in the Bear Creek watershed has been recognized for many years. ODEQ has conducted water quality monitoring since the mid-1980s and determined the Bear Creek watershed is the most impacted watershed in the basin (ODEQ 2001). In 1992, Bear Creek was one of the first watersheds in the State of Oregon to have Total Maximum Daily Loads (TMDLs) developed for total phosphorus, ammonia, nitrogen, and biochemical oxygen demand. TMDLs determine the maximum allowable level of pollutants a water body can assimilate while supporting existing beneficial uses, allocate pollutant loads to different sources in the watershed, and set the stage for implementing corrective actions. The Districts are Designated Management Agencies for both the Bear Creek and Rogue River TMDL processes.

Poor water quality conditions in Bear Creek are the result of elevated point and non-point source pollutants related to urban development, intensive agriculture, and historical upper watershed resource management practices. Several water bodies in the Bear Creek watershed appear in the State of Oregon's 2004/2006 Integrated Report, also known as the Section 303(d) list. Section 303(d) listed waters are thought to be water quality limited by one or more pollutants and a TMDL is required to restore impaired beneficial uses. Table 3-13 shows the Section 303(d)-listed water body segments in the Bear Creek watershed. Elevated water temperature and excess bacteria are the two primary pollutants of concern in the watershed.

Table 3-13. Bear Creek watershed 303(d) listed water body segments in Oregon's 2004/2006 Integrated Report.

Water Body	Listed Segment (RM)	Category[1]	Listed Pollutant
Ashland Creek	0 – 2.8	4a 4a	Fecal Coliform (year around) Temperature (year around)
Ashland Creek / Reeder Reservoir	4.9 – 5.4	4a	Sedimentation
Bear Creek	0 -27.4 0 – 26.3	4a 4a 4a	Dissolved oxygen (Oct. 15 – May 15) Temperature (summer) *E*. *coli* (year around)
Butler Creek	0 – 5.2	4a 4a 4a 4a	Dissolved oxygen (Oct. 15 – May 15) Dissolved oxygen (spring/summer) Temperature (summer) Fecal Coliform (fall/winter/spring)
Carter Creek	0 – 4.8	4a	Temperature (summer)
Coleman Creek	0 – 6.9	4a 4a 4a 4a	Dissolved oxygen (Oct. 15 – May 15) Dissolved oxygen (summer) Temperature (summer) Fecal Coliform (year around)
Crooked Creek	0 – 4.3	4a	Fecal Coliform (year around)
Emigrant Creek	0 – 3.6, 5.6 – 15.4 3.7 – 5.6	4a 5	Temperature (summer) Mercury (year around)
Gaerky Creek	0 – 4.6	4a	Temperature (summer)
Griffin Creek	0 – 14.4	4a 4a 4a	Dissolved oxygen (Oct. 1 – May 31) Fecal Coliform (year around) Temperature (Oct. 1 – May 31)
Hobart Creek	0 – 1	4a	Temperature (summer)
Jackson Creek	0 – 12.6	4a 4a 4a	Temperature (Oct. 1 – May 31) Temperature (summer) Fecal Coliform (year around)
Larson Creek	0 – 6.7	4a 4a 4a 4a	Dissolved oxygen (Oct. 1 – May 31) Temperature (summer) Fecal Coliform (year around) pH (year around)
Lazy Creek	0 – 4.5	4a 4a 4a	Temperature (summer) Fecal Coliform (year around) pH (fall/winter/spring)

Water Body	Listed Segment (RM)	Category[1]	Listed Pollutant
Lone Pine Creek	0 - 5	4a	Temperature (summer)
Meyer Creek	0 – 5.3	4a 4a	Temperature (summer) Fecal Coliform (year around)
Neil Creek	0 – 4.8	4a 4a 4a 4a	Dissolved oxygen (Oct.1 – May 31) Dissolved oxygen (summer) Temperature (Oct.1 – May 31) Temperature (summer)
Payne Creek	1 – 2.1 0 – 2.1	4a 4a 4a 4a	Dissolved oxygen (Oct.1 – May 31) Dissolved oxygen (summer) Temperature (summer) Fecal Coliform (year around)
Tyler Creek	0 - 4	4a	Temperature (summer)
Wagner Creek	0 – 7.4	4a	Temperature (summer)
Walker Creek	0 – 6.7	4a	Temperature (Oct. 1 – May 31)

The RVCOG has collected water quality data from nearly 30 sites in the Bear Creek system since the early 1990s, gathering information and establishing trends for parameters such as dissolved oxygen (DO), phosphorus, ammonia, and bacteria. Water quality monitoring reports calculate each percent exceedance of the established standards for each parameter and shows where pollutants are found in Bear Creek and whether pollutant inputs have a growing cumulative impact as water moves from upstream to downstream. In Olson (2000) and successive RVCOG monitoring reports for 2002-2004, percent exceedances indicate that DO, phosphorus, ammonia, and bacteria do not appear to have a increasing cumulative trend downstream – the percent exceedance seems dependent largely on factors relating to each particular site. However, the data indicates that Bear Creek exceeds TMDL standards throughout its length, demonstrating that mitigating pollutant concerns at one particular point in Bear Creek will not necessarily impact or improve water quality downstream.

Temperature

High water temperatures along a significant portion of Bear Creek exclude use by juvenile coho salmon (Williams et al. 2006; Nickelson 2008; Appendix G). Natural or background sources of solar radiation are by far the largest heat source in the Bear Creek watershed (ODEQ 2006). Other, less prevalent sources of heat include point sources such as municipal and industrial wastewater treatment facilities and diffuse non-point sources such as forestry and agriculture. The Bear Creek temperature TMDL was finalized by ODEQ and approved by EPA on October 2, 2007. The National Pollutant Discharge Elimination System-permitted point sources impacting water temperatures include Associated Fruit, Bear Creek Corporation, Valley View Landfill, Boise Building Solutions Manufacturing, Rogue Aggregates, Rock and Ready Mix, Willow Creek Aggregates, and the City of Ashland. The TMDL separated the diffuse non-point sources into several categories, which included near-stream vegetation disturbance/removal, channel modification and widening, dams, diversion, and other hydrological modifications.

The biologically-based numeric temperature criteria for the Bear Creek watershed is a 7-day moving average of daily maximum water temperature not to exceed 18^{o} C (64.4^{o} F) and 13^{o} C (55.4^{o} F) during times when salmon and steelhead spawning, incubation, and emergence are occurring. Table 3-14 shows the temperature criteria sorted by month and the associated salmonid life stage expected to be occurring during that month. In months where there is life stage overlap, the most stringent criterion is applicable to protect the resource. While the temperature criteria are the same, it should be noted that the spawning and incubation periodicity shown in Table 3-14 is slightly different than the periodicity applied by ODEQ in their Salmon and Steelhead Spawning Use Designation map for the Rogue River basin. The periodicity modifications are based on discussions with the agency representatives and local experts involved in the Rogue PHABSIM workshops held May 12, 2006.

Table 3-14. Applicable temperature criteria in Bear Creek for coho salmon.

LIFE STAGE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Spawning	13°C	--	--	--	--	--	--	--	--	--	13°C	13°C
Incubation	13°C	13°C	13°C	13°C	13°C	--	--	--	--	--	13°C	13°C
Smolt Emigration/ Juvenile Rearing[1]	--	15th-28th 18°C	18°C	18°C	18°C	18°C	--	--	--	--	--	--
Juvenile Rearing	--	--	--	--	--	--	18°C	18°C	18°C	--	--	--
Adult Passage (Gold Ray/Rogue Mainstem)[2]	--	--	--	--	--	--	--	--	18°C	--	--	--
Adult Passage[3]	18°C	--	--	--	--	--	--	--	--	18°C	18°C	18°C

-- These months fall outside the critical period for this life stage
[1] Smolt trap data from ODFW and temperature data from Reclamation's Hydromet Stations
[2] Gold Ray Dam ODFW fish counts (Satterthwaite 2007) and temperature data from Reclamation's Hydromet Stations
[3] Gold Ray fish counts and periodicity charts (Doino 2006)

In summer, water releases from Emigrant Dam benefit salmon by supplementing summer flows in Bear Creek. Through most of the summer, these supplemental flows also benefit salmon by cooling Emigrant Creek and upper Bear Creek relative to ambient temperatures (Appendix G). As illustrated in Figure 3-12, though Bear Creek routinely exceeds the temperature criteria, particularly during the summer months (June through September) and more so in the lower portions of the system where the beneficial cooling effect of Emigrant Reservoir is diminished. Direct solar radiation on unshaded stream reaches and warm air temperatures can cause daytime water temperatures to exceed 26.7° C (80° F) below Medford during the summer (Reclamation 2001). Although release of Project water cools Emigrant Creek and portions of upper Bear Creek, Reclamation found water flow does not relate to water temperature in the middle and lower reaches of Bear Creek (Appendix G) where the high temperatures result largely from solar loading (ODEQ 2007).

The elevated temperatures can hinder juvenile coho salmon and steelhead survival, but most anadromous fish depart the Bear Creek tributaries by July to enter the Rogue River system (RVCOG 2001). Young fall Chinook salmon generally are not affected by summer temperatures because they begin migrating to the ocean shortly after emergence from gravels in the spring.

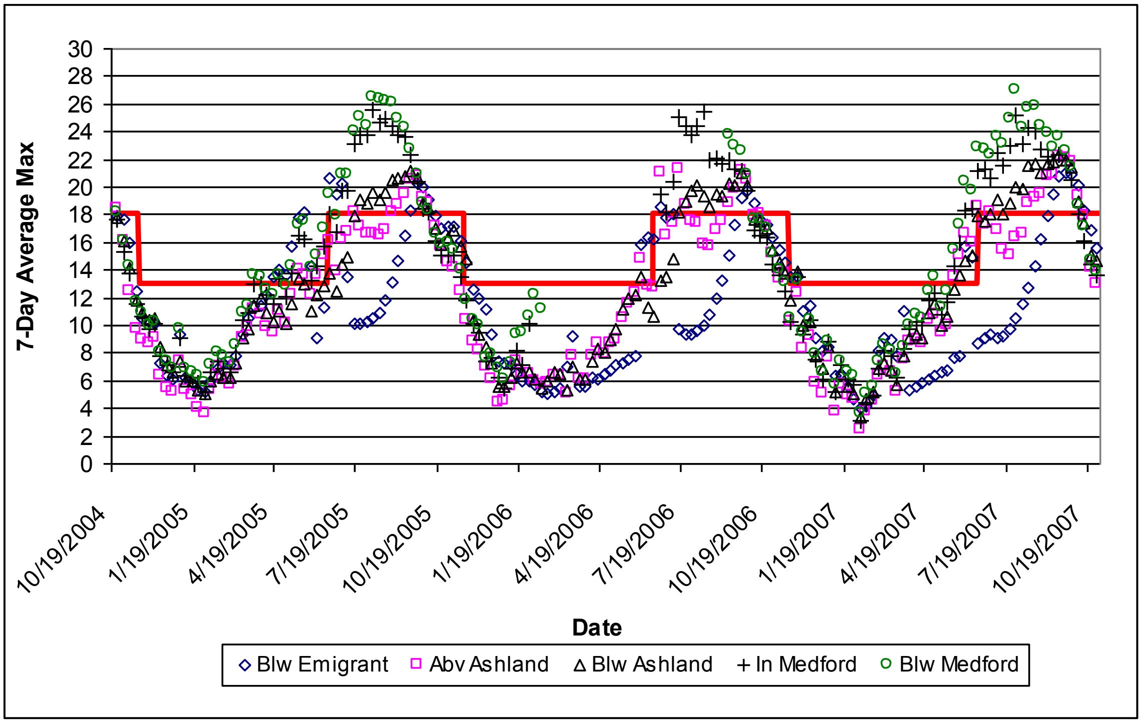


Figure 3-12. October 2004 – October 2007, 7-day average maximum water temperatures in Bear Creek and Emigrant Creek (gaps indicate missing data). The red line indicates the data from Table 3-14.

Reclamation (2001) collected water temperature data during the summer and fall of 1998 at 3 Bear Creek sites and at 15 tributary stream sites. Monitoring occurred from August 1 through the end of October to obtain hourly temperature data to monitor diurnal temperature swings and to determine exceedances of the water temperature criterion. Temperature recorders were installed upstream from irrigated lands on Wagner, Coleman, Griffin, and Jackson creeks, as well as at the confluence with Bear Creek, to evaluate the effects of return flows on water temperature. Monitoring results indicate high diurnal fluctuations in both Bear Creek and its tributaries.

Some tributaries with monitoring locations above and below irrigated lands (Wagner and Coleman creeks) showed water temperature increases between the upper and lower sites. Griffin Creek showed increases during portions of the period of record, while Jackson Creek showed very little change in temperature from the upper to lower site.

In the Bear Creek water temperature modeling report prepared as part of the Bear Creek TMDL, ODEQ reported the maximum water temperature for several tributaries to Bear

Creek (ODEQ 2006). Table 3-15 shows the current maximum water temperature reported for each tributary.

Table 3-15. Current maximum water temperature for tributaries to Bear Creek.

Tributary	Maximum water temperature
Neil Creek††	20°C (68°F)
Gaerkey Creek†	25.2°C (77.4°F)
Ashland Creek††	20.7°C (69.4°F)
Butler Creek†	20.6°C (69.1°F
Meyer Creek†	19.7°C (67.5°F)
Wagner Creek†	21.8°C (71.4°F)
Payne Creek†	21°C (69.8°F)
Larsen Creek	23.5°C (74.9°F)
Lazy Creek†	24°C (75.2°F)
Lone Pine Creek†	28.6°C (83.5°F)
Griffin Creek†	21.8°C (71.4°F)
Jackson Creek†	23.5°C (74.9°F)

†Ephemeral streams (dry above the canals in August)
††Perennial streams

The data shown in Table 3-15 suggest that maximum tributary temperatures have a varying effect on water temperature in Bear Creek, depending on where they enter the system. Some tributaries, particularly those in the upper portion of the watershed, likely warm Bear Creek temperatures during the hottest time of the year, especially since the cooler water from the reservoir reduces base stream temperatures. The cooling effect of the reservoir diminishes progressively moving downstream until equilibrium is reached in Bear Creek near Ashland (Appendix G). Those tributaries in the lower portion of the watershed likely have less of a warming effect because Bear Creek is already warm.

In 2007, Reclamation initiated a multi-year comprehensive water temperature study by placing temperature loggers at the mouth of major tributaries in the watershed (Appendix G). These data can be used to better define how the tributaries are affecting water temperature in Bear Creek.

In August of 2007, 13 coldwater springs, seeps, and tributaries were identified in an inventory conducted by Reclamation (Sutton 2007b). The data from this inventory suggest evidence of possible summer thermal refugia for juvenile coho salmon. Most potential thermal refugia were located in the upper half of Bear Creek watershed, with the majority of it being tributary inflows originating in the southwest portion of Bear Creek watershed.

Bacteria

About half of the Section 303(d) listed stream segments shown in Table 3-13 are listed due to excess bacteria (fecal coliform or *E. coli*). Elevated bacteria in the highly developed Bear Creek watershed are likely attributable to many sources, including cross connections between sanitary and storm sewer systems, certain permitted industrial sites, animal waste on ground surfaces (birds and livestock), illegal dumping into storm sewer systems, and general urban and rural runoff (ODEQ 2001). Elevated bacteria levels impact beneficial uses associated with aesthetic quality and water-contact recreation.

Bacteria loading in Bear Creek exhibits seasonal variation. During the fall, winter, and spring months when there is less recreational and agricultural activity in the watershed and the water is colder, bacteria counts are reduced. In the summer months when recreational and agricultural activity and water temperature increases, the bacteria counts increase as well. Figure 3-13, which is derived from the ODEQ bacteria assessment prepared as part of the Bear Creek TMDL (ODEQ 2006), shows the cumulative loading in Bear Creek at Medford, sorted by month. The graph illustrates April and May as the highest loading months for bacteria. Agriculture practices are just beginning at this time in the Rogue River basin. RVCOG typically posts bacterial warning signs throughout the basin in August.

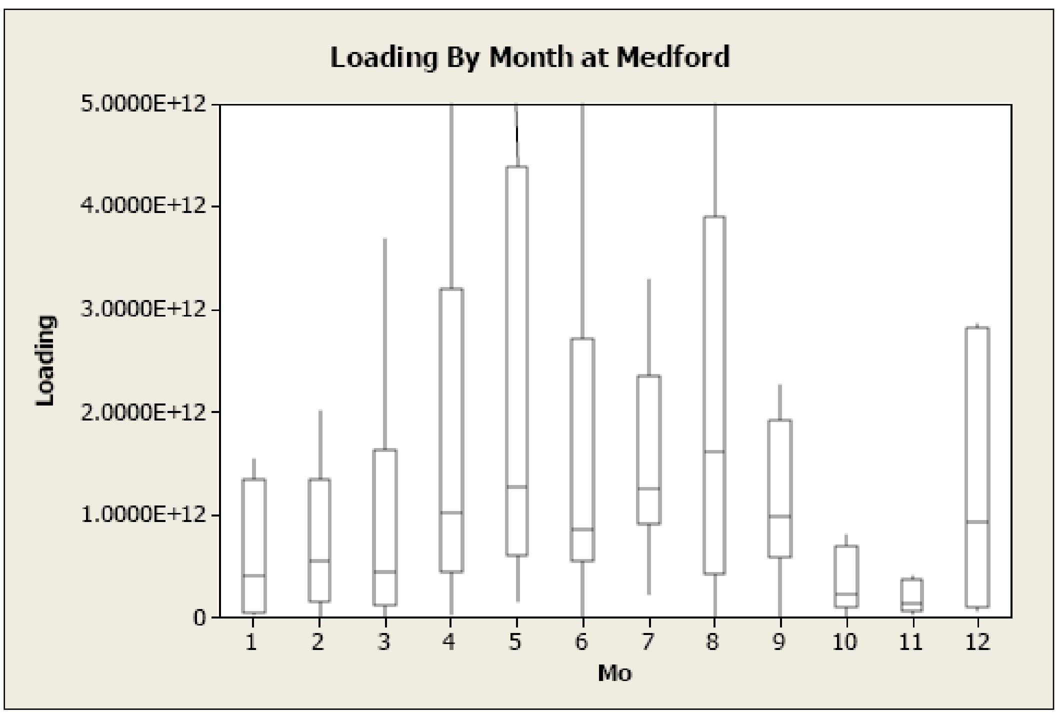


Figure 3-13. Monthly cumulative bacteria loading in Bear Creek at Medford.

In the Bear Creek bacteria assessment, ODEQ also reported the total bacteria loading from several tributaries to Bear Creek over the period from February 1995 through October 1998 (ODEQ 2006). Figure 3-14 shows the relative bacteria loading for each tributary converted to a percentage of the total load.

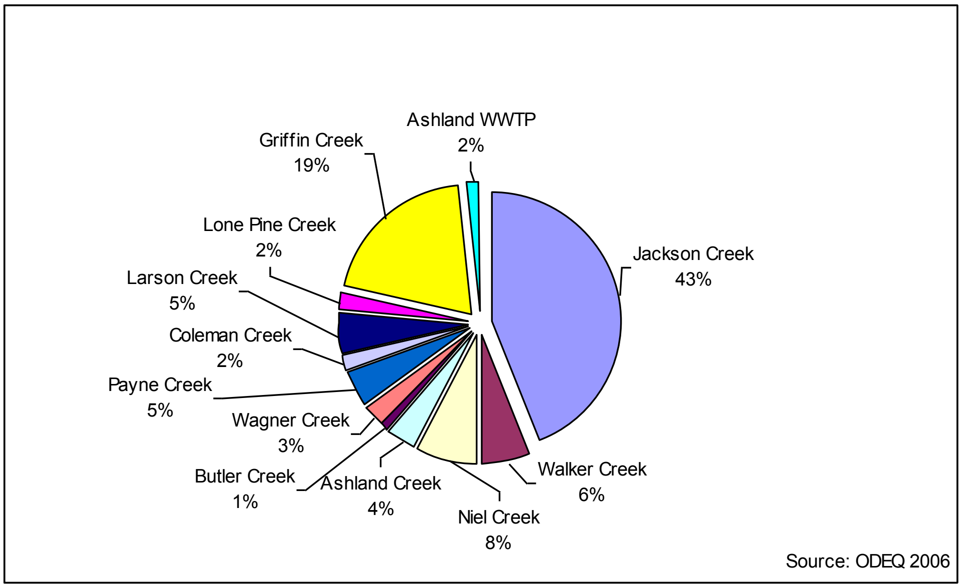


Figure 3-14. Relative percentage of bacteria loading from tributaries to Bear Creek.

Dissolved Oxygen

Since the mid-1970s, water quality in Bear Creek has been compromised by low DO levels (McKenzie and Wittenberg 1977; Wittenberg and McKenzie 1980). The amount of DO in a river is directly affected by river temperature, with higher DO levels in colder water and vice versa. Thus, DO levels fluctuate daily and seasonally, with higher levels generally at night and in the winter. The seasonal trend of higher DO levels during the winter (October through May) has been captured in the Bear Creek system (Olson 2000), but the need for multiple samples per day has limited observations of daily trends.

DO levels are also impacted by Biochemical Oxygen Demand and Chemical Oxygen Demand, reflecting oxygen consumption through biological processes and consumption of oxygen from chemical reactions within the water column. One of the major pollutants in the Bear Creek system is total phosphorus. Phosphorus is fed to the Bear Creek system through treated wastewater effluent, agriculture, and other sources (Reclamation 2001; RVCOG 2003; GeoEngineers 2004). This input can lead to massive algal growth during the summer (April to September) when flows are lower and water temperatures become warmer

(RVCOG 2004). During the day, photosynthesis occurs, but at night, algae can consume DO, lowering those levels in the stream even as temperature improves (JSWCD 1992). Algal decomposition in the winter can also excessively use DO, lowering those higher winter DO levels (Olson 2000; RVCOG 2004).

The 1992 TMDL water quality standard for DO reflects the need for higher DO levels in the winter (11.0 milligrams per liter [mg/l]) for salmon spawning versus in the summer (8.0 mg/l). The phosphorus standard currently is 0.8 mg/l during both summer and winter.

The RVCOG has been monitoring approximately 27 sites since the early 1990s and Olson (2000) conducted a summary analysis of collected data, calculating percent exceedance of the established standards for multiple water quality parameters (including DO and phosphorus) as well as describing distributions of each parameter by site and by year from 1992 to 1999. Measurements were generally monthly (winter) or bi-monthly (summer), but still show some trends. The DO levels exceeded the standard over 50 percent of the time at almost all sampled sites during the winter season. In the summer, the majority of sites experienced over 15 percent exceedance with one site that was below the Ashland waste water treatment facility experiencing over 50 percent exceedance. The winter exceedance is higher most likely due to the change in the numerical DO standard from summer to winter (8.0 mg/l to 11.0 mg/l). In calculating winter exceedance at the summer standard, almost no standard violations were noted; consequently, the winter DO levels are consistently exceeding the standard, but not by much. When examining DO level distribution by site, only the site below the Ashland waste water treatment plant shows consistently lower DO levels in the summer. DO trends at all other sites are comparable to each other. This trend is also the same when looking at DO levels by year.

Phosphorus levels exceed the current standard over 50 percent of the time for both seasons in all sites, with multiple sites showing 100 percent exceedance of the 0.8 mg/l standard. In order to determine which sites have the highest phosphorus readings and hence the worst water quality conditions, Olson (2000) calculated the exceedance at 3 to 4 times the standard (0.24 mg/l or 0.32 mg/l). Many sites continue to show 20 to 60 percent exceedance even at these higher standards, indicating that phosphorus loading is a major pollutant of concern to the Bear Creek system. Previous studies have shown that the Ashland wastewater treatment plant is accountable for up to 80 percent of the nutrient loading in Bear Creek (Reclamation 2001; RVCOG 2004) which has direct and immediate consequences to the aquatic habitat quality.

RVCOG has continued water quality monitoring and calculating standard percent exceedances since Olson (2000), and trends have not changed significantly through 2004 (RVCOG 2004; RVCOG 2005). Efforts continue to reduce phosphorus loading to the Bear Creek system which may help improve overall DO levels.

Fish Passage

The RBFATT of the Rogue Basin Coordinating Council identified a large number of physical fish passage barriers located throughout the Bear Creek watershed, nearly all of them non-federal structures. The RBFATT program prioritizes fish passage funding and improvement projects. Table 3-16 provides a general tally of fish passage barriers identified to date. The RBFATT (2007) inventory lists 212 fish passage barriers in tributaries entering Bear Creek downstream from Emigrant Dam. Road culverts and bridge crossings comprise 186 of these. ODFW judged most of these to be either total fish passage barriers under all flow conditions or to be a passage impediment under most flows. The remaining barriers are mostly non-Federal permanent concrete diversion structures.

The RBFATT list excludes streamside pump locations that have the potential to dewater the stream and entrain juvenile salmonids if not properly screened. The inventory of streamside pumps is outside of their designated purpose.

The inventory for the Rogue River basin is not necessarily complete and does not include all the fish passage barrier locations on Bear Creek tributaries (Ritchey 2001).

Table 3-16. RBFATT inventoried Bear Creek fish passage barriers downstream from Emigrant Dam (RBFATT 2007).

Barrier Type	Mainstem Bear Creek	Bear Creek Tributaries
Diversion dams	3 (Project permanent structures [Oak Street, Phoenix, and Jackson Street] all meet current NOAA Fisheries passage criteria)	18 (6 structures meet current NOAA Fisheries passage criteria); 1 Project structure on Ashland Creek
Pushup dams	none	2 (do not meet current NOAA Fisheries passage criteria)
Road culverts/bridges	none	186
Other fish barriers	none	6
Total RBFATT barriers identified	3	212

Sixteen tributaries that are considered to be fish-bearing streams for salmon and steelhead enter Bear Creek. These streams, plus a few of their respective smaller tributaries, are documented locations for anadromous fish migration, spawning, and rearing (Figure 3-1). Fish passage impediments related to road and highway crossings, urban and rural land uses, and water withdrawal systems are found within all these streams. Though there has been a continuous effort to identify fish barriers, many undocumented, non-Project locations likely exist where water is diverted from the 16 tributaries into ditches or through pump intake locations on private land. Fish passage protection at these locations may be lacking on many non-Project diversions could be upstream from fish migration blockages in lower reaches of the stream. Water users divert from these streams and share in fish passage problems.

Federal Project Facilities

Emigrant Dam, 29 miles upstream from the mouth of Bear Creek on Emigrant Creek, was first built in 1924 and enlarged as part of the authorized Project in 1960. The dam has no fish passage facilities. There are two Federal diversion dams on mainstem Bear Creek downstream from Emigrant Dam: Oak Street Diversion (RM 21.6) and Phoenix Canal Diversion (RM 16.8). Reclamation and the Districts were involved in funding, designing, and making extensive modifications to these diversions and their fish passage facilities from 1997 to 1999 under the Rogue River Basin Fish Passage Improvement Program. This work upgraded fish passage protection at the diversions to the latest NOAA Fisheries criteria for fish ladders, fish screens, and juvenile bypass systems. NOAA Fisheries reviewed and approved the plans for these facilities prior to construction.

New adult fish ladders were constructed at the dams and older fish screens in the canal were replaced with state-of-the-art rotary drum or self-cleaning vertical screens. Juvenile fish bypass systems were also included in the modifications. The Phoenix Canal Diversion fish passage structure is functioning properly since the improvements. The Oak Street Diversion, although designed and constructed to meet NOAA Fisheries criteria at the time, does not provide for efficient salmonid upstream passage and would benefit from design upgrades (see Chapter 4).

There is a recently identified Federal diversion on Ashland Creek less than one mile upstream of the confluence with Bear Creek. The structure does not have fish passage or fish screen components and is a complete blockage to juvenile fish upstream migration. As a Federally-owned structure, improvements to this facility are included in the proposed action in Chapter 4.

Non-Federal Facilities

Jackson Street Diversion (RM 9.6) is a non-Federal diversion dam on Bear Creek downstream from Emigrant Dam. Hopkins Canal Diversion Dam was dismantled and completely rebuilt one-quarter mile upstream from Jackson Street Diversion. Non-Federal facilities were improved under the Rogue River Basin Fish Passage Improvement Program as described above. Adult fish passage in Bear Creek has improved since the fish passage modifications were made (Ritchey 2001). Medford and Phoenix canals cross fish-bearing streams by using concrete dam structures with check boards that can be removed after the irrigation season and siphons at select locations constructed to promote fish passage. Some of the crossings can spill canal water into the natural stream course for conveyance to downslope water users. Creeks where irrigation districts retain natural flow rights can be diverted to the canal.

Bounds Dam, a private dam located about one-half mile downstream from Emigrant Dam on Emigrant Creek, is a blockage to upstream salmon migration. Mainstem Bear Creek may have a number of small private, pump diversions along the stream. It is unknown whether the pump intakes are screened. There are other fish passage barriers and an undocumented number of small irrigation water diversion structures or pumps on Bear Creek tributaries.

3.3.2 Little Butte Creek Watershed

South Fork Little Butte Creek is a designated “coho salmon core area” as identified in the Southwest Oregon Salmon Restoration Initiative (Prevost et al. 1997) and contains about 27 miles of high value stream habitat used by native coho salmon. Coho salmon core areas are streams capable of sustaining year-round coho salmon spawning and rearing. While there may be existing habitat limitations, the resource management intent is to protect and improve these core habitats to help stabilize the basin’s native coho salmon population at a genetically viable level.

The Little Butte Creek Watershed Analysis (USFS and BLM 1997) provided extensive information on ecosystem conditions in Little Butte Creek watershed and includes information on stream habitat elements that may affect anadromous fish production. The analysis also identified limiting factors for aquatic species including: 1) high summer stream temperatures; 2) sedimentation; 3) riparian degradation; 4) instream degradation; 5) fish passage; 6) fish carcass reduction; and 7) wetland and floodplain losses. Instream channel degradation includes channelization, instream wood removal, stream adjacent roads, logging in riparian and landslide prone areas, farming and grazing practices, and urbanization.

In 2003, the Little Butte Creek Watershed Council prepared a watershed assessment for Little Butte Creek (LBCWC 2003). Their findings were in general agreement with the early findings by the USFS and BLM. They concluded that water quantity, water quality, riparian habitat, fish habitat, channel structure, and sediment were significant issues with respect to the degraded health of the watershed.

Stream Habitat Conditions

Much of Little Butte Creek and its tributaries are mostly riffle-dominated single-channels and lack historic side-channel and small-meadow, wetland-type habitats preferred by coho salmon during juvenile rearing stages. Past management activities in the riparian zones have limited the amount of large wood recruitment (valuable for cover, pool maintenance, and fish rearing), thereby reducing stream shading and streambank stability. Streams lack quality pools, especially those with suitable depths and velocities. Reduced riparian vegetation causes streambanks to be less stable. Periodic large storm incidents have taken out streamside riparian vegetation; livestock grazing further impacts it (USFS and BLM 1997).

Water Quality

The Little Butte Creek watershed currently has water-quality limited stream segments in Oregon's 2004/2006 Integrated Report. These stream segments do not meet certain water quality criteria or support certain beneficial uses. In 2006, ODEQ identified impaired stream segments for the 303(d) list and EPA approved the list in February 2007. Table 3-17 shows stream segments in Little Butte Creek watershed that are included on the 303(d) list. The State of Oregon completed the Rogue River basin TMDLs in December 2008 which covered temperature and bacteria.

Table 3-17. Little Butte Creek watershed 303(d) listed waterbody segments in Oregon's 2004/2006 Integrated Report.

Water Body	Listed Segment (RM)	Category[1]	Listed Pollutant
Antelope Creek	0 – 19.7	4a	Temperature (summer) *E. coli* (year around)
Burnt Canyon	0 – 3.2	4a	Temperature (summer)
Conde Creek	0 – 4.4	4a	Temperature (year around)
Dead Indian Creek	0 – 9.6	4a	Temperature (year around)
Deer Creek	0 – 3.2	-	Sedimentation
Lake Creek	0 – 7.8	4a 4a	Temperature (summer) *E. coli* (year around) Sedimentation
Lick Creek	0 – 6.8	- 4a	Dissolved Oxygen (summer) *E. coli* (summer)
Little Butte Creek	0 – 16.7	5 4a - 4a	Dissolved Oxygen (year around) *E. coli* (year around) Sedimentation Temperature (summer)
North Fork Little Butte Creek	0 – 6.5	4a 5 4a	*E. coli* (fall, winter, spring) pH (summer), RM 0 – 17.8 Temperature (summer)
North Fork Little Butte Creek, Fish Lake	15.9 – 17.6	5 -	Aquatic weeds (undefined) pH (summer)
South Fork Little Butte Creek	0 – 16.4	4a - 4a	*E. coli* (summer) Sedimentation Temperature (summer)
Lost Creek	0 – 8.4	- 4a	Sedimentation Temperature (summer)
Salt Creek	0 – 9.0	4a	*E. coli* (year around)
Nichols Branch	0 – 5.0	4a	*E. coli* (year around)
Soda Creek	0 – 5.6	- 4a	Sedimentation Temperature (summer)

[1]Category 4A: water quality limited, TMDL approved; Category 5: water quality limited, TMDL needed

Temperatures

Water temperature data recorded in the Little Butte Creek watershed indicate that several of the segments on the 303(d) list do not meet the water temperature criteria for salmonid rearing during the summer period. The temperature criteria are intended to protect stream rearing cold-water salmonid fish species such as trout, salmon, and steelhead. More recent sampling confirms that the water temperature criterion continues to be unmet in many areas of the Little Butte Creek watershed. This is attributable in part to past practices that have 1) channelized stream segments following flooding events; 2) removed riparian vegetation, reducing shading of the streams during the summer; and 3) reduced flows during summer months.

Summer water temperatures in the Little Butte Creek watershed generally correlate with elevation, with cooler temperatures found at higher elevations. The coolest summer temperature conditions are in stream segments above and elevation of 4000 feet. These streams are primarily on Federal land in the Little Butte Creek watershed and account for 75 to 85 percent of the viable salmonid production during the summer months (USFS and BLM 1997). However, the amount of this habitat available for salmon and steelhead rearing in the watershed appears to be quite limited. Lower elevation stream sections influenced by cool water spring discharge may provide some localized refugia and good summer rearing temperatures.

Little Butte Creek and its tributaries have been designated by ODEQ as having core cold water habitat. Core cold water habitat waters are expected to maintain temperatures within the range generally considered optimal for salmon and steelhead rearing. The biologically based numeric temperature criteria for the Little Butte Creek watershed is a 7-day moving average of daily maximum water temperature not to exceed 16°C (60.8°F) and 13°C (55.4°F) during times when salmon and steelhead spawning, incubation, and emergence are occurring. Table 3-18 shows the temperature criteria sorted by month and the associated salmonid life stage expected to be occurring during that month. In months where there is life stage overlap, the most stringent criterion is applicable to protect the resource. While the temperature criteria are the same, it should be noted that the spawning and incubation periodicity shown in Table 3-18 is slightly different than the periodicity applied by ODEQ in their water Salmon and Steelhead Spawning Use Designation map for the Rogue River basin.

Table 3-18. Applicable temperature criteria in Little Butte Creek for coho salmon.

LIFE STAGE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Spawning	13°C	--	--	--	--	--	--	--	--	--	13°C	13°C
Incubation	13°C	13°C	13°C	13°C	13°C	--	--	--	--	--	13°C	13°C
Smolt Emigration/ Juvenile Rearing[1]	--	15th-28th 16°C	16°C	16°C	16°C	16°C	--	--	--	--	--	--
Juvenile Rearing	--	--	--	--	--	--	16°C	16°C	--	--	--	--
Adult Passage (Gold Ray/Rogue Mainstem)[2]	--	--	--	--	--	--	--	--	16°C	--	--	--
Adult Passage[3]	18°C	--	--	--	--	--	--	--	--	16°C	16°C	16°C

-- These months fall outside the critical period for this life stage
[1] Smolt trap data from ODFW and temperature data from Reclamation's Hydromet Stations
[2] Gold Ray Dam ODFW fish counts (Satterthwaite 2007) and temperature data from Reclamation's Hydromet Stations
[3] Gold Ray fish counts and periodicity charts (Doino 2006)

Figure 3-15 shows the temperature criteria overlaying the 7-day average maximum water temperatures in the South Fork Little Butte Creek at Gilkey. The data show that temperatures typically reach a maximum of around 21°C to 23°C (69.8°F to 73.4°F) during the summer months, which is well above the temperature criteria for those months. However, snorkeling by Reclamation biologists on August 17, 2006, identified the presence of juvenile SONCC coho salmon near Gilkey, indicating the fish are persisting during their most sensitive life stage. The observed fish did not appear to be limited by elevated water temperatures (i.e., they appeared healthy). The most likely explanation for the presence of the juveniles, despite generally elevated water temperatures, is the presence of colder water refugia. Juvenile coho salmon have been observed using thermal refugia in the warm mainstem Klamath River during the summer. Generally, most juveniles move into refugia when mainstem temperatures exceed about 22°C (71.6°F).

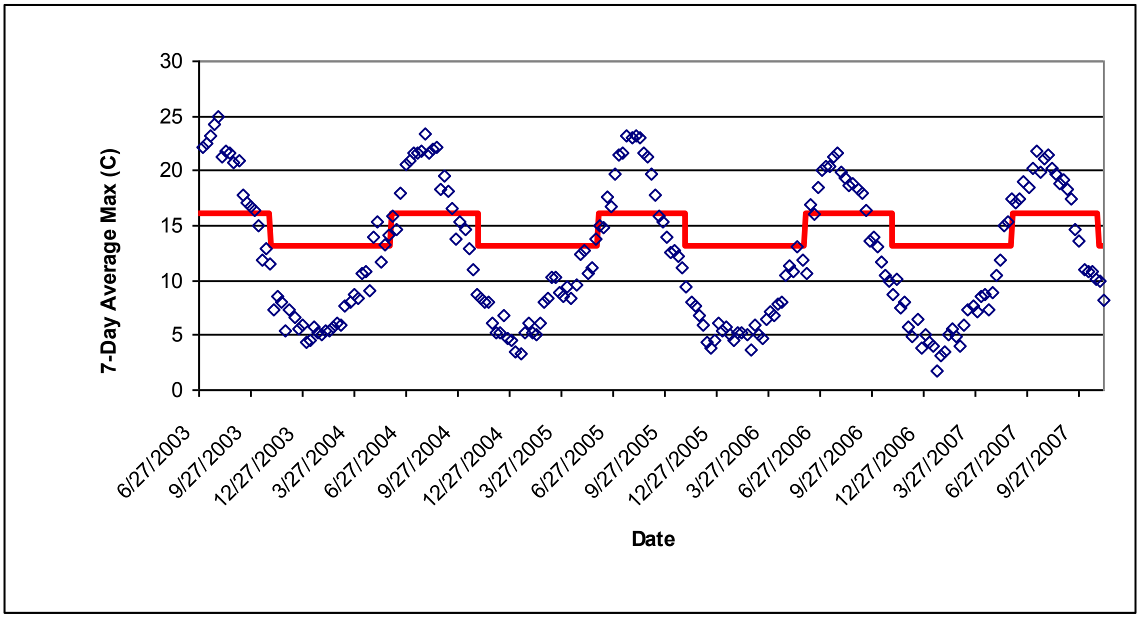


Figure 3-15. July 2003 – November 2007, 7-day average maximum water temperature in South Fork Little Butte Creek at Gilkey. The red line indicates data presented in Table 3-18.

Figure 3-16 compares the 7-day average maximum water temperatures at Gilkey and at the mouth. The comparison between the two locations shows a noticeable increase in water temperature during all times of year, with the increase being more pronounced during the hot summer months.

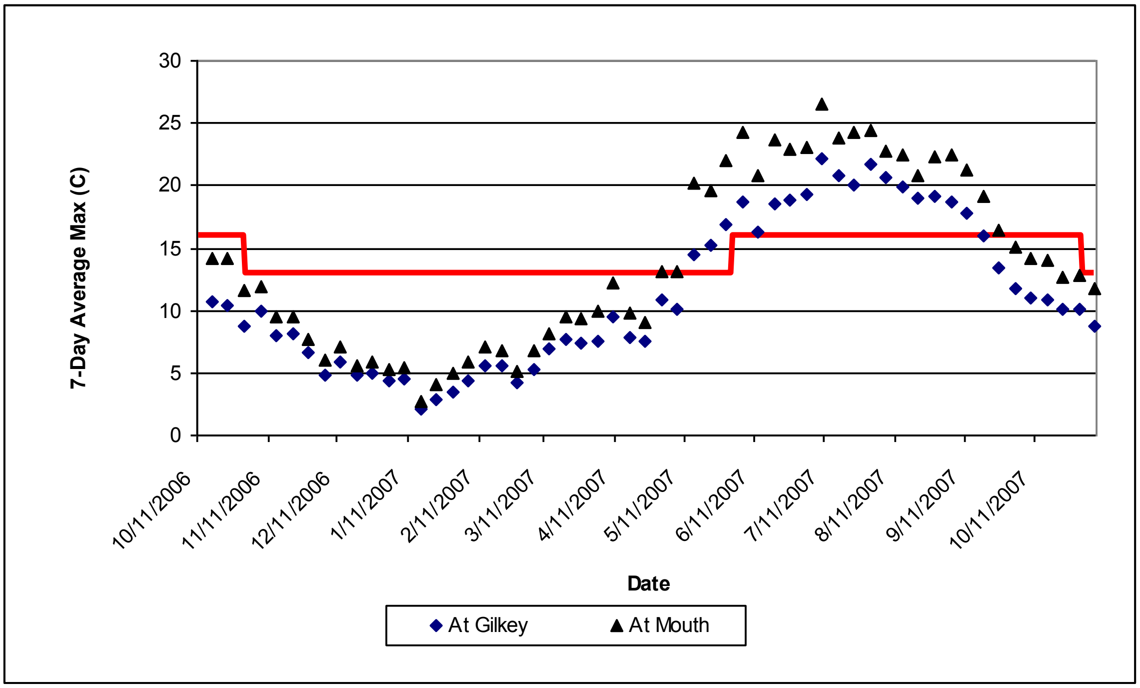


Figure 3-16. 7-day average maximum water temperature in South Fork Little Butte Creek at Gilkey and at the mouth. The red line indicates data presented in Table 3-18.

Water temperatures in Little Butte Creek at Lakecreek continue to exceed the criteria during the summer months. However, when compared to temperature data from the South Fork Little Butte Creek at the mouth for similar dates, the change is de minimis. This indicates that the North Fork Little Butte Creek is not significantly increasing water temperature in Little Butte Creek.

Figure 3-17 compares the 7-day average maximum water temperatures in Little Butte Creek at Lakecreek and below Eagle Point to the temperature criteria. As expected, the criteria continue to be exceeded during the summer months below Eagle Point. However, as illustrated in Figure 3-18, the measured change in temperature between the two locations shows distinct seasonal variability. During the summer irrigation season (April through September), the temperature change is significantly greater than during the non-irrigation season. During the non-irrigation season, the stream decreases in temperature between the two locations.

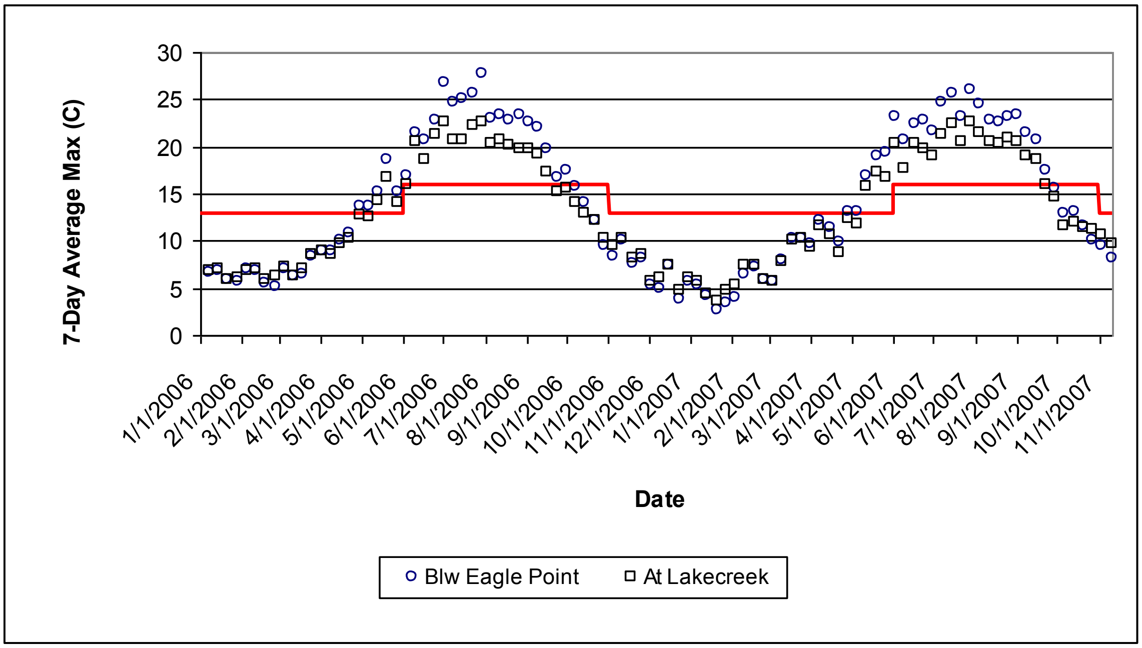


Figure 3-17. 7-day average maximum water temperatures in Little Butte Creek at Lakecreek and below Eagle Point. The red line indicates data presented in Table 3-18.

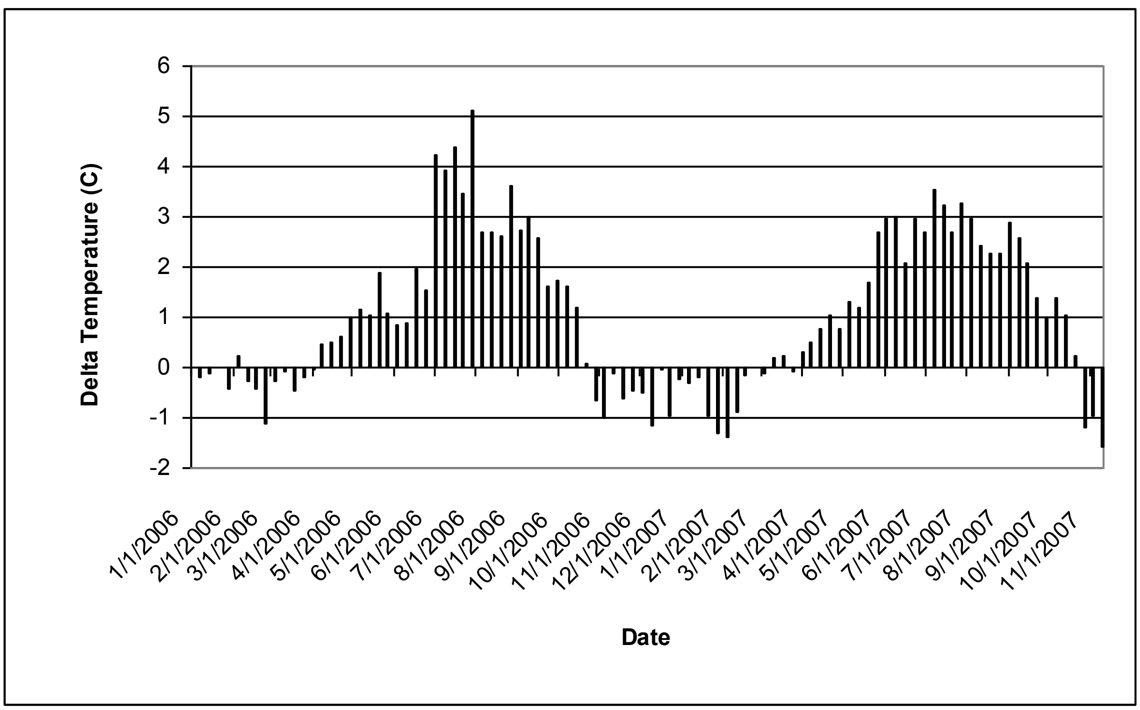


Figure 3-18. Change in Little Butte Creek water temperature between Lakecreek and below Eagle Point.

Reclamation also collected temperature below the confluence of Antelope Creek from August 18 through October 30, 2007 (Figure 3-19). Water temperatures exceed the criteria during the summer months, but when compared to temperature data from Eagle Point, there is very little difference. This indicates that Antelope Creek is not significantly increasing water temperature in Little Butte Creek.

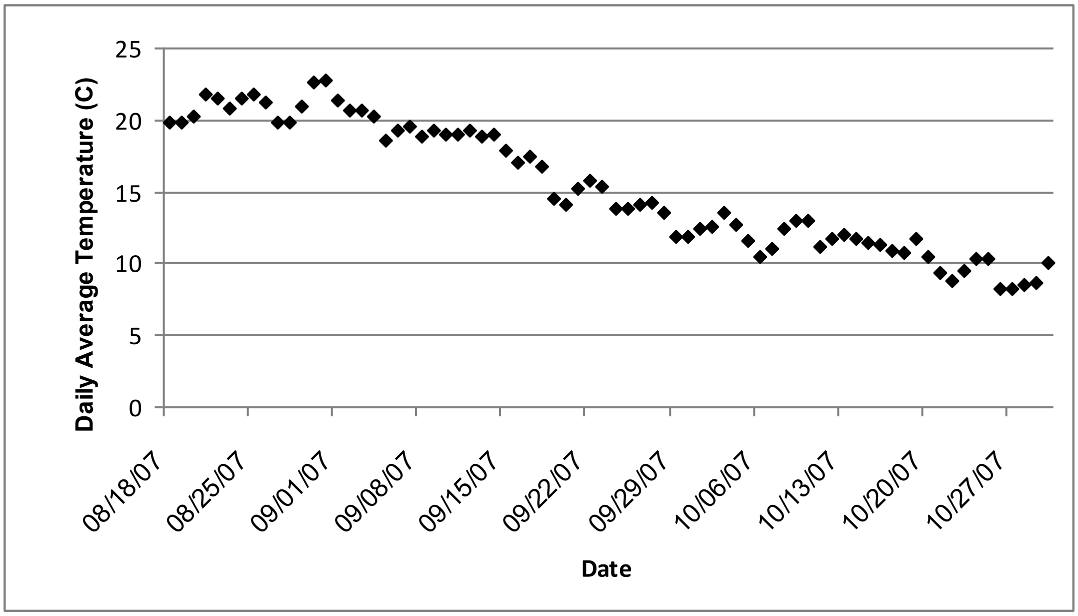


Figure 3-19. Daily average water temperature in Little Butte Creek below Antelope Creek.

For reference purposes, it should be noted that at most sites in the Little Butte Creek basin discussed previously, stream temperatures are at or below the identified criteria during those periods when Project diversions are being made in the headwaters.

Bacteria

Bacterial contamination in the Little Butte Creek watershed is likely attributable to many sources, including animal waste on ground surfaces (wildlife and livestock), failing residential septic systems, cross connections between sanitary and storm sewer systems, certain permitted industrial sites, and general urban and rural runoff. Elevated bacteria levels impact beneficial uses associated with aesthetic quality and water-contact recreation.

The contact recreation water quality standard for bacteria in Oregon is expressed as a 30-day log mean of 126 *E. coli* organisms per 100 milliliter (ml), based on a minimum of five samples, with no single sample exceeding 406 *E. coli* organisms per 100 ml. A water body is generally considered impaired by bacteria if greater than 10 percent of the samples exceed

406 *E. coli* organisms per 100 ml or the 30-day log mean is greater than 126 organisms per 100 ml.

Antelope, Lake, Lick, Salt, North Fork Little Butte, South Fork Little Butte, and Little Butte creeks are 303(d) listed for *E. coli* bacteria on the 2004/2006 Integrated Report. These waters are known to contain levels of bacteria in excess of the criterion. As a result, ODEQ is currently in the process of developing TMDLs for bacteria.

Sediment

Elevated levels of sediment adversely affect aquatic species, particularly salmonid spawning and rearing, by embedding stream gravel and cobble substrates and reducing the quality and quantity of prey-base (macroinvertebrate) habitat. Elevated sediment can also deposit fine material in pools that serve as important habitat for some life stages. Sediment deposition diminishes incubating salmonid egg survival by covering eggs and filling interstitial spaces with fine material.

Storm-triggered landslides, both natural and human-caused from older clear-cuts, and the high number of forest roads are a continuing source of sediment in Little Butte Creek. Major rain-on-snow storm flood events in 1955, 1964, 1974, 1997, and 2005 caused both natural and road/logging-related landslides and transported large amounts of sediment into the Little Butte Creek watershed. These storm events caused major stream channel erosion. As a result, an elevated amount of fine sediment evident in the watershed's lower gradient stream reaches is embedding spawning gravels and filling pools important for juvenile fish rearing.

The sedimentation standard in Oregon is narrative, meaning there is no single criteria that applies to all waters of the state. The narrative criteria says the "formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed."

Deer, Lake, Lost, Soda, South Fork Little Butte, and Little Butte creeks are 303(d) listed for sedimentation on the 2004/2006 Integrated Report. These waters are thought to exceed the narrative standard for sedimentation. As a result, ODEQ is currently in the process of developing TMDLs for sediment.

Dissolved Oxygen

Fish and other aquatic organisms require oxygen to live. When the amount of oxygen dissolved in the water column becomes low, aquatic life may find it difficult to transfer oxygen from the water to their blood stream.

The DO criteria applicable to the Little Butte Creek watershed is expressed as a 30-day mean minimum for the protection of salmon and steelhead spawning and cold-water aquatic life. The salmon and steelhead spawning criteria is not less than 11.0 mg/L or 95 percent of saturation. This criterion applies September 15 through June 15. The cold-water aquatic life criterion is not less than 8.0 mg/L or 90 percent of saturation. There is to be no measurable risk level for these communities.

Lick Creek and Little Butte Creek are 303(d) listed for DO on the 2004/2006 Integrated Report. These waters are thought to exceed the criteria for DO. As a result, ODEQ is currently in the process of developing TMDLs for DO.

Fish Passage

Federal Facilities

Antelope Creek Diversion Dam is a federally-owned facility operated and maintained by RRVID. Reclamation improved adult fish passage and fish screens at RRVID's Antelope Creek Diversion Dam in 1997 and 1998 with NOAA Fisheries design review and input. The improved fish screen system gives ODFW the ability to trap, collect, and haul downstream migrant smolts when streamflow is too low to provide adequate bypass flow back to Antelope Creek. There have been concerns during low flow periods when the ladder is not accessible due to the water flowing under rocks as the base of the ladder (Casad 2008). This has been noted in the RBFATT inventory (RBFATT 2007).

Reclamation constructed six diversion dam structures in the headwater tributaries of South Fork Little Butte Creek watershed. These structures are located upstream from a natural waterfall which blocks fish passage (USFS and BLM 1997). The facilities are Upper South Fork Little Butte Creek Diversion Dam, Daley Creek Diversion Dam, Beaver Creek Diversion Dam, Dead Indian Diversion Dam, Pole Bridge Diversion Dam, and Conde Creek Diversion Dam. Reclamation constructed these facilities to collect water for conveyance across the Cascade Divide for storage in Howard Prairie Lake. TID operates and maintains these diversion facilities. These diversion dams do not block fish passage.

Non-Federal Facilities

MID and RRVID own, operate, and maintain North Fork and lower South Fork Little Butte Creek Diversion Dams. The diversion dams are each about one-half mile upstream from the confluence of the North Fork and South Fork Little Butte Creek. The South Fork Little Butte Creek was improved in 2003 when the current fish screen was installed and the fish ladder was replaced. The fish screen and ladder for the North Fork Little Butte Creek now meet the current standards following improvements made in 2003.

RRVID and MID canals traverse some anadromous fish-bearing streams in the Little Butte Creek watershed; however, all such crossings use flume or siphon structures and pose no fish passage impediments. No water is withdrawn from these streams to augment canal flow, except at Antelope Creek Diversion Dam.

3.3.3 Klamath River Basin

Coho salmon are restricted to the mainstem Klamath River and tributaries below Iron Gate Dam. No passage facilities exist at Iron Gate or Copco dams, which are owned and operated by PacifiCorp. Available recent information suggests adult populations are small to nonexistent in some years. Existing information also indicates that adult coho salmon are present in the Klamath River as early as September and juvenile coho salmon are present in the mainstem Klamath River year round. Reclamation addressed the environmental baseline in the Klamath River basin in a 2008 BA written for the Klamath Project (Reclamation 2008). That analysis is incorporated here by reference.

Within the SONCC coho salmon ESU, dam construction has blocked access to coho salmon habitat in portions of the Eel River, Mad River, Trinity River, Rogue River, and the Klamath River basins. Within the Klamath River basin, an estimated 20 percent of historical coho salmon habitat is no longer available (62 FR 62741).

Past coho salmon harvests by ocean salmon fisheries have also contributed to the decline of SONCC coho salmon ESU. Currently, only incidental "hook-and-release" of natural-origin coho salmon continues in ocean salmon fisheries. For a certain percentage of the coho salmon caught in a "hook-and-release" fishery, the stress of being caught and released causes direct or delayed mortality. However, capture rates for coho salmon have been reduced from a high of 80 percent to a low of 5 percent in recent years in non-tribal fisheries now directed at Chinook salmon (NOAA Fisheries 2002). Poor and uncertain hatchery practices in the past also continue to have lingering adverse effects on natural-origin populations in the ESU. For example, stock transfers from outside of the Klamath River basin, which occurred in the past, might change the genetic bases or phenotypic expression of life-history characteristics in a natural population in such a way that the population might seem more or less distinctive than it was historically.

Timber harvest activities with its associated road construction, grazing, and mining activities have degraded adjacent aquatic habitat conditions. This was acknowledged in the Northwest Forest Plan (USDA and USDI 1994 as cited in NOAA Fisheries 2002) which guides present and future Federal land management activities in the Klamath River basin.

Water was diverted and pumped for use in sluicing and hydraulic mining operations have also contributed to the decline in coho salmon. Mining operations can result in dramatic increases in turbidity levels and physical alterations of the streambed, altering stream morphology. The negative impacts of stream sedimentation on fish abundance from mining were observed as early as the 1930s.

Water management throughout the Klamath River basin has altered the historical hydrology. The magnitude and timing of water flows has significantly changed in the Trinity, Shasta, and Scott rivers and in the mainstem of the Klamath River. Agricultural activities, including return flows from irrigation, are also known to increase nutrient loading through runoff into adjacent streams. These activities have likely resulted in adverse effects to coho salmon as well as other fish species, including other salmonids.

Crop cultivation and livestock grazing in the upper Klamath River basin began in the mid-1850s. Since then, valleys have been cleared of brush and trees to provide more farm land. By the late 1800s, native perennial grasses were replaced by various species of annual grasses and forbs. This, combined with soil compaction, resulted in higher surface erosion and greater peak water flows in streams. Other annual and perennial crops cultivated included grains, alfalfa hay, potatoes, and corn.

Besides irrigation associated with the Klamath Project, other non-Klamath Project irrigators operate within the Klamath River basin. The Project supplies water annually to approximately 200,000 to 220,000 acres of the 240,000 acres within the Project boundaries. Current agricultural development in the Shasta River Valley consists of approximately 51,600 acres of irrigated land. Estimated consumptive use of irrigation water by the crops is approximately 100,000 acre-feet per year. In the Scott River Valley, there are approximately 33,000 acres of irrigated land with an estimated crop consumptive use of approximately 71,000 acre-feet per year.

A series of diversion dams on the Trinity River, a tributary of the Klamath River, transfers water from the Klamath River basin to the Sacramento River basin. The difference in elevation between the Trinity River and the Sacramento River facilitates generation of hydroelectric power. Starting in 1964 and continuing until 1995, an average of 1.2 million acre-feet per year, or 88 percent of the Trinity River flow, was diverted into the Central Valley Project within the Sacramento River basin. This diversion contributed to the decline of coho salmon populations within the Klamath River basin.

Klamath River

Beginning in the late 1800s, construction and operation of the numerous non-Project facilities and, beginning in 1906, Klamath Project facilities have changed the natural hydrographs of the mainstem Klamath River (Reclamation 2001a). Major Project diversion facilities include the A-Canal, Link River Dam, Lost River Diversion Dam, and the Lost River Diversion Channel. Non-Project facilities include Copco Nos. 1 and 2 Dams, J.C. Boyle Hydroelectric Dam, Iron Gate Dam, and Keno Dam. Changes in the flow regime at Keno, Oregon, after the construction of the A-Canal, Link River Dam, and the Lost River Diversion Dam, can be seen in the 1930-to-present flow records. These changes have reduced average flows in summer months and altered the natural seasonal variation of flows to meet peak power and diversion demands (Hecht and Kamman 1996). Flows downstream from Iron Gate Dam affect the quantity and quality of aquatic habitat for coho salmon in the mainstem Klamath River in California.

Iron Gate Dam, located approximately at RM 190 on the mainstem Klamath River, was completed in 1962 and is owned and operated by PacifiCorp. Iron Gate Dam was constructed to re-regulate flow releases from the Copco facilities, but it did not restore the pre-project hydrograph. Minimum streamflows and ramping rate regimes were established in the Federal Energy Regulatory Commission license covering operation of Iron Gate Dam. A fish hatchery was constructed by PacifiCorp as a mitigation measure for the loss of fish habitat between Iron Gate and Copco No. 2 dams.

Currently, the Klamath Project is operated in compliance with a RPA identified in NOAA Fisheries 2002 BiOp. That RPA included a set of minimum streamflows that are being used to govern Project operations. Those flows are identified in Table 3-19.

Table 3-19. The 2002 to 2012 NOAA Fisheries BiOp recommended long-term minimum flows Iron Gate Dam discharge by month, by water year type.

Month	Water Year Type (values in minimum daily cfs)				
	Dry	Below Average	Average	Above Average	Wet
October to February	1,300	1,300	1,300	1,300	1,300
March	1,450	1,725	2,750	2,525	2,300
April	1,500	1,575	2,850	2,700	2,050
May	1,500	1,400	3,025	3,025	2,600
June	1,400	1,525	1,500	3,000	2,900
July to September	1,000	1,000	1,000	1,000	1,000

Source: Table 9, p. 71, NOAA Fisheries 2002.

Water Quality

In addition to hydrologic changes caused by the activities discussed above, human activities have resulted in degraded water quality in the Klamath River basin. The main water quality problem for coho salmon is high water temperature. The Klamath River, from source to mouth, is listed as water quality impaired (by both Oregon and California) under Section 303(d) of the Federal Clean Water Act. In 1992, the California State Water Resources Control Board proposed that the Klamath River be listed under the Clean Water Act as impaired for both temperature and nutrients, requiring the development of TMDL limits and implementation plans. The EPA and the North Coast Regional Water Quality Control Board accepted this action in 1993. The basis for listing the Klamath River as impaired was aquatic habitat degradation due to excessively warm summer water temperatures and algae blooms associated with high nutrient loads, water impoundments, and agricultural water diversions (EPA 1993).

Temperatures periodically reach levels that are lethal to coho salmon within the Klamath River basin. High water temperatures during the late spring and summer months can be an important factor affecting the distribution, growth, and survival of juvenile coho salmon. Water temperatures above 60.8°F (16°C) can trigger movement of juvenile coho salmon during these months. Movement occurs as fish seek refuge from high temperatures. The

National Academy of Science concluded that juvenile coho salmon living in the main stem of the Klamath River probably tolerate the temperature only by staying in pockets of cool water created by ground-water seepage or small tributary flows (NAS 2004).

Generally, during late spring and early summer, flows from Iron Gate Dam tend to be below equilibrium temperature on the order of 2ºC to 4ºC; however, the effect is diminished with increased distance from the dam. The cooler water temperature is attributed to the source of the water, the Iron Gate Reservoir. The warmest reach of the Klamath River at this time is between Scott River and Shasta River.

In late spring and continuing through the summer, temperatures exceed tolerable levels and coho salmon are relegated to thermal refugia throughout most of the mainstem or must migrate into non-natal tributaries. At these times, releases from Iron Gate Dam have little influence on temperatures downstream of the Shasta River.

Temperature modeling done for the Klamath and cited in the 2008 BA (Reclamation 2008) indicates that tributary inputs and meteorological conditions are the primary temperature drivers throughout the year downstream from the Scott River. Thus, the ability to control temperature in the lower Klamath River through flow management at Iron Gate Dam is limited because ambient temperatures and tributary flows downstream are much larger than those from Iron Gate Dam, depending on season and annual variability.

3.4 Critical Habitat for the SONCC Coho Salmon

NOAA Fisheries (62 FR 24588) listed SONCC coho salmon (*Oncorhynchus kisutch*) as threatened on May 6, 1997, under provisions of the ESA. This ESU of coho salmon inhabits coastal rivers and streams between Cape Blanco in southern Oregon to Punta Gorda in northern California. Most of the remaining natural production in this coho salmon ESU takes place in the Rogue, Klamath, Trinity, and Eel River basins. The Rogue River basin and Klamath River basin contain naturally reproducing populations of this coho salmon ESU.

NOAA Fisheries published a final rule designating critical habitat for SONCC coho salmon effective June 4, 1999, which encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between the Mattole River in California and the Elk River in Oregon inclusive. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of coho salmon (64 FR 24049). Inaccessible reaches are those above specific dams as identified in Table 6 of the Federal Register (Iron Gate Dam, Emigrant Dam and Agate Dam) or above longstanding naturally impassable barriers (natural waterfalls in existence for at least several hundred years) (64 FR 24049). Rogue

River basin streams inhabited by SONCC coho salmon and influenced by Project operations include Little Butte Creek and Bear Creek watersheds, as previously described.

Klamath River tributaries downstream from Iron Gate Dam provide habitat critical for coho salmon. Jenny Creek is located upstream of Iron Gate Dam and is not accessible to coho salmon. Most coho salmon spawning occurs in the tributary streams rather than in the mainstem of Klamath River. The mainstem serves primarily as a migratory pathway. Coho salmon move into the tributaries with the onset of fall rains and increased flows. Suitable tributary flows are important to provide coho salmon access to spawning habitat during their upstream migrations. Many coho salmon attempt to migrate as far upstream as possible and then hold in deep pools near good spawning sites until they are ready to spawn a month or more after freshwater entry. Redds (spawning sites) must remain watered throughout the incubation period. After they emerge from the gravel in the spring, the young fish disperse into the available habitat. During the year that juvenile coho salmon spend in freshwater, they utilize pools with good cover and cool water, which are predominantly in the tributaries. Cool water is critical for survival during the warm summer period. Many coho salmon likely move downstream from the spawning location because coho salmon generally spawn near the upstream extent of good rearing habitat. It is unlikely that significant numbers of coho salmon enter the mainstem Klamath for summer rearing because tributary water temperatures are cooler. During winter when water temperature is below about 10°C (50°F) and high flows are more frequent, juvenile coho salmon seek denser cover and lower water velocity than used during the summer. These conditions are often found in off-channel areas of the tributaries.

Chapter 4 EFFECTS OF THE ACTION

Effects of the action refer to the direct and indirect effects of a proposed action on listed species or critical habitat, together with the effects of other activities that are interrelated to or interdependent with that action. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. In accordance with the provisions of the ESA implementing regulations and the USFWS Section 7 Handbook, Reclamation uses the following definitions to make its effects determinations for each listed species:

May Affect - Likely to adversely affect (MA/LAA): Any adverse effect to ESA-listed species or their critical habitat may occur as a direct or indirect result of the proposed actions or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial (see definition of is not likely to adversely affect). In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action is likely to adversely affect the listed species. If incidental take is anticipated to occur as a result of the proposed action, a likely to adversely affect determination should be made.

May Affect - Not likely to adversely affect (MA/NLAA): Effects on ESA-listed species or their critical habitat are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: 1) be able to meaningfully measure, detect, or evaluate insignificant effects; or 2) expect discountable effects to occur.

No Effect (NE): When the action agency determines its proposed action will not affect listed species or critical habitat.

4.1 Overview

The proposed action occurs in and affects the Rogue and Klamath River basins and involves a variety of components with varying environmental effects. The magnitude and significance of effects differ considerably between the two basins. The basic components of the action include: 1) water management actions, 2) fish passage improvements, and 3) habitat restoration actions in the affected Bear and Little Butte Creek watersheds. Water management is the most complex portion of the action and includes: 1) water diversion, 2) water storage, 3) delivery of contract water, 4) infrastructure maintenance, and 5) infrastructure operation, including ramping protocol and instream flows.

The construction components of the proposed action will result in effects on the environment ranging from short term (minutes to hours) to long term (5 to 30 years). The proposed O&M of the Project will have long-term effects on water quantity, water quality, and seasonal fish habitat parameters in several stream reaches of the affected watersheds. The proposed action's components would directly affect SONCC coho salmon and their habitats primarily in the Little Butte Creek and Bear Creek watersheds. Effects include changes in water quality (primarily water temperature), flow-related changes in fish habitats, construction related effects, and effects from structural impediments and the modification of impediments to fish passage. Effects of the proposed action also include long-term, direct and indirect effects resulting from habitat restoration components.

Reclamation developed the instream flow and instream habitat components of the proposed action using a three-phased approach. First, Reclamation determined the net range of hydrologic conditions attributable to the water management activities for the Project using the 2011 MODSIM daily time-step hydrologic model (Appendix A). Second, Reclamation determined the net range of WUA of habitat available to SONCC coho salmon due to water management activities using the PHABSIM habitat models for Emigrant, Bear, and Little Butte creeks. Third, Reclamation identified an optimized combination of instream flows, instream habitat restoration, and riparian zone improvements to address potential adverse effects of the proposed action on SONCC coho and Chinook salmon habitat. The following sections describe the effects to hydrology and to the species and their critical habitat and provide technical information about the effects analysis process.

4.2 Effects to Hydrology

This section describes the effects of the proposed action to hydrology in the Bear Creek watershed, Little Butte Creek watershed, and Klamath River basin.

4.2.1 Methods

To quantify the effects of water management operations on the hydrology of Bear Creek, Reclamation developed the Emigrant and Bear creeks Daily Operations Model (Model), a daily time-step water budget simulation of Emigrant and Bear creeks, major diversions, and Howard Prairie, Hyatt, Keene Creek, and Emigrant reservoirs. The Model was constructed in MODSIM and applied to two scenarios: without Reclamation and "proposed operations."

The without Reclamation scenario was used to estimate the streamflows that likely would have occurred for the period of study if Reclamation-owned water management facilities were not operated. This simulates no inflow to Emigrant Creek from the Klamath basin, no operation of Emigrant Reservoir, and no operation of Reclamation-owned diversion structures. Privately-owned diversion structures continue to operate within the constraints of their water rights. Historical ungaged private diversions also continue, although at an unknown rate. A comparison of these two scenarios serves as a basis for the effects analysis. The model provides simulated flow data for the habitat time series analyses discussed later in this chapter and simulates the impacts of the proposed instream flows on reservoir storage levels.

The North Fork of Little Butte Creek and the South Fork of Little Butte Creek are included in the model. There are no Reclamation-owned facilities on the North Fork of Little Butte Creek and thus no operational constraints on the North Fork of Little Butte Creek from the proposed action; therefore, the model "operates" North Fork of Little Butte Creek statically under both scenarios (i.e., it assumes historical flow conditions). Water delivery from the North Fork of Little Butte Creek to water users on Bear Creek occurs but was not evaluated in this modeling effort. Thus, the model captures reservoir response in meeting historical water use while satisfying the proposed instream flows.

The South Fork of Little Butte Creek has data limitations; Hydromet data collection began March 28, 2005 at the GILO gage on the South Fork of Little Butte Creek near Gilkey, OR. It was not possible to quantify impacts of instream flow targets at GILO without extending the basin inflow dataset to the period of simulation. An analysis was performed to estimate the unregulated inflow to the South Fork of Little Butte Creek for use in modeling without Reclamation and proposed action scenarios (Appendix A).

Reclamation has limited control to meet instream flow targets at GILO. There are two canals that divert water from the South Fork of Little Butte Creek to the Klamath basin into Howard Prairie Reservoir: SFLO - South Fork Little Butte Cr. Collection Canal, OR and DICO - Dead Indian Collection Canal nr. Pinehurst, OR. The only way Reclamation can increase flow to GILO is to restrict transbasin diversions at these collection canals.

The model simulates operations using a daily time-step dataset from March 31, 2001 through August 28, 2011. While short, this period of record provides an adequate representation of the hydrologic conditions (i.e., wet, dry, and average years) within the study area (Appendix A), and provides the most accurate estimates of streamflow given the available data in the watershed to complete a hydrologic model of the system.

Reclamation analyzed simulated streamflow at six Hydromet gage locations on Bear Creek and three gages in the Little Butte Creek watershed. For this analysis, a flow duration curve for each month was constructed by selecting all values for a single month and sorting them. For example, the month of October has 31 days, so for the 10-year period of simulation, there were 310 daily values. These values were sorted and plotted in descending order to create the flow duration graph for October. This method provides a portrait of the range of hydrologic conditions for each scenario. Previous model output analyses used monthly average values. While this is a classical hydrologic analysis method used for water systems engineering, supply/demand calculations, and similar applications, monthly averages can overestimate the flow that may occur most of time within a given month and can mask shorter duration flow characteristics important to particular species, life stages, and habitat functions.

The 20, 50, and 80 percent daily flow duration values for each month were used in the habitat time series analyses discussed later in this chapter to describe high, median, and low flow conditions, respectively. The stations where simulated flows were provided are in Table 4-1. Due to data limitations the analysis at BCAO, BCTO, BCMO, GILO, LBCO, and LBEO were limited to the last 5 years.

Table 4-1. Hydromet gages where simulated streamflow was used to generate daily flow duration values for each month which were provided to the habitat analyses. Model output was limited by the period of simulation or available Hydromet data.

Hydromet pcode	Hydromet Description	Hydromet data starts
EMI	Emigrant Dam and Lake near Ashland, OR	04/15/1992
BCAO	Bear Creek above Ashland, OR	07/19/2005
BASO	Bear Creek below Ashland Cr. at Ashland, OR	07/01/1990
BCTO	Bear Creek below Phoenix Diversion near Talent	05/29/2003
MFDO	Bear Creek at Medford, OR	03/01/1915
BCMO	Bear Creek at Mouth below Central Point, OR	07/19/2005
GILO	South Fork Little Butte Creek at Gilkey, OR	03/28/2005
LBCO	Little Butte Creek at Lakecreek, OR	05/15/2002
LBEO	Little Butte Creek below Eagle Point, OR	02/01/2006

4.2.2 Bear Creek Watershed

Flow duration curves for Emigrant Creek at the EMI Hydromet gage for two scenarios (without Reclamation and the proposed action) are provided in Figure 4-1. These flow duration curves were constructed using daily values of model output using the entire period of record at each gate. A flow duration curve indicates the percent of time flow is at or above a specified level. Flow duration analysis provides a meaningful way of comparing and contrasting different flow regimes or scenarios over a defined period of time. The EMI curves indicate that, over time, the proposed action would provide a distribution of flows at the EMI gage similar to the without Reclamation scenario, although the timing of the distribution of flows would be shifted between scenarios and this timing shift is not distinguishable from the graph. Flows under the proposed action would be slightly lower during high flow conditions, and would be higher during low flow conditions. Under the without Reclamation scenario, Emigrant Creek would have essentially zero flow approximately 10 percent of the time given the conditions of the last 10 years; the proposed action would maintain at least 2 cfs year-round. At the 80 percent exceedance level, without Reclamation flows would be approximately 3 cfs or greater while the proposed action flows would be approximately 6 cfs or greater.

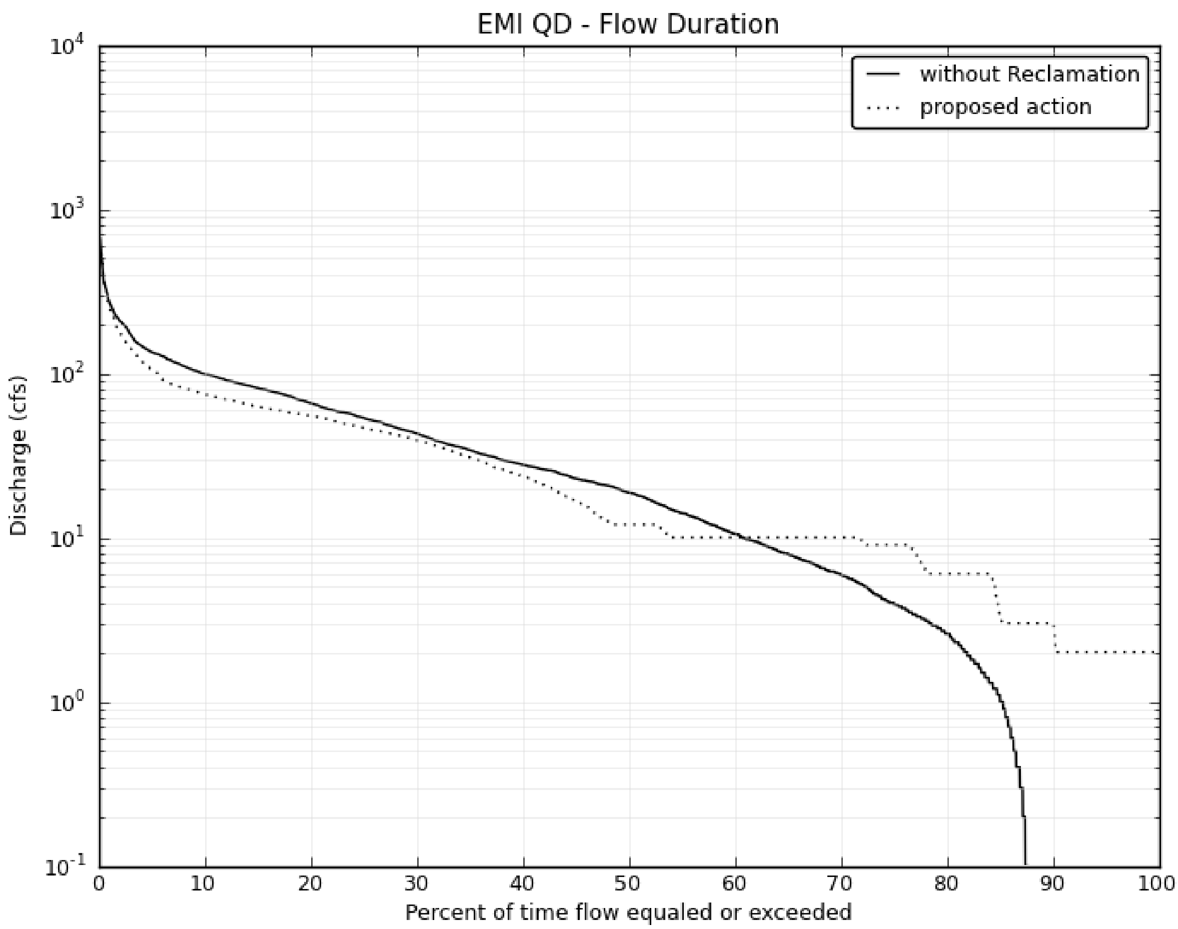


Figure 4-1. Flow duration comparison of simulated flows for Emigrant Creek from March 31, 2001 to August 28, 2011. This shows the percent of time a flow is equaled or exceeded under two modeled scenarios.

The daily flow duration analysis by month (Figure 4-2) at EMI generally shows that from October to December the scenarios are similar, being driven by decreased precipitation and little regulation. From January through May the scenarios diverge; winter/spring precipitation generally would be stored (and excess storage at Emigrant Reservoir would be periodically released during March through May to create flood control space) under proposed operations, while precipitation would tend to appear as natural flow under the without Reclamation scenario. As the irrigation season begins (typically mid-April) flows under proposed operations would increase while the without Reclamation flows would begin to decrease. As June approaches, the scenarios again diverge; the without Reclamation flow in Emigrant Creek would decrease to near zero in late summer while under the proposed action, Emigrant releases would increase throughout the summer to meet irrigation demand. The January to May and late summer flow differences between scenarios diminish as the analysis moves downstream to the confluence with the Rogue River. Early in the year, the effects of regulation in Emigrant Creek would be offset by precipitation that increases streamflow in Bear Creek. In late summer, the flow increases from Emigrant Reservoir to meet irrigation demand are diverted from Bear Creek and thus do not appear as concurrent increases in flow at MFDO and BCMO.

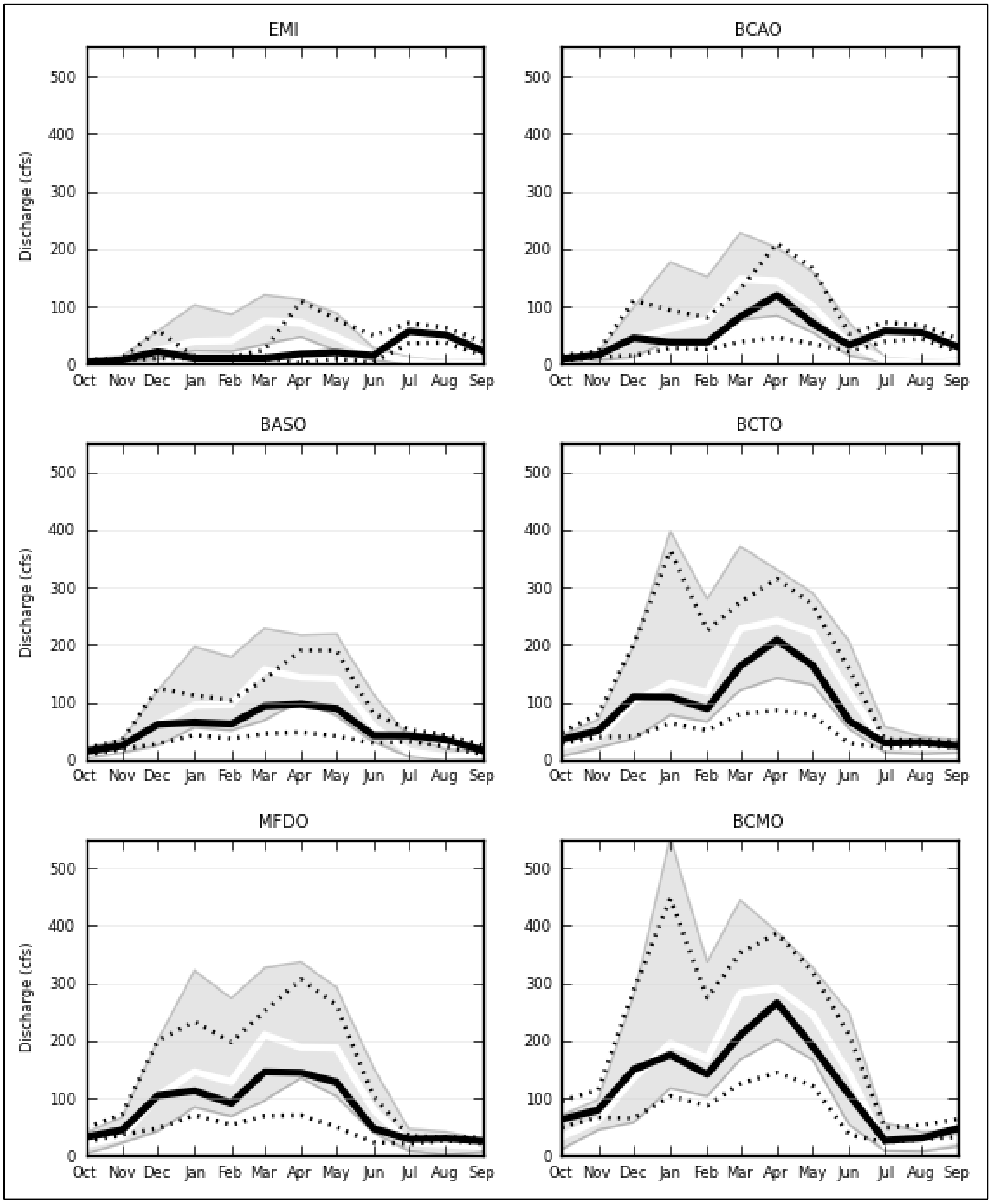


Figure 4-2. Monthly values generated from a daily flow duration analyses by month. The gray shaded region represents the low to high flow condition from the without Reclamation scenario. The dotted lines represent the low to high flow condition from the proposed action. And the solid white and black lines represent the median flow condition from the without Reclamation and proposed action scenarios, respectively. Note: the length of record for each gage may differ, see Table 4-3 below.

Precipitation has a significant impact on streamflows in Emigrant and Bear creeks. The early storage months (i.e., mid-October to December) for the area tend to be drier; thus storage has a comparatively small effect on streamflow during this period. As the storage season progresses, precipitation increases and generally has a greater impact on streamflows (GeoEngineers 2008b). This can be seen in the BCAO and BASO plots of Figure 4-2 under high flow conditions (top dotted line). While the flow at EMI is relatively steady from January through March, much higher and more variable flows are seen at BCAO and BASO due to larger precipitation events.

Ramping Rates on Emigrant Creek and Bear Creek

As part of the consultation process, TID provided Reclamation information regarding ramping rates for the Project that would be expected to reduce fish stranding and displacement. The protocol and analysis of ramping rates at Emigrant Reservoir, Oak Street Diversion Dam, and the Phoenix Canal Diversion Dam was completed in 2011 by GeoEngineers (memorandum provided in Appendix E). The proposed action is to implement the ramping rate laid out in the protocol as part of standard project operations.

4.2.3 Little Butte Creek and Antelope Creek Watersheds

Little Butte Creek Watershed

Flow duration curves for the South Fork of Little Butte Creek (GILO Hydromet gage) for the two scenarios (without Reclamation and proposed operations) are provided in Figure 4-3. The GILO curves indicate that, over time, the proposed action would provide a distribution of flows in the South Fork of Little Butte Creek similar to the without Reclamation scenario, although the timing of the distribution of flows would be shifted between scenarios and this timing shift is not distinguishable from the graph. However, under the proposed action, flows would be lower due to diversions. In general, when more natural flow is available more is diverted, and when less natural flow is available less is diverted. This is evidenced by the larger gap between the curves during median to high flow conditions, and the narrower gap during low flow conditions.

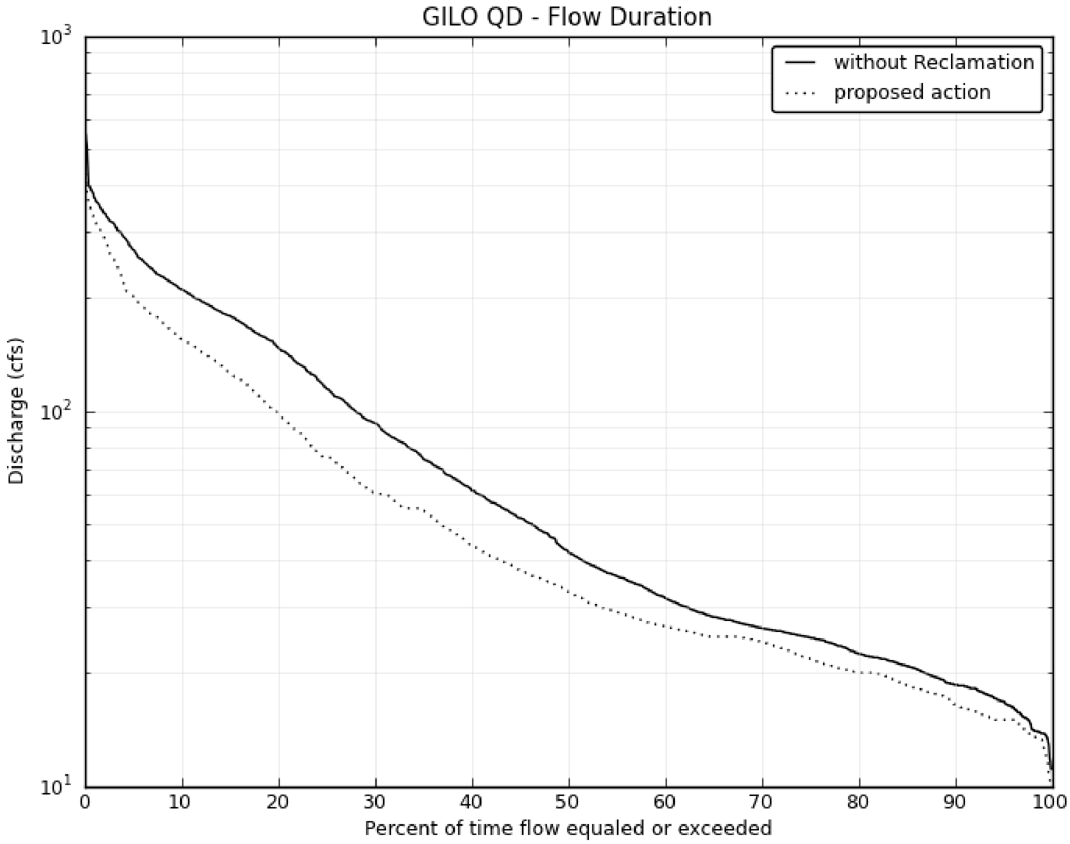


Figure 4-3. Flow duration comparison of simulated flows from the without Reclamation and proposed action scenarios for the South Fork of Little Butte Creek at GILO from March 28, 2005 to August 28, 2011.

Under the proposed action, the shape of seasonal flows in the South Fork of Little Butte Creek generally resembles the without Reclamation annual flow cycle (Figure 4-4, GILO gage). Downstream on Little Butte Creek, the general shape of seasonal flows under both scenarios also would be similar; however, under both modeled scenarios flows at LBCO and LBEO continue to be influenced by the operation of non-Reclamation facilities at Fish Lake and Four Mile reservoirs, on the North Fork of Little Butte Creek. As noted earlier, the modeled without Reclamation flows at LBCO and LBEO only account for (i.e., exclude) the hydrologic effects from operating facilities owned by Reclamation; thus the differences in the monthly flows (i.e., proposed operations vs. without Reclamation) illustrated in Figure 4-4 at LBCO and LBEO are a true reflection of the direct hydrologic effects of the proposed action.

The monthly flow curves in Figure 4-4 also reflect that during the wetter months (typically from January through June) under the proposed action, water would continue to be diverted from the South Fork of Little Butte Creek to Howard Prairie Reservoir to sustain reservoir levels in preparation for the coming irrigation season on Bear Creek. More water generally would be diverted in wetter years than in dry years. Diversions would diminish substantially from July through November in all years.

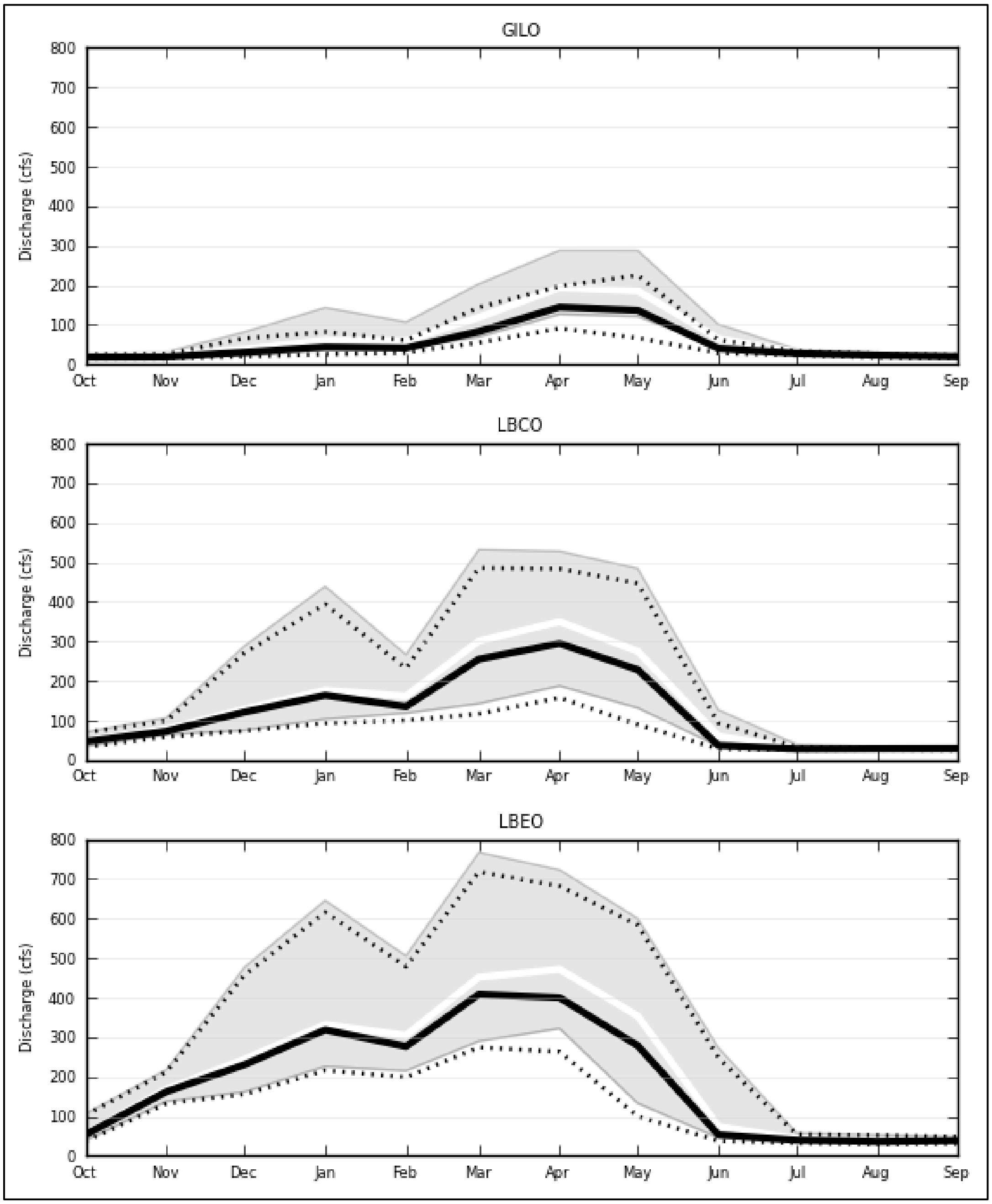


Figure 4-4. Monthly values generated from a daily flow duration analyses by month. The gray shaded region represents the low to high flow condition from the without Reclamation scenario. The dotted lines represent the low to high flow condition from the proposed action. And the white and black lines represent the median flow condition from the without Reclamation and proposed action scenarios, respectively. Note: the length of record for each gage may differ, see Table 4-3 below.

Antelope Creek Watershed

The Antelope Creek Diversion Dam on Antelope Creek diverts into a connector canal extending about 0.1-mile to Hopkins Canal. Flow from Antelope Creek conveyed to Hopkins Canal is mingled with any other flow in the canal; water can then be diverted at a bifurcation structure to Agate Reservoir. Approximately 1,800 acre-feet on average have been diverted annually from Antelope Creek (see Table 4-2). Dry Creek flow is also stored at Agate Reservoir.

From November through March, a minimum flow of 1 cfs must pass downstream from Antelope Creek Diversion Dam for streamflow maintenance and to satisfy senior water rights. The stream is often dry at the diversion dam in the summer months and no diversions are made.

Table 4-2. The historical distribution and timing of monthly average volume of diversion from Antelope Creek for the period from 2004 to 2011 (in acre-feet)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	69	271	253	195	138	288	418	169	29	16	10

4.2.4 Klamath River Basin

The Klamath River basin covers approximately 12,100 square miles in southern Oregon and northern California. There are four creeks within the basin which are affected by Project water management: Jenny Creek, Soda Creek, Keene Creek, and Little Beaver Creek. Of those four creeks, Jenny Creek is the main tributary affected as it receives water from Soda Creek, Keene Creek, Little Beaver Creek, and Johnson Creek. The hydrology of these creeks is primarily dependent on the release and diversion of water which is determined by the time of year.

As described in Chapter 2, water is transferred from the Rogue River basin to storage facilities in the Klamath River basin, and then transferred back to the Rogue River basin. Runoff in the Jenny Creek basin is also captured, stored, and routed to the Rogue River basin. During water years 1961 to 1999 and 2003 to 2011, approximately 24,000 acre-feet of water on average was annually transferred from the Jenny Creek watershed to the Rogue River basin (see Table 2-4 and Table 2-5). Without operation of the Project, this water would remain in the Klamath River basin and eventually would appear downstream. This roughly equates to a daily average of 33 cfs of water diverted from the Klamath basin throughout the year. The majority of this transfer (approximately 22,000 acre-feet) and related flow reductions to the Klamath River are estimated to occur from December to May and would be related to precipitation and snowmelt. During June and July it is expected that diversions and related flow reductions to the Klamath River typically would decline as precipitation decreases and temperatures increase throughout the summer and fall. Additional information regarding the Klamath basin hydrology can be found in the Klamath Project BA (Reclamation 2008).

4.3 General Approach to Species and Critical Habitat Effects Analyses

A combination of hydrology and habitat approaches is used to compare the amount and quality of habitat resulting from the proposed action to habitat conditions that would exist absent operation of the federal Rogue River Basin Project (the without Reclamation scenario).

Reclamation's 2009 BA evaluated the effects of the water management components of the Project by analyzing the impact of future operations relative to the current conditions (Reclamation 2009b). To better understand ongoing effects of water management activities, NOAA Fisheries requested that Reclamation estimate the full range of effects attributable to Reclamation's discretionary operation of the Project. NOAA Fisheries noted that it preferred to use a "with project" and "without project" comparison for several locations in Emigrant, Bear, and Little Butte creeks.

To satisfy this request, a without Reclamation scenario was developed by Reclamation to help inform the determination as to whether the proposed action would adversely modify or destroy critical habitat conditions within the action area or adversely affect listed species. The model used to generate the without Reclamation scenario essentially "turns-off" the collection, storage, and diversion of water over which Reclamation, as a practical matter, generally could exercise discretionary control. This includes any water collected, stored, or diverted through a Reclamation-owned facility and project water diverted through privately owned facilities. Reclamation and NOAA Fisheries believe this is a reasonable approach to provide a broad view of the nature and extent of the effects on fish habitat attributable to Project water management activities. This approach is being taken for effects analysis purposes only and does not constitute a determination by Reclamation as to the scope of its authority.

Reclamation, NOAA Fisheries, and the Districts worked collaboratively to update hydrologic models using the MODSIM modeling tool with the most recently available data from Hydromet gages in the Bear and Little Butte Creek watersheds (Appendix A). This updated data was used to model hydrologic conditions at all 9 Hydromet gages in Emigrant, Bear, and

Little Butte creeks (Table 4-3). Consistent with the modeling approach used in the May 2011 draft BiOp (NOAA Fisheries 2011a); this analysis provides results under low, median, and high flow conditions. To estimate these conditions, Reclamation performed a flow duration analysis for each Hydromet gage where data was available. All gage records were sufficient to estimate the median (50 percent probability of exceedance), low (80 percent probability of exceedance), and high (20 percent probability of exceedance) flow conditions used to inform the following habitat analysis. Table 4-3 identifies the 9 Hydromet gages used in the analysis and indicates the date that flow data information could be extracted from the modeling tool for habitat analysis at each gaging station.

Table 4-3. Station designation, stream location description, and start date at which model output data was available for analysis at each location. The end data at each location was 8/28/2011.

Station Designation	Location Description	Model output data available for analysis
EMI	Emigrant Creek downstream of Emigrant Dam	3/31/2001
BCAO	Bear Creek above Ashland	7/19/2005
BASO	Bear Creek downstream of Oak Street Diversion Dam	3/31/2001
BCTO	Bear Creek below Phoenix Diversion	7/19/2005
MFDO	Bear Creek at Medford	3/31/2001
BCMO	Bear Creek below Jackson Diversion (near mouth)	7/19/2005
GILO	South Fork Little Butte Creek near Gilkey	3/28/2005
LBCO	Little Butte Creek near Lakecreek	3/28/2005
LBEO	Little Butte Creek below Eagle Creek	3/28/2005

Using the updated Hydromet data and the MODSIM model, Reclamation estimated the flow conditions that would exist at each of the aforementioned Hydromet gages (Figure 4-5) under the without Reclamation and proposed action scenarios given median, low, and high flow conditions as defined above.

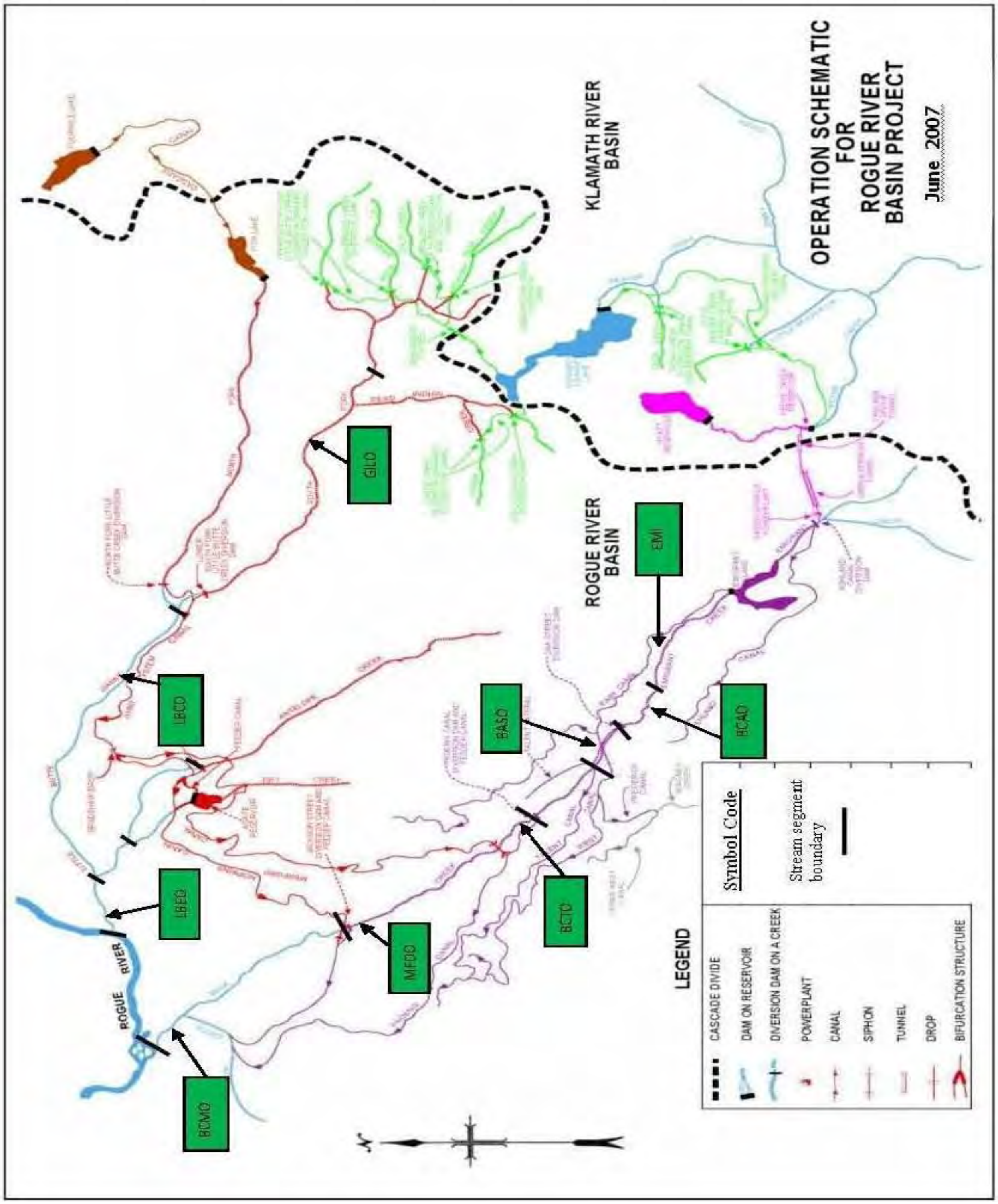


Figure 4-5. Map showing stream segments and Hydromet stations used for instream flow assessment. Reach breaks are indicated by black lines perpendicular to the Bear and Little Butte creek stream channels.

Table 4-4 through Table 4-9 below provide flow data for median, low, and high flow conditions at all 9 Hydromet gages used for monitoring Project streamflows. These data are used for analyzing habitat conditions that result from flow regulation related to the operation of the Project.

The Rogue River basin hydrology data used for this analysis is updated from the data used to analyze flow and habitat conditions in the May 2011 draft BiOp (NOAA Fisheries 2011a). The habitat data has been updated accordingly using the PHABSIM. PHABSIM data was also reanalyzed because the new hydrologic data at each Hydromet gage allowed for a one-to-one pairing of PHABSIM transect data to Hydromet gage. This one-to-one pairing allowed for improved data analysis and interpretation at each of the 9 stream reaches (the May 2011 draft BiOp only included information on 6 Hydromet gages). The updated hydrology and subsequent PHABSIM analysis was used to characterize flow-related habitat effects for each life history stage and month at each of the 9 stream reaches analyzed for each flow condition (i.e., median, low, and high).

Reclamation conducted a detailed instream flow study using the IFIM and PHABSIM to quantify these flow-habitat effects (Reclamation 2007). This model uses known use preferences for the habitat characteristics of water depth, velocity, and channel index (substrate and cover) of each species/life stage of interest to create suitability indices. Habitat suitability indices range from zero (unsuitable) to 1 (most preferred). IFIM/PHABSIM then combines a calibrated hydraulic model developed for the reaches of interest which estimates depths and velocities over a wide range of flows with the suitability indices to create a habitat response curve. This curve provides an estimate of the habitat available to the species/life stage of interest at each flow modeled. The PHABSIM flow approach involves the integration of hydrologic data with the habitat versus discharge relationship illustrated in Figure 4-6. The hydrologic data used for this approach was the monthly median values that were obtained from the daily flows or discharge for a stream reach over a defined period of time. In this approach, habitat is identified by the WUA. WUA is an index of habitat which is typically measured as square feet of usable habitat per 1,000 longitudinal feet of stream. The habitat (WUA) versus discharge (cfs) graph example is the left graph of Figure 4-6.

WUA accounts for fish habitat by looking at depth, velocity, and substrate criteria as well as the amount of habitat that is physically available. As such, the WUA values can be used as a rough index of habitat quality. An increase or decrease in WUA may come about by improving or reducing the quality of existing habitat (i.e., by causing micro-habitat conditions to move toward or away from conditions most suitable for the coho salmon life stages evaluated). Changes in WUA also may come about by changing the amount of habitat available.

Table 4-4 Median flow conditions (50 percent probability of exceedance) in cfs under the without Reclamation scenario; based on flow duration curves using daily timestep data from Hydromet stream gages in the Bear and Little Butte creek drainages (Appendix A).

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
October	4	6	12	24	20	33	21	48	56
November	7	13	21	38	34	62	26	79	169
December	24	43	63	102	104	136	38	129	245
January	40	62	95	133	146	196	61	177	332
February	41	77	97	118	129	170	60	162	305
March	75	148	157	228	210	283	119	301	452
April	72	144	143	242	189	291	194	350	472
May	47	101	141	221	187	246	186	275	354
June	18	35	59	117	81	143	65	61	75
July	6	6	15	25	24	19	31	31	44
August	1	3	6	23	20	18	25	31	37
September	2	4	8	22	17	29	21	31	39

Table 4-5. Median flow conditions (50 percent probability of exceedance) in cfs under the proposed action scenario; based on flow duration curves using daily timestep data from Hydromet stream gages in the Bear and Little Butte Creek drainages (Appendix A).

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
October	3	9	15	36	33	64	18	48	54
November	7	15	25	51	45	80	19	73	162
December	22	45	63	110	105	151	31	122	231
January	10	38	66	109	113	176	44	164	319
February	10	38	63	89	91	142	41	136	278
March	10	82	94	163	146	210	83	255	408

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
April	17	120	97	208	145	266	145	295	400
May	20	72	89	165	128	191	137	229	279
June	15	33	43	68	48	106	40	37	54
July	57	58	43	30	29	27	28	29	40
August	51	55	35	31	31	31	23	30	36
September	23	30	17	25	26	48	20	30	39

Table 4-6. Low flow conditions (80 percent probability of exceedance) in cfs under the without Reclamation scenario; based on flow duration curves using daily timestep data from Hydromet stream gages in the Bear and Little Butte Creek drainages (Appendix A).

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
October	1	3	4	7	4	11	17	35	39
November	3	6	13	21	23	45	20	65	138
December	8	12	25	37	43	58	22	75	160
January	23	42	57	78	84	117	35	103	226
February	22	37	51	66	69	102	41	117	209
March	34	76	69	120	95	164	68	142	289
April	47	84	102	142	135	199	126	186	314
May	23	54	76	130	102	167	120	132	132
June	7	14	31	53	40	53	44	35	46
July	0	3	6	13	9	9	25	27	34
August	0	0	2	11	1	7	18	27	30
September	0	0	3	13	6	17	17	26	31

Table 4-7. Low flow conditions (80 percent probability of exceedance) in cfs under the proposed action scenario; based on flow duration curves using daily timestep data from Hydromet stream gages in the Bear and Little Butte Creek drainages (Appendix A).

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
October	3	6	9	29	24	50	15	33	37
November	6	12	19	40	37	67	15	59	133
December	10	15	27	41	48	66	20	75	155
January	4	27	44	64	71	103	26	92	214
February	5	25	37	52	54	87	30	100	199
March	4	38	46	79	69	123	55	117	274
April	4	46	48	86	70	143	90	158	257
May	8	35	42	77	50	119	66	90	100
June	4	22	29	28	24	37	29	29	38
July	36	39	32	21	21	24	23	26	32
August	37	44	23	26	27	29	17	27	29
September	15	20	10	22	22	33	16	26	31

Table 4-8. High flow conditions (20 percent probability of exceedance) in cfs under the without Reclamation scenario; based on flow duration curves using daily timestep data from Hydromet stream gages in the Bear and Little Butte Creek drainages (Appendix A).

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
October	9	12	21	43	41	72	25	72	107
November	14	21	36	71	68	98	32	110	221
December	58	99	122	200	203	284	84	290	486
January	103	180	198	402	325	557	145	445	648
February	87	152	181	286	275	347	108	269	506
March	120	229	230	373	328	455	204	533	775

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
April	112	202	218	332	338	390	290	533	725
May	89	161	219	291	293	330	289	486	601
June	29	73	116	206	155	250	101	130	278
July	12	12	39	61	48	64	38	41	59
August	6	7	19	42	42	44	28	35	54
September	6	9	15	36	30	43	25	33	50

Table 4-9. High flow conditions (20 percent probability of exceedance) in cfs under the proposed action scenario; based on flow duration curves using daily timestep data from Hydromet stream gages in the Bear and Little Butte Creek drainages (Appendix A).

Month	Bear Creek						Little Butte Creek		
	Hydromet Gage Designation						Hydromet Gage Designation		
	EMI	BCAO	BASO	BCTO	MFDO	BCMO	GILO	LBCO	LBEO
October	7	15	20	48	49	96	24	70	104
November	10	22	35	81	74	115	26	100	214
December	60	110	125	206	200	289	67	271	464
January	12	95	113	374	235	456	82	403	618
February	12	81	103	228	198	276	62	237	484
March	25	131	141	279	251	357	144	486	720
April	109	210	192	325	307	393	201	485	682
May	78	169	190	270	262	325	228	448	583
June	50	56	81	161	104	214	62	96	252
July	71	73	53	37	35	51	34	34	55
August	64	67	44	34	33	54	27	33	53
September	39	44	25	33	32	65	23	32	49

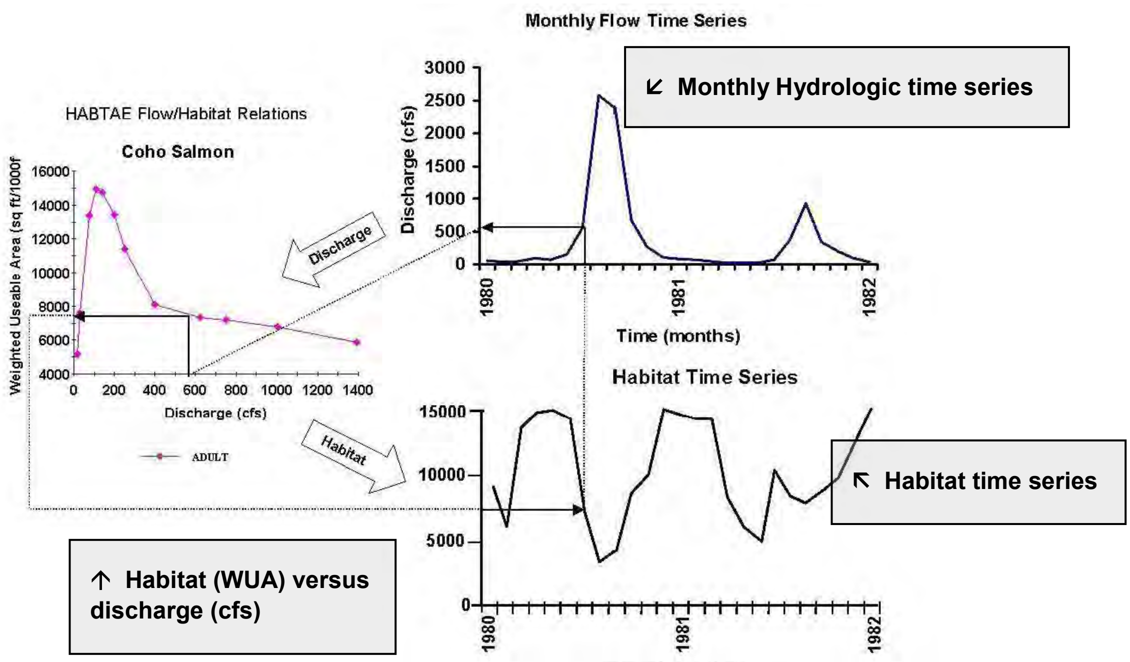


Figure 4-6. Illustration of a generic PHABSIM flow-habitat relationship development.

The PHABSIM modeling methods used and the results obtained from this analysis are considered to be the best currently available scientific information applicable to this consultation. Use of all nine available IFIM/PHABSIM modeling locations for analyzing changes in habitat with flow allows for a thorough representation of habitat conditions and effects. Improvements over past analyses also result from the wider geographic distribution of habitat monitoring locations across the affected stream systems, allowing for better resolution of effects on a reach by reach basis.

4.4 Effects to SONCC Coho Salmon Critical Habitat

This section describes the effects of the proposed action on designated critical habitat for SONCC coho salmon inhabiting the Rogue River basin and the mainstem Klamath River downstream from Iron Gate Dam. The specific critical habitat affected by the proposed action is within the Bear Creek 5th field watershed (HUC # 1710030801) and within the Little Butte Creek 5th field watershed (HUC # 1710030708). Critical habitat within affected 5th field watersheds of the Klamath River basin is also evaluated in this BA. SONCC coho salmon use both Bear and Little Butte Creek watersheds for spawning and juvenile rearing as well as migration for adults and juveniles. The portion of the Klamath basin watershed that is directly affected by the future O&M of the Project is not accessible to coho salmon due to the presence of Iron Gate Dam on the Klamath River. The primary constituent elements (PCEs) that support these life stages and their conservation requirements are presented in Table 4-10. These PCEs are the focus of the critical habitat analysis.

Table 4-10. Critical habitat PCEs for SONCC coho salmon, site attributes supporting those PCEs, and corresponding species life history events within the action area.

Primary Constituent Element (PCE)	Site Attribute	Species Life History Event
Spawning and Incubation	Cover/shelter Riparian vegetation Space Spawning gravel Water quality Water quantity Water temperature Water velocity	Adult spawning Embryo incubation Alevin development Fry emergence
Juvenile Rearing	Cover/shelter Food (juvenile rearing) Riparian vegetation Space Water quality Water quantity Water temperature Water velocity	Fry/parr growth and development Fry/parr smoltification Smolt growth and development
Juvenile Migration Corridors	Cover/shelter Food Riparian vegetation Safe Passage Space Substrate Water quality Water quantity Water temperature Water velocity	Fry/parr smolt transformation Smolt growth and development Smolt seaward migration

Primary Constituent Element (PCE)	Site Attribute	Species Life History Event
Areas for growth and development to adulthood	Ocean areas – not identified within action area	Smolt/adult transition Adult growth and development Adult sexual maturation
Adult Migration Corridors	Cover/shelter Riparian vegetation Safe passage Space Substrate Water quality Water quantity Water temperature Water velocity	Adult sexual maturation Adult upstream migration

The ESA requires that the designation of critical habitat be based on the conditions which are found at the time of designation. An occupied area must contain one or more of the PCEs to be eligible for designation as critical habitat and cannot be designated as critical habitat unless it contained physical or biological features essential to the conservation of the species (70 FR 52630). In designating critical habitat for SONCC coho salmon, NOAA Fisheries focused on the known physical and biological features, referred to as PCEs, that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

Stages of the SONCC coho salmon life cycle can be delineated based on usage of five essential habitat types: 1) juvenile salmon summer and winter rearing areas; 2) juvenile salmon migration corridors; 3) areas for growth and development to adulthood; 4) adult migration corridors; and 5) spawning areas. Essential features or attributes supporting PCEs associated with these areas are identified in Table 4-10. The PCE attributes identified within the action area include adequate: 1) substrate, 2) water quality, 3) water quantity, 4) water temperature, 5) water velocity, 6) cover/shelter, 7) food, 8) riparian vegetation, 9) space, and 10) safe passage conditions including all areas accessible to any life-stage up to long-standing, natural barriers and adjacent riparian zones (64 FR 24049).

For this analysis, a difference in WUA for coho salmon indicates a difference in potential critical habitat conditions. Negative differences in WUA indicate detriments to critical habitat; positive differences in WUA indicate benefits to critical habitat conditions. Impacts from the proposed action on designated critical habitat for coho salmon are generally expressed throughout the remainder of this analysis as outlined in Table 4-11. Reach-specific effects are based on comparisons of WUA habitat values for the proposed action vs. without Reclamation scenarios. For example, where the analysis indicates that the proposed action will result in a difference of 5 to 10 percent in WUA when compared to the WUA that would be available at the same location under the without Reclamation scenario, effects are characterized as either small benefits or small detriments. Habitat differences are considered substantial where the difference in WUA between scenarios exceeds 20 percent. This approach is consistent with that used in Reclamation's 2009 BA (Reclamation 2009b) and similar to the approach used by NOAA Fisheries in the 2002 BiOp for the Operation of the Klamath Project (NOAA Fisheries 2002).

Table 4-11. Characterizing effects of the proposed action on potential coho salmon critical habitat through comparison of WUAs (proposed action vs. without Reclamation scenarios).

Critical habitat effect	Difference in WUAs (Proposed Action vs. without Reclamation)	Effect to %WUA Relative to Without Reclamation conditions
Substantial benefit	Greater than 20%	>120%
Moderate benefit	11 to 20%	111% to 120%
Small benefit	5 to 10%	106% to 110%
Very small benefit	1 to 5%	101% to 105%
No difference	0	100%
Very small detriment	-1 to -5%	95% to 99%
Small detriment	-5 to -10%	90% to 94%
Moderate detriment	-11 to -20%	80% to 89%
Substantial detriment	Greater than -20%	<80%

To evaluate how Reclamation's water management affects fish habitat potential in the Bear and Little Butte Creek watersheds, Reclamation compared the WUA of habitat that would be available by month under the without Reclamation scenario to the WUA that would be available under the proposed action. The resulting difference in WUAs indicates the change in habitat potential resulting from proposed water management activities and instream flows.

Using the updated daily time-step Hydrology data, Reclamation analyzed the WUA that would result in each stream reach of the Bear and Little Butte Creek watersheds at high, median, and low flow conditions for both the without Reclamation and proposed action scenarios. As described in the Hydrology section, the proposed action flows presented in this analysis are simulated (modeled) flows that would be expected if the proposed instream flow targets are implemented at Emigrant Dam (EMI gage), Oak Street Diversion (BASO gage) and Phoenix Diversion (BCTO gage) and the South Fork Little Butte Creek Collection Facilities (GILO gage) in the headwaters of South Fork Little Butte Creek.

The effects of individual instream flow targets, when they occur, are addressed in this analysis according to the probability with which they are to be exceeded. For instance, average state flow targets for Emigrant Creek drive median flow conditions from January through March. In April however, modeling predicts that median flows are more likely to result from operational releases from Emigrant Reservoir than from the instream flow target. In these months, Reclamation analyzes the instream flow target that is likely to be met or exceeded at least 80 percent of the time, or, if the flow target is met or exceeded greater than 80 percent of the time, Reclamation analyzes the modeled low flow value because it is more likely to occur.

For this approach, WUA comparisons between proposed action and without Reclamation scenarios are made at similar flow conditions. Monthly WUA values resulting from median, low, and high flow conditions are presented in Table 4-12 through Table 4-38 and are shown for both without Reclamation and proposed action scenarios and for all nine Hydromet gages used by NOAA Fisheries for analyzing habitat effects in the May 2011 draft BiOp (NOAA Fisheries 2011a). These tables indicate the degree of habitat effect (ft^2 per 1,000 ft of stream channel) attributable to flow management under the proposed action in the Emigrant, Bear, and Little Butte Creek watersheds. Table 4-12 through Table 4-38 also indicate the percent WUA that would occur by month and coho salmon life stage with implementation of the proposed action relative to the maximum amount of WUA that would be anticipated to occur under the without Reclamation scenario. These effects were evaluated and conclusions were developed for individual stream reaches in both the Bear and Little Butte Creek watersheds.

Reclamation notes that a comparison of the proposed action to without Reclamation conditions provides an assessment of the effect of the Project on habitat potential. While, immediate effects of the action on currently existing coho habitat are not addressed in this analysis, Reclamation anticipates increases in instream flows under the proposed action will cause habitat availability to improve relative to conditions in the environmental baseline. The intent of the following analysis is to determine whether Reclamation’s action may affect future populations of coho salmon in the action area.

Table 4-12. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Emigrant Creek downstream from Emigrant Dam near Ashland Oregon under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the EMI Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	3	23477		5679		4	24471		5986			-307			95%	
November	7	27178	5332		4334	7	27178	5332		4334	0		0	100%		100%
December	22	29907	9094		5323	24	30136	9359		5377	-265		-54	97%		99%
January	10	28217	6397		4695	40	31434	10668		5536	-4271		-841	60%		85%
February	10	28217	6397		4695	41	31535	10709		5543	-4312		-848	60%		85%
March	10	28217	6397		4695	75	33917	10870		5540	-4473		-845	59%		85%
April	17	29250	8390		5151	72	33818	10924		5532	-2534		-381	77%		93%
May	20	29679	8829	7629		47	32180	11136	7438		-2307	191		79%	103%	
June	15	29088		7468		18	29420		7565			-97			99%	
July	57	33292		7126		6	26311		6450			676			110%	
August	51	32658		7349		1	21403		4804			2545			153%	
September	23	30022		7670		2	22446		5252			2418			146%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-13. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Emigrant Creek downstream from Emigrant Dam near Ashland Oregon under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the EMI Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	3	23477		5679		1	21403		4804			875			118%	
November	6	26311	4859		4181	3	23477	2847		3586	2012		595	171%		117%
December	10	28217	6397		4695	8	27573	5710		4462	687		233	112%		105%
January	4	24471	3571		3819	23	30022	9227		5351	-5656		-1532	39%		71%
February	5	25423	4223		4012	22	29907	9094		5325	-4871		-1313	46%		75%
March	4	24471	3571		3819	34	31024	10308		5516	-6737		-1697	35%		69%
April	4	24471	3571		3819	47	32150	10924		5581	-7353		-1762	33%		68%
May	8	27573	5710	6800		23	30022	9227	7678		-3517	-878		62%	89%	
June	4	24471		5986		7	27178		6645			-659			90%	
July	36	31163		7620		0	13267		3036			4584			251%	
August	37	31231		7601		0	13267		3036			4565			250%	
September	15	29088		7468		0	13267		3036			4432			246%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-14. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Emigrant Creek downstream from Emigrant Dam near Ashland Oregon under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the EMI Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	7	27178		6645		9	27968		6958			-313			96%	
November	10	28217	6397		4695	14	28913	7509		4995	-1112		-300	85%		94%
December	60	33408	11090		5564	58	33292	11080		5576	10		-12	100%		100%
January	12	28565	6953		4845	103	34886	10935		5621	-3982		-776	64%		86%
February	12	28565	6953		4845	87	34298	10915		5572	-3962		-727	64%		87%
March	25	30212	9458		5397	120	35740	11071		5678	-1613		-281	85%		95%
April	109	35100	10975		5631	112	35170	11003		5640	-28		-9	100%		100%
May	78	34024	10881	6669		89	34340	10919	6580		-38	89		100%	101%	
June	50	32543		7379		29	30481		7692			-313			96%	
July	71	33785		6765		12	28565		7232			-467			94%	
August	64	33548		6892		6	26311		6450			442			107%	
September	39	31330		7564		6	26311		6450			1114			117%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-15. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between Emigrant Creek and the Oak Street diversion near Ashland Oregon under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the BCAO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	9	21592		2724		6	20800		2450			274			111%	
November	15	24392	8629		2024	13	23000	7835		1880	794		144	110%		108%
December	45	34639	13064		3326	43	34369	12830		3221	234		105	102%		103%
January	38	33159	12166		2947	62	37249	14520		3824	-2354		-877	84%		77%
February	38	33159	12166		2947	77	38007	14014		3878	-1848		-931	87%		76%
March	82	38208	14045		3941	148	41658	13622		4084	423		-143	103%		96%
April	120	40212	13738		4271	144	41026	13862		4097	-124		174	99%		104%
May	72	37767	14145	4958		101	39617	14032	4909		113	49		101%	101%	
June	33	31083		3739		35	31953		3831			-92			98%	
July	58	36923		5095		6	20800		2500			2595			204%	
August	55	36639		5066		3	20150		2400			2666			211%	
September	30	29777		3602		4	21046		2450			1152			147%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-16. Simulated monthly habitat areas (ft[2] per 1,000 linear ft) for SONCC coho in Bear Creek between Emigrant Creek and the Oak Street diversion near Ashland Oregon under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the BCAO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft[2] per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	6	20800		2550		3	20150		2450			100			104%	
November	12	22876	7817		1840	6	20800	5981		1531	1836		309	131%		120%
December	15	24392	8629		2024	12	22876	7817		1840	812		184	110%		110%
January	27	28787	10612		2497	42	34233	12713		3169	-2101		-672	83%		79%
February	25	28127	10345		2453	37	32757	12010		2888	-1665		-435	86%		85%
March	38	33159	12166		2946	76	37972	14113		3863	-1947		-917	86%		76%
April	46	35109	13370		3424	84	38315	14059		3966	-689		-542	95%		86%
May	35	31953	11698	3831		54	36474	14403	5020		-2705	-1189		81%	76%	
June	22	27100		3420		14	23600		2950			470			116%	
July	39	33563		4185		3	20150		2450			1735			171%	
August	44	34500		4470		0	14000		1350			3120			331%	
September	20	26600		3400		0	14000		1350			2050			252%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-17. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between Emigrant Creek and the Oak Street diversion near Ashland Oregon under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the BCAO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	15	24392		3092		12	22876		2905			187			106%	
November	22	27100	9750		2375	21	26905	9693		2347	57		28	101%		101%
December	110	39899	13878		4205	99	39586	14018		4139	-140		66	99%		102%
January	95	39425	14015		4125	180	42869	13000		4638	1015		-513	108%		89%
February	81	38139	14032		3923	152	41800	13744		4421	288		-498	102%		89%
March	131	40500	13600		4250	229	43405	12310		4944	1290		-694	110%		86%
April	210	43107	12443		4881	202	42810	12576		4819	-133		62	99%		101%
May	169	41960	12800	4356		161	41800	12998	4425		-198	-69	0	98%	98%	
June	56	36714		5077		73	37843		4946			131			103%	
July	73	37843		4946		12	22876		2905			2041			170%	
August	67	37593		5000		7	21046		2613			2387			191%	
September	44	34500		4470		9	21592		2724			1746			164%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-18. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between the Oak Street diversion and Valley View Road near Ashland Oregon under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the BASO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1,2]			Habitat Effects (% of w/o Recl. WUA)		
Month	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	15	24392		3092		12	22876		2905			187			106%	
November	25	28127	10345		2453	21	26905	9693		2347	652		106	107%		105%
December	63	37214	14534		3812	63	37214	14534		3812	0		0	100%		100%
January	66	37433	14407		3812	95	39038	14006		4078	401		-266	103%		93%
February	63	37214	14534		3812	97	39283	14009		4104	525		-292	104%		93%
March	94	38928	14006		4065	157	41800	13744		4421	262		-356	102%		92%
April	97	39283	14009		4104	143	41001	13895		4105	114		-1	101%		100%
May	89	38418	14007	4874		141	40925	13915	4825		92	49		101%	101%	
June	43	34369		4414		59	36923		5112			-698			86%	
July	43	34369		4414		15	24392		3092			1322			143%	
August	35	31953		3831		6	20800		2500			1331			153%	
September	17	25275		3215		8	21300		2680			535			120%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Note: 2. PHABSIM transects from an upstream location (BCAO transects) were used to determine WUA habitat affects for the flows at BASO because the BASO PHABSIM transect location downstream of the Oak Street diversion provided insufficient data to use in the WUA analysis at Median to high flows.

Table 4-19. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between the Oak Street diversion and Valley View Road near Ashland Oregon under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the BASO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	9	21592		2724		4	20650		2500			224			109%	
November	19	26158	9350		2262	13	23000	7835		1880	1515		382	119%		120%
December	27	28787	10612		2497	25	28127	10345		2453	267		44	103%		102%
January	44	34504	12947		3274	57	36781	14592		3787	-1645		-513	89%		86%
February	37	32757	12010		2888	51	35975	13950		3571	-1940		-683	86%		81%
March	46	35109	13370		3424	69	37726	14239		3831	-869		-407	94%		89%
April	48	35344	13523		3473	102	39648	13990		4153	-467		-680	97%		84%
May	42	34233	12713	3195		76	37972	14113	3860		-1400	-665		90%	83%	
June	29	29236		3568		31	30212		3648			-80			98%	
July	32	30450		3695		6	20800		2550			1145			145%	
August	23	27350		3445		2	20150		2450			995			141%	
September	10	21865		2779		3	20150		2450			329			113%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Note: 2. PHABSIM transects from an upstream location (BCAO transects) were used to determine WUA habitat affects for the flows at BASO because the BASO PHABSIM transect location downstream of the Oak Street diversion provided insufficient data to use in the WUA analysis at Median to high flows.

Table 4-20. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between the Oak Street diversion and Valley View Road near Ashland Oregon under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the BASO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1,2]			Habitat Effects (% of w/o Recl. WUA)		
Month	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	20	26600		3400		21	26905		3420			-20			99%	
November	35	31953	11698		2772	36	32757	12010		2830	-312		-58	97%		98%
December	125	40369	13871		4297	122	40275	13710		4260	161		37	101%		101%
January	113	40028	13834		4218	198	42810	12576		4819	1258		-601	110%		88%
February	103	39680	14000		4142	181	42869	13000		4638	1000		-496	108%		89%
March	141	40807	13472		4396	230	43405	12310		4944	1162		-548	109%		89%
April	192	42830	12814		4738	218	43137	12687		4905	127		-167	101%		97%
May	190	42835	12864	3163		219	43137	12687	2685		177	478		101%	118%	
June	81	38139		4932		116	40068		4877			55			101%	
July	53	36308		4975		39	33563		4185			790			119%	
August	44	34500		4470		19	26158		3338			1132			134%	
September	25	28127		3472		15	24392		3092			380			112%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Note: 2. PHABSIM transects from an upstream location (BCAO transects) were used to determine WUA habitat affects for the flows at BASO because the BASO PHABSIM transect location downstream of the Oak Street diversion provided insufficient data to use in the WUA analysis at Median to high flows.

Table 4-21. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between Valley View Road and the Phoenix diversion under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the BCTO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	36	37007		4851		24	34258		4870			-19			100%	
November	51	41109	21632		3667	38	37603	20325		3697	1307		-30	106%		99%
December	110	49453	22981		3822	102	49195	23179		3806	-198		16	99%		100%
January	109	49419	23006		3820	133	50143	21967		3866	1039		-46	105%		99%
February	89	47832	23302		3789	118	49703	22721		3846	581		-57	103%		99%
March	163	51890	20245		3890	228	52901	17450		3980	2795		-90	116%		98%
April	208	52360	18058		3945	242	53489	16450		3992	1608		-47	110%		99%
May	165	51890	20245	4400		221	52742	17348	4015		2897	385		117%	110%	
June	68	45894		4652		117	49672		4620			32			101%	
July	30	35760		4889		25	34617		4879			10			100%	
August	31	35950		4884		23	33900		4860			24			100%	
September	25	34617		4879		22	33676		4849			30			101%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-22. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between Valley View Road and the Phoenix diversion under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the BCTO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	29	35508		4886		7	28003		4273			613			114%	
November	40	38199	20596		3701	21	33363	16866		3563	3730		138	122%		104%
December	41	38439	20689		3700	37	37305	20190		3694	499		6	102%		100%
January	64	45585	22373		3701	78	46890	23119		3794	-746		-93	97%		98%
February	52	41338	21706		3668	66	45791	22481		3704	-775		-36	97%		99%
March	79	47001	23193		3808	120	49764	22642		3851	551		-43	102%		99%
April	86	47580	23137		3783	142	50360	21558		3874	1579		-91	107%		98%
May	77	46780	23047	4721		130	50056	22123	4570		924	151		104%	103%	
June	28	35303		4884		53	41800		4629			255			106%	
July	21	33363		4838		13	30850		4670			168			104%	
August	26	35074		4883		11	30152		4588			295			106%	
September	22	33676		4849		13	30850		4670			179			104%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-23. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between Valley View Road and the Phoenix diversion under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the BCTO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	48	40289		4679		43	38920		4761			-82			98%	
November	81	47111	23265		3822	71	46101	22642		3708	623		114	103%		103%
December	206	52246	18231		3945	200	52188	18334		3942	-103		3	99%		100%
January	374	61521	15541		4357	402	63092	14597		4426	944		-69	106%		98%
February	228	54923	19505		4069	286	57751	17806		4192	1699		-123	110%		97%
March	279	57437	17995		4179	373	61521	15541		4357	2454		-178	116%		96%
April	325	59322	16862		4261	332	59950	16485		4288	377		-27	102%		99%
May	270	56808	18372	4158		291	57751	17806	4098		566	60		103%	101%	
June	161	51860		4401		206	52246		4359			42			101%	
July	37	37305		4825		61	44078		4618			207			104%	
August	34	36519		4867		42	38802		4768			99			102%	
September	33	35950		4884		36	37007		4851			33			101%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-24. Simulated monthly habitat areas (ft² per 1,000 linear ft) for SONCC coho in Bear Creek between the Phoenix diversion and the Jackson Street diversion near Medford Oregon under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the MFDO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft² per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	33	30152		3762		20	27187		3987			-225			94%	
November	45	32114	9893		2732	34	30314	9168		2758	725		-26	108%		99%
December	105	35460	10266		2600	104	35400	10287		2597	-21		3	100%		100%
January	113	35724	10014		2622	146	36745	9272		2680	742		-58	108%		98%
February	91	34897	10542		2566	129	36237	9580		2660	962		-94	110%		96%
March	146	36745	9272		2680	210	38613	8239		2755	1033		-75	113%		97%
April	145	36700	9272		2678	189	37981	8533		2712	739		-34	109%		99%
May	128	36237	9580	2916		187	37950	8543	2790		1037	126		112%	105%	
June	48	32300		3458		81	34525		2969			489			116%	
July	29	29450		3840		24	28116		3924			-84			98%	
August	31	29828		3801		20	27187		3987			-186			95%	
September	26	28750		3870		17	25995		4036			-166			96%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-25. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Bear Creek between the Phoenix diversion and the Jackson Street diversion near Medford Oregon under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the MFDO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	24	28219		3924		4	20895		3800			124			103%	
November	37	30963	9490		2758	23	27961	8002		2760	1488		-2	119%		100%
December	48	32489	10075		2730	43	31618	9748		2748	327		-18	103%		99%
January	71	33628	10734		2570	84	34673	10570		2553	164		17	102%		101%
February	54	32763	10417		2692	69	33600	10733		2578	-316		114	97%		104%
March	69	33600	10733		2578	95	35074	10483		2575	250		3	102%		100%
April	70	33628	10734		2570	135	36443	9440		2669	1294		-99	114%		96%
May	50	32489	10075	3432		102	35327	10385	2940		-310	492		97%	117%	
June	24	28116		3924		40	31287		3626			298			108%	
July	21	27445		3969		9	23000		4015			-46			99%	
August	27	28953		3867		1	12500		2650			1217			146%	
September	22	27703		3951		6	21717		3886			65			102%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-26. Simulated monthly habitat areas (ft² per 1,000 linear ft) for SONCC coho in Bear Creek between the Phoenix diversion and the Jackson Street diversion near Medford Oregon under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the MFDO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft² per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	49	32367		3451		41	31407		3607			-156			96%	
November	74	33845	10662		2553	68	33513	10730		2593	-68		-40	99%		98%
December	200	38313	8379		2735	203	38397	8316		2734	63		1	101%		100%
January	235	39176	7842		2751	325	41802	6366		2832	1476		-81	123%		97%
February	198	38180	8400		2720	275	40661	7256		2899	1144		-179	116%		94%
March	251	40015	7525		2850	328	42093	6202		2841	1323		9	121%		100%
April	307	41510	6530		2823	338	42385	6038		2850	492		-27	108%		99%
May	262	40051	7350	2677		293	40926	6858	2627		492	50		107%	102%	
June	104	35426		2938		155	36988		2854			84			103%	
July	35	30500		3700		48	32247		3470			230			107%	
August	33	30152		3762		42	31527		3588			174			105%	
September	32	29828		3801		30	29666		3820			-19			100%	

Table 4-27. Simulated monthly habitat areas using River2D Modeling (m^2 per 93 m) for SONCC coho in Bear Creek between Jackson Street diversion and the mouth under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the BCMO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (m^2 per 93 m) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	64			428		33			455			-27			94%	
November	80		606		425	62		620		435	-14		-10	98%		98%
December	151		548		427	136		554		427	-6		0	99%		100%
January	176		537		416	196		519		414	18		2	103%		100%
February	142		550		426	170		542		419	8		7	101%		102%
March	210		510		414	283		456		407	54		7	112%		102%
April	266		465		408	291		450		406	15		2	103%		100%
May	191		525	402		246		466	400		59	2		113%	101%	
June	106			418		143			416			2			100%	
July	27			453		19			446			7			102%	
August	31			455		18			444			11			102%	
September	48			445		29			455			-10			98%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-28. Simulated monthly habitat areas using River2D Modeling (m^2 per 93 m) for SONCC coho in Bear Creek between Jackson Street diversion and the mouth under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the BCMO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (m^2 per 93 m) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	50			443		11			430			13			103%	
November	67		620		434	45		607		454	13		-20	102%		96%
December	66		620		434	58		619		440	1		-6	100%		99%
January	103		585		425	117		569		428	16		-3	103%		99%
February	87		600		425	102		586		424	14		1	102%		100%
March	123		564		429	164		544		420	20		9	104%		102%
April	143		550		426	199		518		415	32		11	106%		103%
May	119		566	421		167		543	409		23	12		104%	103%	
June	37			454		53			439			15			103%	
July	24			451		9			420			31			107%	
August	29			454		7			403			51			113%	
September	33			455		17			442			13			103%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-29. Simulated monthly habitat areas using River2D Modeling (m^2 per 93 m) for SONCC coho in Bear Creek between Jackson Street diversion and the mouth under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the BCMO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (m^2 per 93 m) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	96			418		72			425			-7			98%	
November	115		571		428	98		590		424	-19		4	97%		101%
December	289		458		396	284		450		406	8		-10	102%		98%
January	456		352		364	557		278		342	74		22	127%		106%
February	276		456		407	347		418		384	38		23	109%		106%
March	357		412		382	455		352		364	60		18	117%		105%
April	393		390		376	390		390		376	0		0	100%		100%
May	325		435	374		330		432	372		3	2		101%	101%	
June	214			402		250			409			-7			98%	
July	51			442		64			429			13			103%	
August	54			439		44			450			-11			98%	
September	65			429		43			449			-20			96%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-30. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in South Fork Little Butte Creek downstream of Dead Indian Creek under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the GILO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	18	23654		2630		21	25057		2684			-54			98%	
November	19	24178	6439		1357	26	26908	7125		1512	-686		-155	90%		90%
December	31	28950	7471		1609	38	31724	7704		1692	-233		-83	97%		95%
January	44	32509	7833		1772	61	33622	8645		1907	-812		-135	91%		93%
February	41	32129	7767		1736	60	33558	8618		1900	-851		-164	90%		91%
March	83	34906	9089		2043	119	37784	8178		2352	911		-309	111%		87%
April	145	39774	7816		2551	194	41935	7105		2875	711		-324	110%		89%
May	137	39090	7910	3697		186	41785	7168	4050		742	-353		110%	91%	
June	40	32003		2998		65	33878		3217			-219			93%	
July	28	27772		2785		31	28950		2828			-43			98%	
August	23	25750		2700		25	26476		2749			-49			98%	
September	20	24702		2668		21	25057		2684			-16			99%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-31. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in South Fork Little Butte Creek downstream of Dead Indian Creek under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the GILO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	15	22081		2572		17	23129		2610			-38			99%	
November	15	22081	5894		1254	20	24702	6575		1383	-681		-129	90%		91%
December	20	24702	6575		1383	22	25412	6761		1427	-186		-44	97%		97%
January	26	26476	7042		1491	35	30320	7574		1652	-532		-161	93%		90%
February	30	28637	7403		1580	41	32129	7767		1736	-364		-156	95%		91%
March	55	33245	8467		1861	68	34061	8901		1954	-434		-93	95%		95%
April	90	35423	9069		2090	126	38060	8103		2382	966		-292	112%		88%
May	66	33910	8801	3217		120	37855	8159	3572		642	-355		108%	90%	
June	29	28637		2808		44	32500		3065			-257			92%	
July	23	25750		2700		25	26476		2749			-49			98%	
August	17	23129		2610		18	23654		2630			-20			99%	
September	16	22600		2592		17	23129		2610			-18			99%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-32. Simulated monthly average habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in South Fork Little Butte Creek downstream of Dead Indian Creek **under** high flow conditions (20% exceedance) **for proposed action and without Reclamation scenarios at the GILO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Reclamation 2012).**

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	24	26121		2721		25	26476		2749			-28			99%	
November	26	26908	7125		1512	32	29310	7471		1609	-346		-97	95%		94%
December	67	33910	8801		1939	84	34960	9089		2047	-288		-108	97%		95%
January	82	34853	9089		2037	145	39774	7816		2551	1273		-514	116%		80%
February	62	33650	8675		1913	108	36983	8574		2262	101		-349	101%		85%
March	144	39683	7831		2544	204	44240	5867		2994	1964		-450	133%		85%
April	201	44111	5898		2978	290	45325	2631		3722	3267		-744	224%		80%
May	228	46477	4845	4367		289	45325	2631	4800		2214	-610		184%	91%	
June	62	33750		3210		101	36194		3399			-189			94%	
July	34	29983		2884		38	31724		2960			-76			97%	
August	27	28054		2773		28	27772		2785			-12			100%	
September	23	25057		2684		25	26476		2749			-65			98%	

Note: 1. Positive numbers or WUA over 100% reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100% reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-33. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Little Butte Creek downstream of Lake Creek under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the LBCO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	48	50905		6373		48	50905		6373			0			100%	
November	73	53531	26092		5102	79	53969	26064		5196	28		-94	100%		98%
December	122	55534	24686		5816	129	55755	24322		5889	364		-73	101%		99%
January	164	57062	22738		6152	177	57465	22306		6231	432		-79	102%		99%
February	136	55997	24120		5937	162	56991	22824		6139	1296		-202	106%		97%
March	255	60150	19074		6892	301	62114	17260		7264	1814		-372	111%		95%
April	295	61940	17429		7223	350	63484	15879		7685	1550		-462	110%		94%
May	229	59477	20205	8711		275	61150	18204	8985		2001	-274		111%	97%	
June	37	48860		5669		61	52177		6836			-1167			83%	
July	29	47350		5073		31	47809		5223			-150			97%	
August	30	47634		5149		31	47809		5223			-74			99%	
September	30	47634		5149		31	47809		5223			-74			99%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-34. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Little Butte Creek downstream of Lake Creek under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the LBCO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	33	48335		5446		35	48510		5521			-75			99%	
November	59	51944	25481		4773	65	52787	25863		4905	-382		-132	99%		97%
December	75	53531	26092		5102	75	53531	26092		5102	0		0	100%		100%
January	92	54490	25969		5398	103	54879	25870		5559	99		-161	100%		97%
February	100	54774	25741		5514	117	55019	25440		5619	301		-105	101%		98%
March	117	55655	24982		5750	142	56235	23715		5982	1267		-232	105%		96%
April	158	56919	22912		6125	186	57916	21800		6332	1112		-207	105%		97%
May	90	54385	26065	7466		132	56050	24200	8080		1865	-614		108%	92%	
June	29	47350		5073		35	48510		5521			-448			92%	
July	26	46757		4845		27	46865		4960			-115			98%	
August	27	46865		4960		27	46865		4960			0			100%	
September	26	46757		4845		26	46757		4845			0			100%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-35. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Little Butte Creek downstream of Lake Creek under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the LBCO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	70	53176		7079		72	53318		7125			-46			99%	
November	100	54774	25741		5514	110	55127	25307		5659	434		-145	102%		97%
December	271	60998	18468		7016	290	61742	17663		7181	805		-165	105%		98%
January	403	65833	13234		8090	445	67320	11624		8420	1610		-330	114%		96%
February	237	59882	19676		6768	269	60998	18468		7016	1208		-248	107%		96%
March	486	69180	9611		8833	533	70667	8000		9164	1611		-331	120%		96%
April	485	69180	9611		8833	533	70667	8000		9164	1611		-331	120%		96%
May	448	67692	11221	10062		486	69180	9611	10307		1610	-245		117%	98%	
June	96	54521		7551		130	55755		8065			-514			94%	
July	34	48335		5446		41	49386		5892			-446			92%	
August	33	48159		5372		35	48860		5669			-297			95%	
September	32	47809		5223		33	48159		5372			-149			97%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-36. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Little Butte Creek below Antelope Creek near Eagle Point Oregon under median flow conditions (50 percent exceedance) for proposed action and without Reclamation scenarios at the LBEO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
Month	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Median Flow (50% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	54	62011		4362		56	62106		4365			-3			100%	
November	162	74059	20572		3126	169	74522	20661		3154	-89		-28	100%		99%
December	231	76992	18717		3632	245	77625	18000		3724	717		-92	104%		98%
January	319	80650	15800		4264	332	80612	15087		4432	713		-168	105%		96%
February	278	79000	16200		4110	305	79200	16050		4125	150		-15	101%		100%
March	408	82050	13200		4555	452	97045	12000		4600	1200		-45	110%		99%
April	400	82000	13200		4550	472	99978	11485		4785	1715		-235	115%		95%
May	279	79000	16200	3548		354	81140	14800	3430		1400	118		109%	103%	
June	54	62011		4362		75	64105		4334			28			101%	
July	40	59745		4187		44	59969		4210			-23			99%	
August	36	58182		4109		37	58573		4129			-20			100%	
September	39	59550		4174		39	59550		4174			0			100%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-37. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Little Butte Creek below Antelope Creek near Eagle Point Oregon under low flow conditions (80 percent exceedance) for proposed action and without Reclamation scenarios at the LBEO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Low Flow (80% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	37	59350		4168		39	59550		4174			-6			100%	
November	133	72074	19694		3019	138	72200	19823		3026	-129		-7	99%		100%
December	155	73348	20391		3084	160	73751	20512		3107	-121		-23	99%		99%
January	214	78091	21801		3296	226	76811	19898		3592	1903		-296	110%		92%
February	199	76968	21432		3250	209	77771	21696		3284	-264		-34	99%		99%
March	274	78124	17664		3864	289	79000	16200		4110	1464		-246	109%		94%
April	257	78042	17664		3864	314	79852	15849		4264	1815		-400	111%		91%
May	100	67879	18775	4075		132	71948	19565	3986		-790	89		96%	102%	
June	38	59350		4168		46	60860		4302			-134			97%	
July	32	55820		4045		34	57266		4074			-29			99%	
August	29	54939		3986		30	55162		4009			-23			99%	
September	31	55688		4025		31	55688		4025			0			100%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

Table 4-38. Simulated monthly habitat areas (ft^2 per 1,000 linear ft) for SONCC coho in Little Butte Creek below Antelope Creek near Eagle Point Oregon under high flow conditions (20 percent exceedance) for proposed action and without Reclamation scenarios at the LBEO Hydromet gage. Estimated fish habitat effects of the proposed action are shown in both habitat area (ft^2 per 1,000 linear ft) and as a percentage of the maximum WUA occurring under the without Reclamation scenario. Source (Appendix B).

Month	Proposed Action Scenario					Without Reclamation Scenario					Habitat Effects (Area)[1]			Habitat Effects (% of w/o Recl. WUA)		
	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	High Flow (20% exc)	Total Wetted Area	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter	Spawning/ Incubation	Juv. Summer	Juv. Winter
October	104	68768		4045		107	68353		4035			10			100%	
November	214	77771	21696		3284	221	78574	21960		3319	-264		-35	99%		99%
December	464	97849	28293		4145	486	100258	29085		4248	-792		-103	97%		98%
January	618	110699	32515		4695	648	113108	33307		4799	-792		-104	98%		98%
February	484	99455	28821		4214	506	101865	29613		4317	-792		-103	97%		98%
March	720	118730	35154		5040	775	122746	36474		5212	-1320		-172	96%		97%
April	682	115518	34099		4902	725	118730	35154		5074	-1055		-172	97%		97%
May	583	107486	31460	2796		601	109093	31988	2743		-528	53		98%	102%	
June	252	80984		3668		278	83393		3589			79			102%	
July	55	62011		4362		59	62553		4380			-18			100%	
August	53	61611		4338		54	62011		4362			-24			99%	
September	49	61424		4322		50	61424		4322			0			100%	

Note: 1. Positive numbers or WUA over 100 percent reflect conditions where the proposed action would result in more habitat than simulated under the without Reclamation flow scenario. Negative numbers or WUA under 100 percent reflect conditions where the proposed action would result in less habitat than simulated under the without Reclamation flow scenario.

4.4.1 Bear Creek Watershed

Effects of Flows on Habitat

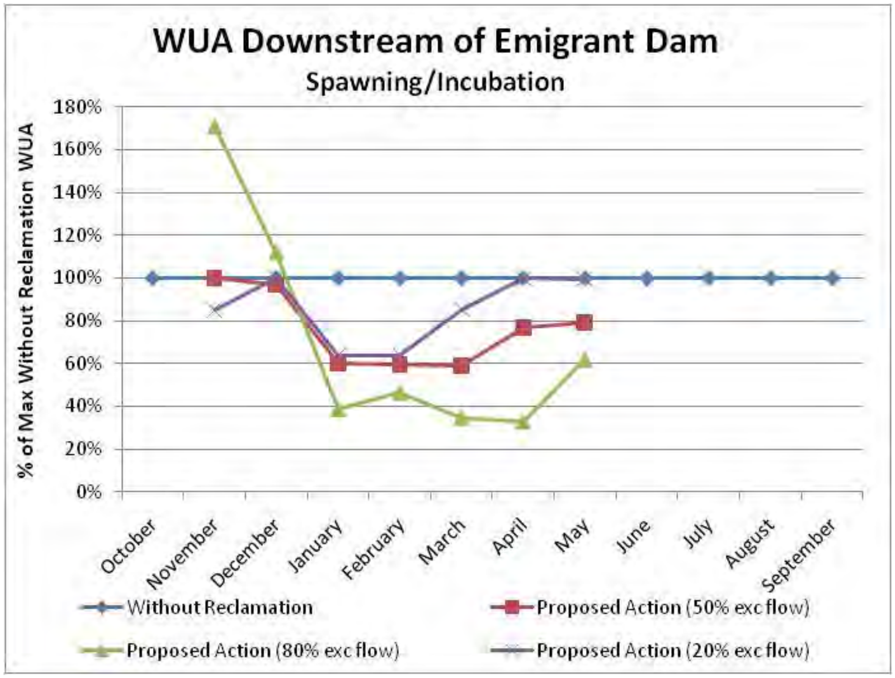
Operation of the Project under the proposed action would affect flows in Emigrant Creek from the outfall of Emigrant Dam to the stream's mouth at its confluence with Bear Creek and in Bear Creek from the Emigrant Creek confluence to the stream's mouth at the Rogue River. These effects would vary by location, season, and flow condition.

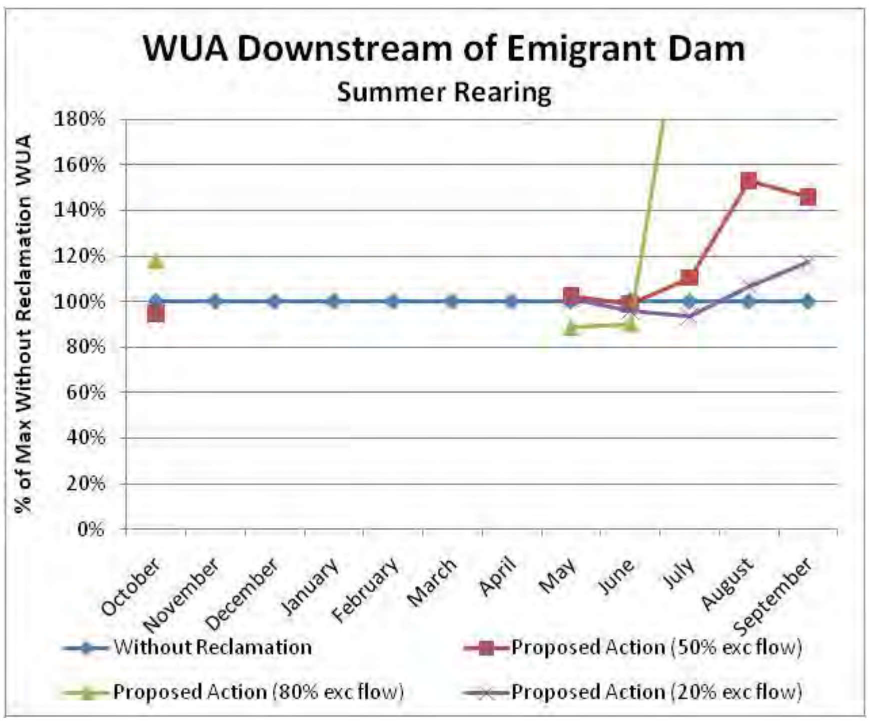
Emigrant Creek from Emigrant Dam to Confluence of Bear Creek

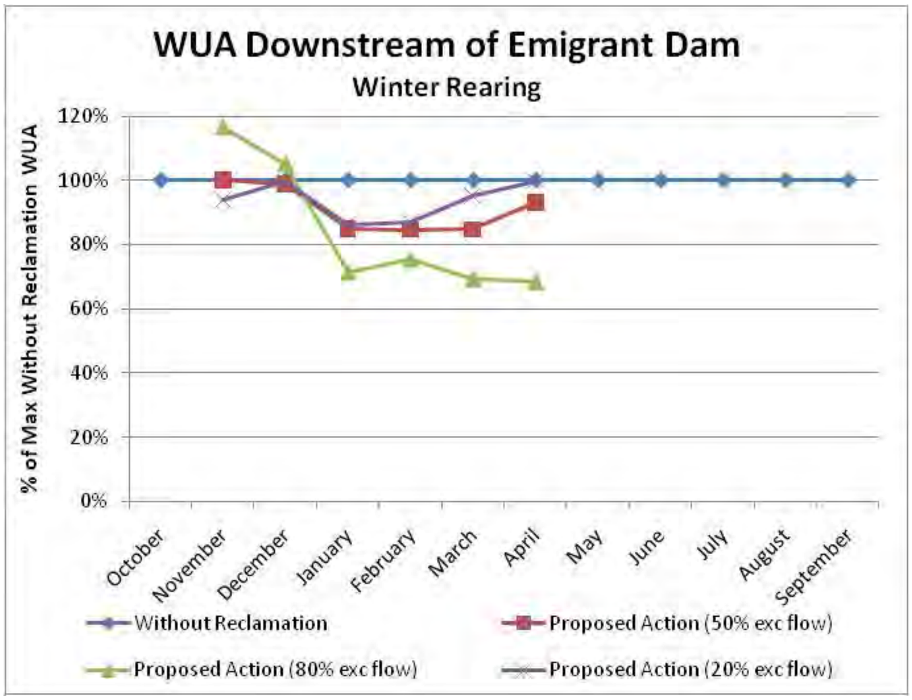
Modeled differences in available habitat in this stream reach vary considerably between life stages and flow condition (see Table 4-12 through Table 4-14). Modeled differences in available habitat for all flow conditions generally indicate that the proposed action would result in less available coho salmon spawning, incubation, and juvenile winter rearing habitat than would be available under the without Reclamation scenario.

Increases in available juvenile summer rearing habitat occur under all flow conditions due to flow releases from Emigrant Dam during the irrigation season. Based on these data, it appears that absent the proposed action, Emigrant Creek in this reach would be intermittent with zero or near zero flow during some summer months. Under the proposed action, Emigrant Creek would be a perennial stream at this location over all flow conditions.

While summer rearing habitat benefits from Project operations, low winter flows as the Project refills Emigrant Reservoir result in an overall reduction in coho habitat availability when compared to a without Reclamation scenario. Under all flow conditions analyzed, the proposed action generally would result in an overall reduction in spawning and incubation critical habitat in Emigrant Creek compared to the without Reclamation scenario (Table 4-12 through Table 4-14 and Figure 4-7a). However, during the prime November to December coho spawning period, spawning habitat area would be greater than or similar to that provided under the without Reclamation scenario under all flow conditions. During January to May, spawning habitat area would be reduced by 60 percent under the low flow condition and by approximately 20 to 40 percent in median and high flow conditions (Figure 4-7a).

a) 
WUA Downstream of Emigrant Dam
Spawning/Incubation
% of Max Without Reclamation WUA
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

b) 
WUA Downstream of Emigrant Dam
Summer Rearing
% of Max Without Reclamation WUA
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)



c)

Figure 4-7. Percent of maximum Without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from Proposed Action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Emigrant Creek.

Similar habitat reductions would also occur during incubation through April. Under median flow conditions, reductions in spawning and incubation habitat in Emigrant Creek would result in reduced levels of SONCC coho salmon critical habitat for spawning and winter rearing in this stream reach as compared to conditions that would exist absent the Project (Figure 4-7a).

During May and June, summer juvenile rearing habitat would be reduced by approximately 15 percent (Figure 4-7b) under low flow conditions. However, under median and high flow conditions, juvenile summer habitat would be similar to without Reclamation habitat levels in these months. Under all flow conditions, the proposed action would provide a minimum of 95 percent of without Reclamation summer habitat levels; under median and high flow conditions, the proposed action would result in significantly increased summer juvenile rearing habitat between July and September (Figure 4-7b). Under median flow conditions, the proposed action would generally increase summer juvenile rearing habitat in Emigrant Creek. During July, August, and September rearing habitat would be increased by 10, 55, and 48 percent respectively (Figure 4-7b). Summer rearing habitat would be negligibly reduced in June and July. By converting this intermittent stream to a perennial stream the proposed action would increase juvenile rearing habitat and the continuity of flowing water would allow juvenile movement within the watershed, facilitating habitat selection behaviors such as seeking temperature refuges.

Winter juvenile rearing habitat would be increased in November and December under low flow conditions but would remain essentially unchanged in these months under median and high flow conditions. Winter rearing habitat would be reduced from January through April under all flow conditions. Habitat availability during this period would range from 70 percent of without Reclamation WUA during the low flow condition to approximately 85 to 90 percent of without Reclamation WUA for median and high flow conditions (Figure 4-7c). Reductions in winter rearing habitat have the potential to increase over-wintering mortality.

Although substantial reductions in both spawning/incubation and winter rearing habitat levels are evident from modeling the proposed action, there would likely remain sufficient spawning habitat areas to allow for a significant amount of spawning to occur. Reclmation documented that even with implementation of the proposed action and modeled spawning habitat detriments of between 40 and 60 percent relative to without Reclamation conditions, more spawning habitat will be available than the available rearing habitats can sustain (Appendix B). That is, spawning habitat availability was found not to be limiting the coho salmon population in this reach. Insufficient rearing habitat increases interspecies and intraspecies competition, resulting in lower growth and survival rates.

The effects of the proposed instream flows were evaluated using a habitat time series analysis to assess effects of this feature of the proposed action on coho salmon designated critical habitat in portions of Emigrant Creek and upper Bear Creek. Several of the PCEs would not be affected by this part of the proposed action. Water temperatures, water quality, riparian habitat, substrate, and food would not likely be affected by the release of 2 to 12 cfs during low flow periods in the winter. Water temperatures in Emigrant Creek and Bear Creek are consistently below the 13°C standard and generally suitable for coho salmon during this time period. This would not change with the instream flows. There are no water quality issues currently associated with the water released from Emigrant Dam and the minimum winter flow releases described here would not alter that. The instream target flow releases from Emigrant Dam during all parts of the year would not affect riparian habitat as they occur during the non-growing season and are too low to scour existing vegetation. Also, winter operational flow releases should not affect the substrate as they are too low to scour or redistribute the existing substrate. Finally, since winter is not a biologically productive period for aquatic invertebrates, it should have little effect on food production.

Other PCEs, including water quantity, cover/shelter, water velocity, and space would be affected by the instream flow releases. Water quantity would be increased as higher flows are released. Providing consistent winter flows would create additional space for coho salmon by consistently wetting more of the channel over time. Water velocity conditions may also be improved and the steady flows provided by the proposed action instream flow targets would allow coho salmon in the streams to make use of additional cover and shelter.

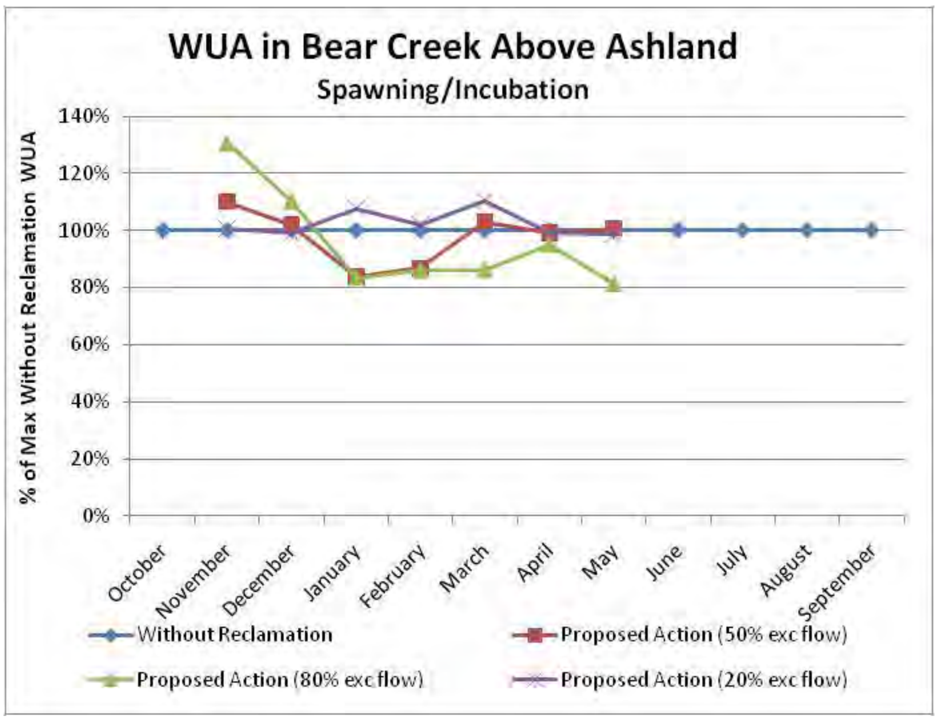
Bear Creek – Emigrant Creek to Oak Street Diversion

Because there are no Project facilities located between the confluence of Emigrant Creek and the Oak Street Diversion Dam, the proposed action will have little impact on natural flows into this reach or on regulated flows through this reach aside from those impacts that may occur from winter operational releases at Emigrant Dam. Consistent with the effects noted in the Emigrant Creek reach above, the proposed action would decrease flows in this reach of Bear Creek during the winter and spring due to water storage in Emigrant Dam during this time period and would increase flows during the summer months relative to the without Reclamation flow scenario during the latter portion of the irrigation season (June or July through October) due to increased water releases for irrigation at Emigrant Dam.

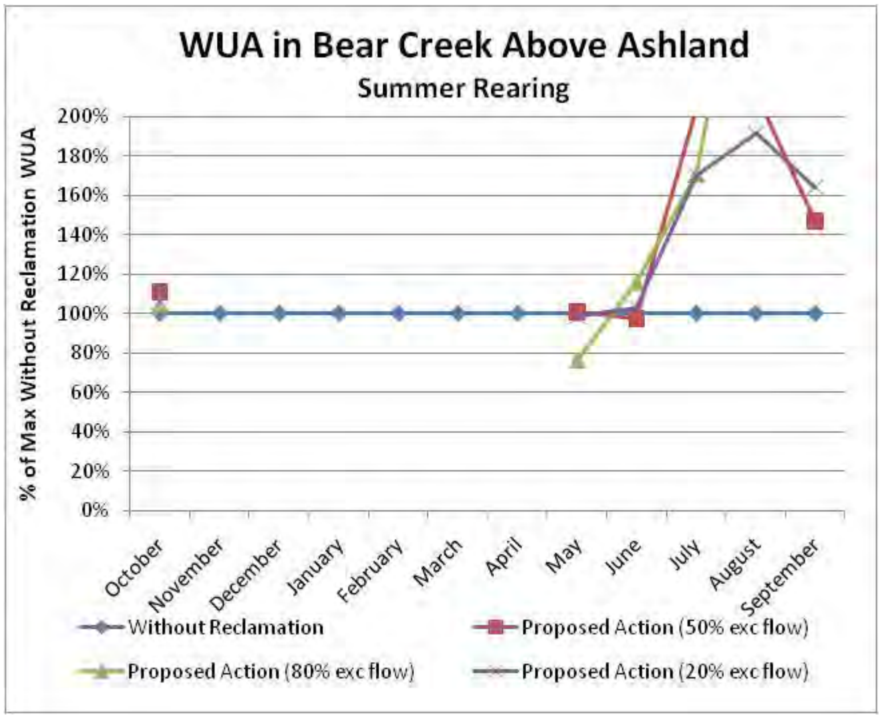
Modeled differences in available habitat in the upper Bear Creek stream reach from the confluence with Emigrant Creek down to the Oak Street diversion are fairly consistent between life stages and flow conditions with some positive and negative results (Table 4-15 through Table 4-17). Differences in available spawning habitat for low and median streamflow conditions would be considered to be moderate detriments for the months of January through May for the low flow condition and for the months of January and February under the median flow condition. For the remaining months of the year for the median water year type, however, spawning habitat is not affected by the proposed action as it is approximately at 100 percent of without Reclamation WUA levels (Figure 4-8a). Both increases and decreases in available incubation habitat occur, depending on the flow, although these are not biologically meaningful due to available incubation habitat exceeding spawning habitat as WUAs remain steady or increase over the winter and spring months.

Similar to the Emigrant Creek reach, available juvenile summer rearing habitat increases occur for all flow conditions as a result of water released from Emigrant Dam and the lack of Project water diversions through this reach. Under all flow conditions the proposed action would generally increase summer juvenile rearing habitat for all months when summer rearing occurs with the possible exception of May when juvenile summer rearing habitat would be unaffected by the proposed action. In June, July, August, and September rearing habitat would be increased by 20 percent to over 100 percent relative to without Reclamation conditions (Figure 4-8a). Summer water temperatures reach levels above the desired 18ºC (Reclamation 2009b), however; this reach is likely suitable summer rearing habitat for long periods of time. The proposed action would likely benefit rearing juveniles and increase summer survival.

For all flow conditions analyzed, amounts of WUA resulting from the proposed action relative to the without Reclamation flow condition tend to experience small to moderate benefits to winter rearing habitat during the months of November and December (Figure 4-8c). However, during the months of January through March when winter rearing habitat is most important, the proposed action flows result in winter rearing habitat detriments of between 10 and 20 percent of without Reclamation habitat levels. This constitutes a moderate to substantial reduction in critical habitat for this life history stage and would be likely to adversely affect coho salmon in this reach.



a)

b) 

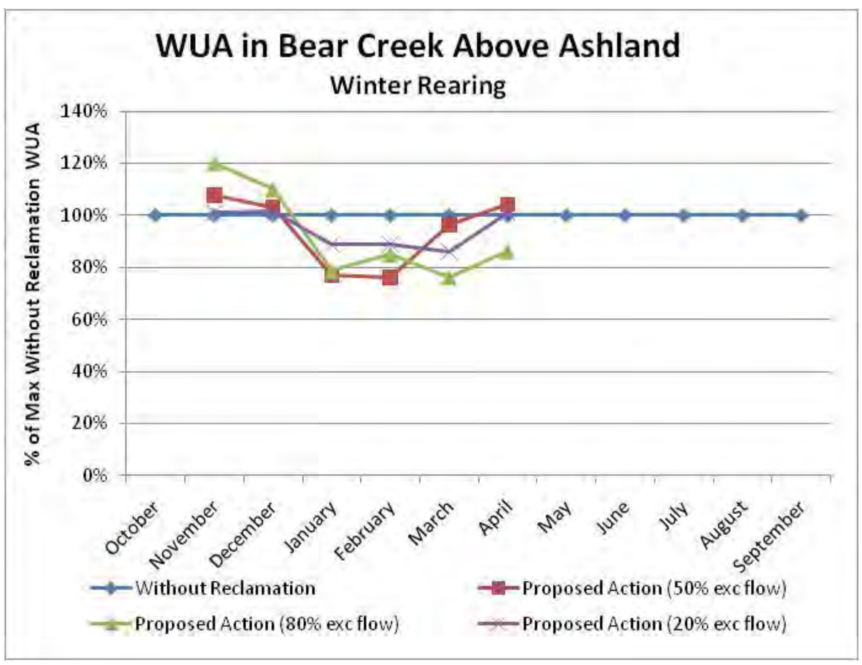
c) 

Figure 4-8. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in upper Bear Creek from the Emigrant Creek confluence to the Oak Street Diversion.

Although, WUAs for winter rearing habitat improves for all but the low flow condition in the subsequent months of April (Figure 4-8c) the previous habitat detriments that occurred were likely to have negative effects on overwintering juvenile coho salmon that can not be aided by further increases in habitat in April. Moderate and substantial decreases in available winter rearing habitat are likely to reduce winter juvenile coho salmon habitat due to the proposed action.

Bear Creek – Oak Street Diversion to Phoenix Diversion

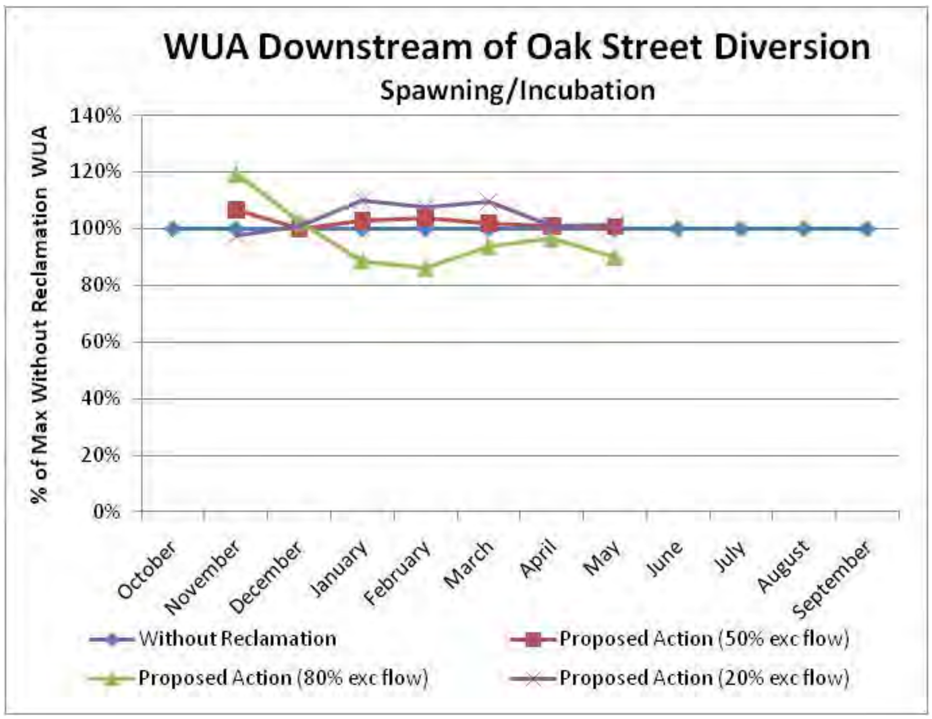
Monthly WUA values resulting from proposed action flows under all flow conditions for coho salmon spawning/incubation and juvenile rearing life stages in Bear Creek to Oak Street Diversion to Phoenix Canal Diversion are shown in Figure 4-9a-c, respectively. Modeled differences in available habitat in the Bear Creek stream reach from the Oak Street Diversion downstream to Valley View Road vary between life stages and flow (median or low flow conditions), with some positive and negative results (Table 4-18 through Table 4-20 and Figure 4-9). Examination of these figures shows that the proposed action has a minimal effect on critical habitat conditions in this reach.

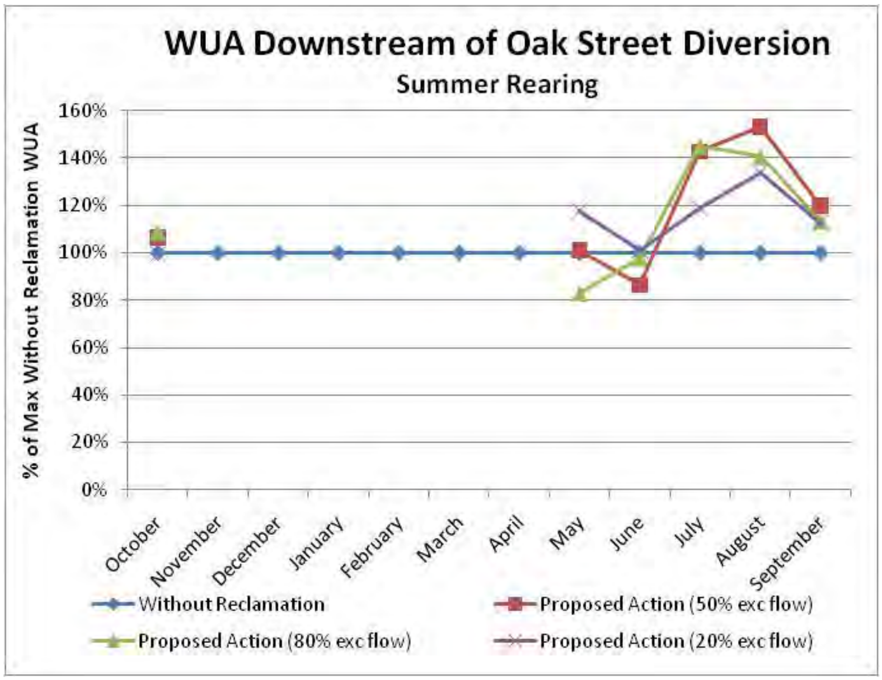
Available spawning habitat under a median or low flow condition ranged from a small to moderate decrease under low flow conditions during the months of January through May, to no difference or very small benefits to spawning/incubation WUA relative to the without Reclamation scenario under both median and high flow conditions. Incubation habitat condition followed a similar pattern with very good conditions occurring under median and high flow conditions and only moderate reductions under low flow conditions. For the median and high flow conditions, available incubation habitat exceeds spawning habitat in this reach. These results suggest that under typically provided conditions that are represented by the median (50 percent exceedance) and high flow (20 percent exceedance) conditions, that significant spawning habitat followed by small increases in incubation habitat will be provided by the proposed action and that successful reproduction conditions in this reach should be provided by the proposed action flows. Water diversions into the Talent Canal at the Oak Street Diversion Dam are not occurring during the winter spawning and incubation period so these habitat values indicate that the affect of water releases from Emigrant Dam under the proposed action, along with natural flow increases from tributaries, are sufficient to provide adequate protection to spawning and incubation habitat with median and high flow conditions.

Reductions in spawning/incubation WUA during the low flow condition range from 85 to 95 percent of without Reclamation habitat levels. This amount of habitat reduction would be considered a moderate to small effect to critical habitat for spawning when this flow condition occurs.

Early season summer rearing habitat will be moderately reduced from without Reclamation WUA levels (15 to 20 percent reduction in May and June for the median and low flow conditions, respectively) from proposed action implementation. However, juvenile summer rearing conditions will be moderately to substantially increased later in the season for all flow conditions. Even with diversions occurring into the Talent Canal at the Oak Street Diversion, summer rearing under low and median flow conditions will result in substantial increases in available summer rearing habitat (Figure 4-9b). Summer habitat values show observed increases of 20 to 50 percent relative to the without Reclamation scenario due to irrigation releases made at Emigrant Dam and moderate levels of diversion made at the Talent Canal during this time period.

a)





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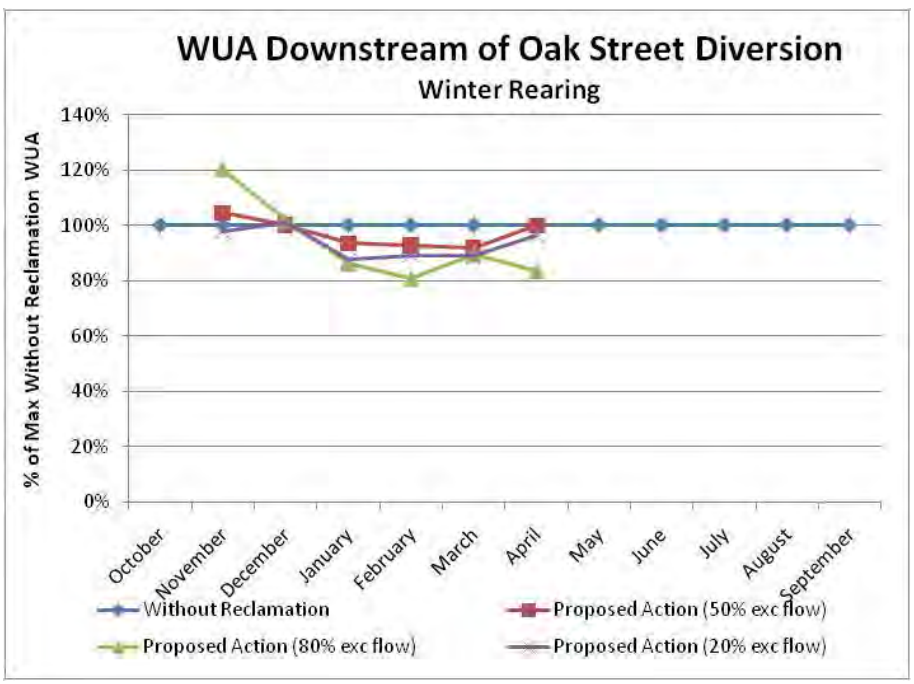


c)

Figure 4-9. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Bear Creek between the Oak Street Diversion and the Phoenix Diversion.

No effects to winter rearing habitat WUA were observed as a result of the proposed action flows for all flow conditions during the initial months for overwintering coho salmon (November and December). However, for the remaining months when overwintering conditions are important to rearing coho salmon (January through April) there were small to moderate impacts resulting from implementation of the proposed action. These impacts to winter rearing habitat were greatest (moderate detriments of 10 to 20 percent from without Reclamation conditions) for the low flow condition. Only small detriments were observed (between 5 percent and less than 10 percent reductions) for proposed action effects to winter rearing habitat conditions for the median and high flow conditions (Figure 4-9c).

Although juvenile winter rearing critical habitat is moderately affected during low flow conditions and is only slightly affected for median and high flow conditions, these impacts are not expected to limit the survival of coho salmon in this reach. This is because for all flow conditions analyzed, the summer benefit likely offsets the winter detriment if the reach is habitable due to high summer water temperatures. Summer water temperatures do exceed the desired 18˚C, but the reach is likely suitable for summer rearing habitat on the shoulder periods of the highest temperature and where cool water refugia exist. Given the limits on juvenile rearing use of this stream reach imposed by adverse water temperature conditions, the propensity for rearing coho salmon to seasonally move to select suitable habitats suggest that by providing more flow and more suitable habitat during the summer in this stream reach, the proposed action would likely benefit rearing juveniles.

Table 4-18 through Table 4-20 and Figure 4-9a-c summarize the results of the effects of the proposed action on coho salmon WUA in Bear Creek between Oak Street Diversion and Phoenix Canal Diversion. For this analysis, benefits to WUA are presumed to represent improvements in critical habitat conditions as conditions for PCEs including water quantity, water quality, water velocity, and cover and shelter are maintained at levels that provide for the conservation of the species in the proposed action.

Bear Creek – Phoenix Diversion to Jackson Diversion

Two flow monitoring locations are situated in this stream reach that can be used for evaluating proposed action effects to coho critical habitat downstream of the Phoenix Diversion Canal. The BCTO Hydromet stream gage is located immediately downstream of the Phoenix Diversion Canal and represents flow and habitat conditions that fish experience as a result of streamflows that occur after water diversion actions have occurred into the Phoenix Canal during the summer months. The other monitoring location in this stream reach is the MFDO Hydromet stream gage which is located in the city of Medford just upstream of the Jackson Street Diversion. This Hydromet gage is located in an intermediate location between a Project diversion (Phoenix Diversion) and a non-Project diversion facility (Jackson Street Diversion). The MFDO gage, therefore can be used to evaluate the affects to critical habitat from streamflow conditions that occur downstream of the last federal irrigation facility on Bear Creek.

Table 4-21 through Table 4-26 summarize tabular results of the effects of the proposed action on coho salmon critical WUA and by extension critical habitat in Bear Creek between Phoenix Diversion and Jackson Street Diversion at these two Hydromet gages in this stream reach.

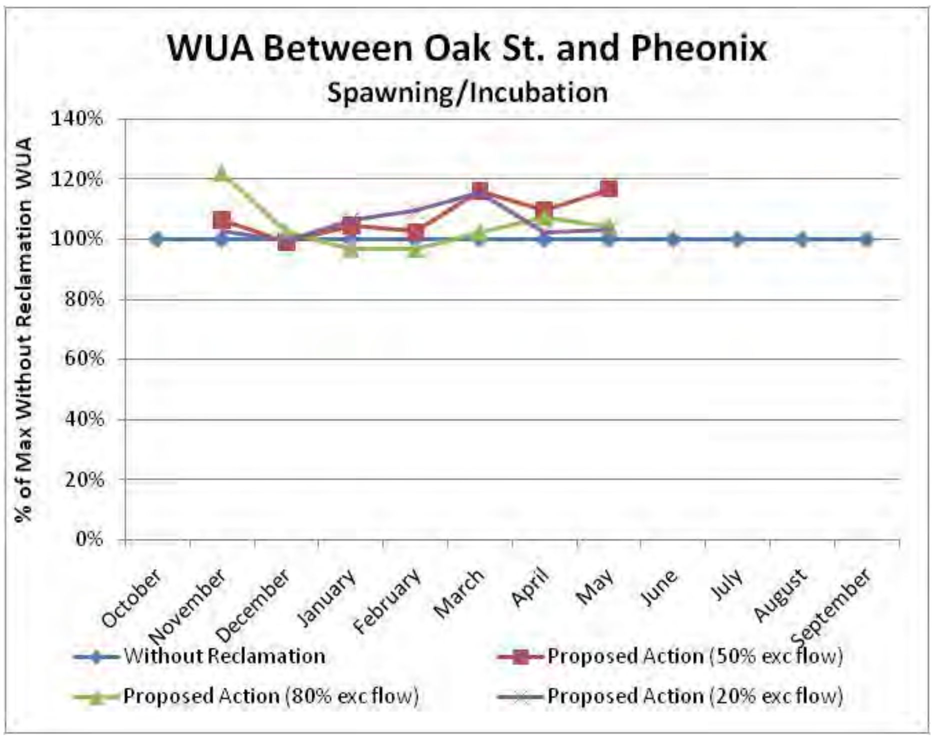
Monthly WUA values resulting from proposed action flows under all flow conditions for coho salmon juveniles and spawning/incubation life stages in Bear Creek to Phoenix Diversion to Jackson Street Diversion Dam are shown in Figure 4-10a-c and Figure 4-11a-c, respectively. Modeled differences in available habitat in this stream reach vary between life stages and flow, with generally moderate to small positive affects for all life history stages analyzed and only very small negative results or habitat detriments as a result of implementing the proposed action over all flow conditions (Table 4-21 through Table 4-23 and Figure 4-10). Examination of these figures shows that the proposed action has a minimal effect on critical habitat conditions.

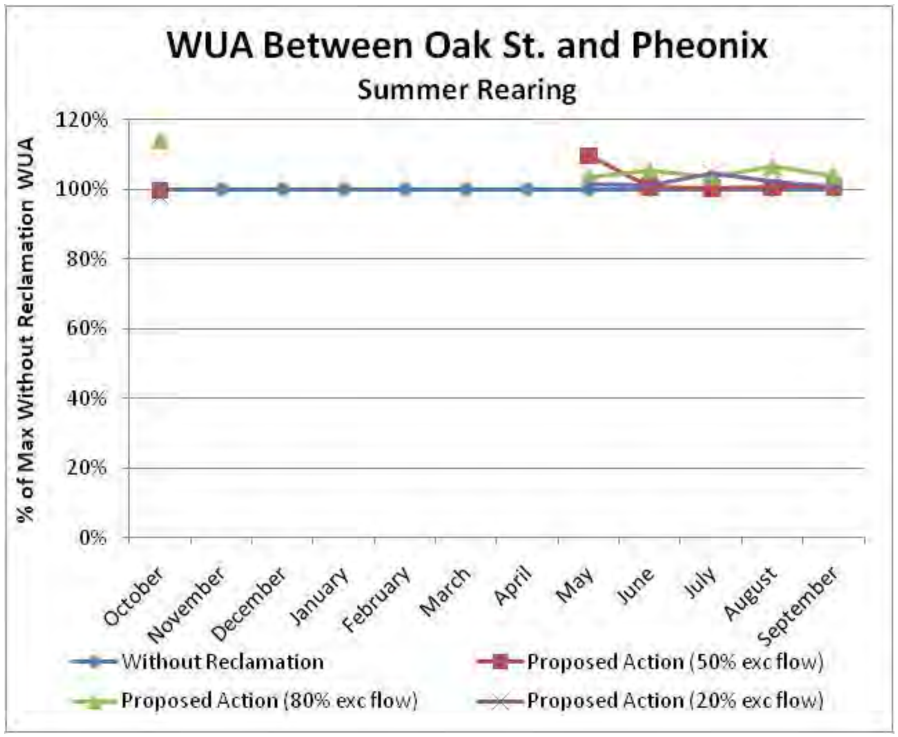
Spawning/incubation habitat conditions resulting from proposed action flows, whether evaluated at the BCTO Hydromet gage (Figure 4-10a) or the MFDO Hydromet gage (Table 4-24 through Table 4-26 and Figure 4-11a) indicate that there is either no difference in spawning/incubation WUA or small to moderate benefits to spawning habitat relative to the without Reclamation condition for the median and high flow conditions. Spawning habitat would be slightly reduced in this reach by approximately 5 percent from without Reclamation low flow conditions. For all flow conditions, the amount of incubation habitat increases over the amount of spawning habitat indicating that incubation habitat would be adequate to support any spawning activity that would occur.

Under all flow conditions, WUA generated by the proposed action would generally have no effect or would only show a very small benefit to summer juvenile rearing habitat relative to the without Reclamation scenario (Figure 4-10b). No difference in summer rearing habitat WUA was observed for the median flow condition at the BCTO gage. However, very small benefits were predominantly observed for the low and high flow conditions at this location. Amounts of summer rearing habitat WUA for the MFDO gage indicate no difference from the without Reclamation flow conditions to substantial benefits to summer rearing conditions for coho salmon during low flow condition with no adverse affect occurring (Figure 4-11b). Very small adverse affects (5 percent habitat reductions) are indicated to summer rearing habitat for median flow conditions.

No difference, or very small differences in summer habitat WUA relative to the pre-project condition at this location indicate that summer irrigation diversions are in a good balance with water releases from Emigrant Dam and natural flow inputs from upstream tributaries. As a result, summer rearing habitat conditions mimic those that would have occurred in the absence of the Project at this location. This is a difference compared to the summer rearing habitat increases that were predicted to occur in more upstream reaches. The summer rearing habitat benefits from increased flows due to summer water releases from Emigrant Dam in other reaches are not observed in the reach of Bear Creek because flow increases have attenuated by the time they reach this and other downstream reaches of Bear Creek. One consideration, summer stream temperatures likely limit suitability of this reach for juvenile rearing habitat; therefore the biological meaning of this amount of summer habitat is unclear.

a)





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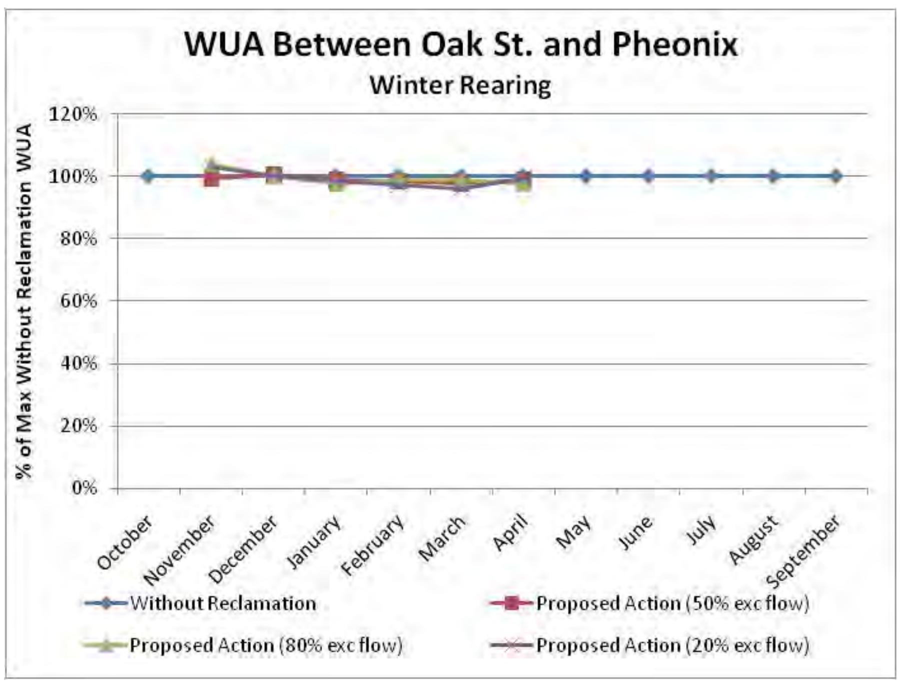
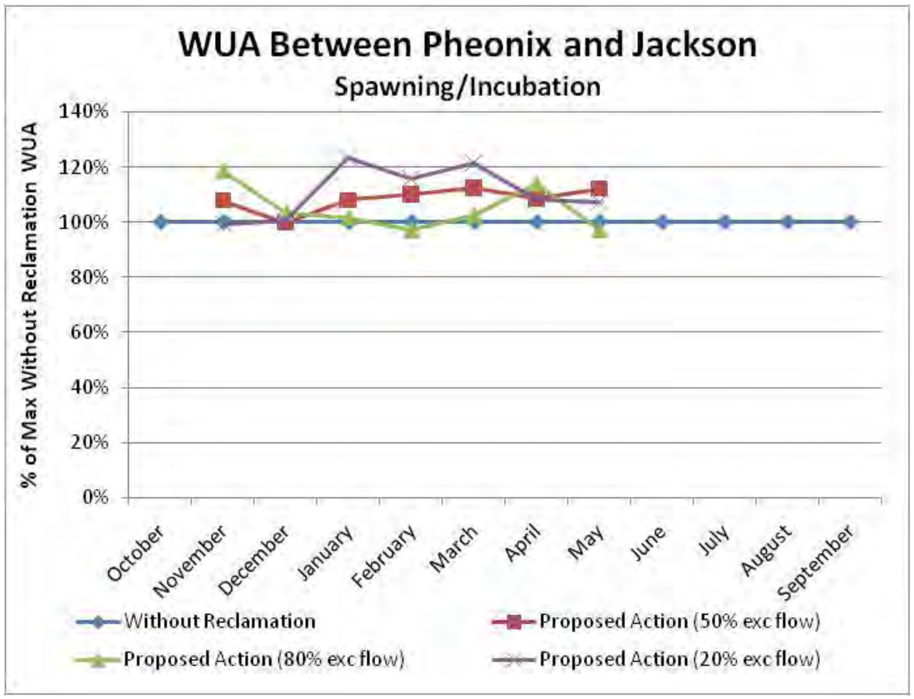
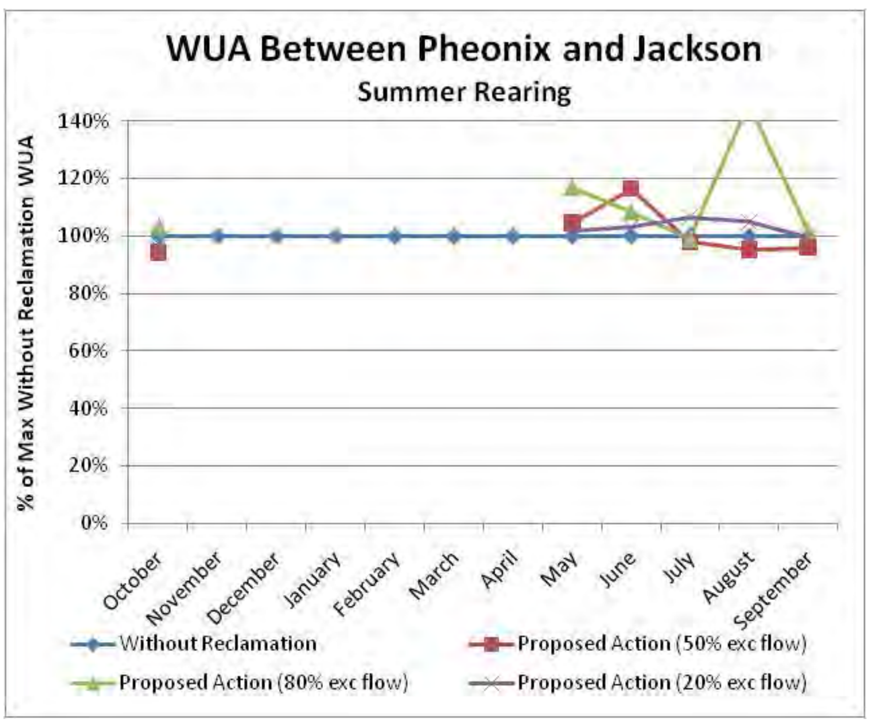


c)

Figure 4-10. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Bear Creek between the Oak Street Diversion and the city of Phoenix.


WUA Between Pheonix and Jackson
Spawning/Incubation
% of Max Without Reclamation WUA
140%
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

a)


WUA Between Pheonix and Jackson
Summer Rearing
% of Max Without Reclamation WUA
140%
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

b)

c)

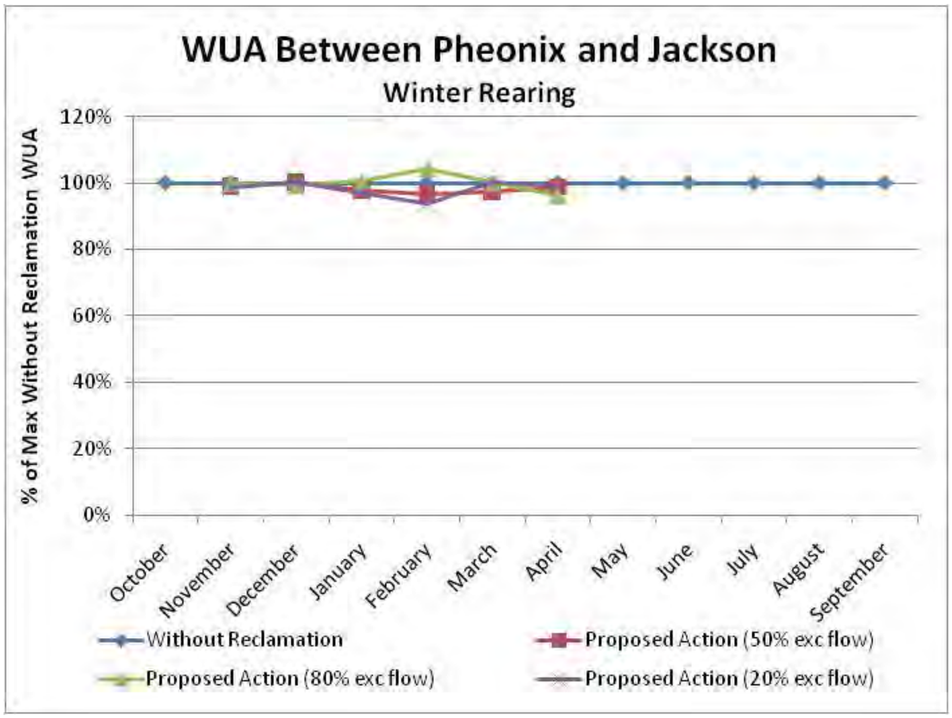


Figure 4-11. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Bear Creek between the Phoenix and Jackson Street Diversions.

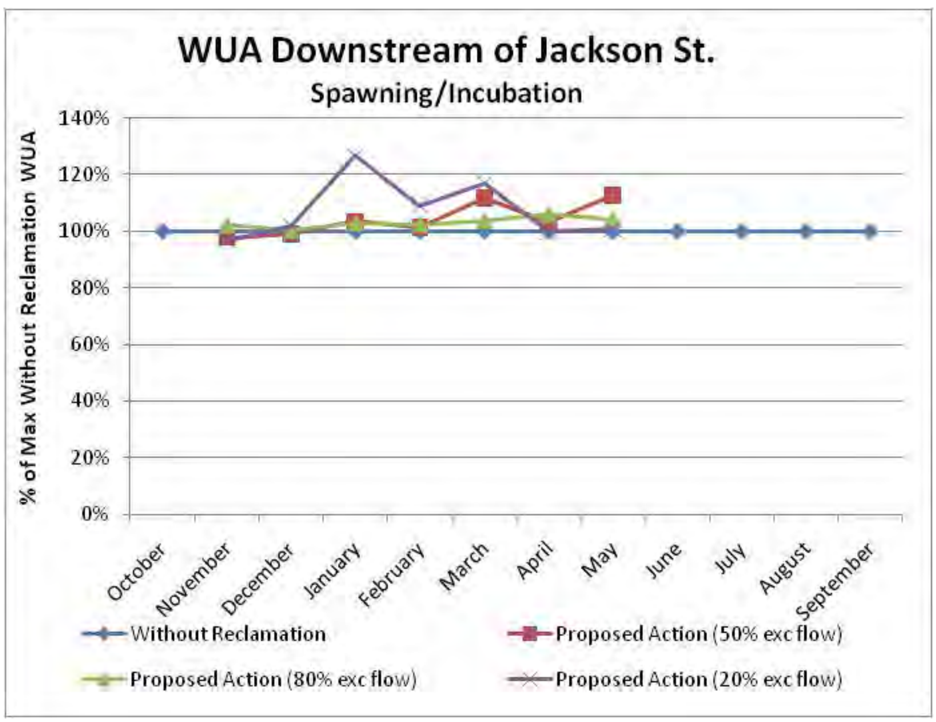
As indicated by WUA amounts at both the BCTO and MFDO Hydromet gages, no difference or only very small differences are predicted to occur to juvenile winter rearing habitat as a result of the proposed action (Figure 4-10c and Figure 4-11c). No moderate or major juvenile salmon WUA benefits or detriments to juvenile winter rearing critical habitat would occur in this reach as a result of the proposed action. Potential winter habitat reductions of less than 5 percent from without Reclamation levels are not likely to adversely affect coho salmon critical habitat and would likely have either no affect or a very small effect on survival of juvenile coho salmon. These small effects constitute negligible differences between the without Reclamation condition and the proposed action management scenarios.

Bear Creek – Jackson Diversion to Bear Creek Mouth

The Jackson Street Diversion is not owned by Reclamation so the effects of this facility are not effects of the proposed action. However, delivery of transbasin diversions and releases of stored water affect flows in this segment of Bear Creek. Under the proposed action, natural flows and flows released at Emigrant Dam would be intercepted by the Jackson Street

Diversion, downstream from the Phoenix Diversion. During the irrigation season the diversion would divert water for irrigation and flows in Bear Creek would be slightly reduced. Consistent with the effects noted above, the proposed action would decrease flows in this reach of Bear Creek during the winter and spring and would increase flows during the latter portion of the irrigation season (June or July through October).

Modeled differences in available habitat in the Bear Creek stream reach from the Jackson Street Diversion downstream to the confluence with the Rogue River vary considerably between life stages and flow (median or low flow conditions) (Table 4-27 through Table 4-29 and Figure 4-12a-c). The modeling results show that spawning and incubation habitat would have either no difference or show very small increases when all flow conditions are considered. Winter rearing habitat WUA effects follow a similar pattern with either no difference relative to without Reclamation flow conditions of very small WUA increases. Either no difference or very small summer rearing habitat detriments are anticipated to occur for all flow conditions from implementation of the proposed action. However, this reach of Bear Creek has limited use as summer rearing coho salmon habitat due to high water temperatures and therefore, the slight reduction predicted by the model has very limited biological meaning.



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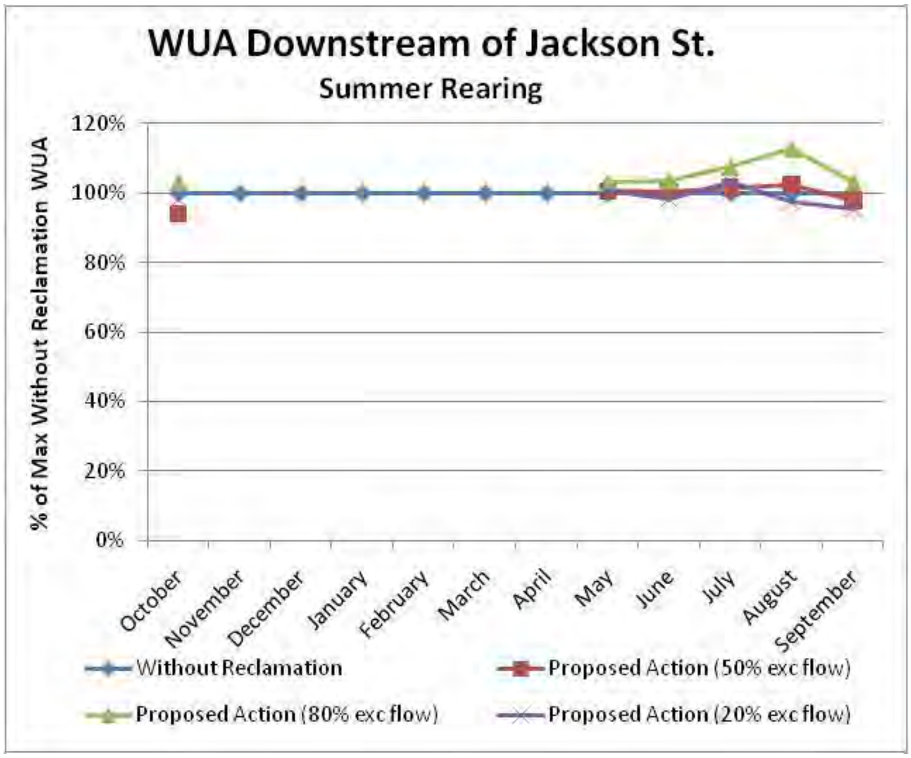

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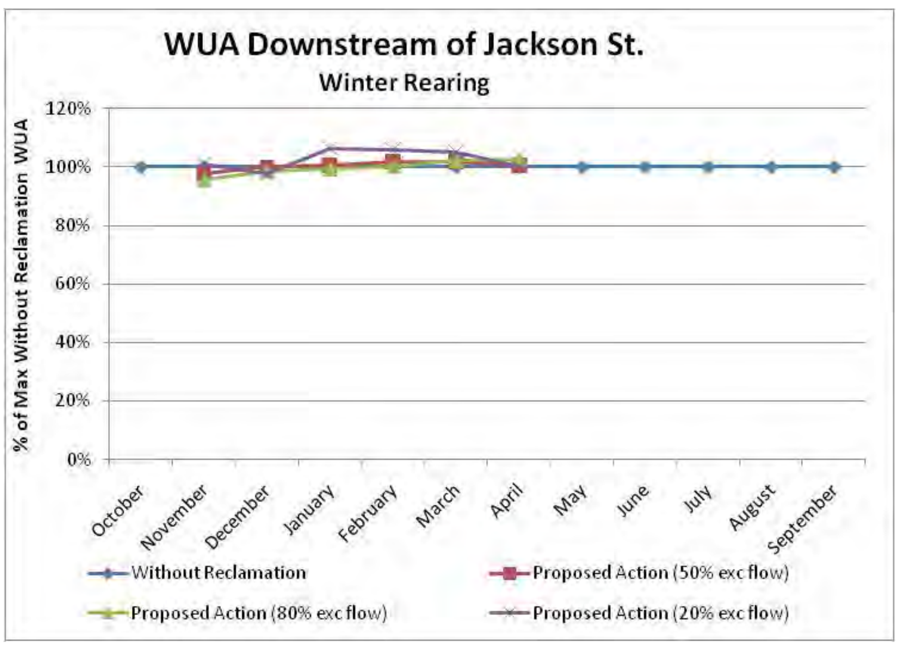


c)

Figure 4-12. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Bear Creek between the Jackson Street Diversion and the mouth of Bear Creek.

Ramping Rates in Emigrant and Bear Creeks

As part of the consultation process, TID provided Reclamation information regarding ramping rates for Emigrant Dam that would be expected to reduce fish stranding and displacement. The protocol and analysis of ramping rates at Emigrant Dam was completed in 2012 by GeoEngineers (memorandum provided in Appendix C). This ramping rate description has been included as part of the proposed action for this consultation and it is the intent of Reclamation and the Districts to implement the ramping rate procedure laid out in the protocol as part of the standard Project operations in the proposed action.

Although rapid increases in discharge can displace aquatic organisms, it is unlikely that the proposed action would result in an increase in the magnitude, rate, or frequency of rapid increases in discharge. For this reason, rapid increases in discharge are not a considerable concern with the proposed action. Rapid decreases in discharge can kill juvenile fish which often occupy habitats at the margins of streams to avoid high water velocities and predatory fish. This tendency leaves them vulnerable to entrapment (caught in isolated pools or depressions) and stranding. Proposed water management activities that are designed to moderate these effects at Emigrant Dam and at diversion canals can result in accelerated rates and magnitudes of flow reductions as compared to conditions that would exist without the Project. Such changes in Project operations are relatively infrequent suggesting that adverse effects on SONCC coho from rapid flow fluctuations caused by the Project are likely to be modest when they occur.

It was concluded that the level of protection to fish from changes in the reservoir releases and ramping protocols laid out in the proposed action are similar to what would occur naturally (Appendix E). TID will use the ramping rate schedule described in the proposed action section at the end of each irrigation season and at other times during the year when necessary at the Oak Street Diversion and Phoenix Diversion as indicated in the ramping rate memorandum based on data obtained from specific Hydromet stations related to each particular facility where ramping rates would apply (e.g., EMI, BASO, and BCTO Hydromet gages).

Project operations have had two periods each year of rapidly changing discharge. The first is during the winter, in response to precipitation events, the other is at the beginning and the end of the irrigation season (e.g., generally May through June and October). When these time periods are considered in relation to the coho salmon periodicity in the Bear Creek watershed it appears that adult salmon are only present in the creek from October to January, whereas juveniles are present as fry, juveniles, and smolts throughout the year. Adult salmon are unlikely to be entrapped or stranded by rapid flow fluctuations because of their strong swimming ability and because of the low rate of flow reductions proposed in the ramping protocols that are being implemented under the proposed action. Conversely, juvenile coho salmon live in or near their natal streams for a year or longer before out migrating, they are weak swimmers, and due to preference for shallow, low-velocity habitats, are often found near stream margins. Young-of-the-year and juvenile coho salmon are highly susceptible to entrapment and stranding during rapid flow reductions. Therefore, juvenile life stages are most susceptible to rapid fluctuations in discharge.

The prescribed flow reduction limits are adapted from Hunter (1992) and designed to minimize the risk of entrapment and stranding caused by flow reductions. As outlined above, ramping rates at Emigrant Dam would change under the proposed action and more closely mimic naturally declining flow patterns. Utilizing the ramping rate protocol would reduce fish stranding and displacement of coho salmon in Emigrant Creek as releases from Emigrant Dam are decreased at the end of an irrigation season and following a non-irrigation season release. This should improve fall and winter rearing conditions by improving PCEs including water quantity, cover/shelter, and, in a fashion, safe passage conditions as juveniles move from one portion of the stream channel to the low flow channel as flows decline. Other PCEs, such as substrate, water quality, temperature, velocity and riparian vegetation, would not be affected by the ramping rate protocol. Overall, the implementation of the ramping rate protocol would improve conditions of the critical habitat in Emigrant Creek during those brief periods when the protocol is in effect and flows are being reduced.

Ramping rates presented in the proposed action section are likely to improve the conditions in the action area within the Rogue River basin. Ramping rates implemented for Emigrant Creek, Bear Creek downstream of the Oak Street Diversion and Phoenix Diversions, will improve conditions in Emigrant Creek and reduce the likelihood of fry or juvenile coho salmon stranding.

Fish Passage Actions

Project diversion facilities occur in Bear Creek and Ashland Creek in reaches of those streams that are likely inhabited by listed coho salmon. These facilities include diversion structures, fish screens and bypasses, and fish ladders. With the exception of Ashland Creek, the structures in place were designed, built, and maintained to meet fish passage and protective criteria. The proposed action will improve fish passage by installing a NOAA Fisheries-conforming screen at the Ashland Creek Diversion and fish passage design and operation improvements at the Oak Street Diversion. Micro-habitat will be improved by altering water velocities and physical structure of the facilities to conform to NOAA Fisheries fish passage guidelines. Safe and improved passage for juvenile and adult coho salmon would result in improvements to critical habitat and will likely lead to improved survival for these life-stages.

Oak Street Diversion Fish Passage

The Oak Street Diversion on Bear Creek has been identified as creating an impediment to upstream passage for adult SONCC coho salmon. The proposed action would correct this situation by modifying the existing fish ladder so that it would no longer impede coho salmon passage at the Oak Street Diversion Dam. Construction-related effects on coho salmon from modifications to the existing ladder are outlined in Section 4.5.1. Additional consultation on the construction-related effects may be necessary once designs are completed and construction plans are finalized. At this time, Reclamation is preparing the final engineering design specifications for this fish passage structure. Because of the completion of the final design documents and the likelihood of receiving funding for this component of the proposed action, Reclamation is confident that the fish passage improvements that are being proposed for this facility are reasonably likely to occur and be completed by the fall of 2015.

With respect to critical habitat, the modifications to the fish ladder at the Oak Street Diversion Dam would improve safe passage conditions, an identified PCE, at the site. Access to Bear Creek and its tributaries above the Oak Street Diversion Dam, including Emigrant and Neil creeks, would be improved relative to the current condition and would provide conditions that meet the conservation needs of the species for both adult and juvenile coho salmon. The improvement in passage conditions would be a beneficial effect on critical habitat for these areas.

Ashland Creek Diversion Fish Passage

The Ashland Creek Diversion on Ashland Creek has been identified as creating an impediment to upstream passage for juvenile SONCC coho salmon. In addition, there is no fish screen at the existing headgate structure at the diversion dam. Both of these problems would be corrected as part of the proposed action. Construction-related effects on coho salmon from modifications at the diversion dam are outlined in Section 4.5.1. Additional consultation on the construction-related effects may be necessary once designs are completed and construction plans are finalized. At this time, Reclamation has prepared a final pre-design technical memorandum and will be preparing the final engineering design specifications for this fish passage structure. Because of the completion of pre-designs and the likelihood of receiving funding for this component of the proposed action, Reclamation is confident that the fish passage improvements that are being proposed for this facility are reasonably likely to occur and be completed by the fall of 2015.

The proposed action will improve fish passage by installing a NOAA Fisheries-conforming screen at the Ashland Creek diversion and fish passage design and operation improvements at the Ashland Creek Diversion Dam. Micro-habitat will be improved by altering water velocities and physical structure of the facilities to conform to NOAA Fisheries fish passage guidelines. Safe and improved passage for juvenile and adult coho salmon would result in improved survival for these life-stages. With respect to critical habitat, the modifications at the Ashland Creek Diversion Dam would improve safe passage conditions, an identified PCE, at the site. Access to Ashland Creek for juvenile coho salmon would be improved and protection of all life stages would increase with installation of a screen. The improvement in safe passage conditions would be a beneficial effect on critical habitat for this area.

Effects of Proposed Restoration Actions on Critical Habitat

Instream Large Woody Debris (LWD) Placement Actions

Reclamation's proposed action of implementing an instream flow restoration component will be planned for completion by the year 2017 with substantial progress towards completion of the plan by 2015. The instream habitat restoration plan will be designed to reduce the level of adverse affect to juvenile winter and summer rearing habitats by creating sufficient rearing habitat to offset habitat detriments that are anticipated to occur as a result of implementing the proposed action. Instream wood structures LWD will be placed in stream reaches where summer or winter rearing habitat has been determined to be substantially (i.e. greater than a 20 percent reduction from habitat conditions that would be expected under the without Reclamation flow conditions) or moderately (between 11 and 20 percent of without Reclamation habitat) effected by the proposed action streamflows. Proposed LWD placement restoration components will effectively reduce the negative impacts to critical habitat from substantial detriments (greater than 20 percent WUA detriment) where they occur in the Emigrant and upper Bear Creek systems to only small detriments (0 percent to a maximum 10 percent detriment) when compared against without Reclamation flow and habitat conditions.

Reclamation, NOAA Fisheries, and the Districts have cooperated in the development of this instream habitat restoration planning effort. Further, both Reclamation and NOAA Fisheries have determined that implementation of instream LWD structures in agreed upon amounts that can be shown to offset habitat detriments for both winter and summer rearing WUA habitat to less than 10 percent of without Reclamation modeled habitat conditions, that the proposed action affects will be adequately minimized to allow for the conservation of the species. As such, Reclamation believes that full implementation of the LWD restoration plan will not adversely affect SONCC coho salmon critical habitat.

Riparian Zone Management Plan Actions

Analysis of data collected in Bear Creek and its tributaries has shown substantial summertime exceedance of the Oregon water temperature standard. In general, climatic variables, air temperatures, solar radiation, humidity, and time of year probably have the greatest effect on Bear Creek water temperatures. Additional riparian vegetation restoration is needed to increase summer shading of stream surfaces to bring this important water quality variable to within more acceptable levels for supporting fish production. Although the past operation of the Project has not affected the amount of riparian zone vegetation that currently exists, nor will the future operation of the Project result in further reductions of riparian zone health, Reclamation has committed to undertaking the action of planting up to 3 miles of vegetation within riparian zone areas that are currently lacking riparian zone vegetation and where riparian zone benefits would occur in the Bear Creek watershed. This action will lead to reductions in water temperature through stream shading as well as provide additional benefits to Bear Creek from other water quality improvements and food web functioning.

Although water temperature beneficial effects are not quantified in this assessment, the completion of a riparian zone management plan and the planned implementation of riparian zone plantings in the Bear Creek watershed will have positive benefits to water quality in the basin; primarily on water temperature and sediment control, but also on nutrient inputs to the creek. This action will compliment many other riparian zone management actions that are currently occurring in the Bear Creek watershed and will have a positive long-term benefit to SONCC coho salmon critical habitat in the action area.

Effects from Construction Activities Associated with Fish Passage Construction and Instream Habitat Restoration Activities

There are three activities associated with construction occurring in the Bear Creek watershed. Construction activity will occur during the in-water work period of June 15 through September 15. As described above, fish passage improvements are proposed at the Oak Street Diversion, which is located at RM 21.59 on the mainstem of Bear Creek. Fish passage improvement and fish screen installation are also proposed for the Ashland Creek Diversion which is located on Ashland Creek, a tributary of Bear Creek. Finally, installation of LWD structures associated with the instream restoration component of the proposed action will require substantial construction activity involving both riparian staging and in-water work activities. Unlike the fish passage improvement projects at the Oak Street and Ashland Diversion Dam locations, which are located in specific sites, the instream restoration components will largely occur at numerous locations in the Emigrant Creek, upper Bear Creek reaches, and in the South Fork Little Butte Creek watershed.

Juvenile coho salmon are the only life stage that will be exposed to the short-term construction related activities that generate sediment, toxic contaminants, and capture in the isolation areas. All of these likely stressors are short term, hours to days. Long-term consequences (one year to 30 years) related to the reduction of streamside vegetation will also expose younger fry coho salmon, smolts, and adults to stressors such as reductions in forage, instream structure/cover, and shade (water temperature). A reduction of macroinvertebrates that may occur due to the desiccation of the streambed is a potential stressor that may last for several months. Riparian vegetation lost from gaining access to the work site will be replaced by plantings, but full recovery of that vegetation will vary from one year, for grasses, to 5 to 30 years for shrubs and trees. Aquatic organisms will have fewer sources of nutrients from riparian vegetation, as well as the loss of terrestrial insects that inhabit the terrestrial vegetation and frequently fall into the water. All age classes of SONCC coho salmon will be exposed to this lost riparian vegetation.

Based on this analysis, the three work area isolation actions are likely to result in the injury of some juvenile coho salmon due to capture, stranding, or handling stress. There will not be any adult SONCC coho salmon in the streams to salvage because salvage will occur before migrating adults reach the action area in late October and November. Individuals present within the action area will not be inhibited from moving away from suspended sediment plumes because the plumes will be small, temporary, and localized. Therefore, while some SONCC coho salmon may be exposed to project-related increased suspended sediment when the Project site is inundated, the concentration and duration of the elevated suspended sediments is likely to result in minor effects to juvenile coho salmon during in-water construction activities.

Some adverse effects to juvenile coho salmon may occur from fish salvage and instream sedimentation resulting from Project construction activities. However, these effects are suspected to be minimal in duration. As a result, Reclamation anticipates that some take may occur from these actions but that these take levels will be incidental to the projects and will be minor in extent.

4.4.2 Little Butte Creek Watershed

Effects of Flows on Habitat

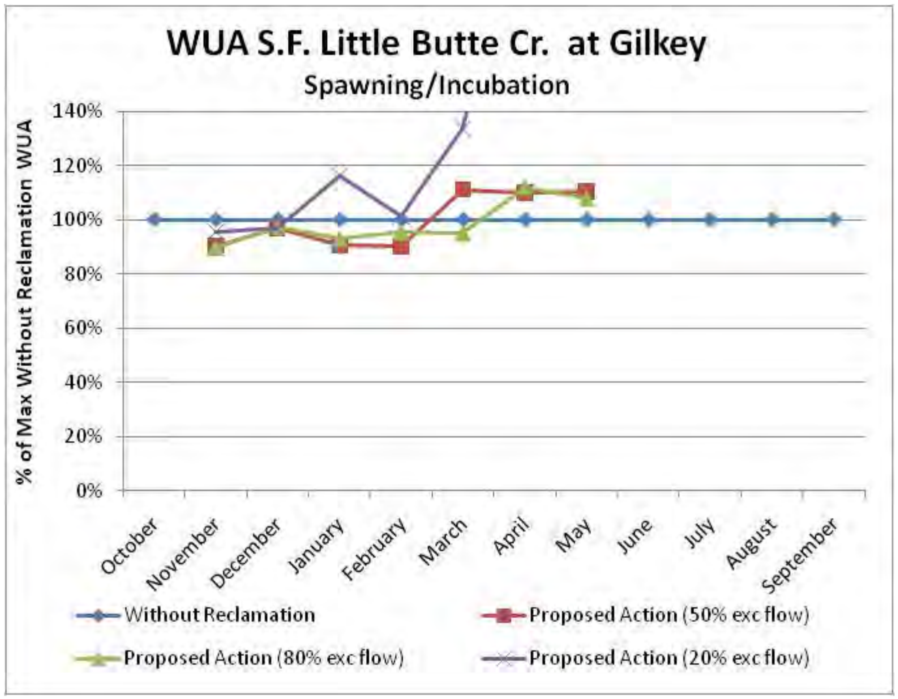
South Fork Little Butte Creek

Operation of the Project under the proposed action would affect flows in South Fork Little Butte Creek and its tributaries downstream from the various points of diversion. These effects would vary by location, season, and flow condition (e.g., high, low, median) under the proposed action (Table 4-30 through Table 4-32). Diversions would occur in the upper South Fork Little Butte Creek basin, including diversions at the Dead Indian Creek Collection Canal and the South Fork Little Butte Creek Collection Canal. These diversions would be made mostly during the winter and spring during periods of high runoff. No additional facilities would be constructed as part of the proposed action. The diversions would be made using the existing diversions, conveyance, and storage facilities. Consistent with the proposed action's operation of the Little Butte Creek watershed transbasin diversion system, streamflow in the South Fork Little Butte Creek would be reduced primarily from November through May. Summer flows would be virtually unchanged by the proposed action.

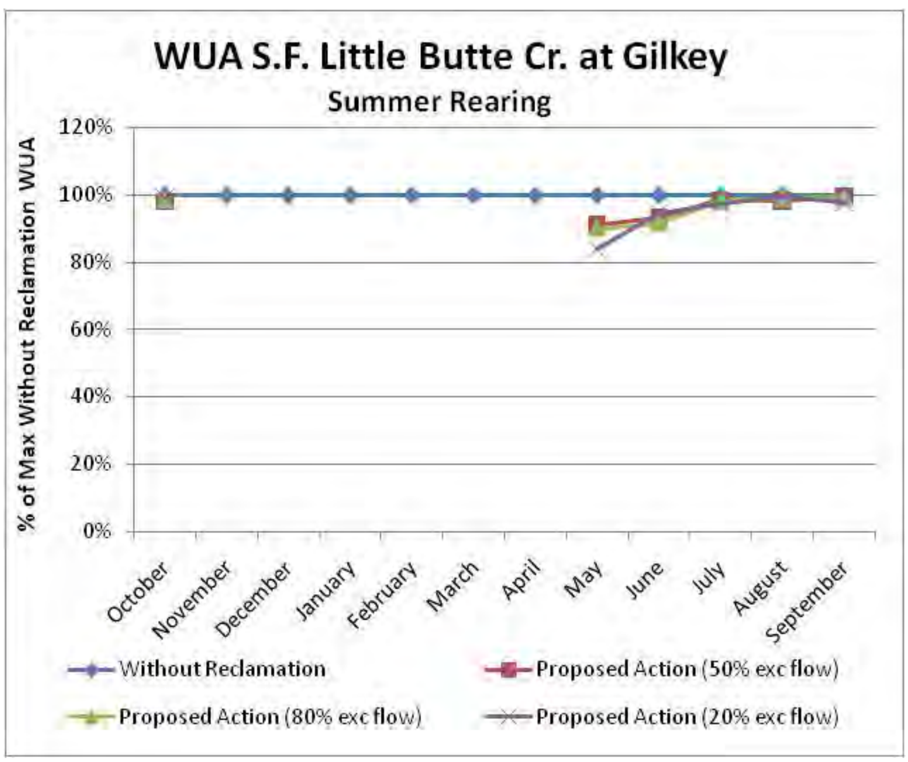
Figure 4-13a-c indicate the amount of WUA as a percentage of the without Reclamation WUA that would exist in the absence of the Project. These can be used to measure habitat for coho salmon spawning/incubation, juvenile summer and winter rearing conditions, respectively, in South Fork Little Butte Creek near the Gilkey Hydromet station. WUA takes into account habitat value by looking at depth, velocity, and substrate criteria as well as the amount of habitat that is physically available in each individual stream reach analyzed. As such, the WUA values can be used as a rough index to explore possible changes in space available and water velocity for the various life stages.

Modeled differences in available habitat in the South Fork Little Butte Creek reach downstream from Dead Indian Creek to the Lake Creek confluence vary considerably between life stages and flow (median or low flow condition) as a result of the proposed action (Table 4-30 through Table 4-32). Differences in available spawning and incubation habitat are predicted to be small to moderate for both low and median flow conditions, particularly between the months of November through February when modeled WUA will be reduced by 5 to 10 percent compared to the without Reclamation condition. The proposed action will increase WUA for spawning and incubation habitat in this reach in March through May for the median and low flow conditions, and in January through May for the high flow condition.

The differences in available incubation habitat in March through May, however, are likely to be biologically meaningless because available habitat in those months would exceed the habitat available during spawning. Spawning habitat improvements relative to the without Reclamation flow condition are caused by Project water diversions that reduce streamflow during high flow events that correspond with the spawning and incubation period. Reducing streamflows provides for more acceptable spawning and incubation habitat conditions as modeled by the PHABSIM model by improving micro-habitat conditions within spawning habitat. Moderate increases are predicted for incubation habitat under all flow conditions due to steadily increasing streamflows in the months following spawning.


WUA S.F. Little Butte Cr. at Gilkey
Spawning/Incubation
% of Max Without Reclamation WUA
140%
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

a)


WUA S.F. Little Butte Cr. at Gilkey
Summer Rearing
% of Max Without Reclamation WUA
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

b)

c)

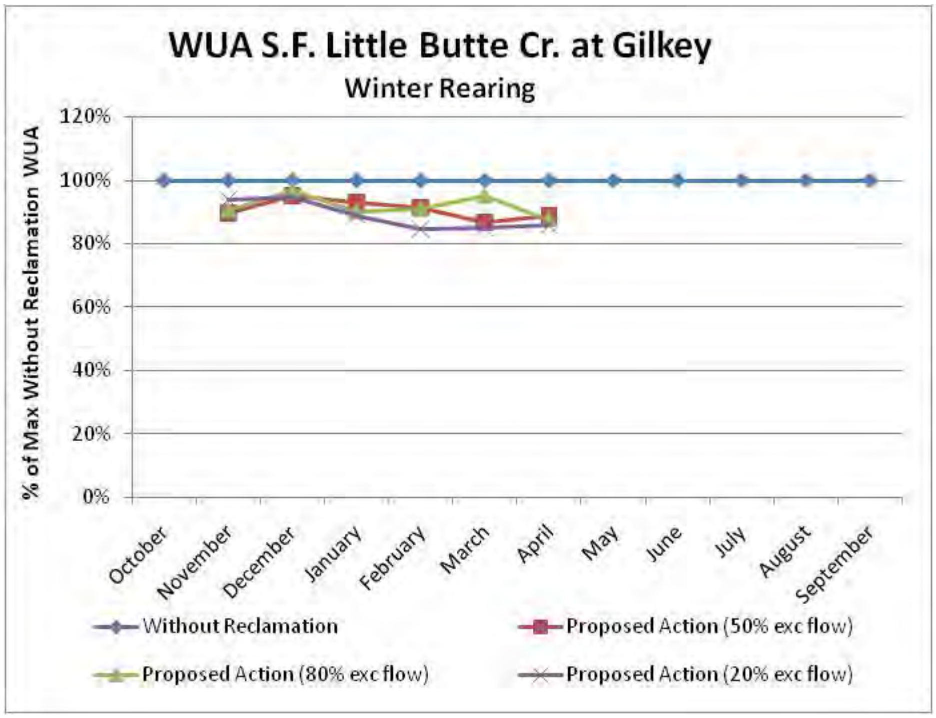


Figure 4-13. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in the South Fork Little Butte Creek.

Thus, under low and median flow conditions, the proposed action would likely have a small negative effect on spawning and incubation critical habitat within this stream reach due to the 5 to 10 percent reduction in WUA relative to the without Reclamation condition. These results suggest that spawning habitat would be moderately reduced under the proposed action. Reclamation's proposed action is designed to have no more than a 10 percent reduction in pre-project WUA habitat areas for all life stages, if at all possible. Comparison of without Reclamation and proposed action spawning and incubation WUA habitat indicates that for all flow conditions analyzed, the proposed action would likely have a very small adverse affect to the amount of spawning habitat in this important reach. This habitat effect would appear to have an adverse effect on the spawning success of coho salmon for low flow conditions. However, these reductions may not be biologically meaningful because there would likely remain sufficient spawning habitat areas to allow for a significant amount of spawning to occur if the proposed action is implemented. Reclamation documented that even with implementation of the proposed action and spawning habitat detriments of between 5 and 10 percent from without Reclamation conditions that more spawning habitat will be available then the subsequent rearing habitats can sustain (Appendix B). Therefore spawning habitat was found to not be limiting the coho salmon population in this reach.

Under median flow conditions (depicted here as the monthly median flows), the proposed action would have small adverse effects on summer juvenile rearing habitat in the South Fork Little Butte Creek near Gilkey (Figure 4-13b). Juvenile rearing habitat would be decreased by approximately 10 percent from without Reclamation WUA habitat conditions in May and June for the low and median flow conditions, and would be reduced by approximately 15 percent in the month of May under a high flow condition. These small to moderate reductions in summer rearing habitat would occur during these months because of diversion operations at the South Fork Little Butte Creek and Dead Indian Creek Collection Canal facilities. WUA for summer rearing during the months of July through October would be unaffected by the proposed action as diversion operations in the South Fork little Butte Creek system cease. The overall effect of the proposed action on summer rearing critical habitat is therefore small, although the reduction in summer habitat in the early months of the summer rearing period could have some adverse affects to coho production.

Winter juvenile rearing habitat would also be reduced in all months between November and April for all flow conditions. The amount of WUA reduction from the without Reclamation flow condition would be about a 5 to 10 percent reduction under low flow conditions to 5 to 15 percent habitat detriment for the median and high flow conditions. In general, flow conditions under the proposed action will result in WUA habitat reductions less than 10 percent of without Reclamation WUA conditions most of the time. The proposed instream habitat and riparian zone restoration actions that are included as part of the proposed action will be designed to increase the amount of WUA to levels that are less than 10 percent reductions from pre-project habitat levels for summer and winter rearing habitat. As a result, the reduction in winter rearing habitat based on these proposed flows are considered to be small rather than moderate detriments. These reductions in juvenile winter rearing habitat quantity and quality are small to moderate and would likely have a small to moderate adverse effect on availability of SONCC coho salmon critical habitat.

The safe passage PCE would not be affected by the proposed action in this area because the proposed action hydrograph is similar to the without Reclamation hydrology during periods of adult and juvenile migration. In addition, all structures within the South Fork Little Butte Creek stream reach currently provide physical facilities that are equipped with safe passage for coho salmon. As a result, passage at these sites would be maintained as it currently exists. All water diversion facilities that effect flow at the GILO Hydromet gage, mainly the structures currently used to divert in the South Fork of Little Butte Creek and Dead Indian Creek, are located in areas above an impassible barrier in locations where coho salmon do not have access. These facilities would not be altered in the proposed action nor would they interfere with coho salmon safe passage due to physical presence or rates of water diversion under the proposed action. Overall, it appears that the proposed action in the South Fork of

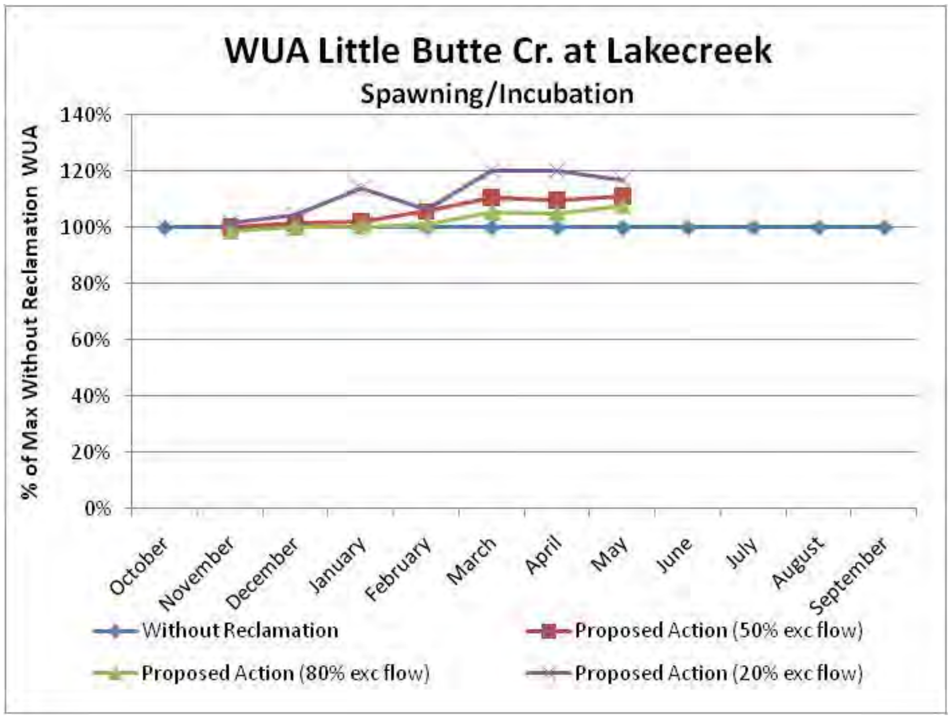
Little Butte Creek would not cause deterioration in current conditions to these designated critical habitat PCEs.

Little Butte Creek – South Fork Little Butte Creek to Little Butte Creek at Lakecreek

Modeled differences in available habitat in Little Butte Creek from the confluence of the South Fork Little Butte Creek downstream from the Lake Creek confluence vary considerably between life stages and flow (median or low flow conditions) (Table 4-33 through Table 4-35).

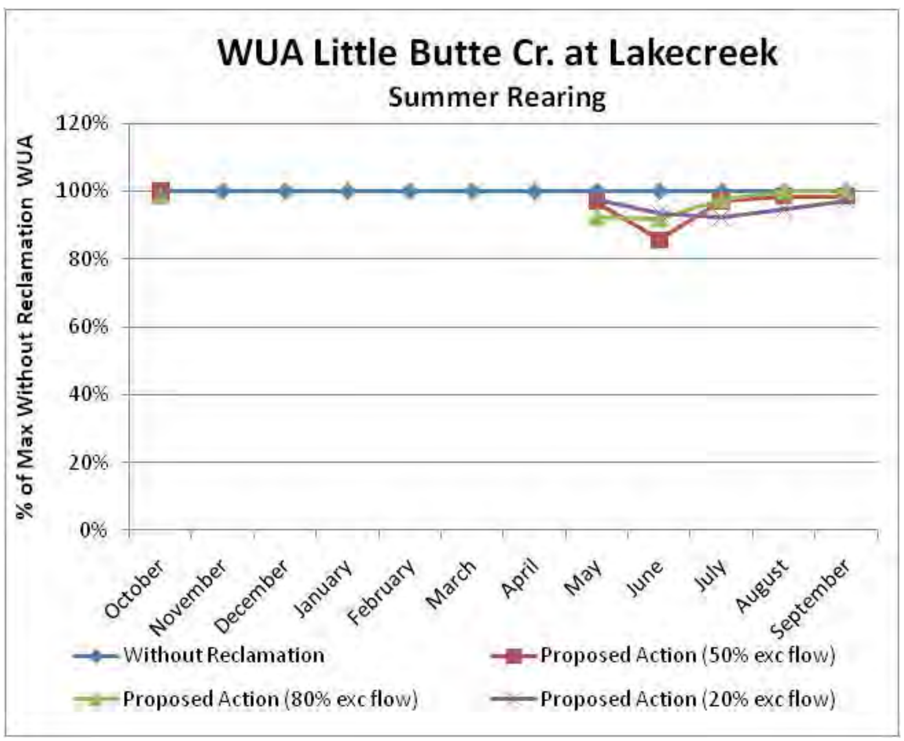
Differences in available spawning and incubation habitat are very small for the median and low flow conditions from November through January, with small to moderate benefits to habitat occurring from February through May for these flow conditions. Substantial benefits to spawning and incubation habitat are provided by the proposed action when the high flow condition is considered (Figure 4-14a), with habitat benefits of 15 to 20 percent over without Reclamation conditions during the high flow conditions. Spawning and incubation habitats would be increased by anywhere from 8 percent in February to 12 percent in April and May for the median and low flow proposed action conditions. These results suggest that spawning habitat in this stream reach would be either unaffected or increased to varying degrees during all flow conditions under the proposed action. This habitat effect would likely have a slight, but likely very small beneficial effect on the Little Butte Creek SONCC coho salmon spawning and incubation success. Moderate increases are predicted for incubation habitat under all flow conditions due to steadily increasing streamflows in the months following spawning. The proposed action's effects on spawning habitat in this stream reach under median flow conditions are very small and would be unlikely to affect the success of spawning and incubation.

Moderate to small decreases in summer rearing habitat are identified for all flow conditions analyzed, particularly during the months of May through July in Little Butte Creek. Habitat detriments range from 5 to 15 percent detriment compared to the without Reclamation flow scenario as a result of flows provided under the proposed action. Similar to the South Fork Little Butte Creek reach described above, streamflows during the late summer months improves to about 100 percent of without Reclamation WUA due to the reduction in diversions from the upper basin. As a result, very few habitat differences to summer rearing habitat occurs under the proposed action after the month of July. Some very small adverse affects are caused by slight reductions in summer rearing habitat for the high flow condition (Figure 4-14b), but those impacts are limited to no more than a 5 percent reduction from pre-project habitat levels.


WUA Little Butte Cr. at Lakecreek
Spawning/Incubation
% of Max Without Reclamation WUA
140%
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

a)

*


WUA Little Butte Cr. at Lakecreek
Summer Rearing
% of Max Without Reclamation WUA
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

b)

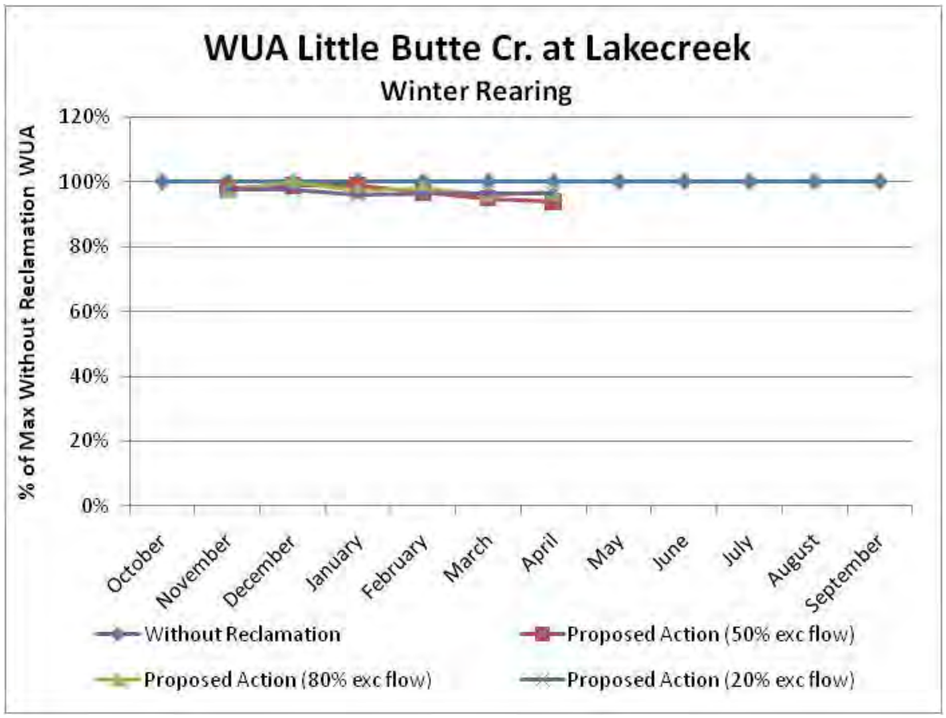
c) 

Figure 4-14. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Little Butte Creek near Lakecreek.

Small to very small reductions (1 to 5 percent habitat detriment) in winter rearing habitat occur in all flow conditions analyzed, with habitats remaining unchanged in the early winter rearing period (November and December). Small reduction in winter rearing habitat is reasonably likely to result in slightly reduced winter survival of juvenile SONCC coho salmon. Because winter rearing habitat is often population limiting, the slight reductions in winter rearing habitat likely have a stronger population effect than the similar increases in summer rearing habitat. Thus, the proposed action would likely slightly decrease juvenile rearing habitat and would slightly adversely affect the winter survival of juvenile SONCC coho salmon from the Little Butte Creek sub-population under median flow conditions. However, these reductions in juvenile rearing habitat quantity and quality would be mostly small to negligible.

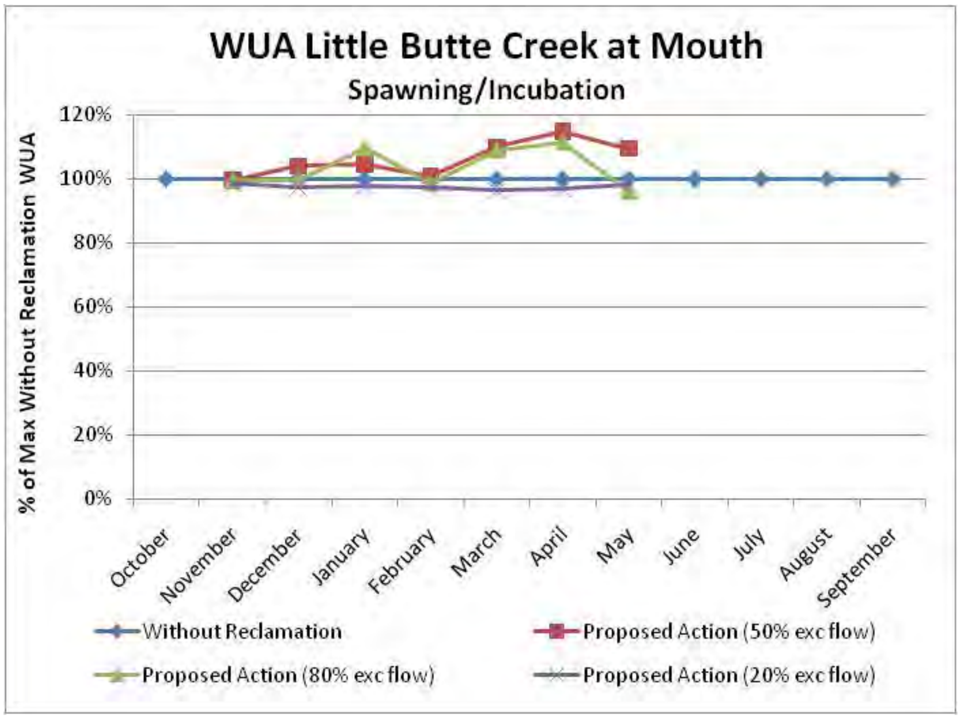
Little Butte Creek – Little Butte Creek at Lakecreek to Little Butte Creek Mouth

Available habitats in the Little Butte Creek reach downstream from Antelope Creek to the confluence with the Rogue River would be slightly affected by the proposed action (Table 4-

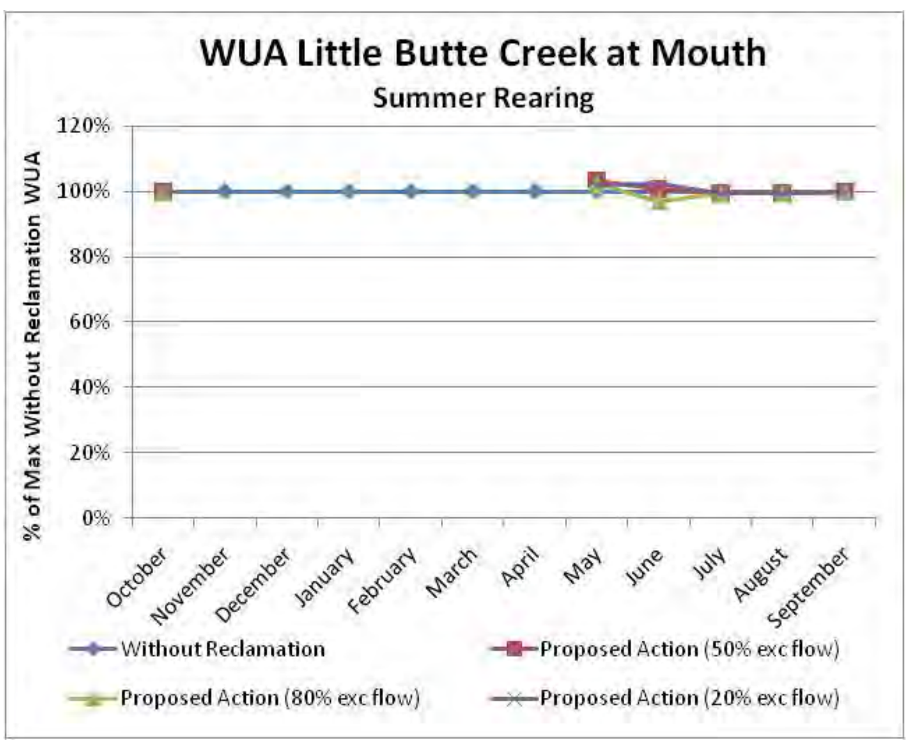
36 through Table 4-38). Spawning habitat would be affected very little under high flow conditions (Figure 4-15a), but would see moderate to small benefits under median and low flow conditions relative to the without Reclamation scenario. This is particularly the case for median and low flow conditions in the months of March and April when WUA under the proposed action are increased by 10 to 15 percent. Incubation habitat are likely to increase as a result of flows under the proposed action. However, incubation habitat differences are not biologically meaningful due to their exceedance of the available spawning habitat in most years.

In Little Butte Creek near Eagle Point, juvenile salmon WUA is in the upper quartile; that is greater than 75 percent of maximum, WUA over 99 percent of the time within the range of simulated flows for the PHABSIM modeling. As on the South Fork, the low point occurs in the summer when Project diversions from the basin are very low or non-existent. During the winter when diversions are occurring, the juvenile salmon WUA is near the optimum. Spawning and incubation habitat at this site could not be routinely modeled as most flows exceeded the range that could be simulated.

Summer rearing habitat during all flow conditions would be virtually unaffected by implementation of the proposed action in this reach of Little Butte Creek. Juvenile rearing habitat would be increased by 0.1 percent in May, 7.1 percent in June, 1.6 percent in July, 4.0 percent in August, 5.6 percent in September, and 8.4 percent in October. Under low flow conditions (depicted here as the monthly 80 percent exceedance flows), the proposed action would generally have small to very small effects on juvenile rearing habitat (Figure 4-15b). During May, summer juvenile rearing habitat would be reduced by 1.4 percent. From June through September, juvenile flows and juvenile rearing habitat would be unaffected by the proposed action.


WUA Little Butte Creek at Mouth
Spawning/Incubation
% of Max Without Reclamation WUA
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

a)


WUA Little Butte Creek at Mouth
Summer Rearing
% of Max Without Reclamation WUA
120%
100%
80%
60%
40%
20%
0%
October
November
December
January
February
March
April
May
June
July
August
September
Without Reclamation
Proposed Action (50% exc flow)
Proposed Action (80% exc flow)
Proposed Action (20% exc flow)

b)

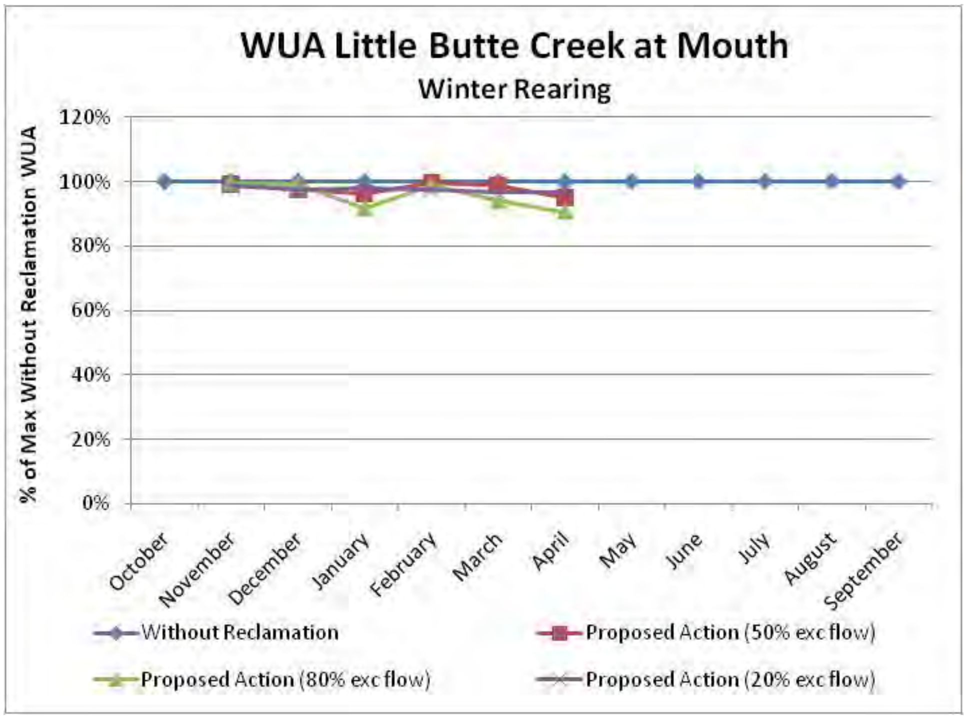
c) 

Figure 4-15. Percent of maximum without Reclamation WUA for three coho salmon life history stages a) spawning/incubation, b) summer rearing, and c) winter rearing resulting from proposed action streamflows provided for median year (50 percent exc. flow), dry year (80 percent exc. flow) and wet year (20 percent exc. flow) flow conditions in Little Butte Creek between Lakecreek and the mouth of Little Butte Creek.

Juvenile salmon WUA reaches its low point in the summer when Project diversions are very low and spawning salmon WUA is near optimum throughout the spawning and incubation periods. The conditions for juvenile salmon rearing WUA and salmon spawning/incubation WUA would remain unchanged in Little Butte Creek under the proposed future operation so the space and water velocity PCEs would be unaffected. Overall, the proposed action's effects on juvenile habitat during low flow conditions would be small and beneficial and would likely have a small beneficial effect on the Little Butte Creek SONCC coho salmon survival rates.

Small to very small reductions (1 to 5 percent habitat detriment) in winter rearing habitat occur in all flow years modeled, with habitats remaining unchanged in the early winter rearing period (November and December). Due to reductions in winter rearing habitat under median flow conditions, the proposed action would slightly reduce survival of SONCC coho salmon in this reach of Little Butte Creek. Some moderate reductions in winter habitat conditions were modeled under the low flow condition which occurred in January and April. The small to moderate reduction in winter rearing habitat is reasonably likely to result in slightly reduced winter survival of juvenile SONCC coho salmon during these months. Because winter rearing habitat is often population limiting, the slight reductions in winter rearing habitat likely have a stronger population effect than the similar increases in summer rearing habitat. Thus, the proposed action would likely slightly decrease juvenile rearing habitat and would slightly adversely affect the winter survival of juvenile SONCC coho salmon from the Little Butte Creek sub-population under median flow conditions. However, these reductions in juvenile rearing habitat quantity and quality would be mostly small to negligible.

Other PCEs of concern in the Little Butte Creek basin that may possibly be affected by the proposed action include substrate, water quality, water temperature, cover/shelter, riparian vegetation, and safe passage conditions. The Little Butte Creek Watershed Assessment evaluated conditions in the Little Butte Creek watershed shortly after the critical habitat for SONCC coho salmon was designated (LBCWC 2003). Much of the data used in the assessment represented watershed conditions at the time the designation was being considered. It addressed several of the PCEs either directly or indirectly and identified factors which were thought to contribute to the current conditions for them.

While the substrate PCE was not addressed directly in the watershed assessment, the assessment did address the issue of sediment which can have significant impacts on the substrate in streams and the value of the substrate for fish, including coho salmon. The assessment concluded that the three main sources of sediment to streams are road runoff, road instability, and mass wasting. Forestry practices were also identified as being of concern with respect to the potential for sediment delivery to streams. None of these sources are related to the proposed action or influenced by the proposed action so it appears that diversions from the South Fork Little Butte Creek basin, through the South Fork and Dead Indian Collection Canals, would not affect the substrate PCE, at least as it relates to sedimentation. Streambank erosion was identified as being of moderate concern. The proposed action does not involve any construction activities which could affect stream banks and the diversion of flows during a high flow period, when streambank erosion may occur, but would tend to lessen, rather than exacerbate, bank erosion.

Water quality was addressed in the watershed assessment directly. The assessment identified sediment, temperature, bacteria, DO, and nutrients as issues with respect to water quality. Sediment was addressed above relative to its potential effects to the substrate PCE. Suspended sediment can also affect fish both chronically at low levels and acutely when levels are high. None of the sources of sediment discussed above are related to the proposed action or influenced by the proposed action so it appears that diversions from the South Fork Little Butte Creek basin (i.e., Dead Indian Creek and Antelope Creek) would not affect the sediment as it relates to the water quality PCE. The same is true with regard to the water quality issues associated with bacteria and nutrients. Runoff from agricultural land is thought to contribute to the water quality issues associated with bacteria and nutrients. The diversions proposed as part of the proposed action would not result in any increased runoff from agricultural lands in the Little Butte Creek basin; therefore, these aspects of the water quality PCE would not be affected.

Water temperature is one most important water quality issues identified in the Little Butte Creek Watershed Assessment. It is also an identified PCE distinct from water quality. In the Little Butte Creek watershed, high temperatures in the summer are the issue of concern regarding water temperature and was an issue of concern at the time that critical habitat was designated in this area. The proposed action involves some diversions during the summer, but only at very low levels and so may contribute in a minor way to the current water temperature profile of the South Fork of Little Butte Creek, Dead Indian Creek, Little Butte Creek, and Antelope Creek. Diversions identified as part of the proposed action are not expected to cause any further deterioration over time in water temperatures in the South Fork of Little Butte Creek, Dead Indian Creek, or Little Butte Creek beyond the current conditions which are similar to the conditions present when the critical habitat was designated.

Riparian vegetation conditions in the Little Butte Creek basin are thought to be influenced significantly by logging and agricultural practices as well as other land use activities such as mining and rural development (LBCWC 2003). None of these activities or practices are influenced by or affected by the diversion of water from the South Fork of Little Butte Creek. As such, the proposed action would not have an effect on the riparian PCE.

The cover/shelter PCE was not directly addressed in the Little Butte Creek Watershed Assessment, but the assessment does look at the production of LWD which can provide cover and shelter for coho salmon. While LWD is important because it provides cover for coho salmon, its role in creating pools is likely even more important. The assessment concluded that under the conditions at that time, which were not likely substantially different than conditions at the time of critical habitat designation, LWD and the pools they create were generally lacking and conditions with respect to both LWD and pools were undesirable. Factors contributing to the lack of LWD were not specifically identified, but appear to be related to the land use practices which have impacted riparian zones in general, as discussed above. The lack of large conifers in the riparian zones, which can become LWD, was attributed to past logging practices. It should be noted that where riparian zones exist, they are vegetated with other species, including cottonwood and alder, and generally provide good shading of the streams. This suggests that current flow levels are sufficient to sustain riparian zones where other factors do not prevent it; consequently, the diversions in the proposed action would not cause deterioration in the riparian zones that exist to the point where LWD is no longer produced. The proposed action also would not affect the production of conifers in the riparian zones. As a result, effects to the cover/shelter PCE, as measured by LWD production and presence are not expected.

Antelope Creek

Reclamation improved adult fish passage and fish screens at the Antelope Creek Diversion Dam in 1997 and 1998 by installing a pool and weir facility. This facility upgrade still functions and provides for good passage conditions for adult fish.

Antelope Creek merges with Little Butte Creek at RM 3.2 downstream from the city of Eagle Point. Most water at Antelope Creek Diversion Dam is diverted into Agate Reservoir in the winter and spring when there are sufficient supplies of water to divert and adequate water flow to provide instream flows into downstream reaches. A minimum flow of 1 cfs must pass downstream from Antelope Creek Diversion Dam for streamflow maintenance from November to March. From April to October, 2 cfs, or the natural streamflow, whichever is the lesser, must be bypassed for streamflow maintenance and senior water rights. Operational releases from Agate Reservoir of 1 cfs for streamflow maintenance in Dry Creek are made when inflow is equal to or greater than that amount. If inflow is less than 1 cfs, the entire flow is released for streamflow maintenance. These releases are made through a 6-inch bypass line in the outlet works.

No summertime diversions occur at Antelope Creek Diversion Dam; therefore, habitat conditions for summer rearing juveniles and stream water temperatures downstream from this diversion are unaffected by operations. Juvenile salmon WUA is routinely high throughout the year (Figure 5-35 in Reclamation 2009b), although brief, steep declines have occurred when the stream dries completely. Such dewatering are not typically the result of Project diversions and have not been observed since the minimum flow releases have occurred in Antelope Creek. Overall, it appears that Project operations have little effect on juvenile salmon WUA.

Salmon spawning/incubation WUA fluctuates considerably (Figure 5-36 in Reclamation 2009b). This is due to the flashy nature of the stream rather than Project operations. In 2007 and 2008, salmon spawning/incubation WUA tended to be high during the months of peak diversion in the spring while in 2009, salmon spawning/incubation WUA fluctuated widely irrespective of Project diversions. The conditions for juvenile salmon rearing WUA and salmon spawning/incubation WUA would remain unchanged in Antelope Creek under proposed future operations of the Project. The space, water velocity, and substrate PCEs would be similarly unaffected.

Effects of Proposed Restoration Actions on Habitat

Instream LWD Placement Actions

Reclamation's proposed action of implementing an instream flow restoration component will be planned for completion by the year 2017 with substantial progress towards completion of the plan by 2015. The instream habitat restoration plan will be designed to reduce the level of adverse affect to juvenile winter and summer rearing habitats by creating sufficient rearing habitat to offset habitat detriments that are anticipated to occur as a result of implementing the proposed action. Instream wood structures (LWD) will be placed in stream reaches where summer or winter rearing habitat has been determined to be substantially (i.e., greater than a 20 percent reduction from habitat conditions that would be expected under the without Reclamation flow conditions) or moderately (between 11 to 20 percent of without Reclamation habitat) effected by the proposed action streamflows. Proposed LWD placement restoration components will effectively reduce the negative impacts to critical habitat from major detriments (greater than 20 percent WUA detriment) where they occur in the South Fork Little Butte Creek watershed to only minor detriments (0 percent to a maximum 10 percent detriment) compared to without Reclamation flow and habitat conditions.

Reclamation, NOAA Fisheries, and the Districts have cooperated in the development of this instream habitat restoration planning effort. Further both Reclamation and NOAA Fisheries have determined that implementation of instream LWD structures in agreed upon amounts that can be shown to offset habitat detriments for both winter and summer rearing WUA habitat to less than 10 percent of without Reclamation modeled habitat conditions, that the proposed action affects will be adequately minimized to allow for the conservation of the species. As such, Reclamation believes that full implementation of the LWD restoration plan will not adversely affect SONCC coho salmon critical habitat.

4.4.3 Klamath River Watershed

The specific critical habitat affected by the proposed action is for SONCC coho salmon in the mainstem Klamath River from the base of Iron Gate Dam to the Seiad Valley. Jenny Creek, the subbasin within the Klamath River basin from which Project diversions are in part made, empties into Iron Gate Reservoir above Iron Gate Dam. SONCC coho salmon use the mainstem Klamath River for spawning, rearing, and migration for adults and smolts.

The diversion of water from Jenny Creek will continue to slightly affect mainstem Klamath River flows below Iron Gate Dam. Approximately 24, 000 acre-feet of water is diverted annually from the Jenny Creek drainage to Bear Creek in the Rogue River basin. As noted in Reclamation's 2003 BA, pre-Klamath Project estimated average annual flow at Iron Gate for a normal water year, which accounts for accretions in flow below Keno, was approximately 1.8 million acre-feet. Thus, Jenny Creek contributes approximately 1.3 percent of the total water balance in the upper Klamath River basin. Average monthly percent changes in available flow at the outflow of Iron Gate Dam ranged from a low of 0 (July, August, and September) to a high of 4.7 percent in March. Further downstream, with the inflow of the Shasta and Scott rivers, these percentages diminish.

4.4.4 Critical Habitat Effects Summary

Habitat modeling using the IFIM approach and PHABSIM was used to analyze most of the differences in available habitat due to flow management from the proposed action. Detailed discussion of potential effects to critical habitat by stream reach was provided in the effects to the environment section above. The following is a summary of these results to critical habitat PCEs within the action area. These effects differ by reach and watershed and occur primarily in the Rogue River basin.

Rogue River Basin

1. Cover/Shelter (migration and rearing). This component of the proposed action is a water management action. Land use in riparian areas would only be affected by construction activities at the various facilities. By decreasing flows during the winter period, the proposed action would result in the stream wetted area being reduced in Emigrant, upper Bear Creek and in the South Fork Little Butte Creek system, exposing streambanks and reducing the value of riparian vegetation as overhead cover. Increases in flow, particularly during the summer would provide a greater wetted width of the channel increasing cover in these same stream reaches. Cover is one of three parameters considered in the IFIM study (Reclamation 2007). It is very difficult to provide a quantitative analysis of the changes in cover with changes in flow due to the potential for both positive and negative effects. Reclamation concludes, however, that the proposed action effects to cover are minimal when considering the small habitat effects anticipated to occur in the majority of stream reaches analyzed and when considering the amount of cover created by the LWD and riparian zone restoration components of the proposed action.

2. Food (juvenile migration and rearing). Forage for juvenile coho salmon is not a direct measure from the habitat modeling. A reduction in wetted area during the winter months relative to the without Reclamation scenario indicates decreased forage production from the proposed action. However, an increase in wetted area during the summer period comensurate with increased summer flows will likewise increase forage production in these areas. Riparian zone improvement actions related to the proposed action are likely to enhance allocthanous food production inputs to the system over time which will constitute an improvement to this component of the PCE. However, increases or decreases in the conservation value of this PCE are not predictable for both watersheds at this time.

3. Riparian Vegetation (migration and rearing). Consequences of implementing the proposed action to riparian vegetation growth and maintenance are speculative and not predictable. However, the proposed action riparian zone management plan component will consist of increases in riparian zone planting along 3 miles of Emigrant and upper Bear Creek. These riparian zone actions will only lead to increased riparian zone production increases over time and will not result in any negative effects to critical habitat.

4. Safe Passage (migration). The proposed action generally provides the required flows for adult passage in the Bear Creek stream reaches (Reclamation 2009b). At times, these are not met during low flow conditions (80 percent exceedance) in October and November for the Emigrant Creek to Oak Street Diversion and would result in migration delays. This also may occur in the Phoenix to Jackson Street Diversion reach in October during low flow conditions. Emigrant Creek does not reach the required flows to provide adult migration during the fall months of October through December. However, flow data from above Emigrant Dam indicates the required flows rarely meet the required 31 cfs and therefore the current channel configuration is not likely to provide access by adult coho salmon even under the without Reclamation flow condition. Reclamation also concludes that safe passage conditions in the Emigrant Creek reach will be improved by the proposed action due to the planned placement of large wood structures that will be designed to eliminate hydraulic constriction points in the channel. Reclamation also believes that the safe passage attribute of critical habitat in these areas will be improved as a result of the fish passage improvements that will be made to the Oak Street and Ashland Creek diversions.

Reclamation concludes the proposed action would not change adult migration in Little Butte Creek watershed because the limited periods when migration delays could occur correspond with times when little water is diverted by the Project; therefore, poor passage conditions would not be caused by the proposed action.

5. Space (migration and rearing). Space is both adversely and beneficially affected by the proposed action. The proposed action increases space (or available habitat) for summer rearing in Emigrant Creek and Bear Creek in all flow conditions. At times these are substantial increases in summer rearing habitat. There are a few times when decreases in wetted areas and therefore rearing space occur as a result of the proposed action. The results for winter rearing habitat contrast with those for summer rearing habitat. Major detriments to winter rearing habitat occur due to the proposed action in Emigrant Creek. However, small detriments to winter habitat are also anticipated to occur in Bear Creek from the confluence of Emigrant Creek downstream to the Phoenix Diversion. Downstream of Phoenix the affects of the action to winter rearing habitat return to levels that would exist under the without Reclamation scenario. These large and small reductions in rearing habitat likely reduce the conservation value of each stream reach in which they occur. The proposed action instream flow component, as well as the instream LWD restoration component of the proposed action, are designed to work in concert to decrease the overall Project related reductions in available space so that only small detriments occur rather than large detriments. To this end, the proposed action will have some adverse affects to available rearing space in the winter, but these affects will be reduced to acceptable levels through large wood installation components of the action.

Within the Little Butte Creek watershed, summer and winter rearing habitat are also adversely affected by the proposed action. In contrast to the Bear Creek drainage, the proposed action removes water from the watershed. Again, the moderate and substantial reductions in summer (Little Butte Creek) and the winter rearing habitat indicate the conservation value of this habitat is reduced by the proposed action in these stream reaches. Instream flow and LWD installation actions in the South Fork Little Butte Creek reach are designed to limit the adverse affect to no more than small detriments to rearing space compared to the without Reclamation scenario.

6. Spawning Gravel. The proposed action will have differing results on available habitat depending on the reach and the flow year. In the Emigrant and upper Bear Creek watershed, the proposed action will substantially reduce available spawning habitat compared to the without Reclamation flow condition. However, in other reaches and under other flow conditions the action is anticipated to result in increases in the available spawning habitat WUA for adult coho salmon. Detailed discussions, presented earlier in this critical habitat effects section, describes the PHABSIM modeling and subsequent critical habitat analyses by stream reach. Although both large and moderate detriments as well as benefits to available spawning habitat WUA will occur as a result of the proposed action, neither benefits nor detriments to available spawning habitat are likely to effect this PCE for the Bear Creek watershed. This results in the fact that under all flow scenarios modeled (proposed action and without Reclamation) that sufficient spawning habitat exists to support many more adult coho than are currently observed in the Bear Creek system. Enough spawning habitat exists under the proposed action to provide for the conservation of the species and to support recovered adult abundance levels for the SONCC ESU.

Similarly, in the Little Butte Creek watershed, reductions in streamflow would have both beneficial and adverse effects on SONCC spawning habitat depending on the month and flow condition (median or low). During low flow conditions, moderate reductions in spawning habitat would occur in the South Fork Little Butte Creek. Most reaches would have very few differences in available spawning under the median flow condition relative to the without Reclamation scenario since water diversions that would reduce flows typically occur after the coho spawning period in this watershed. Incubation habitat may be decreased in available area compared to the without Reclamation scenario, however, effects of this reduction are not likely to result in decreased production since incubation flows are always held higher than spawning flows under all proposed action flow conditions analyzed.

7. Substrate (migration). Reclamation concludes that the conservation value of substrates needed for migration is not likely to be changed as a result of the proposed action.

8. Water Quality (migration and rearing). Summer water temperature conditions in the environmental baseline are adverse in the Bear Creek and Little Butte Creek watersheds and are expected to continue under the proposed action. During the summer period when elevated temperatures are most likely to result in poor rearing conditions for coho salmon, Reclamation’s proposed action is anticipated to benefit fish due to the release of large amounts of cold water at Emigrant Dam. This benefit, however, only occurs in Emigrant Creek and in the upper sections of Bear Creek. Beneficial effects to water temperature resulting from water releases at Emigrant Dam decrease as water flows downstream and all benefits of cool water releases are ameliorated as solar inputs overcome the cooling effect, primarily downstream of the Oak Street Diversion. Reclamation's proposed action does not impact water temperature in the Little Butte Creek watershed because little or no diversions occur from the South Fork Little Butte Creek during the summer months in the proposed action when elevated temperature impacts are the greatest to the coho salmon population.

9. Water Quantity (migration and rearing). As described in detail above, the proposed action has both beneficial and adverse effects on the conservation value of the SONCC coho salmon critical habitat in Little Butte Creek and Bear Creek watersheds as a result of water management activities. The PHABSIM modeling reported in the effects analysis section predicts the changes in relationships between instream flows and fish habitat. As the proposed action changes water quantity, changes occur in the available critical habitat required to sustain SONCC coho salmon in the action area. This relationship varies by life stage and specific life history requirements. The overall increase or decrease of coho salmon habitat due to changes in water quantity was discussed in detail in the critical habitat effects section above (summarized in Table 4-12 through Table 4-38). Within these tables, values that represent decreases in available habitat (WUA less than 99 percent of without Reclamation habitat) are considered effects on critical habitat PCEs that are likely to result in the loss of conservation value for the life stage and life history function. Also, as presented in these tables, habitat increases represented as WUA's greater than 100 percent of without Reclamation habitat, result in increases in conditions that are required to support the conservation value for the species.

Water management is the primary component of the proposed action and purpose of the Project; therefore, water quantity is greatly affected by the proposed action. This results in both beneficial outcomes and adverse outcomes to juvenile SONCC coho salmon summer and winter rearing habitat. The addition of water to the Bear Creek mainstem has beneficial results by increasing juvenile summer rearing habitat in some reaches. This benefit is most frequently observed for low and median flow conditions where the proposed action substantially increases available summer rearing habitat. In general, the lower reaches of Bear Creek that may receive additional water and that result in increased available physical habitat may not fully benefit juvenile coho salmon due to elevated water temperatures limiting the suitability of the reach to summer rearing. Relatively large reductions observed in winter rearing habitat are substantial adverse effects and likely limit the conservation value of this PCE.

Alteration of the Little Butte Creek watershed water management is more complex than the Bear Creek watershed due to non-project irrigation diversions. These diversions also occur within the Bear Creek watershed, but of a different magnitude. At times, particularly during the winter high flow season, reductions in flow increase spawning and incubation habitats according to the PHABSIM modeling analysis. However, flow reductions generally reduce juvenile rearing habitat in the South Fork Little Butte Creek reach. In general, little habitat change is expected to occur in available summer and winter rearing habitat or spawning habitat in mainstem reaches of Little Butte Creek because any impacts from flow diversions become moderate and eventually lost as flows increase in downstream reaches of the Little Butte Creek system. Reduction in available habitat likely results in a reduction of the conservation value of this critical habitat PCE in the South Fork Little Butte Creek drainage, although the conservation value in mainstem areas of Little Butte Creek are not likely to be diminished as a result of the proposed action.

10. Water Temperature (migration). During the juvenile outmigration season (spring) and the adult spawning migration, the proposed action would have little effect on water temperatures. Early migrating adults and late migrating juveniles may be subject to adverse water temperature conditions in the Bear Creek/Emigrant Creek watershed, but those effects appear to be unassociated with the proposed action.

11. Water Velocity (migration). Reclamation concludes that there are no passage delays and obstructions due to water velocity in either the Bear Creek or Little Butte Creek watersheds. Any adverse water velocity conditions that exist at the Oak Street Diversion fish passage facility are likely to be removed when this facility is improved in 2015.

In general, an evaluation of WUA conditions that would result from implementation of the proposed action relative to WUAs that would be anticipated to occur under the without Reclamation flow scenario indicates that the proposed action would have small (5 percent habitat detriment) to substantial (greater than 20 percent habitat detriment) adverse affects to the spawning/incubation and winter rearing life history stages of coho salmon in many of the stream reaches analyzed. Adverse affects to SONCC coho salmon spawning/incubation and winter rearing critical habitat were primarily observed in the Emigrant Creek and upper Bear Creek reaches in the Bear Creek watershed and in the South Fork Little Butte Creek reach of the Little Butte Creek watershed. Adverse affects to these critical habitat areas and life stages decreased in the downstream direction as flow impacts from Project operations were moderated with increasing distance from Emigrant Dam in the Bear Creek watershed or from the South Fork Little Butte Creek diversion canals in the Little Butte Creek watershed. Only small effects (both positive and negative) were observed in the lower reaches of both watersheds to spawning/incubation and winter rearing critical habitat areas.

Conversely, the proposed action was found to have either minor affects or would result in improved conditions when compared against without Reclamation flow conditions for summer rearing coho salmon through much of the Bear and Little Butte Creek stream reaches analyzed. These results were observed due to no Project water diversions occurring in the Little Butte Creek watershed, or as increased water delivery from Emigrant Dam in the Bear

Creek watershed increased summer rearing WUAs relative to without Reclamation conditions in the summer period.

Despite the fact that proposed action flows frequently resulted in moderate to substantial adverse affects to spawning/incubation and winter rearing habitat WUA as indicated by the PHABSIM model, the overall proposed action affects were limited to only small adverse affects (less than 10 percent habitat reductions from without Reclamation WUA levels) due to the incorporation of both instream flows and an instream habitat restoration component (LWD placement and riparian zone management actions) that were designed to create habitat conditions that were equal to or greater than 90 percent of critical habitat that would have existed in the absence of the Project.

The critical habitat within the action area provides the essential physical and biological features that provide for the conservation of several different SONCC coho salmon populations. The designated critical habitat currently supports the conservation of the URR independently functioning population and the potential subpopulations residing in the Bear and Little Butte Creek watersheds. Despite this conclusion, Reclamation has determined that the proposed action may affect, and is likely to adversely affect designated critical habitat for SONCC coho salmon in the Federal action area. However, the proposed action contains several elements to minimize these adverse affects to the greatest amount practicable. The modification of the passage facility at Oak Street Diversion Dam and the provision of passage and protection at the Ashland Creek Diversion Dam would improve the safe passage PCE. Additionally, modifications to operations including instream flow releases into the Emigrant/Bear Creek reach and diversion limitations in the Little Butte Creek watersheds, along with implementation of a ramping rate protocol, and construction of an instream habitat restoration component and a riparian zone management plan would result in the improvement of some PCEs without degrading others and would limit adverse affects of the proposed action to acceptable levels.

Klamath River Basin

The proposed action will continue to reduce flows slightly in the Klamath River below Iron Gate Dam and will have associated minor effects on the availability of fry habitat, and negligible effects on adult migration and spawning habitat.

4.5 Effects to SONCC Coho Salmon

Effects to the species are described below for: 1) adult migration, 2) spawning and incubation, and 3) juvenile summer and winter rearing. These effects are analyzed on a reach by reach basis for both the Bear and Little Butte Creek watersheds. Reach breaks analyzed for species affects were the same as those used for analyzing critical habitat in Section 4.3 above.

Because very little information exists on coho salmon survival, growth, productivity, or other specific biological measures of population health within the Bear and Little Butte Creek watersheds to use for analyzing effects to the species, Reclamation relied heavily on habitat availability data derived from the PHABSIM model to estimate effects to the species. Reclamation assumed that habitat differences resulting from the comparison of the proposed action to the without Reclamation flow condition would be an acceptable surrogate for representing effects to the species. To estimate the fish habitat effects of the proposed action, Reclamation compared the WUA for the species/life stage of interest under the proposed action to the WUA under the without Reclamation flow condition as described in the critical habitat analysis section. Table 4-12 through Table 4-38 provide a summary of these WUA effects for all flow conditions analyzed and for all stream reaches within the action area. The results of modeling habitat differences provide some means to evaluate effects of the future operation of the proposed action on SONCC coho salmon. The results of our analysis are presented in terms of overall differences per month in available habitat and, in general, provide a predictor of changes in available habitat, thus likely effects on growth and survival of individual coho salmon or spawning success due to habitat availability.

As described in the proposed action section and in the critical habitat analysis sections above, Reclamation will be implementing an instream restoration component to mitigate for any adverse affects that may occur as a result of flow management actions. The intent of the instream restoration component of the proposed action is to limit adverse affects to less than 10 percent reductions from WUA levels that would be expected to occur in the absence of the Project. In other words, Reclamation will install LWD structures to improve habitat complexity and thereby create habitats with sufficient WUA values to offset moderate to substantial adverse affect down to only small adverse affects. Reclamation will not be implementing the habitat restoration actions (LWD placements) in reaches where habitat affects are found to be adverse but are considered small (less than 10 percent habitat reduction compared to without Reclamation conditions) due to instream flow commitments in the proposed action. The effects to the species section will highlight which stream reaches are adversely affected by the proposed action flows and will indicate which reaches have more than a moderate adverse affect and will therefore receive LWD structures to reduce adverse affects to acceptable levels. After implementing this approach to reduce the overall level of adverse project affects, no stream reach should have more than a 10 percent WUA reduction to either summer or winter rearing habitat in either watershed within the action area.

4.5.1 Bear Creek Watershed

Emigrant Creek from Emigrant Dam to Confluence of Bear Creek

Adult Migration

Reclamation (2007), as part of an instream flow study, made estimates of the flows needed to meet adult coho salmon passage needs. This study located IFIM transects at PHABSIM study sites at the shallowest points of the stream channel, points that are critical for passage, and collected necessary flow and cross-sectional data. A range of flows through the site was modeled for the transects to determine the flow at which at least 25 percent of the transect had a minimum depth of at least 0.6 feet with at least one continuous portion meeting that criteria equal to at least 10 percent of the total width. These criteria came from Thompson (1972). For the Emigrant Creek stream reach, the threshold passage criteria needed for fish passage at the most constricted portion of the stream channel was found to be 31 cfs.

Generally, flows on Emigrant Creek do not reach the 31 cfs threshold necessary for adult passage during the adult migration period under the proposed action. Flows during periods of flood control releases could possibly exceed the 31 cfs threshold estimated necessary for optimum adult passage; however, the instream flows included in the proposed action for the dry to wet system state of 2 to 12 cfs, are well below this flow volume. As a result, while flow conditions during the adult migration period would improve from past flow conditions under the proposed action, during years when the instream flow release is made in October through January, they would not reach the identified adult passage threshold as modeled in PHABSIM for Emigrant Creek.

It should be noted however, that flows under the without Reclamation condition would also be inadequate to provide fish passage in Emigrant Creek as flows above Emigrant Dam are usually well below the passage threshold of 31 cfs as well (Reclamation 2007) (Table 4-12). Flow data indicate that the current channel configuration is not likely to provide consistent access by adult coho salmon even under the without Reclamation flow condition. A gage above the reservoir has been in operation since 2003 and data collected since then shows that flows over 31 cfs occur only sporadically during the adult migration period, usually during or following storm events. In most years when flows over 31 cfs do occur, they occur late in the migration period, usually after mid-December. In some winters (i.e., 2007 to 2008; 2008 to 2009, 2011 to 2012), flows over 31 cfs almost never occur in Emigrant Creek above the reservoir. This may explain in large part the lack of use of Emigrant Creek by adult coho salmon even though sufficient spawning habitat exists to support several hundred adult coho salmon spawners (Appendix B).

Table 4-12. Emigrant Creek flows during the adult migration period under the proposed action and for the without Reclamation flow condition (October – January). Blue shaded areas indicate where flows would be sufficient to provide fish passage through the reach.

Percent exceedance level		October	November	December	January
Emigrant Creek (31 cfs passage threshold flow)					
Minimum operational flow		2-12	2-12	2-12	2-12
Without Reclamation	20% exc	9	14	58	103
	50% exc	4	7	24	40
	80% exc	1	3	8	23

Although, it appears that instream flows provided under the the proposed action (2 to 12 cfs) will not provide adequate migration conditions for adult coho salmon to pass through the Emigrant Creek reach, Reclamation will improve passage conditions at channel restriction points through the placement of LWD structural elements. These structures can be used to narrow and deepen the channel, thereby improving micro-habitat conditions such as water depth and velocity to provide more favorable conditions for adult fish migration. Placement of LWD structures can therefore be used to effectively remove or reduce hydraulic constrictions that limit fish passage. In Emigrant Creek for example, the hydraulic control that currently restricts adult passage at flows under 31 cfs has been identified and will be the focus of LWD structure design and placement to improve passage conditions at this location. LWD complexity improvements at such locations can increase both winter rearing habitat conditions as well as improving adult passage by confining and deepening the channel at hydraulic constriction points. The instream restoration component of the proposed action will focus on such areas to improve passage conditions to acceptable levels at flow rates provided under the proposed action. Although, channel constrictions and flow rates will be provided to aid in adult coho migration conditions in the Emigrant Creek reach, the proposed action will likely have adverse affects to this life history stage of coho salmon.

In addition to the passage problems that adult coho salmon find in Emigrant Creek due to channel constrictions under both proposed and historic flow rates, it should be noted that a private dam known as Bounds Pond is located about one-half mile downstream from Emigrant Dam on Emigrant Creek. This non-project dam is considered to be a complete blockage to upstream salmon migration. This dam has existed in the environmental baseline and no proposed modifications to make this dam passable are considered in this proposed action.

Adult Spawning and Incubation

Under all flow conditions analyzed, the proposed action flow conditions would lead to an overall reduction in spawning and incubation habitat in Emigrant Creek compared to the without Reclamation flow scenario (Table 4-12 through Table 4-14 and Figure 4-7a). However, during November and December, which is the prime coho spawning period, spawning habitat would be increased from or similar to conditions that would be provided under the without Reclamation flow scenario for all flow conditions.

As noted in the previous section, flows in Emigrant Creek would not meet the safe adult passage criteria under most conditions. It appears that spawning coho salmon would experience difficulty accessing all portions of this reach in all years even under improved conditions under the proposed action. The existing conditions for coho salmon spawning and incubation under the proposed action would be increased or maintained in this stream reach by providing stable flow releases out of Emigrant Dam in all years.

Although substantial reductions in both spawning/incubation and winter rearing habitat levels would be anticipated under the proposed action, there would likely remain sufficient spawning habitat areas to allow for a significant amount of spawning to occur if the proposed action is implemented. Reclamation documented that even with implementation of the proposed action and spawning habitat detriments of between 40 and 60 percent from without Reclamation conditions that more spawning habitat will be available than the subsequent rearing habitats can sustain (Appendix B). Therefore, spawning habitat was found to not be limiting the coho salmon population in this reach. In addition, the stable flows provided by the proposed action at Emigrant Dam during the incubation period will lead to acceptable incubation conditions will little chance for redd dewatering or redd scour and any decreases in the number of redds or egg and alevin survival in any discernable way is not expected. Flood control operations at Emigrant Dam that occur on an infrequent basis could result in some redd scour and loss of incubating eggs. However, these flood flow operations would be targeted for slow increases and decreases in Emigrant Creek flow rates to avoid this from occurring.

Juvenile Rearing

Available juvenile summer rearing habitat increases occur for median, low, and high flow conditions due to the proposed action flow releases from Emigrant Dam being higher than the without Reclamation scenario during the irrigation season. Increased juvenile rearing habitat is likely to reduce intraspecies and inter-species competition and result in increased survival for juvenile coho salmon. By converting this intermittent stream to a perennial stream the proposed action would increase juvenile rearing habitat and the continuity of flowing water would allow juvenile movement within the watershed, facilitating habitat selection behaviors such as seeking temperature refuges. This improvement in juvenile rearing habitat under all flow conditions would likely increase the survival of juvenile coho salmon in this reach compared to the without Reclamation condition.

Winter juvenile rearing habitat would be reduced from January through April, under all flow conditions. Reductions would range from 70 percent of without Reclamation WUA for the low flow condition to approximately 85 to 90 percent of without Reclamation WUA for median and high flow conditions (Figure 4-7c). Reductions in winter rearing habitat have the potential to increase over-wintering mortality due to space limitations as well as increasing inter-species and intraspecies competition, resulting in lower growth and survival rates. In addition, the reduced amount of winter rearing habitat was indicated to be the ultimate limiting factor to coho salmon production in the Emigrant Creek reach in the limiting factors analysis (Appendix B). However, the decrease in winter rearing habitat was found to limit the coho population at higher juvenile abundance levels than are currently observed in this section of Emigrant Creek. As a result, there is currently more winter habitat available than current winter parr production leading to underseeded habitat areas in this stream reach. Despite the reduction in winter rearing habitat compared to the without Reclamation flow condition, the amount of winter habitat that would be provided under the proposed action will still provide adequate habitat for a greatly expanded coho population than is currently observed in the Bear Creek watershed (Appendix B).

Finally, the instream habitat restoration component of the proposed action will be designed to improve the winter rearing habitat areas for coho salmon. These projects were proposed to decrease adverse affects from the proposed action flow management operations to levels that were considered to be only small adverse affects, rather than moderate to substantially adverse. Because the instream LWD structural components will decrease adverse affects from the proposed action, winter rearing habitat will be increased and will be available to support expanded coho salmon populations in this reach as larger numbers of fish spawn and successfully rear in this stream reach over time.

Due to instream flow rates and winter habitat WUA that are significantly reduced from pre-project habitat levels, Reclamation believes that juvenile winter rearing will be adversely affected by the proposed action. However, the proposed action flows provided will be adequate to allow for fish rearing in summer and winter, and because of further improvements to channel complexity for juvenile rearing in this reach, these effects will be mitigated to acceptable levels.

Bear Creek – Emigrant Creek to Oak Street Diversion

Adult Migration

The Bear Creek median condition (50 percent exceedance) flows under the proposed action exceed the flows determined necessary to provide passage for coho salmon adults. During the month of October, median flows approach the minimal levels for passage; however, releases for irrigation early in the month augment background flow levels. The proposed action generally provides the required flows for adult passage in this Bear Creek stream reach. At times, these are not met during low flow conditions (80 percent exceedance) in October and November for the Emigrant Creek to Oak Street Diversion and would result in migration delays (Table 4-13). Limiting access to the upstream reaches of Bear Creek and these upstream tributaries, such as Neil Creek, is likely to substantially reduce the potential production of these stream reaches. Based on Gold Ray Dam data counting station data, approximately 90 percent of the URR adult coho salmon migrate past the station prior to December 1. A passage barrier in Bear Creek that prevents upstream migration of these fish until later in December would likely result in delayed spawning or fish seeking alternative locations for spawning.

Table 4-13. Bear Creek flows between Emigrant Creek and the Oak Street Diversion Dam during the adult migration period under the proposed action and for the without Reclamation flow condition (October – January). Blue shaded areas indicate where flows would be sufficient to provide fish passage through the reach.

Percent exceedance level		October	November	December	January
Bear Creek (Emigrant Creek to Oak Street Diversion)(15 cfs passage threshold)					
Proposed Action	20% exc	15	22	110	95
	50% exc	9	15	38	45
	80% exc	6	12	15	27
Without Reclamation	20% exc	12	21	99	180
	50% exc	6	13	43	62
	80% exc	3	6	12	42

According to the passage analysis in Table 4-13 for the proposed action and without Reclamation flow scenario, fish passage through this reach would typically be improved with implementation of the proposed action as flows meeting the passage criteria of 15 cfs will be met approximately one month earlier under all flow conditions under the proposed action. For example, optimal fish passage conditions will be met beginning in November under proposed action flows under the median flow condition but passage conditions are predicted to be delayed until December for the median flow conditions under the without Reclamation scenario. Flow management under the proposed action is therefore believed to provide a benefit to adult migration conditions by allowing for adequate passage flows earlier in the migration season than the pre-project action.

In addition, the proposed action will not adversely affect adult fish passage into this reach as improvement of adult passage facilities at the Oak Street Diversion Dam will be made under the proposed action. These improvements would provide for increased passage success and less passage delays by coho salmon into these upstream reaches of Bear Creek.

The proposed action provides a steady flow that is higher than the without Reclamation flow in October through December in the Emigrant Creek to Oak Street Diversion reach. In addition, flows steadily increase from October through February in all reaches downstream of Emigrant Creek due to increases from tributary flows. These increasing flows tend to provide for adequate fish passage through mainstem reaches as well as allowing adult fish passage into tributaries to spawn.

Similar to the Emigrant Creek reach, passage conditions may also be improved through this reach in the proposed action by siting instream restoration structures on hydraulic constriction points that may limit passage conditions at low streamflows. LWD complexity improvements at such locations can increase both winter rearing habitat conditions as well as improving adult passage by confining and deepening the channel at hydraulic constriction points.

Due to adequate instream flow rates provided to allow for fish passage, fish passage improvements made at the Oak Street Diversion Dam fish passage facilities, and because of further improvements to channel complexity for adult fish passage conditions in this reach, Reclamation believes that adult passage will not be adversely affected by the proposed action.

Adult Spawning and Incubation

Differences in available spawning habitat for low and median streamflow conditions would be considered to be moderate detriments for the months of January through May for the low flow condition and for the months of January and February under the median flow condition. For the remaining months of the year for the median flow condition, however, spawning habitat is not affected by the proposed action as it is approximately at 100 percent of without Reclamation WUA levels. Both increases and decreases in available incubation habitat occur, depending on the flow, although these are not biologically meaningful due to available incubation habitat exceeding spawning habitat as WUAs remain steady or increase over the winter and spring months.

As described above, the proposed action provides flows that increase or maintain the ability for coho salmon adults to access this reach of Bear Creek. In addition, the fish passage improvements at the Oak Street Diversion Dam fish passage facilities and some LWD placement at channel constriction points will further ensure that adult spawners have access to this reach during the winter spawning period (October through January). As a result, the proposed action will not adversely affect the ability of coho salmon adult access to available spawning areas upstream of the Oak Street Diversion.

Reclamation documented that even with implementation of the proposed action and spawning habitat detriments of between 10 and 30 percent from without Reclamation conditions in this reach that more spawning habitat will be available than the subsequent rearing habitats can sustain (Appendix B). Therefore, spawning habitat was found to not be limiting the coho salmon population in this reach. In addition, the stable flows provided by the proposed action through winter releases at Emigrant Dam during the incubation period will lead to acceptable incubation conditions will little chance for redd dewatering or redd scour and any decreases in the number of redds or egg and alevin survival in any discernable way is not expected.

Juvenile Rearing

Similar to the Emigrant Creek reach, available juvenile summer rearing habitat increases occur for all flow conditions as a result stored water releases at Emigrant Dam and the lack of Project water diversions through this reach. Under all flow conditions, the proposed action would generally increase summer juvenile rearing habitat for all months when summer rearing occurs with the possible exception of May when juvenile summer rearing habitat would be unaffected by the proposed action. In June, July, August, and September rearing habitat would be increased by 20 percent to over 100 percent relative to without Reclamation conditions (Figure 4-8b). Increased juvenile rearing habitat is likely to reduce intraspecies and inter-species competition and result in increase survival for juvenile coho salmon. By converting this intermittent stream to a perennial stream, the proposed action would increase juvenile rearing habitat and the continuity of flowing water would allow juvenile movement within the watershed, facilitating habitat selection behaviors such as seeking temperature refuges. This improvement in juvenile rearing habitat during all flow conditions would likely increase the survival of juvenile coho salmon in this reach. Summer water temperatures reach levels above the desired 18º C (Reclamation 2009b), however; this reach is likely suitable summer rearing habitat for long periods of time. The proposed action would likely benefit rearing juveniles and increase summer survival.

During the months of January through March, proposed action flows result in winter rearing habitat detriments of between 10 and 20 percent of without Reclamation habitat levels. This constitutes a moderate to substantial reduction in critical habitat for this life history stage. Although, WUAs for winter rearing habitat improves for all but the low flow condition in the subsequent months of April (Figure 4-8c), the previous habitat detriments that occurred were likely to have negative effects on overwintering juvenile coho salmon that can not be aided by further increases in habitat in April. Moderate and substantial decreases in available winter rearing habitat are likely to reduce winter juvenile coho salmon habitat due to the proposed action.

However, insufficient information exists regarding the distribution differences of juvenile coho salmon between summer and winter rearing habitat to determine whether the improvements in summer habitat availability would have a larger population effect than the decreases in winter habitat availability. Moderate reductions in over wintering rearing habitat would likely reduce juvenile coho salmon winter survival. Unless the juvenile coho salmon can seek out other winter rearing habitat, the winter rearing habitat could likely limit overall survival of juvenile coho salmon in this reach.

These flow and habitat effects would likely adversely affect fry and winter rearing juvenile coho salmon. Fry would likely be displaced into unsuitable habitat and exposed to predation. Based on this analysis, the proposed action may affect, and is likely to adversely affect fry and juvenile, life stages for coho salmon in Bear Creek upstream of the Oak Street Diversion Dam. However, LWD restoration components of the proposed action will be implemented in this reach which will decrease adverse affects to winter rearing habitat to less than 10 percent of pre-project levels.

Bear Creek – Oak Street Diversion to Phoenix Diversion

Adult Migration

No fish passage impediments were noted to occur in this mainstem reach of Bear Creek nor were any fish passage threshold values reported during the instream flow study (Reclamation 2007), However, the proposed action provides a steady flow at Emigrant Dam that is higher than the without Reclamation flow in October through December in all downstream reaches including the Oak Street to Phoenix Diversion reach. In addition, flows steadily increase from October through February in all reaches downstream of Emigrant Creek due to increases from tributary flows. These increasing flows tend to provide for adequate fish passage through mainstem reaches as well as allowing adult fish passage into tributaries to spawn. As a result, Reclamation has determined that there will be no adverse affects to adult salmon migration due to the proposed action in this reach of Bear Creek.

Adult Spawning and Incubation

Available spawning habitat under median and low flow conditions ranged from a small to moderate decrease in low flow years during the months of January through May, to no difference or very small benefits to spawning/incubation WUA relative to the without Reclamation scenario under both median and high flow conditions. Incubation habitat condition followed a similar pattern with very good conditions occurring in median and high flow conditions and only moderate reductions in a low flow condition. For the median and high flow conditions, available incubation habitat exceeds spawning habitat in this reach. These results suggest that under typically provided conditions that are represented by the median and high flow conditions that significant spawning habitat followed by small increases in incubation habitat will be provided by the proposed action and that successful reproduction conditions in this reach should be provided by the proposed action flows.

Juvenile Rearing

Juvenile summer rearing conditions will be moderately to substantially increased later in the season for all flow conditions. Even with diversions occurring at the Talent Canal at the Oak Street Diversion, summer rearing in low and median flow conditions will result in substantial increases in available summer rearing habitat (Figure 4-9b). Summer habitat values show observed increases of 20 to 50 percent relative to the without Reclamation condition due to increase irrigation releases made at Emigrant Dam and moderate levels of diversion made at the Talent Canal during this time period.

For the winter months when overwintering conditions are important to rearing coho salmon (January through April), there were small to moderate impacts resulting from implementation of the proposed action. These impacts to winter rearing habitat were greatest (moderate detriments of 10 to 20 percent from without Reclamation conditions) for the low flow condition. Only small detriments were observed (between 5 percent and less than 10 percent reductions) for proposed action effects to winter rearing habitat conditions for the median and high flow conditions (Figure 4-9c).

Although juvenile winter rearing is moderately affected during low water conditions and is only slightly affected for median and high flow conditions, these impacts are not expected to limit the survival of coho salmon in this reach. This is because for all flow conditions analyzed, the summer benefit likely offsets the winter detriment if the reach is habitable due to high summer water temperatures. Summer water temperatures do exceed the desired 18˚C, but the reach is likely suitable for summer rearing habitat on the shoulder periods of the highest temperature and where cool water refugia exist. Given the limits on juvenile rearing use of this stream reach imposed by adverse water temperature conditions for most of the summer period, the propensity for rearing coho salmon to seasonally move to select suitable habitats suggest that by providing more flow and more suitable habitat during the summer in this stream reach, the proposed action would likely benefit rearing juveniles.

Bear Creek – Phoenix Diversion to Jackson Diversion

Adult Migration

The proposed action generally provides the required flows for adult passage in the Bear Creek stream reaches downstream of the Oak Street Diversion Dam (Reclamation 2009b). At times, these are not met during low flow conditions (80 percent exceedance) in October for the lower section of Bear Creek downstream of the Phoenix Diversion Dam under the without Reclamation flow condition and may have resulted in migration delays during this month at flows provided in the absence of the proposed action during low flow conditions (Table 4-14). However, flows provided under the proposed action for all flow conditions indicate that the fish passage criteria of 20 cfs for optimum adult passage through this reach is met in all months when adult salmon will be migrating (October through January). Reclamation believes that adequate adult migration conditions will be provided under the proposed action and no adverse affects will occur as a result.

Table 4-14. Emigrant Creek and Bear Creek flows during adult migration under the proposed action and for the without Reclamation flow condition (October – January). Blue shaded areas indicate where flows would be sufficient to provide fish passage through the reach.

Percent exceedance level		October	November	December	January
Bear (Phoenix Diversion to Jackson Street Diversion) (20 cfs passage threshold)					
Proposed Action	20% exc	48	81	206	374
	50% exc	36	51	110	109
	80% exc	29	40	41	64
Without Reclamation	20% exc	43	71	200	402
	50% exc	24	38	102	133
	80% exc	7	21	37	78

Adult Spawning and Incubation

Spawning/incubation habitat conditions resulting from proposed action flows, whether evaluated at the BCTO Hydromet gage (Figure 4-10a) or the MFDO Hydromet gage (Figure

4-11a) indicate that there is either no difference in spawning/incubation WUA or small to moderate benefits to spawning habitat relative to the without Reclamation scenario for median and high flow conditions. Spawning habitat would be slightly reduced in this reach by approximately 5 percent from the without Reclamation scenario for the low flow condition. For all flow conditions, the amount of incubation habitat increases over the amount of spawning habitat indicating that incubation habitat would be adequate to support any spawning activity that would occur.

Conditions for spawning and incubation in the Bear Creek area may improve slightly with the proposed action. In most years at most sites, there would be an increase in the amount of spawning habitat in November and December, with possibly modest increases in other months. Given that the benefits are expected to be quite small and, in most cases, conditions would be unchanged, no significant increases in the number of redds would be expected. Similarly, while incubation conditions may improve slightly, the expected changes with the proposed action are not likely to increase or decrease egg or alevin survival in any discernable way compared to the conditions that existed under the without Reclamation flow scenario.

Juvenile Rearing

Under all flow conditions, WUA generated by the proposed action would generally have no effect or would only show a very small benefit to summer juvenile rearing habitat relative to without Reclamation flow conditions (Figure 4-10b and Figure 4-11b). No difference in summer rearing habitat WUA was observed for the median flow condition at the BCTO gage. However, very small benefits were predominantly observed for the low and high flow conditions at this location. Amounts of summer rearing habitat WUA for the MFDO gage indicate no difference from the without Reclamation flow conditions to substantial benefits to summer rearing conditions for coho salmon under the low flow condition with no adverse affect occurring (Figure 4-11b). Very small adverse affects (5 percent habitat reductions) are indicated to summer rearing habitat for median flow conditions. Little biological effects to rearing coho salmon would be expected from summer increases or decreases in WUA in this reach as water temperatures in lower Bear Creek would make any projected increase in habitat availability or suitability questionable.

As indicated by WUA amounts at both the BCTO and MFDO Hydromet gages, no difference or only very small differences are predicted to occur to juvenile winter rearing habitat as a result of the proposed action. No moderate or even small juvenile salmon WUA benefits or detriments to juvenile winter rearing would occur in this reach as a result of the proposed action. The worst condition modeled amount to less than a 5 percent detriment to winter rearing habitat relative to without Reclamation habitat conditions. Potential winter habitat reductions of less than 5 percent from without Reclamation levels are not likely to adversely affect coho salmon individuals and would likely have either no affect or a very small effect on survival of the Bear Creek coho salmon population. These small effects constitute negligible differences between the without Reclamation condition and the proposed action management scenarios.

Bear Creek – Jackson Diversion to Bear Creek Mouth

Adult Migration

No fish passage impediments were noted to occur in this mainstem reach of Bear Creek nor were any fish passage threshold values reported during the instream flow study (Reclamation 2007). However, flows steadily increase from October through February in all reaches downstream of Emigrant Creek due to increases from tributary flows. These increasing flows tend to provide for adequate fish passage through mainstem reaches as well as allowing adult fish passage into tributaries to spawn. Because of the substantial number of tributaries and return flow inputs to the mainstem of Bear Creek upstream of this reach, streamflows during the adult migration period of October through January are not considered to be limited in any way. This is true even for the low flow condition. Access into Bear Creek is therefore not believed to be impeded and adults are not delayed due to inadequate flow conditions under the proposed action.

Adult Spawning and Incubation

The modeling results show that spawning and incubation habitat would have either no difference or show very small increases when all flow conditions are considered. Conditions for spawning and incubation therefore, in the lower Bear Creek area may improve slightly with the proposed action. In most years at most sites, there would be an increase in the amount of spawning habitat in November and December, with possibly modest increases in other months. Given that the benefits are expected to be quite small and, in most cases, conditions would be unchanged, no significant increases in the number of redds would be expected. Similarly, while incubation conditions may improve slightly, the expected changes with the proposed action are not likely to increase egg or alevin survival in any discernable way.

Juvenile Rearing

For all flow conditions considered winter rearing habitat WUA, effects follow a similar pattern to spawning and incubation impacts with either no differences relative to without Reclamation flow conditions of very small WUA increases. Either no difference or very small summer rearing habitat detriments are anticipated to occur for all flow conditions from implementation of the proposed action. However, this reach of Bear Creek has limited use as summer rearing coho salmon habitat due to high water temperatures and therefore the slight reduction predicted by the model has very limited biological meaning.

Past fish surveys found few juvenile coho salmon and steelhead rearing in mainstem Bear Creek. Most habitat conditions in mainstem Bear Creek, except for fall Chinook salmon, appear unfavorable for salmonids, and warm water temperatures are likely a significant major limiting factor for coho salmon and steelhead survival.

Effects of Ramping Rate Protocol on Coho Salmon

By adopting a formalized ramping rate for Emigrant Dam, discharges from the dam into Emigrant Creek would be decreased at a rate less than 50 percent which would mimic the natural hydrograph in many cases. Furthermore, ramping rate adjustments will also be closely monitored and reduced at greater rates when streamflows are below critical flow levels that have been identified for specific Bear Creek stream reaches. The gradual reduction of flows in the creek would decrease the occurrences of fish stranding that are common with sudden changes in releases. The ramping rate would increase the chances of survivability for juvenile coho salmon and have a positive effect on the population numbers. Even with the ramping rate protocol in place, the possibility that stranding of juveniles may occur cannot be totally eliminated. As a result, take may occur in Emigrant Creek when flows are reduced at the end of the irrigation season or following flood control releases. Given that Bear Creek appears to receive very limited use by coho salmon as based on smolt counts and snorkeling surveys discussed earlier, any stranding in Emigrant Creek would likely be minor, particularly with the ramping rate protocol in use. Rapid down ramping may strand small fish and other aquatic organisms in isolated pools.

Effects of Fish Passage Facility Improvement and Operation on Coho Salmon

Even though current and prospective facilities would meet the current passage and protection criteria, the possibility that take of outmigrants, in the form of harm, may occur when they encounter the diversion dams, fish screens and bypasses, and ladders cannot be discounted. This potential take at screen sites can involve injury due to encountering the screen and bypass structures, predation in screen forebays and at bypass outlets, and potential entrainment past the screens into the canal. While take is a possibility, it is expected that such take would be very limited. As NOAA Fisheries noted in the preamble to the final 4(d) rule governing take of 14 threatened salmon and steelhead ESUs, extensive biological evaluations have revealed little or no injury to fish if the screens are built and maintained to their criteria (65 FR 42422). Given that Bear Creek does not appear to harbor a large population of coho salmon and the screens in the basin have been built to meet required criteria, any take of outmigrating coho salmon would be very minor.

Juvenile fish passage at the Oak Street and Phoenix Canal diversion dams was modified in the late 1990s to meet NOAA Fisheries design and criteria. Most canals cross Bear Creek's fish-bearing tributaries by buried siphons or overhead flumes (Ashland, East, West, Talent, and Hopkins canals) and cause no fish passage delays. Although not a Federal irrigation facility, juvenile fish passage at the Jackson Street Diversion Dam (interrelated and interdependent facility) was modified in the late 1990s to meet NOAA Fisheries design and criteria standards. As a result, adverse affects from fish passage and screening structures in the Project is thought to be minimal and within acceptable levels for fish passage and screening facilities.

Construction and Restoration Project Effects on Coho Salmon in Bear Creek

Modifications to the ladder at Oak Street Diversion may impact juvenile rearing during construction of the proposed upgrades. As discussed in Chapter 2, construction of the cofferdam to isolate the work area from Bear Creek would create a small amount of turbidity that would be temporary and confined to the area close to the operation. The turbidity would be relative minor and last for only a short period as the cofferdams are installed and then removed. It is unlikely that SONCC coho salmon juvenile salmons would be present in the vicinity of the Oak Street Diversion during construction given the elevated stream temperatures present in this reach during the June 15 to September 15 in-water work period (Broderick 2000). It is also possible that coho salmon could become trapped in the isolated area behind the cofferdams. In the unlikely event that juveniles are trapped behind the berm, they would be salvaged immediately from the area and returned to the stream channel.

Similar impacts could occur if a fish passage facility and fish screen is constructed at the Ashland Creek Diversion dam. Cofferdams above and below the diversion dam would likely be needed to construct a passage facility and fish bypass. These facilities would likely be built in the summer construction window and could possibly affect rearing coho salmon. Sediment from the installation and removal of the cofferdams could affect downstream habitat quality, but BMPs would be employed to minimize those effects. Some riparian habitat would possibly be removed to gain access to the site, some permanently due to the footprint of the new facilities. This area would likely not amount to more than 100 to 200 lineal feet of riparian habitat, most of which could be reestablished once construction is done. As at Oak Street, any fish trapped behind the cofferdams would be safely salvaged and returned to the stream.

The installation of LWD structures in the Emigrant Creek reach below Emigrant Dam, Neil Creek, and in upper Bear Creek between Emigrant Creek downstream to the Phoenix Diversion would result in minor short-term construction-related impacts to rearing coho salmon. Suitable conditions for rearing coho salmon occur in these upper Bear Creek stream reaches so effects are likely to occur. A small amount of turbidity would be created in the immediate area where LWD pieces are placed, both instream and along streambanks where some structures may be anchored, for a short period of time during the in-water work period.

A small amount of riparian vegetation may be removed permanently to allow for access to some installation areas and during construction activities.

Additional consultation on construction-related impacts would take place before any of these construction projects proceeded.

4.5.2 Little Butte Creek Watershed

South Fork Little Butte Creek

Adult Migration

For the site on the South Fork Little Butte Creek, the adult passage criteria were met at a flow of 30 cfs according to the instream flow study that was conducted on channel constriction points as part of the IFIM/PHABSIM study conducted by Reclamation (Reclamation 2007). During the adult migration period, the median flow condition did not equal or exceed this value in the months of October and December when median flows were 18 to19 cfs at the gage near Gilkey (Table 4-15). However, it is noted that median flows under the without Reclamation scenario for median flow condition also indicates that flows were insufficient to provide adult fish passage in the absence of the Project as well. In fact, the proposed action flows provide very similar passage conditions during the months of October through January, and only result in reduced passage conditions at the high flow condition (Table 4-15).

As a result, while flow conditions during the adult migration period would improve from past flow conditions under the proposed action, during years when the instream flow target is provided in October through January, they would not reach the identified adult passage threshold as modeled in PHABSIM for the South Fork Little Butte Creek. Thus, the proposed action may adversely affect adult coho migrations in the South Fork Little Butte Creek under the proposed instream flow target for dry system states primarily because of shallow water depths and slow velocities for passage and spawning. However, at the time of year that adult fish are migrating the Project diverts very little from the South Fork Little Butte Creek either in the environmental baseline or under the proposed action; therefore, the passage conditions that currently exist for adult coho salmon under without Reclamation flow condition would be maintained in this stream with the proposed future operations in this stream reach.

Table 4-15. South Fork Little Butte Creek flows during the adult migration period under the proposed action and for the without Reclamation flow condition (October – January). Blue shaded areas indicate where flows would be sufficient to provide fish passage through the reach.

Percent exceedance level		October	November	December	January
South Fork Little Butte Creek Mouth (30 cfs passage threshold)					
Proposed Action	20% exc	24	26	67	82
	50% exc	18	19	31	44
	80% exc	15	15	20	26
Without Reclamation	20% exc	25	32	84	145
	50% exc	21	26	38	61
	80% exc	17	20	22	35

Although, it appears that instream flows provided under the the proposed action will not provide adequate migration conditions for adult coho salmon to pass through the South Fork Little Butte Creek reach, Reclamation will improve passage conditions at channel restriction points through the placement of LWD structural elements. These structures can be used to narrow and deepen the channel, thereby improving micro-habitat conditions such as water depth and velocity to provide more favorable conditions for adult fish migration. Placement of LWD structures can therefore be used to effectively remove or reduce hydraulic constrictions that limit fish passage. LWD complexity improvements at such locations can increase both winter rearing habitat conditions as well as improving adult passage by confining and deepening the channel at hydraulic constriction points. The instream restoration component of the proposed action will focus on such areas to improve passage conditions to acceptable levels at flow rates provided under the proposed action.

Reclamation concludes the proposed action would not change adult migration in Little Butte Creek watershed. Despite some periods, primarily October and November in all flow conditions, and in all months for the dry system state, when desired flows for migration are not met, Reclamation concludes that these are times when little water is diverted by the Project and therefore not caused by the proposed action. Although, channel constrictions and flow rates will be provided to aid in adult coho migration conditions in the South Fork Little Butte Creek reach, the proposed action will likely have adverse affects to this life history stage of coho salmon.

Adult Spawning and Incubation

Changes in available spawning and incubation habitat are predicted to be small to moderate under both low and median flow conditions, particularly between the months of November through February when modeled WUA will be reduced by 5 to 10 percent compared to the without Reclamation condition. The proposed action will increase WUA for spawning and incubation habitat in this reach in March through May for the median and low flow conditions, and in January through May for high flow conditions. The changes in available incubation habitat in March through May, however, are likely to be biologically meaningless because available habitat in those months would exceed the habitat available during spawning. Thus, under low and median flow conditions the proposed action would likely have a small negative effect on spawning and incubation habitat within this stream reach due to the 5 to 10 percent reduction in WUA relative to the without Reclamation condition. These results suggest that spawning habitat would be moderately reduced under the proposed action. Reclamation's proposed action is designed to have no more than a 10 percent reduction in pre-project WUA habitat areas for all life stages if at all possible. Comparison of spawning and incubation WUA habitat to the without Reclamation scenario indicates that for all flow conditions analyzed the proposed action would likely have a very small adverse affect to the amount of spawning habitat in this important reach. This habitat effect would appear to have an adverse effect on the spawning success of coho salmon under the low flow condition. However, these reductions may not be biologically meaningful because there would likely remain sufficient spawning habitat areas to allow for a significant amount of spawning to occur if the proposed action is implemented. Reclamation documented that even with implementation of the proposed action and spawning habitat detriments of between 5 and 10 percent from without Reclamation conditions that more spawning habitat will be available then the subsequent rearing habitats can sustain (Appendix B). Therefore, spawning habitat was found to not be limiting the coho salmon population in this reach.

Coho salmon spawning/incubation WUA is generally in the range of 80 to 100 percent of optimum and often exceeds 90 percent of the optimum value in the environmental baseline and with the proposed action. It is generally at its lowest level early in the spawning period when little, if any, flow is being diverted from South Fork Little Butte Creek. Under the proposed action, few diversions for the Project, if any, would continue to occur early in the spawning period when WUA for salmon spawning/incubation is at its lowest under the proposed action flows and under the without Reclamation flow conditions. Under the proposed action, habitat conditions for spawning and incubation in this area would be maintained at similar levels to pre-project conditions. Very few biological effects to spawning and incubation habitat areas are therefore anticipated to occur as a result of the proposed action.

Juvenile Rearing

Under median flow conditions, the proposed action would have small adverse effects on summer juvenile rearing habitat in the South Fork Little Butte Creek near Gilkey (Figure 4-13b). Juvenile rearing habitat would be decreased by approximately 10 percent from without Reclamation WUA habitat conditions in May and June for the low and median flow conditions, and would be reduced by approximately 15 percent in the month of May for the high flow condition. Small proposed action effects are anticipated to occur to coho salmon summer rearing habitat due to the small amount of Project water diversion that may occur during the months of May and June. Small to moderate reductions in summer rearing habitat would occur during these months because of diversion operations at the South Fork Little Butte Creek and Dead Indian Creek Collection Canal facilities. In general, instream flows will reduce summer rearing habitat during these months to 70 to 85 percent of without Reclamation WUA levels when they occur. As a result, the instream flow proposed action under both the median and low flow water year conditions will have a moderate to substantial adverse affect to summer rearing habitat conditions in this reach of the Project.

PHABSIM results discussed in Section 4.4.2 demonstrate that juvenile salmon rearing habitat in the South Fork of Little Butte Creek reaches its lowest level during the summer months when the stream is at its base flow. During the summer periods, Project diversions from the South Fork have been very low to non-existent and are expected to remain very low to non-existent in the future. As a result, they will not contribute to further declines in WUA conditions during such periods. Because there are no Project diversion operations occurring during the late summer months from July through October, there is no proposed action occurring to affect habitat in this reach during these months. Reclamation and the Districts will not be operating during July through October and streamflows in the creek will be from natural flows only. If streamflows fall below the instream flows during months when no operations are occurring, any adverse effects to coho salmon will result from low natural flows and will not be the result of the proposed action.

The amount of WUA reduction as a result of the proposed action compared to the without Reclamation flow condition would be about a 5 to 10 percent reduction for the low flow condition to 5 to 15 percent habitat detriment to the median and high flow conditions. In general, habitat reductions under the proposed action will be limited to less than 10 percent of without Reclamation WUA conditions most of the time. The proposed restoration actions that are included as part of the proposed action will be designed to increase the amount of WUA to levels that are less than 10 percent reductions from pre-project habitat levels for summer and winter rearing habitat. As a result, the reduction in winter rearing habitat based on these proposed flows are considered to be small rather than moderate detriments. These reductions in juvenile winter rearing habitat quantity and quality are small to moderate and would likely have a small to moderate adverse effect on SONCC coho salmon survival and recovery within the action area.

Based on this analysis, the proposed action may affect, and is likely to adversely affect fry and both summer and winter juvenile rearing conditions for coho salmon in the South Fork Little Butte Creek. However, LWD restoration components of the proposed action will be implemented in this reach which will decrease adverse affects to summer and winter rearing habitat to less than 10 percent of pre-project levels. A small adverse affect is therefore likely to occur in this reach as a result of the proposed action.

Little Butte Creek – South Fork Little Butte Creek to Little Butte Creek at Lakecreek

Adult Migration

Under present habitat conditions, Little Butte Creek provides an important seasonal migration corridor for upstream and downstream migrating salmon and steelhead. Similar to other stream reaches analyzed for this BA, a fish passage analysis was done for Little Butte Creek (Reclamation 2007). At a site near the mouth of Little Butte Creek, the adult passage criteria were met at 16 cfs. At a site near Brownsboro, the criteria were not met until flows reached 40 cfs (Table 4-16). The median flow condition in Little Butte Creek near Lake Creek, in both the environmental baseline and under the proposed action, exceed both of these values for the adult migration period from October through January. The lowest median monthly flow is 33 cfs which occurs in October when few Project diversions upstream on the South Fork Little Butte Creek are being made under the proposed action; therefore, the proposed action would not change adult migration in the Little Butte Creek drainage. Given that the Little Butte Creek drainage currently supports some of the best remaining coho salmon production in the basin under conditions found in the environmental baseline, this result was not unexpected.

Table 4-16. Little Butte Creek near Brownsboro adult coho salmon passage analysis during the adult migration period under the proposed action and for the without Reclamation flow condition (October – January). Blue shaded areas indicate where flows would be sufficient to provide fish passage through the reach.

Percent exceedance level		October	November	December	January
Little Butte Creek near Brownsboro (40 cfs passage threshold)					
Proposed Action	20% exc	70	100	271	403
	50% exc	48	73	122	164
	80% exc	33	59	75	92
Without Reclamation	20% exc	72	110	290	486
	50% exc	48	79	129	177
	80% exc	35	65	75	103

Adult Spawning and Incubation

Changes in available spawning and incubation habitat are very small for the median and low flow conditions from November through January, with small to moderate benefits to habitat occurring from February through May for these flow conditions. Substantial benefits to spawning and incubation habitat are provided by the proposed action when the high flow condition is considered (Figure 4-14a), with habitat benefits of 15 to 20 percent over the without Reclamation scenario. Spawning and incubation habitats would be increased by anywhere from 8 percent in February to 12 percent in April and May for the median and low flow proposed action conditions. These results suggest that spawning habitat in this stream reach would be either unaffected or increased to varying degrees under all flow conditions in the proposed action. This habitat effect would likely have a slight, but likely very small beneficial effect on the Little Butte Creek SONCC coho salmon spawning and incubation success.

Juvenile Rearing

Moderate to small decreases in summer rearing habitat are identified for all flow conditions analyzed, particularly during the months of May through July in this reach of Little Butte Creek. Habitat detriments range from 5 to 15 percent compared to the without Reclamation flow scenario as a result of flows provided under the proposed action. Similar to the South Fork Little Butte Creek reach described above, streamflows during the late summer months improves to about 100 percent of without Reclamation WUA due to the reduction in diversions from the upper basin. As a result, very little habitat change to summer rearing habitat occurs under the proposed action after the month of July. Some very small adverse affects are caused by slight reductions in summer rearing habitat for the high flow condition (Figure 4-14b) but those impacts are limited to no more than a 5 percent reduction from pre-project habitat levels. Little biological benefit to rearing coho salmon would be expected from summer increases in WUA in this reach as water temperatures in the mainstem of Little Butte Creek would make any projected increase in habitat availability or suitability questionable.

Small to very small reductions (1 to 5 percent habitat detriment) in winter rearing habitat occur in all flow years modeled, with habitats remaining unchanged in the early winter rearing period (November and December). Small reduction in winter rearing habitat is reasonably likely to result in slightly reduced winter survival of juvenile SONCC coho salmon. Because winter rearing habitat is often population limiting, the slight reductions in winter rearing habitat likely have a stronger population effect than the similar increases in summer rearing habitat. Thus, the proposed action would likely slightly decrease juvenile rearing habitat and would slightly adversely affect the winter survival of juvenile SONCC coho salmon from the Little Butte Creek subpopulation under median flow conditions. However, these reductions in juvenile rearing habitat quantity and quality would mostly be small to negligible and would be well under the levels that were found to be acceptable for long-term population survival and recovery (NOAA Fisheries 2011a).

Little Butte Creek – Little Butte Creek at Lakecreek to Little Butte Creek Mouth

Adult Migration

No fish passage impediments were noted to occur in this mainstem reach of Little Butte Creek nor were any fish passage threshold values reported during the instream flow study conducted by Reclamation using the IFIM habitat transects for the PHABSIM model (Reclamation 2007). However, flows steadily increase from October through February in all reaches downstream of the South Fork Little Butte Creek due to increases from tributary flows in this watershed. These increasing flows tend to provide for adequate fish passage through mainstem reaches as well as allowing adult fish passage into tributaries to spawn. Because of the substantial number of tributaries that flow into the mainstem of Little Butte Creek upstream of this reach, streamflows during the adult migration period of October through January are not considered to be limited in any way. This is true even for low flow conditions. Adult fish access into Little Butte Creek from the Rogue River is therefore not impeded, and adults are not delayed due to flow conditions under the proposed action.

Adult Spawning and Incubation

Spawning habitat would be affected very little for the high flow condition (Figure 4-15a), but would see moderate to small benefits during median and low flow conditions relative to the without Reclamation scenario in the lowest reach of the Little Butte Creek watershed. This is particularly the case for median and low flow conditions in the months of March and April when WUA under the proposed action are increased by 10 to 15 percent. Incubation habitat are likely to increase as a result of flows under the proposed action. However, incubation habitat changes are not biologically meaningful due to their exceedance of the available spawning habitat in most years.

Juvenile Rearing

Summer rearing habitat during all flow conditions would be virtually unaffected by implementation of the proposed action in this reach of Little Butte Creek. Juvenile rearing habitat would be increased by varying degrees between May and October. Under low flow conditions (depicted here as the monthly 80 percent exceedance flows), the proposed action would generally have small to very small effects on juvenile rearing habitat (Figure 4-15b). From June through September, flows for juvenile summer habitat would be unaffected by the proposed action. Little biological benefit to rearing coho salmon would be expected from summer increases in WUA in this reach as water temperatures in the lower reaches of Little

Butte Creek would make any projected increase in habitat availability or suitability questionable.

Small to very small reductions (1 to 5 percent habitat detriment) in winter rearing habitat occur in all flow years modeled, with habitats remaining unchanged in the early winter rearing period (November and December). Due to reductions in winter rearing habitat under median flow conditions, the proposed action would slightly reduce survival of SONCC coho salmon in this reach of Little Butte Creek. Some moderate reductions in winter habitat conditions were modeled under the low flow condition which occurred in January and April. The small to moderate reduction in winter rearing habitat is reasonably likely to result in slightly reduced winter survival of juvenile SONCC coho salmon during these months. Because winter rearing habitat is often population limiting, the slight reductions in winter rearing habitat likely have a stronger population effect than the similar increases in summer rearing habitat. Thus, the proposed action would likely slightly decrease juvenile rearing habitat and would slightly adversely affect the winter survival of juvenile SONCC coho salmon from the Little Butte Creek subpopulation under median flow conditions. However, these reductions in juvenile rearing habitat quantity and quality would be mostly small to negligible.

While there is no empirical data concerning flow/survival relationships for this system, Little Butte Creek drainage currently supports some of the best remaining coho salmon production in the basin and these conditions appear conducive to their survival. Little Butte Creek flows at its mouth would remain unchanged from the current conditions under the proposed action. Based on this analysis, the proposed action may affect, and is not likely to adversely affect juvenile rearing conditions for this life stage of SONCC coho salmon in the Little Butte Creek mainstem.

Antelope Creek

Very little is known about coho salmon use of Antelope Creek, although coho salmon are able to use the lower 6.3 miles of Antelope Creek (Ritchey 2001). Flow conditions for adult coho salmon migration and spawning are provided during November through March, however these are probably of short duration and may affect opportunistic spawner migration in stream reaches downstream from the diversion. This is likely to adversely affect coho salmon migration and spawning. Diversions during high flows impact adult migrants trying to reach spawning grounds and minimum flows are not likely sufficient to provide adequate instream fish passage into this tributary. Despite, the lack of good passage conditions at times, coho salmon spawning/incubation WUA fluctuates considerably (Figure 5-36 in Reclamation 2009b) and often indicates good conditions for spawning and incubation. This is due to the flashy nature of the stream rather than Project operations. Operations that result in low monthly flows during the winter and spring months may therefore have an adverse impact on spawning and incubation for coho salmon in Antelope Creek.

4.5.3 Klamath River Watershed

Adult Migration

Under the proposed action, flow diversion from the Jenny Creek basin would occur throughout the year, but mostly in the late winter and early spring which is outside of the adult coho salmon migration period. During the adult migration period, diversions under the proposed action would generally be less than 1 percent of the Klamath River flow at Iron Gate Dam, the upstream limit of fish passage. As a result, adult coho salmon passage would not be appreciably affected by the proposed future operations of the Project.

Spawning and Incubation

Effects to coho salmon spawning and incubation in the Klamath River would be confined to the mainstem below Iron Gate Dam which blocks further upstream passage. Coho salmon spawning in the mainstem appears to be limited, but it is known to occur (Reclamation 2007). NOAA Fisheries (2002) concluded that coho salmon are primarily tributary spawners in the Klamath River basin and that mainstem spawning and rearing habitat is likely not limiting at the current population size.

Coho salmon spawning in the Klamath River basin typically occurs during December and January (60 FR 38011). During that time period, 20 to 40 cfs, or about 1 to 2 percent of the Klamath River flows at Iron Gate Dam, are being diverted and stored from the Jenny Creek drainage. Under the proposed action, these flow conditions would not change. Reclamation (2007) has committed to maintaining the long-term minimum flows for releases from Iron Gate Dam during the October through February period as part of the RPA recommended by NOAA Fisheries in its 2002 BiOp concerning the operations of the Klamath Project. The proposed action for the Project would not alter those flow releases and generally would have little or no effect on the limited spawning that occurs in the mainstem of the Klamath River.

Juvenile Rearing and Migration

During the period of 1961 to 2001, the average June diversion from the Jenny Creek drainage to the Rogue River basin was 12 cfs. For the months of July, August, and September during the same time period, the average monthly diversions were 6 cfs, 4 cfs, and 4 cfs respectively (Reclamation 2003). In terms of the flows in the Klamath River at Iron Gate Dam, these diversions amount to a 0.1 percent or less reduction. Consequently, these diversions do not affect rearing conditions in the Klamath below Iron Gate Dam in any way that can be meaningfully evaluated. They would make little or no contribution to the warm water temperature issues on the Klamath River which periodically reach lethal levels for coho salmon and would have little or no effect on the physical availability of habitat (Reclamation 2007. Under the proposed action, no additional impacts to the environmental baseline would occur and there would be no new or additional effects (either positive or negative) to the current status of the species relative to juvenile salmon rearing in the Klamath River.

Juvenile coho salmon outmigration occurs from March through June on the Klamath River (Reclamation 2007). Flow diversions from the Jenny Creek basin are at their peak in March and April. For the period from 1961 to 2001, March diversions average about 100 cfs and April diversions average about 120 cfs, with diversions in May averaging just over 40 cfs and about 12 cfs in June. These diversion levels would remain unchanged in the proposed future operation of the Project. Klamath River flows are generally rising and at their peak during the March, April, and May time period. During these months, the diversions in the Jenny Creek basin would have minor effects on the Klamath River flows at Iron Gate Dam because they generally average less than 5 percent of the total discharge. Given that diversions from the Jenny Creek basin are minor relative to the overall Klamath River flows during smolt migration, it is not likely that they significantly affect outmigrant survival on the Klamath River.

4.5.4 Effects to the Species Summary

Reclamation evaluated coho salmon production potential and described the various physical habitats that could be limiting coho salmon production by life stage in both Emigrant and South Fork Little Butte creeks under a range of environmental conditions (Appendix B). This analysis evaluated all habitat types required by coho salmon within the action area starting with spawning habitat, then summer rearing habitat, then winter rearing habitat. These habitat areas were analyzed separately and sequentially to determine production potential by life stage given expected levels of available habitat under both the proposed action and without Reclamation flow scenarios. Finally, production potential over all life history stages was compared and assessed together to determine which factor is likely to be most limiting to coho salmon production in these Rogue River basin stream systems under varying flow conditions.

Despite the reduced amounts of spawning and incubation WUA that result from implementation of the proposed action relative to the without Reclamation flow scenario, given the large amount of usable spawning and incubation habitat that is currently available and which will continue to be available in both the Emigrant and South Fork Little Butte Creek stream reaches, it is Reclamation's conclusion that sufficient levels of spawning and incubation habitat will continue to be provided to allow for successful spawning and incubation in Project affected streams and to allow for an adequate potential for recovery of SONCC coho salmon. Implementation of the proposed action flows will likely provide more than enough spawning and incubation habitat to support the current population levels as well as the habitat needed for the expansion of the Emigrant, upper Bear and South Fork Little Butte creeks coho populations to recovery levels. Currently, spawning and incubation habitat availability does not appear to limit coho salmon abundance in the Project area and the proposed action flows are capable of supporting a large and viable coho population. Because of the abundance of available spawning habitat in Project affected stream reaches under the proposed action, there exists enough spawning habitat to fully seed these stream reaches with summer fry and parr.

Under the proposed action, the amount of summer habitat available is increased relative to the without Reclamation scenario, and as a result, both smolts and adult production potentials are anticipated to be higher than they would be under the without Reclamation flow scenario when summer rearing habitat is looked at in isolation. Summer rearing habitat availability and the optimal number of female spawners needed to fully seed that available habitat increases under the proposed action relative to the without Reclamation flow scenario in the Emigrant Creek stream reach. This results from more summer rearing habitat being provided during the irrigation season due to increased water releases from Emigrant Dam. For the South Fork Little Butte Creek stream reach, available summer habitat is slightly reduced with implementation of the proposed action flow regime relative to the without Reclamation scenario. As a result, the production potential for both coho salmon smolts and adults are also commensurately reduced by a small amount.

In the case of the two uppermost stream reaches analyzed by Reclamation, the proposed action provides for either increased production potential in Emigrant Creek compared to the without Reclamation flow scenario, or for approximately equal production potential in the case of the South Fork Little Butte Creek stream reach, because summer flow operations in Emigrant Creek provide more flow and support more suitable summer habitat conditions than would be provided under the without Reclamation flow scenario (Appendix B). For the South Fork Little Butte Creek stream reach, summer production potential estimates for smolts and adults are equal to those for the without Reclamation flow scenario since little or no Project operations occur during the summer months in South Fork Little Butte Creek irrigation system facilities.

Smolt and adult coho salmon production estimates derived from winter rearing habitat analysis under all three flow conditions were substantially lower than those calculated based on either the amount of spawning habitat available or summer rearing habitat available (see Appendix B). This indicates that winter rearing habitat is most likely to be the ultimate limiting factor to coho production in the two Rogue River basin stream reaches analyzed. This conclusion is based on the assumption that the life stage that results in the lowest potential smolt yield is the critical life stage and the amount and type of habitat needed by that life stage is the limiting habitat. Because winter habitat area is the ultimate limiting factor to coho salmon production potential, increases in this limiting habitat variable will eventually be needed to allow for increased production potential in both stream reaches analyzed. Increasing the amount of available winter rearing habitat will relieve the population bottleneck created by this most restricting habitat variable to coho production. Although winter rearing habitat is estimated as being the ultimate factor limiting coho production, it is important to note that this habitat will only be the limiting factor at full seeding levels in these creeks.

Sufficient amounts of available and useable habitat for spawning, summer rearing, and winter rearing will exist under the proposed action to support coho salmon in both the Emigrant Creek and South Fork Little Butte Creek systems at greater abundance levels than are currently observed in these stream systems. In summary, sufficient spawning habitat is currently available to support enough adult coho spawners to fully seed available summer rearing habitat found in these two important Rogue River basin stream systems. Similarly, sufficient summer rearing habitat exists under the without and proposed action flow scenarios to provide sufficient summer parr survival and production to fully seed available winter rearing habitat in both stream reaches analyzed. Finally, the amount of winter rearing habitat available was found to be the ultimate limiting factor for both the without Reclamation flow scenario as well as under the proposed action.

Winter habitat appears to be the limiting factor to coho production at higher spawner abundance levels. However, winter rearing habitat will not limit the population until returning adult coho salmon spawner abundance levels produce enough offspring to fully seed available winter habitat that is presently available and is not currently being used at its full potential. Current adult production levels, especially in the Emigrant/Bear Creek system are insufficient to fully seed the available summer or winter rearing habitat. As a result, winter rearing habitat is not currently limiting the population and is not acting as a bottleneck to population productivity at this time. Winter rearing habitat may become limiting, but only at significantly higher adult spawner abundance levels than are currently observed. Until higher spawner abundance levels are achieved, the limiting factor to coho salmon production will remain adult spawner abundance.

The SONCC ESU Technical Review Team that was convened by NOAA Fisheries to establish recovery criteria for the Oregon and Northern California Coast Recovery Domain observed that coho production in the URR production area was currently at approximately 9.2 to 9.8 spawners/Intrinsic Potential km (IP km). The Technical Review Team further concluded that approximately 20 spawners/IP km was required for the URR coho population to meet the low risk of extinction threshold necessary to survive and recover (Williams et al 2006; Williams et al. 2008).

Reclamation concludes from the smolt and adult production potential estimates for the proposed action (Appendix B) that there is sufficient spawning/incubation, summer rearing, and winter rearing habitat available under the proposed action to support both the current URR estimate of 9.2 spawners per Intrinsic Potential (IP) km and expansion to the 20 spawners per IP km spawner density goal recommended by the SONCC coho salmon Technical Review Team to achieve a low risk threshold necessary for SONCC coho salmon to survive and recover (Williams et al. 2008). The adult production potential estimates produced from Reclamation's limiting factors assessment for Emigrant Creek and upper Bear Creek (Appendix B) indicate that there is sufficient habitat under all flow scenarios modeled to meet the Technical Review Team recovery target for spawner density of 20 spawners/IP km. For the South Fork Little Butte Creek stream reach there appears to be a sufficient amount of habitat to support the current URR spawning density of 9.2 fish/IP km and allow for increases in spawning density under the proposed action. It is unlikely, however, that adult production will meet the 20 spawners/IP km recovery goal for the Little Butte Creek system as a maximum spawner density of only 15.5 adults/IP km could be met over the long term. Even using available habitat under the without Reclamation flow scenario, there appears to be an insufficient amount of habitat to allow for establishment of recovery target spawning densities identified by Williams et al. (2008) in the South Fork Little Butte Creek stream reach.

The fact that the production potential estimates from Reclamation's limiting factors analysis (Appendix B) do not agree with observed numbers in Emigrant Creek indicate that other factors in the lower basin are preventing the full production potential from occurring in the upper reaches of Bear and Emigrant creeks.

Although spawning numbers are not accurately tracked or well documented in this reach it is clear that adult or juvenile coho salmon are not using the habitat areas that are currently available. Presently, abundance of SONCC coho is depressed in the Bear Creek watershed. Smolt trapping surveys have demonstrated few coho salmon are surviving in the watershed and adult carcass and redd surveys have been discontinued due to low spawner abundance in Bear Creek. Other important factors such as warm water temperatures in the summer will likely displace young coho salmon downstream for rearing and may preclude successful summer rearing in most reaches. Based on some limited information that indicates high summertime water temperatures, we suspect that actual production in this reach would be lower. For example, high water temperatures that are sufficiently elevated in the lower Bear Creek watershed to have high mortality for coho juveniles are known to occur. Several authors have noted the presence of high water temperatures as being the ultimate limiting factor to coho production in Bear Creek (Bredikin et al. 2006; RVCOG 2001; Reclamation 2009b; Williams et al. 2006). Most recently, Nickelson (2008) performed a smolt capacity estimate for many streams within the Oregon portion of the SONCC ESU, including Bear Creek, and concluded that despite the presence of available habitat in this stream system that coho production levels were ultimately limited by high water temperatures. Nickelson (2008) recommended that water temperatures be reduced in such watersheds before other habitat restoration actions are pursued due to the limitations to production that water temperatures present. This recommendation is consistent with other authors who evaluate both physical and biological habitat limiting factors and present methods for identification of limiting factors (Reeves et al. 1989).

Reclamation's Rogue Project was completed between 1958 and 1962, and as described above, affects the URR habitat in Little Butte Creek and Bear Creek watersheds. In summer, the project cools ambient water temperatures in lower Emigrant Creek and upper Bear Creek through delivery of stored reservoir water (Appendix G). However, no relationship was found between flow levels in Bear Creek and water temperatures below Oak Street Diversion dam suggesting that thermal loading occurring downstream of the reservoir negates any benefits provided by the cool water inputs and supplemental flows provided by the Reclamation project (Appendix G). ODEQ (2007) found that thermal loading in Bear Creek watershed is driven primarily by solar inputs. The water temperature data collected on project affected stream reaches suggest that maximum summertime water temperatures sometimes exceed the preferred range for rearing coho salmon, but did not approach the lethal temperature. This warm water flowing downstream contributes to increased river water temperature. A few locations of groundwater upwelling have been identified, but the flow from these, even though they may have a localized cooling effect on the river, is apparently insufficient to offset the larger effect of warm water from the lower reaches of Bear and Little Butte creeks. In winter, Reclamation's project primarily reduces streamflow along Emigrant Creek (GeoEngineers 2008b), which comprises about 3 percent of streams accessible to coho salmon (Nickelson 2008). Water storage in Emigrant reservoir in winter also reduces the magnitude of high flow events in Emigrant and Bear creeks (GeoEngineers 2008b).

Reclamation's proposed action will involve habitat restoration actions to increase the amount of winter rearing habitat to support improved adult spawner abundances over time. Instream restoration actions involving placement of large wood structural components will be targeted at increasing the amount and quality of winter rearing habitat. If winter rearing habitat is limiting, the increased amount of habitat created by these instream structures will sequentially remove the production bottlenecks caused by limitations in this most limiting habitat element. However, as mentioned previously, these habitat restoration actions will not increase production until adult abundance in these reaches increase to the point that available rearing habitat becomes limiting.

As noted earlier, the proposed action will continue to reduce flows slightly in the Klamath River below Iron Gate Dam and will have associated minor effects on the availability of fry habitat, and negligible effects on adult migration and spawning habitat. Associated effects to the species will remain at low levels.

4.6 Effects Determination

In general, an evaluation of WUA conditions that would result from implementation of the proposed action relative to WUAs that would be anticipated to occur under the without Reclamation flow scenario indicates that the proposed action would have small (5 percent habitat detriment) to substantial (greater than 20 percent habitat detriment) adverse affects to the spawning/incubation and winter rearing life history stages of coho salmon in many of the stream reaches analyzed. Adverse affects to SONCC coho salmon spawning/incubation and winter rearing were primarily observed in the Emigrant Creek and upper Bear Creek reaches in the Bear Creek watershed and in the South Fork Little Butte Creek reach of the Little Butte Creek watershed. Adverse affects to these habitat areas and their associated affects to coho life stages decreased in the downstream direction as flow impacts from Project operations were moderated with increasing distance from Emigrant Dam in the Bear Creek watershed or from the South Fork Little Butte Creek diversion canals in the Little Butte Creek watershed. Only small effects (both positive and negative) were observed in the lower reaches of both watersheds to spawning/incubation and winter rearing critical habitat areas.

Conversely, the proposed action was found to have either minor affects or would result in improved conditions when compared against without Reclamation flow conditions for summer rearing coho salmon through much of the Bear and Little Butte Creek stream reaches analyzed. These results were observed due to no Project water diversions occurring in the Little Butte Creek watershed, or as increased water delivery from Emigrant Dam in the Bear Creek watershed increased summer rearing WUAs relative to without Reclamation conditions in the summer period.

Despite the fact that proposed action flows frequently result in moderate to substantial adverse affects to spawning/incubation and winter rearing habitat WUA as indicated by the PHABSIM model, the overall proposed action affects are limited to only small adverse affects (less than 10 percent habitat reductions from without Reclamation WUA levels) due to the incorporation of both instream flows and an instream habitat restoration component (LWD placement and riparian zone management actions) that were designed to create habitat conditions that were equal to or greater than 90 percent of critical habitat that would have existed in the absence of the Project.

Improvements would be made in Bear Creek and Emigrant Creek through modifying passage impediments and continuing to implement instream flows to support coho salmon habitat through the summer and winter months at levels that are protective of habitat and the species. The instream flow releases in Emigrant Creek would ensure that the creek is not dry in the summer and winter and that sufficient habitat will exist to positively affect spawning and rearing habitat availability. Reclamation’s proposed action restricts adverse affects to winter rearing habitat to less than 10 percent reductions from habitat available under the without Reclamation flow condition which is considered sufficient to only have small adverse affects to the species and which will continue to allow for coho salmon survival and recovery in the Bear and Little Butte Creek watersheds. The availability of coho salmon habitat for the spawning/incubation, summer rearing, and winter rearing life history stages in these watersheds is in suitable amounts and conditions to provide for the production of juvenile and adult coho and will remain in good condition with implementation of the proposed action to support SONCC coho salmon populations in these basins.

Improvements of fish passage facilities at the Oak Street and Ashland Creek diversion dams would provide better passage to habitat area that had previously been blocked or impeded passage conditions in Bear Creek, Ashland Creek, and Emigrant Creek. The formalized ramping rates would also decrease the probability of stranding fish when releases from Emigrant Dam are curtailed and as water diversions are taken from Bear Creek at the Oak Street and Phoenix Diversion dams. There would likely be short-term effects that would occur during construction of the new passage facilities and during the installation of instream habitat restoration components; however, these effects would be offset by the long-term benefits gained from these components of the proposed action.

Take of coho salmon may occur at the Project diversions on Bear Creek and Ashland Creek. However, site specific information about possible take is not available at the sites so case-by-case assessment cannot be done. Any take that may occur is expected to be minor as the sites are or would be screened to meet criteria for fish protection. While the use of the ramping rate protocol to govern some operations of Emigrant Reservoir and Project water diversions at diversion dams is expected to improve conditions for coho salmon, some minor take is possible as coho salmon may be stranded to some degree during reservoir shutdown or as a result of diversions under the proposed action.

Take is defined under the ESA as an adverse affect. Reclamation has determined that the proposed action may affect, and is likely to adversely affect (MA/LAA), the SONCC coho salmon ESU. The possibility of minor amounts of take at properly screened diversions cannot be ruled out completely. Potential stranding may occur associated with the fall shutdown of Emigrant Reservoir resulting in a potential take. Short-term construction effects may also occur, but these would be temporary in duration and limited in geographic extent. Construction activities would be scheduled to occur during the ODFW-established in-water work period to avoid and minimize effects. Best management practices, potential conservation actions, methods, materials, and timing are all designed to reduce or eliminate adverse effects to anadromous fish and habitat during construction activities associated with installation of LWD structures and fish passage facility upgrades; however, incidental take of individual fish may still occur. Anticipated levels of take are not expected to severely impact the overall survival and recovery of SONCC coho as a result of the proposed action.

Chapter 5 CUMULATIVE EFFECTS

This chapter describes the cumulative effects for the SONCC coho salmon ESU and their designated critical habitat in the collective action area for the proposed action. ESA regulations define cumulative effects as "those effects of future Tribal, State, or private activities, not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation" (50 CFR 402.02). Listed below are a few activities that may be reasonably certain to occur as a result of Tribal, State or private actions within the Federal action area. Future Federal actions will be reviewed through separate section 7 consultation processes. Although effects resulting from some of these actions cannot be directly quantified, a qualitative description of the likely effects to listed species resulting from the actions is provided.

5.1 Water Conservation Efforts

As previously outlined in Appendix F, there are numerous ongoing conservation efforts in the Rogue River basin. These include many small projects being investigated by the Project and non-Project irrigation entities as well as larger efforts, such as the WISE Project, which involve multiple stakeholders. The identified projects are in various states of development, but the majority of them cannot yet be classified as reasonable certain to occur. Many are in the planning stage and most lack sufficient funds or have no funds for implementation. For example, the WISE project is in the feasibility study stage so the actual elements of a potential final project are unknown at this time; consequently, detailed analysis of the potential effects cannot be done. However, substantial progress has been made in advancing the WISE Project as it is now sponsored by Oregon Solutions, a private fundraising and lobbying organization with ties to the Oregon Governor's Salmon Recovery Office. The hightened awareness of water resource management in the Rogue River basin will likely intensify water conservation efforts that are designed to benefit both irrigated agriculture and aquatic ecosystem management in the basin.

The goal of many of these water conservation efforts is to make more efficient use of existing water supplies. From a cumulative impacts standpoint, these projects individually and collectively should improve streamflows in area streams and improving habitat conditions for coho salmon. The improvements in streamflows would likely be reach specific, occurring in the stream reaches affected by irrigation diversions and return flows. Based on the projects identified to date, this would include reaches of Bear Creek as well as some of its tributaries.

The improvements would also generally occur during the irrigation season as demands and subsequent diversion requirements are reduced. Potential improvements may occur during the non-irrigation season to the extent the conservation efforts offset the need for stored water so that the need for off-season refill is reduced. Water conservation measures, retirement of select diversions, and overall system improvements have continued to be made by irrigation districts to improve the efficiency of water use from the Project and to help alleviate negative pressures on fisheries resources. These efforts will continue as opportunities and funding sources are identified.

5.2 Fish Passage Improvements

Currently efforts are underway to improve fish passage in the basin. As discussed in Section 3.3, RBFATT has inventoried fish passage impediments and various parties have undertaken efforts to remove or provide passage at those impediments. This activity is expected to occur in the future as well. The purpose of these actions is to improve fish passage including passage for coho salmon. As such, these efforts would complement the proposed action which includes passage improvements at the Oak Street and Ashland Creek diversions.

While in most cases the final designs for these future improvements are not completed, most would likely involve some minor instream work. This would result in temporary impacts during the construction similar to the potential impacts discussed in Section 4.4.1 in reference to the improvements at the Oak Street and Ashland Creek diversions. These impacts would be of short duration during the project construction, but cumulatively they are not expected to be significant. The most significant impact from the activity would be an overall improvement in fish passage conditions in the basin.

Recently, three major dams that impeded fish passage on the Rogue River were removed: Gold Hill Dam (2008), Savage Rapids Dam (2009), and Gold Ray Dam (2010) and one notched (i.e., Elk Creek Dam in 2008) to restore natural flow and fish passage (NOAA Fisheries 2011a). As a result, the Rogue River now flows unimpeded for 157 miles from the Cascade foothills to the ocean. In ESA consultations completed for the removal of these dams, NOAA Fisheries projected that these projects would improve fish production in the URR. These fish passage projects are anticipated to improve salmon returns by an estimated 22 percent as measured at the lower Rogue River. Because these mainstem Rogue River dams were removed after completion of the Williams et al. (2008) extinction risk evaluation, the risk evaluation should be revised to reflect these recent improvements and provide a more quantitative analysis of benefits from dam removal on the Rogue River. Although, sufficient time has not passed to demonstrate results related to increased adult returns to the Bear or Little Butte Creek watersheds as a result of these mainstem dam removals, they will likely have a substantial influence on adult returns in the near future and will likely have a major cumulative benefit to this population. Monitoring is underway and is necessary to determine how returning adults distribute in the URR basin in response to dam removal.

5.3 Watershed Management and Restoration Improvements

Agricultural practices continue to be evaluated and improved in the Rouge basin and these improvements are expected to continue in the future for both Project and non-Project water users. New ideas to capture and cool flood irrigation water prior to returning it to the stream are being investigated and developed in conjunction with Natural Resources Conservation Service to advance the overall reduction of thermal loading from agricultural practices. In addition, local communities have adopted specific action plans to address thermal loading in Bear Creek and are embarking on an aggressive plan to install riparian plantings along up to 8 miles of Bear Creek shoreline (Cities of Ashland and Medford) to comply with EPA and ODEQ water quality standards for thermal loading to streams. Although, the full benefit of these riparian zone and water quality improvement actions are not expected to be fully completed for the next 20 years, these actions in concert with the planting program NOAA Fisheries has requested as part of this ESA consultation for the Project will have significant long-term benefits. These substantial efforts by private and municipal entities will have a cumulative effect on water temperature and other water quality parameters and will lead to improved conditions in the Bear Creek watershed over time.

5.4 Population Growth and Associated Development

Between the 2000 Census and July 1, 2007, the population of Jackson County, Oregon grew from 181,269 to 202,310, an 11.6 percent population growth (PSU 2008). Such growth will likely continue within the Bear Creek and Little Butte Creek watersheds. The demand for agricultural, commercial, and residential development will continue to grow in the area in the foreseeable future. The effects of new development resulting from this steady population growth are likely to continue to adversely affect water quality and quantity in the Bear Creek watershed and to adversely affect riparian habitat. Offsetting these pressures somewhat are ongoing programs funded by Oregon Watershed Enhancement Board through the Bear Creek Watershed Council, as well as the RVCOG. These programs and other local government, land use planning, and development regulations are designed to manage the impacts of population growth; applying these in a balanced manner that protects coho salmon habitat while supporting economic growth and private property rights would require a strong commitment from local governments, landowners, and the public at large.

5.5 Climate Change

The Climate Impacts Group at the University of Washington analyzed the effects of global climate change on the Pacific Northwest and on Washington in particular (Littell et al 2009). That evaluation used up to 20 different General Climate Models and two different emission scenarios to explore potential impacts at three different time periods extending out to near the end of the century. The global climate models generally agree that future conditions in the future in the Pacific Northwest will be warmer. The individual models, though, predict various amounts of increase with Mantua et al. (2009) reporting that "the range of projected changes from individual models can be as extreme as 15 to 200 percent of the multi-model average." There is consensus among the climate models that some amount of future warming is likely to occur in the Pacific Northwest region; however, the models are not as consistent regarding increases in mean annual precipitation, with about 75 percent of the models predicting increases in precipitation in the Northwest (Reclamation 2008). Recent studies have continued to identify the relative wide range of future projections of precipitation. Mote and Salathe (2009) report that models used in their study gave equivocal results relative to the projected future changes in precipitation. They report that individual models produce changes of a much as -10 percent or +20 percent by the 2080s. On a seasonal basis, they indicate that some models produce modest reductions in fall or winter precipitation while others predict very large increases (up to 42 percent).

A recently published study by Doppelt et al. (2008) investigated climate change impacts to the Rogue River basin. That study relied on three general climate models and a single emission scenario that was different than the scenarios used in the Climate Impacts Group study discussed previously. Because the Rogue River basin falls directly in the transition between two major global climate bands identified as the wet north and dry subtropics, the future forecast patterns for this area are uncertain. However, models used in a recent study forecast increased severity and variability of precipitation events in this region (Doppelt et al. 2008). As with other climate change estimates, however, there is a significant amount of uncertainty related to the estimates made.

The report suggests that the annual average temperatures are likely to increase from 1° F to 3° F in approximately 30 years. The total precipitation will likely remain similar to historic levels, but more rainfall will occur than snowfall. The wet and dry cycles will likely last longer and be more extreme, leading to both periods of deeper drought and extensive flooding (Doppelt et al. 2008). These components lead to broad issues to be addressed in the changing climate such as increased potential of wildfires, changes in the aquatic systems and species, and impacts on the human and economic systems in the Rogue River basin (Doppelt et al. 2008). The report concludes by offering recommendations for increasing the capability of ecosystems, species, and communities to withstand and adapt to the stressors related to climate change.

Brekke et al. (2009), in evaluating approaches to incorporating climate change into water resource management decisions, suggest that climate change information may be most useful in informing decisions with application horizons greater than roughly 20 years. Decisions made for actions that occur in less than 20 years involve time spans which are shorter than those required for detecting climate change (IPCC 2007). In the case of this consultation, the proposed action covers a 10-year time period; consequently, incorporating climate change is not appropriate in this situation.

5.6 Klamath Basin

The 2010 BiOp for the Operation and Maintenance of the Klamath Project identified the following cumulative effects in the greater Klamath basin:

> "NOAA Fisheries conducted a search for non-Federal activities, and requested information from the state of California and Klamath basin tribes (NOAA Fisheries 2008c). NOAA Fisheries has determined that with the completion of the mainstem Klamath River TMDL in California and in the next few years, private, municipal, and industrial entities contributing to the degradation of water quality will be required to develop and implement water quality management plans that reduce nutrient loading and aid in the improvement of water quality in the mainstemKlamath River. NOAA Fisheries is also aware that the completion of the water adjudication process for the Klamath basin in Oregon is expected in 2010. The adjudication process may provide for more efficient water management in the Klamath River basin, and result in increased water availability for resource and Project needs.
>
> Bartholow (2005) simulated the effects of climate change on the spatial and temporal water temperature patterns within the mainstem Klamath River from 1962 to 2001 using existing data and statistical software. Although there were large degrees of uncertainty in the simulation, including the short thermograph records, large data gaps in thermograph records, and ordinary intra-annual variability that resulted in few statistically significant trend estimates, Bartholow (2005) determined that the average trend in mainstem water temperatures has been an increase of 0.5ºC/decade. Bartholow (2005) suggests trends of (1) cumulative exposure to stressful temperatures that have been increasing in both number and duration; (2) the length of the annual period of potentially stressful temperatures that has been increasing (i.e., summer effectively starts earlier in the spring and extends longer into the fall); and (3) the average length of river with suitable temperatures has been decreasing. As discussed, above, water temperatures in the lower mainstem Klamath River are currently marginal for anadromous salmonids. If water temperature trends of the magnitude found for the mainstem Klamath River continue into future decades, some populations may decline to levels insufficient to ensure population survival (Bartholow 2005)" (NOAA Fisheries 2010b).

Chapter 6 ESSENTIAL FISH HABITAT

6.1 Background

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Act (MSA) to establish requirements for Federal agencies to consult with National Marine Fisheries Service (NOAA Fisheries) on activities that may adversely affect EFH. The EFH regulations require that Federal action agencies obligated to consult on EFH also provide NOAA Fisheries with a written assessment of the effects of their action on EFH (50 CFR 600.920). Under Appendix A of Amendment 14 to the Pacific Coast Salmon Fishery Management Plan (PFMC 1999), the Pacific Fisheries Management Council (PFMC) has identified and described EFH for Southern Oregon Northern California Coast (SONCC) salmon and SONCC coho salmon in the middle Rogue River hydrologic unit code (HUC) and upper Klamath River HUC within the proposed action area. The MSA also requires Federal action agencies receiving NOAA Fisheries EFH Conservation Recommendations to provide a detailed written response to NOAA Fisheries within 30 days upon receipt detailing how they intend to avoid, mitigate, or offset the impact of the activity on EFH (Section 305(b)(4)(B)).

6.2 Identification of Essential Fish Habitat

The geographic extent of freshwater EFH for the Pacific salmon fishery is proposed as waters currently or historically accessible to salmon within specific U.S. Geological Survey (USGS) hydrologic units (PFMC 1999). For the Rogue River Basin Project, Talent Division (Project), the aquatic areas identified as EFH for Chinook salmon and SONCC coho salmon are within the designated critical habitat for coho salmon. This includes:

1. Bear Creek and its tributaries downstream from Emigrant Dam (Rogue River basin).
2. The entire Little Butte Creek drainage downstream from Fish Lake Dam on North Fork Little Butte Creek and Agate Dam on Antelope Creek (Rogue River basin).
3. Klamath River and its tributaries downstream from Iron Gate Dam (Klamath River basin) (PFMC 1999).

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH, "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

The important stages with regard to Chinook salmon EFH within the action area are: 1) freshwater spawning and incubation; 2) freshwater juvenile rearing; and 3) juvenile and adult freshwater migration. Other important life stages for Chinook salmon are estuarine rearing, early ocean rearing, and adult marine growth. Although these later life stages are important components of Chinook salmon EFH and will be briefly discussed in this document, they will not be analyzed as they occur outside of the action area and the proposed action will have no affect to estuarine and marine EFH components.

Reclamation's proposed action is described in Chapter 4 of the 2009 BA (Reclamation 2009b) and in this Proposed Action document. Chapter 5 of the 2009 BA addresses impacts to the threatened Northern California/Southern Oregon Evolutionarily Significant Unit (ESU) coho salmon (*Oncorhynchus kisutch*), listed as threatened under the Endangered Species Act (ESA). These impacts include adverse effects to the habitat conditions required by coho salmon and which are also identified EFH as provided by the MSA. The Rogue River and Klamath River basins also provide EFH to SONCC Chinook salmon (*O. tshawytscha*), which are covered under the EFH provisions of the MSA but are not listed under the ESA. This EFH consultation addresses both species but also refers the reader to more specific information pertaining to the habitat requirements of coho salmon contained in Reclamation's 2009 BA (Reclamation 2009b).

The objective of this EFH assessment is to describe potential adverse effects to designated EFH for federally managed fisheries species within the proposed action area. It also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

6.3 Identification of Essential Fish Habitat for Southern Oregon/Northern California Chinook Salmon

The SONCC ESU includes all naturally spawned populations of Chinook salmon from rivers and streams between Cape Blanco, Oregon (excluding the Elk River), and the lower Klamath River; and California, excluding populations in the Klamath River basin upstream from the confluence of the Klamath and Trinity rivers. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 6,528 square miles in California and Oregon. The following counties lie partially or entirely within these basins: California - Del Norte, Humboldt, and Siskiyou; Oregon - Coos, Curry, Douglas, Jackson, Josephine, and Klamath.

Chinook salmon within this ESU exhibit an ocean-type life history with distribution (based on marine coded wire tag recoveries) predominantly off the California and Oregon coasts. Ecologically, the majority of river systems in this ESU are relatively small and heavily influenced by a maritime climate. Low summer flows and high temperatures in many rivers result in seasonal physical and thermal barrier bars that block movement by anadromous fish.

6.4 Essential Fish Habitat Requirements for Chinook Salmon

General life history information for Chinook salmon is summarized below. Further detailed information on Chinook salmon is available in the NOAA Fisheries status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998), and the NOAA Fisheries proposed rule for listing several ESUs of Chinook salmon (NMFS 1998).

The Rogue River and Klamath River basins contain populations of spring-run and fall-run Chinook (Campbell and Moyle 1990; Healey 1991). Within these basins, there are statistically significant, but modest, genetic differences between the fall and spring runs. The majority of spring and fall-run fish emigrate to the marine environment primarily as subyearlings, but have a significant proportion of yearling smolts. These Chinook salmon populations all exhibit an ocean-type life history. The majority of fish immigrate to the ocean as subyearlings, although yearling smolts can constitute up to approximately 1/5 of outmigrants. However, the proportion of fish that smolt as subyearling versus yearling varies from year to year (Snyder 1931; Schluchter and Lichatowich 1977; Nicholas and Hankin 1988; Barnhart 1995). This fluctuation in age at smoltification is more characteristic of an ocean-type life history.

Chinook salmon in the Southern Oregon and California Coastal ESU exhibit a predominantly ocean-type life history, that is, they typically migrate to seawater in their first year of life (NMFS 1998). However, when environmental conditions are not conducive to subyearling emigration, ocean-type Chinook salmon may remain in freshwater for their entire first year (NMFS 1998).

6.5 Freshwater Essential Habitat

Freshwater EFH for Chinook salmon consists of habitat suitable for four critical stages: 1) juvenile rearing; 2) juvenile migration; 3) adult migration and holding; and 4) spawning and incubation. Important features of essential habitat for spawning, rearing, and migration include adequate: 1) substrate composition; 2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); 3) water quantity, depth and velocity; 4) channel gradient and stability; 5) food; 6) cover and habitat complexity (e.g., large woody material, pools, channel complexity, aquatic vegetation, etc.); 7) space; 8) access and passage; and 9) flood plain and habitat connectivity. Chinook salmon EFH includes all those streams, lakes, ponds, wetlands, distributaries, and other waterbodies currently and historically utilized by Chinook salmon in Washington, Oregon, Idaho, and California.

6.6 Juvenile Chinook Salmon

6.6.1 Freshwater Rearing

At the time of emergence from their gravel nests, most fry disperse downstream towards the estuary, hiding in the gravel or stationing in calm, shallow waters with fine sediment substrates and riparian bank cover such as tree roots, logs, and submerged or overhead vegetation. Hardy and Addley (2001) noted that Chinook fry utilized habitat along the stream margins in association with cover versus the use of the main river channel. The authors also noted that a relatively small proportion of Chinook fry were found associated with substrate specific cover compared to inundated streamside vegetation cover types at depths less than 2 feet. This association with shallow, vegetative escape cover indicates the importance of riparian habitat to the early life history stage of juvenile Chinook. Chinook salmon fry are typically 1.3 to 1.4 inches in length when they emerge; however, there is considerable variation among populations and size at emergence, which is determined, in part by egg size. As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore until eventual emigration from the streams and rivers as smolts from April through June (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic vegetation, logs, riparian vegetation, and undercut banks provide food, shade, and juvenile protection from predation. The length of freshwater residence before seaward migration is as variable as size. Ocean-type fish can migrate seaward immediately after yolk absorption, but most migrate 30 to 90 days after emergence.

Water habitat quality and quantity determine the productivity of a watershed for Chinook salmon. Both stream- and ocean-type fish utilize a variety of habitats during their freshwater residency, and are dependent on the quality of the entire watershed, from headwater to estuary. Juvenile Chinook inhabit primarily pools and stream margins, particularly undercut banks, behind woody debris accumulations, and other areas with cover and reduced water velocity (Bjornn and Reiser 1991; Lister and Genoe 1970). While Chinook salmon habitat preferences are similar to those for coho salmon, Chinook inhabit slightly deeper (2 to 47 inches) and higher velocity (0 to 15 inches per second) areas than coho (Bjornn and Reiser 1991; Healey 1991). The stream or river must provide adequate summer and winter rearing habitat, as well as migration corridors from spawning and rearing areas to the sea.

The principal foods in freshwater systems are larval and adult insects, while those in estuarine systems include epibenthic organisms, insects, and zooplankton such as Daphnia, flies, gnats, mosquitoes, or copepods (Kjelson et al. 1982), stonefly nymphs or beetle larvae (Chapman and Quistdorff 1938) as well as other estuarine and freshwater invertebrates. Growth rates, during the period of initial freshwater residency, depend on the quality of habitat occupied by the fish. Growth rates between 0.008 inch per day and 0.024 inch per day have been reported for ocean-type fish (Healey 1991; Kjelson et al. 1982; Mains and Smith 1964; Meehan and Sniff 1962; Rich 1920). For ocean-type fish, growth rates in estuarine habitats are generally much higher than in riverine or stream habitats. This is most likely due to a higher abundance of prey.

6.6.2 Estuarine rearing

Ocean-type Chinook salmon typically reside in estuaries for several months before entering coastal waters of higher salinity (Healey 1980, 1982; Congleton et al. 1981; Levy and Northcote 1982; Kjelson et al. 1982). Ocean-type Chinook salmon typically begin their estuarine residence as fry (immediately after emergence) or as fingerling (after spending several months in freshwater). Fry generally enter the upper reaches of estuaries in late winter or early spring, beginning in January at the southern end of their range in the Sacramento-San Joaquin Delta, and as late as April farther north, such as in the Fraser River Delta (Sasaki 1966; Dunford 1975; Levy et al. 1979; Healey 1980, 1982; Gordon and Levings 1984). In contrast, Chinook salmon fingerlings typically enter estuarine habitats between June and July (April to June in the Sacramento Delta) or around the same time period that Chinook salmon who arrived in the estuary as fry are beginning to emigrate to higher salinity marine waters. Regardless of time of entrance, juvenile ocean-type Chinook salmon spend from 1 to 3 months in estuarine habitats (Rich 1920; Myers 1980 in Floyd 2003; Kjelson et al. 1982; Levy and Northcote 1982; Healey 1980, 1982; Levings 1982).

Chinook salmon fry prefer protected estuarine habitats with lower salinity, moving from the edges of marshes during high tide to protected tidal channels and creeks during low tide; they venture into less protected areas at night (Healey 1980, 1982; Levy and Northcote 1979, 1982; Kjelson et al. 1982; and Levings 1982). As the fish grow larger, they increasingly enter higher-salinity waters and less protected habitats, including delta fronts and estuary edges, before finally dispersing into strictly marine habitats. In contrast to fry, Chinook fingerling, with their larger size, immediately take up residence in deeper-water estuarine habitats (Everest and Chapman 1972; Healey 1991).

The Chinook diet during estuarine residence is highly variable, and is dependent upon the particular estuary, year, and season, as well as prey abundance. In general, Chinook are opportunistic feeders consuming larval, adult insects and amphipods when they first enter estuaries, while increasing their dependency on larval and juvenile fish as they grow larger. Preferred diet items for Chinook salmon include aquatic and terrestrial insects such as chironomid larvae, dipterans, cladocerans such as Daphnia, amphipods including Eogammarus and Corophium and other crustaceans such as Neomysis, crab larvae and cumaceans (Sasaki 1966; Dunford 1975; Birtwell 1978 in Floyd 2003; Levy et al. 1979; Levy and Northcote et al. 1979 in Floyd 2003; Healey 1980; 1982; Kjelson et al. 1982; Levy and Northcote 1982; Levings 1982; Gordon and Levings 1984; and Myers 1980 in Floyd 2003). Larger juvenile Chinook consume juvenile fishes such as anchovy (*Engraulidae*), smelt (*Osmeridae*), herring (*Clupeidae*), and stickleback (*Gasterosteidae*). Growth in estuaries is quite rapid, and Chinook may enter the upper reaches of estuarine environments as 1.4 to 1.6-inch fry and leave as 2.8 to 4.3-inch smolts (Rich 1920; Levy and Northcote 1979, 1982; and Healey 1980). Growth rates during this period are difficult to estimate because small individuals are continually entering the estuary from upstream, while larger individual depart for marine waters. Reported growth for populations range from 0.008 inch per day to 0.034 inch per day, and are as high as 0.052 inch per day for groups of marked fish (Levy and Northcote 1979, 1982; Healey 1980; Kjelson et al. 1982; Healey 1991; and Levings et al. 1982).

6.6.3 Marine Rearing

After leaving the freshwater and estuarine environment, juvenile Chinook disperse to marine feeding areas. Ocean-type fish, which have a longer estuarine residence, tend to be coast-oriented, preferring protected waters and waters along the continental shelf (Healey 1982). In contrast, stream-type fish that pass quickly through estuaries, are highly migratory, and may migrate great distances into the open ocean. Chinook salmon typically remain at sea for 1 to 6 years. They have been found in oceanic waters at temperatures ranging from 34 to 50 degrees Fahrenheit (°F), although few are found in waters below 41°F (Major et al. 1978). They do not concentrate at the surface as other Pacific salmon, but are most abundant at depths of 98 to 230 feet and are often associated with bottom topography (Taylor 1969; and

Argue 1970 in Floyd 2003). However, during their first several months at sea, juvenile Chinook salmon less than 5 inches in length are predominantly found at depths of less than 121 feet (Fisher and Pearcy 1995). Because of their distribution in the water column, the majority of Chinook salmon harvested in commercial troll fisheries are caught at depths of 98 feet or greater.

Overall, Chinook salmon marine distribution is extensive (varies seasonally and internally) and can only be defined generally. While limited information exists on Chinook habitat use in marine waters, it is clear that those habitats utilized during early-ocean entry are the most important. Furthermore, available research (Pearcy and Fisher 1988; Fisher and Pearcy 1995), catch data, and interviews with commercial fisherman all indicate and confirm that juvenile and maturing Chinook salmon are found in highest concentrations along the continental shelf within 35 miles of the Washington, Oregon, and California coastlines. Therefore, the geographic extent of essential marine habitat for Chinook salmon includes all waters from mean high water to 35 miles offshore north of Point Conception, California.

6.7 Adult Chinook Salmon

Throughout their range, adult Chinook salmon may enter freshwater during almost any month of the year, although there are generally one to three peaks of migratory activity. In northern areas, Chinook salmon river entry peaks in June, while in rivers such as the Fraser and Columbia, entry occurs between March and November, and peaks in spring (March-May), summer (May-July), and fall (August-September). The Sacramento River also has a winter-run population, which enters freshwater between December and July. Chinook salmon become sexually mature at anywhere between 2 and 8 years of age, with "jacks" (precocious males) mature after only 1 to 2 years. Overall, the most common age for the sexual maturity of ocean- and stream-type fish is 3 to 5 years, with males tending to mature slightly younger than females. In general, stream-type fish have a longer generation time than do ocean-type fish, presumably due to their longer freshwater residence. Chinook salmon from Alaska and more northern latitudes typically mature a year or more later than their southern counterparts (Roni 1992; Floyd 2003).

Run timing for spring-run Chinook salmon in the Klamath River typically begins in March and continues through August, with peak migration occurring in May and June (Table 6-1). Hardy and Addley (2001) noted that spring Chinook can enter as early as February. Run timing for fall-run Chinook salmon varies depending on the size of the river. In the lower reaches of the Klamath River, fall-run freshwater entry begins later in October, with peak spawning in late November and December– often extending into January (Leidy and Leidy 1984; Nicholas and Hankin 1988; Barnhart 1995).

Table 6-1. Summary of timing for key salmon life history events related to EFH for Chinook and coho salmon.

	Adult Immigration	Spawning	Smolt Emigration
Spring run Chinook	Feb. – Aug.	Late Aug. – Sept. Peaks in Sept.	March – July
Fall run Chinook	Aug. – Sept.	Sept. – early Jan.	April – June
Late-fall run Chinook	Nov. – Dec. but may be as late as Feb.	Unavailable	Unavailable
Coho salmon	Sept. – Dec.	Nov. - March	April – July with Peak in May

The size and age of adults at sexual maturity varies considerably among populations and years, and is influenced by both genetic and environmental factors. Size at maturity is thought to represent adaptation to local spawning environment (Ricker 1980; Healey 1991; Roni 1992). Most adult Chinook salmon females are 26 to 33 inches in length, while the slightly younger males are 20 to 33 inches. However, male and female fish larger than 39 inches in length at maturity are not uncommon in many populations. Prior to sexual maturation and spawning, adult Chinook salmon often rest, or hold, in large deep, low velocity pools, with abundant large woody material or other cover features. These areas may serve as a refuge from high river temperatures or predators, where they can reduce metabolic demands and reserve energy prior to spawning (Berman and Quinn 1991). The spawning densities of Chinook and coho salmon have been correlated with large woody material and pool frequency (Floyd 2003).

Chinook salmon spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs at depths greater than 6 inches, usually 1 to 3 feet to 10 to 15 feet. Preferred spawning substrate is clean and loose, medium to large-sized gravel. Hardy and Addley (2001) report that Chinook also use small cobble substrate. Egg incubation generally occurs from 40 to 60 days with alevins and fry remaining in the gravel between 2 to 4 weeks and emerging during December. Hardy and Addley (2001) reported that suitable incubation temperatures were assumed to be between approximately 5˚C (41˚F) and 14˚C (57˚F) as significant mortality occurs beyond this range.

In the Rogue River basin, adult spring Chinook migrate upstream past Gold Ray Dam before August 15; fall Chinook pass this point after August 15. Fall Chinook salmon have been observed by the Oregon Department of Fish and Wildlife (ODFW) as far upstream as river mile 23 in Bear Creek; about 4 miles downstream from the confluence of Walker and Emigrant creeks (Vogt 2003-2011). Fall Chinook spawning in Bear Creek occurs in November and December. Little spawning habitat occurs in Emigrant Creek downstream from Emigrant Dam. Spring Chinook have been observed about 1.5 miles upstream in South

Fork Little Butte Creek. Fall Chinook spawn up to the confluence of North and South Fork Little Butte creeks (Vogt 2003-2011). Chinook salmon probably do not spawn very much in Antelope Creek due to its small size.

All Chinook stocks utilize resting pools as they migrate upstream (Myers et al. 1998). As noted in Myers et al. (1998), these pools provide an energetic refuge from river currents, a thermal refuge from high summer and autumn temperatures, and a refuge from potential predators (Berman and Quinn 1991; Hockersmith et al. 1994). Furthermore, the utilization of resting pools may maximize the success of the spawning migration through decreases in metabolic rate and the potential reduction in susceptibility to pathogens (Bouck et al. 1975; Berman and Quinn 1991). Spawning for spring run Chinook salmon may occur from September through mid -November (Hardy and Addley 2001) and can peak in September (Myers et al. 1998). Spawning for fall-run Chinook begins in September through early January.

The survival of Chinook salmon is affected by factors including run type (i.e., spring, summer, fall), freshwater migration length, and year. Hatchery spring and summer Chinook salmon have smolt-to-adult survival rates that average one percent, although survival of many upper Columbia and Snake River basin hatchery stocks is typically less than 0.2 percent (Coronado-Hernandez 1995). Wild stocks from these areas are thought to have ocean survival rates 2 to 10 times greater than hatchery fish (Coronado-Hernandez 1995). Fall Chinook hatchery stocks also survive from smolt to adult at approximately one percent; fish from some areas, such as the Oregon coast, are consistently higher, though typically less than five percent (Coronado-Hernandez 1995).

6.8 Effects of Proposed Action on Chinook EFH

As described in detail in Chapter 5 of the 2009 BA (Reclamation 2009b) and in this biological assessment (BA) document the proposed action may result in short- and long-term adverse effects to a variety of habitat parameters important to coho salmon. While Chinook are not listed under the ESA and are not specifically addressed in this BA, the effects on Chinook salmon are not as severe due to life history difference between the two species when compared to the proposed action effects. Table 6-2 below summarizes the potential effects to EFH for Chinook salmon resulting from the proposed action.

Table 6-2. The potential effects of the future operation of the Project on Chinook EFH habitat.

Habitat Features	Effects of Proposed Action
Substrate composition	No change from current condition.
Water quality	Little to no change from current condition. Riparian zone revegetation components of the proposed action may increase stream shade and decrease water temperatures in the Bear Creek system.
Water quantity, depth and velocity	Water quantity effects are limited to spawning and incubation during the early fall when irrigation operations ceases and instream flows drop to normal levels. Irrigation operations artificially increase instream flow throughout the spring and summer months which benefits the freshwater juvenile life stage for Chinook. The PA has been crafted to avoid unnecessary ramping conditions outside of natural flow events.
Channel gradient and stability	No change from current condition.
Food	No change from current condition. Some benefits could accrue to Chinook salmon juveniles as riparian vegetation components of the proposed action
Cover and habitat complexity (large woody debris, pools, channel complexity, aquatic vegetation)	The Proposed Action incorporates habitat improvements that will add large woody debris form added complexity and riparian planting to address temperature issues.
Space	No change from current condition.
Access & passage	Increased instream flows and reduced ramping rates will improve access and passage issues within the Project Action Area.
Floodplain & habitat connectivity	No change from current condition.

As described in the 2009 BA, the proposed action can adversely affect coho salmon by decreasing survival and abundance of several freshwater life history stages of coho, including fry, juveniles, and outmigrating smolts. Although adult coho may be adversely affected by the proposed action in the Rogue River basin, adverse effects to Chinook salmon EFH will be less due to their greater reliance on Little Butte Creek and Bear Creek mainstem habitat and less on tributaries. Minimal impacts are expected to coho and Chinook EFH in the Klamath River with the minor transbasin diversion under Reclamation's control.

During August through March, the proposed action could have an impact on the EFH function of providing unimpeded passage conditions for upstream migrating Chinook salmon. However, the timing of adult Chinook upstream passage occurs during a period of natural low flow in the Rogue River basin and the proposed action typically enhances those flows through water releases at storage facilities through the month of October. The proposed action attempts to maintain water releases at a fairly constant level during the

Chinook salmon migration period and only curtails flow during the very end of October when naturally low streamflows resume. Chinook salmon spawning and incubation success in the Bear Creek and Little Butte Creek drainages could be affected by the proposed action flows. These impacts will be decreased under the proposed action described in this BA document because of increased instream flow commitments in mainstem reaches under the proposed action. Flow increases during the winter at EMI in particular will increase winter flows in Bear Creek that will increase winter rearing conditions for incubating redds, emergent fry, and for early juvenile rearing. Reclamation-owned diversion structures (i.e., Antelope Creek, Ashland, Oak Street, and Phoenix) all meet NOAA Fisheries fish protection criteria. However, some Reclamation-owned canals that cross tributaries to Little Butte Creek and Bear Creek that remain checked with poorly functioning diversion structures are likely to cause adult fish migration delays and juvenile losses where they do not meet NOAA Fisheries fish protection criteria.

Spring flows in the mainstems and tributaries of Bear Creek and Little Butte Creek provide important EFH that supports rearing and juvenile emigration functions for coho and Chinook salmon. During the early spring months, the proposed action will slightly reduce flows, which will affect salmon fry rearing for individuals either originating from the main stems or migrating down from tributaries. However, flows in the late spring will be greater as a result of increased water releases from storage reservoirs and as a result of natural streamflow increases from precipitation events. Because the amount of suitable EFH in the stream channels is related to the amount of flow for rearing salmon, salmon fry habitat will be protected and improved over baseline conditions by implementation of the instream flows proposed in the BA. The instream flow levels provided in Emigrant, Bear, and Little Butte Creek systems will be sufficient to maintain fry and juvenile salmon rearing habitat at appropriate levels as a result of the proposed action. Furthermore, the survival of Chinook salmon juveniles and emigrating smolts will be enhanced by the adequate flow levels proposed to occur during the late spring and summer months when Chinook smolts will be emigrating from the systems.

In addition to supporting important juvenile and fry rearing function, springtime high flows that result from the proposed action will facilitate the outmigration of salmon smolts. Although specific relationships between Bear Creek and Little Butte Creek flows and smolt survival have not been established, information from other locations indicates a positive relationship between smolt survival and river flows. Thus, the proposed action will likely provide sufficient springtime flows to provide for satisfactory coho and Chinook salmon smolt outmigration survival.

As noted previously, much of the salmon rearing is associated with riparian corridors. The riparian zone acts as the interface between terrestrial and aquatic ecosystems by moderating the effects of upslope processes and provides important ecological functions including bank stabilization, nutrient cycling, food web support, and important stream microclimate and shading functions (Spence et al. 1996; NRC 2002). Riparian vegetation, including shaded riverine aquatic cover, provides juvenile salmon cover from predators, increases habitat complexity, provides a source of insect prey, and provides shade for maintaining water temperatures within suitable ranges for all life stages. The functional values of riparian corridors and the benefits they provide to stream fish populations are well documented (Karr and Schlosser 1978; Wesche et al. 1987; Gregory et al. 1991; Caselle et al. 1994). As noted by the NRC (2002), the reintroduction or maintenance of the full range of flow regimes, in addition to minimum streamflow, is essential for restoring and sustaining, respectively, healthy riparian systems. The proposed action provides for variable flow regimes that create conditions, which may effectively separate much of the riparian zone from the waters of the river, thereby limiting the function of the riparian zone. However, these times are brief and affect relatively short reaches of Project affected streams. Riparian zone management actions will compensate for these effects and will improve overall riparian zone condition and functioning over time. Collectively, these factors indicate that the proposed action will not adversely affect riparian zone function in the Bear and Little Butte Creek systems sufficient to adversely affect Chinook salmon EFH.

Because of the riparian zone revegetation components that are proposed to occur as part of the Proposed Action, no adverse effects to EFH will also result from reductions in water quality (e.g., water temperatures). While the relationship between flows and water temperature is poorly understood, the 2009 BA concluded that Project irrigation withdrawal at Reclamation-owned diversion dams in Little Butte Creek and Bear Creek does not remove a sufficient amount of water to counteract the stream cooling effect of cool water Project releases into the Bear Creek system from Emigrant Reservoir. As a result, the proposed action likely has minimal effects to overall water temperature regime in Bear Creek and Little Butte Creek systems. No adverse affects are anticipated to occur to stream water temperatures in the Klamath River as a result of Project-related flow depletions.

6.8.1 Determination of Effects on Pacific Salmon EFH

Operation of the Project has occurred over the past 55 years. Improvements to the Project physical structures and operations have been frequent and responsive to increased knowledge and awareness over time. The proposed action increases minimum instream flows, improves ramping rates, increases operational attention to critical life stages for fish, and adds habitat complexity to address long-term habitat degradation within the Bear Creek and Little Butte Creek drainages.

Based on this analysis for the Project, Reclamation makes a determination of, ***may affect, not likely to adversely affect*** for Pacific salmon EFH. The environmental performance standards and temporal staging of the proposed action described in this BA description and also in Section 4 and 5 of Reclamation's 2009 BA (Reclamation 2009b) are considered adequate to minimize adverse effects on Pacific salmon EFH for this Project. These conclusions are based on the following considerations: 1) Reclamation has committed resources and attention to place as much piping as economically feasible for the Project to derive more water for instream flow; and 2) the cumulative effect of the proposed conservation measures will ensure that any short-term effects on water quality, habitat access, habitat elements, channel conditions and dynamics, flows, and watershed conditions will be brief and insignificant. Water conservation and water quality improvement projects contribute to Bear Creek watershed water quality improvements. These projects will continue into the future as part of the environmental baseline and as part of the proposed action.

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Appendices

Appendix A

TECHNICAL MEMORANDUM

Regulation Model of Bear and Little Butte Creeks and Modeled Scenarios

PREPARED FOR: Chris Eder

PREPARED BY: Leslie Stillwater

TECHNICAL REVIEW: Bob Lounsbury

DATE: February 23, 2012

INTRODUCTION

This document describes the 2011 daily time step Modsim[1] model developed to simulate the surface waters, return flows, natural flow rights, and storage accounting of Reclamation's Rogue Project (Talent Division). The daily time step model includes:

- daily unregulated flow inputs from 3/31/2001 through 8/28/2011[2],
- Emigrant, Bear, and South Fork Little Butte Creeks,
- Howard Prairie, Hyatt, Keene Creek, and Emigrant Reservoirs,
- transbasin diversions from South Fork Little Butte Creek into Howard Prairie Reservoir and deliveries through the Howard Prairie Delivery Canal,
- minimum flow requirements for dry, average, and wet system states,
- diversion requests equal to historical diversions for the Ashland Lateral (ASLO), East Lateral (EMI QJ), Talent Lateral (TALO), Phoenix Canal (PHXO), and Bear Creek Canal (BCCO).

This Modsim model was developed in parallel with a similar RiverWare[3] model. RiverWare is widely used, well supported, and accessible. RiverWare will eventually be applied to future simulation studies of the Rogue Project. However, the RiverWare model does not yet include water rights and storage contracts. Therefore, only the assumptions and results from the Modsim model will be discussed in this document.

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[1] Modsim was developed at Colorado State University in the 1970's and from 1992 through 2009 under joint agreement with the U.S. Bureau of Reclamation Pacific Northwest Region (PNRO).

[2] A description of the data and methods used in the calculation of the local inflows and losses and the limitations of the unregulation is in Appendix A. *Unregulation of Bear and Little Butte Creeks.*

[3] CADSWES, Center for Advanced Decision Support for Water and Environmental Systems, University of Colorado at Boulder, 2010.

BACKGROUND AND PURPOSE OF MODEL

Daily Time Step

This model simulates operations and provides results on a daily time step. A daily time step was selected for three reasons. First, a daily time step provides the best resolution of streamflow in low flow reaches or reaches with highly variable flows. Second, a daily time step more accurately captures intra-monthly operational decisions likely to occur in meeting minimum streamflows. Third, a daily time step is necessary to capture intra-monthly variations in streamflow which may affect the availability of fish habitat.

One adverse consequence of a daily time step is, at times, the without Reclamation flows used for model input can be negative. This presents a problem for analysts who want to use without Reclamation flows as an approximation of unregulated flows, but does not create a problem for the simulation of regulation scenarios.

Data

This model uses reservoir, streamflow, and diversion data from Reclamation's automated hydrologic data collection system, Hydromet. A list of gages and their respective periods of record is provided in Appendix A: Table 13. The simulation begins on March 31, 2001, and continues through August 28, 2011. During that period, the necessary gages were operating and reporting enough data to develop daily unregulated streamflows at most locations, with exceptions described in Appendix A. Missing data was estimated or simulated to complete the dataset and permit the model to run for the entire period of simulation. While the method of simulation reasonably estimates reservoir volumes, estimates of daily streamflow values at certain locations are limited to the historical period of record at that location. Despite these shortcomings, the model represents the best available science for the requirements of the Biological Assessment.

Is the Period of Simulation Representative of the Hydrologic Record?

To determine whether the 10 year simulation period is representative of project hydrology, the period of record was evaluated in two ways. First, the annual water year volume of inflow to Howard Prairie Reservoir from 1963 through 2011 was compared to the Model period of simulation (Table 1). Second, a flow duration analysis was performed over the past 95 years compared with the past 10 and 5 year periods in Bear Creek at Medford (MFDO). This analysis used daily flow values by month at the 20, 50, and 80 percent probabilities of exceedance (Table 2) or high, median, and low flow regimes, respectively.

In the first method an exceedance was calculated for each water year's volume of inflow, and high flow years defined as those years where the volume was greater than or equal to the 30%

exceedance volume, low flow years when the volume was less than the 70% exceedence volume, and the remaining years were considered average flow years. The volumes for the past 10 years of simulation are highlighted in Table 1. Although the record shows more average and low flow years within the last 10 years, there is a range of year types within the last 10 years that provide a relatively good hydrologic sample for simulation of reservoir volumes.

The second method computed monthly exceedance levels using daily data by month to compare different flow regimes at MFDO. They represent the amount of time a specific flow by month is equaled or exceeded. These results indicate monthly flow values over the past ten years are reasonably representative of the past ninety-five years. Flows for the past 5 years are higher from March to May, 50% of the time, than historically.

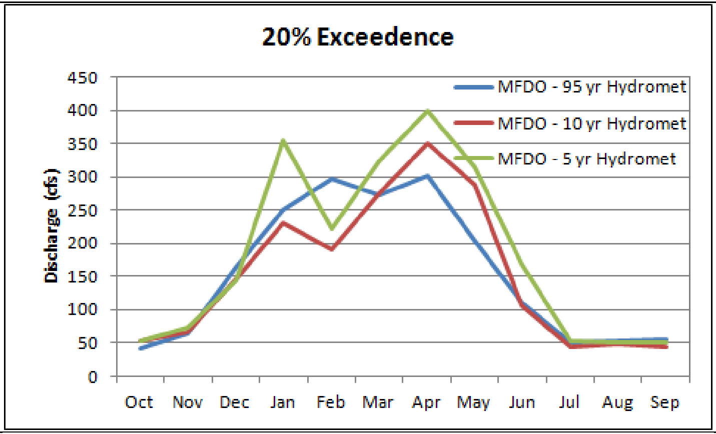
Both methods provided confidence that the model period of simulation is within satisfactory bounds of historical conditions and would supply useful information in support of the Biological Assessment.

Table 1. Annual water-year volume of inflow to Howard Prairie Reservoir sorted by probability of exceedance. Volumes greater than the 30% exceedence volume were defined as wet, volumes less than the 70% exceedance volume as dry, and the remaining years were considered average. Years within the period of simulation highlighted in blue.

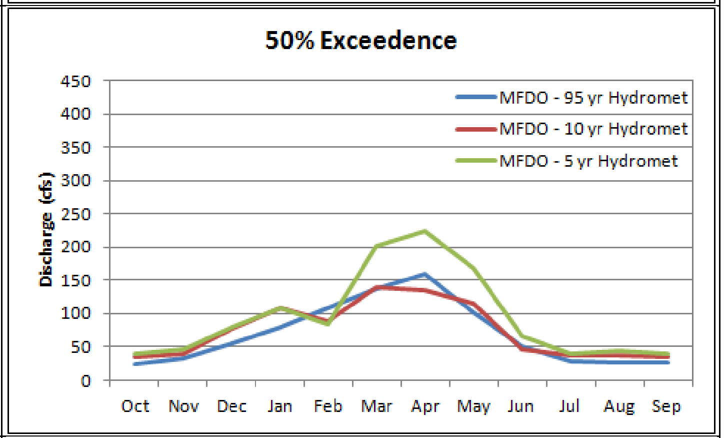
High Flow Years			Average Flow Years			Low Flow Years		
WY	Annual Volume (1000 ac-ft)	Exceedance	WY	Annual Volume (1000 ac-ft)	Exceedance	WY	Annual Volume (1000 ac-ft)	Exceedance
1995	51.3	2%	1989	40.2	32%	2007	27.1	70%
1971	49.5	4%	1975	38.9	34%	1999	25.4	72%
1982	49.4	6%	1996	38.8	36%	1990	23.0	74%
1974	48.9	8%	1997	38.0	38%	2005	22.7	76%
1969	47.7	10%	1970	36.3	40%	1973	22.5	78%
1993	47.5	12%	2004	36.1	42%	2010	21.4	80%
1979	46.9	14%	1983	35.5	44%	1988	20.7	82%
1963	45.5	16%	1976	33.0	46%	1966	20.5	84%
1972	45.3	18%	1980	32.3	48%	1987	19.0	86%
2006	44.9	20%	1986	31.6	50%	1981	16.5	88%
1978	44.6	22%	2003	31.3	52%	1968	12.4	90%
1984	43.7	24%	2008	30.8	54%	2001	11.3	92%
1965	41.6	26%	1991	30.5	56%	1992	10.4	94%
1967	40.6	28%	2002	30.4	58%	1994	10.0	96%
2011	40.4	30%	2009	29.5	60%	1977	9.5	98%
			1985	29.2	62%			
			1964	29.1	64%			
			2000	28.3	66%			
			1998	27.3	68%			

Table 2. Historic monthly values generated from a daily flow duration analyses by month in Bear Creek at Medford (MFDO).

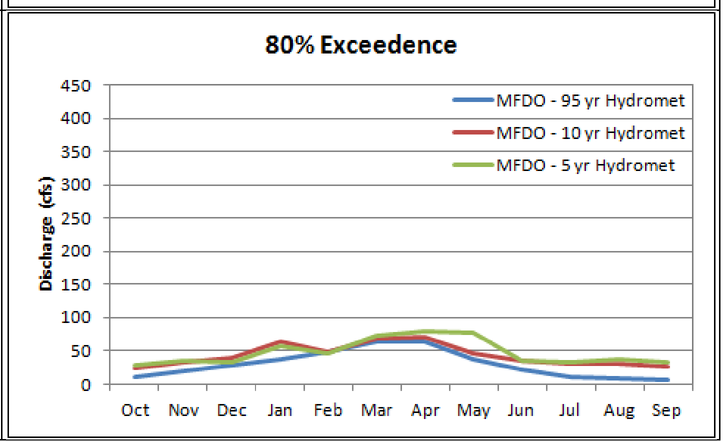
20%	MFDO - 95 yr Hydromet	MFDO - 10 yr Hydromet	MFDO - 5 yr Hydromet
Oct	41.3	52.8	53.0
Nov	65.2	65.9	71.9
Dec	164.3	145.5	145.1
Jan	250.3	231.6	354.0
Feb	297.2	190.8	222.0
Mar	273.0	274.5	323.3
Apr	300.5	350.2	398.8
May	204.4	289.2	314.6
Jun	110.9	106.2	168.2
Jul	50.5	44.1	52.2
Aug	53.1	48.0	50.9
Sep	54.3	44.6	50.5



50%	MFDO - 95 yr Hydromet	MFDO - 10 yr Hydromet	MFDO - 5 yr Hydromet
Oct	24.5	36.2	39.9
Nov	33.9	40.2	45.2
Dec	54.2	78.2	79.6
Jan	79.6	108.8	108.0
Feb	108.8	89.3	84.2
Mar	138.2	139.2	202.5
Apr	160.5	135.3	224.7
May	101.0	116.0	169.3
Jun	50.4	47.2	66.7
Jul	27.7	36.8	40.3
Aug	25.8	38.2	43.4
Sep	25.5	35.5	40.0



80%	MFDO - 95 yr Hydromet	MFDO - 10 yr Hydromet	MFDO - 5 yr Hydromet
Oct	10.1	24.1	29.6
Nov	19.3	33.1	35.3
Dec	27.7	39.2	33.8
Jan	37.1	64.5	57.3
Feb	48.9	48.9	46.1
Mar	63.5	68.3	73.7
Apr	63.5	69.7	80.2
May	36.9	45.3	77.4
Jun	21.9	34.4	36.2
Jul	10.3	30.1	33.3
Aug	8.0	31.1	36.8
Sep	7.0	27.1	33.2



Alternative Datasets Available to Reclamation

In 2003, Reclamation developed a monthly time step Modsim model of the Rogue project which simulated the period 1962 through 1999. The unregulated flows developed for the 2003 model were not used in this analysis because the intra-monthly variations in flow relevant to the availability of fish habitat required a daily time step.

Also, the 2003 model did not have the spatial resolution required. Additional gages came online since 1999 which provide better spatial coverage of streamflows. With better spatial coverage, better estimates can be made of reach gains and losses and where they occur so that a finer resolution of flow can be developed for the reaches with instream flow requirements. The location of each reach gain and loss is critical because it affects the need to release water from storage to satisfy minimum flows and meet diversions.

Statistics on streamflows simulated using the 2003 monthly model may differ from the statistics on streamflows simulated using the daily time step model. The daily time step model simulates only the 10 years prior to 2011, whereas the 2003 monthly model simulates 36 years of record prior to 1999. Since the 2003 model was calibrated to many of the same gages used in this study's model, unregulated flows would have been similarly calculated. However, further analysis would be required to determine if any differences between the monthly and daily simulations are due to: the statistical significance of a 10 year sample compared to a 36 year sample of hydrology, shifts in hydrology since 1999, differences in operations since 1999, or the improved ability of the new model to resolve flows temporally and spatially.

Period of Simulation

This model simulates reservoir and streamflow conditions from March 31, 2001 through August 28, 2011. Due to the short simulation period, a portion of the simulation is affected by reservoir starting conditions. As a result, this 10 year period of simulation cannot identify all system impacts or define their extent. Nonetheless, these simulations can be used to answer questions such as: "What would reservoir conditions have been in August 2011 if new minimum flow requirements had been implemented starting in 2001?"

MODELED SCENARIOS

This section describes the simulation scenarios used to evaluate reservoir storage and streamflows for each alternative.

The following regulation scenarios were developed:

1) **Without Reclamation**, in which only facilities not owned by Reclamation were allowed to operate. This scenario reflects the streamflow that would have occurred without Reclamation's projects. The Without Reclamation scenario does not impose minimum flow requirements.
2) **BOR Proposed Action**, in which system operations were governed by current practices and the minimum flow requirements of the 2009 Biological Assessment (BA). Refer to Table 4. The Proposed Action scenario was used as a reference scenario for comparison to other action scenarios.
3) **NMFS RPA**, in which minimum streamflow requirements from NMFS's May 2011 draft BiOp were applied below Emigrant Dam (EMI QD), Bear Creek below Ashland Creek (BASO), Bear Creek at Medford (MFDO), and South Fork Little Butte Creek at Gilkey (GILO). Refer to Table 5.
4) **BOR Alternative 1.1**, in which alternative minimum streamflow requirements were applied below Emigrant Dam (EMI QD) and South Fork Little Butte Creek at Gilkey (GILO). Refer to Table 6.
5) **BOR Alternative 1.2**, in which alternative minimum streamflow requirements were applied below Emigrant Dam (EMI QD), Bear Creek below Ashland Creek (BASO), Bear Creek below Phoenix Diversion near Talent (BCTO), and South Fork Little Butte Creek at Gilkey (GILO). Refer to Table 7.

Dry, Average, and Wet System States

For this study, total reservoir storage for Emigrant, Howard Prairie, and Hyatt Reservoirs is used as an indicator of the relative system state - dry, average, or wet. Total storage is more informative than historical snowpack, naturalized streamflows, or runoff forecasts because the system relies on transbasin deliveries (from South Fork Little Butte Creek and the Klamath Basin), and the Howard Prairie Delivery Canal limits the rate water can be delivered to Emigrant Reservoir.

A dry, average, or wet system state was determined at the beginning of each day of simulation using the sum of storage in Emigrant, Howard Prairie, and Hyatt Reservoirs. The definitions of system states were based on observed system storage from water years 1992 through 2010. The upper and lower limits were defined as the average observed system storage on that day, ± 15,000 acre-feet. Dry conditions were anything less than average minus 15,000 acre-feet and wet conditions were anything greater than average plus 15,000 acre-feet. Figure 1 shows these storage conditions for water years 1992 through 2010 and the boundaries defined for dry and wet system states.

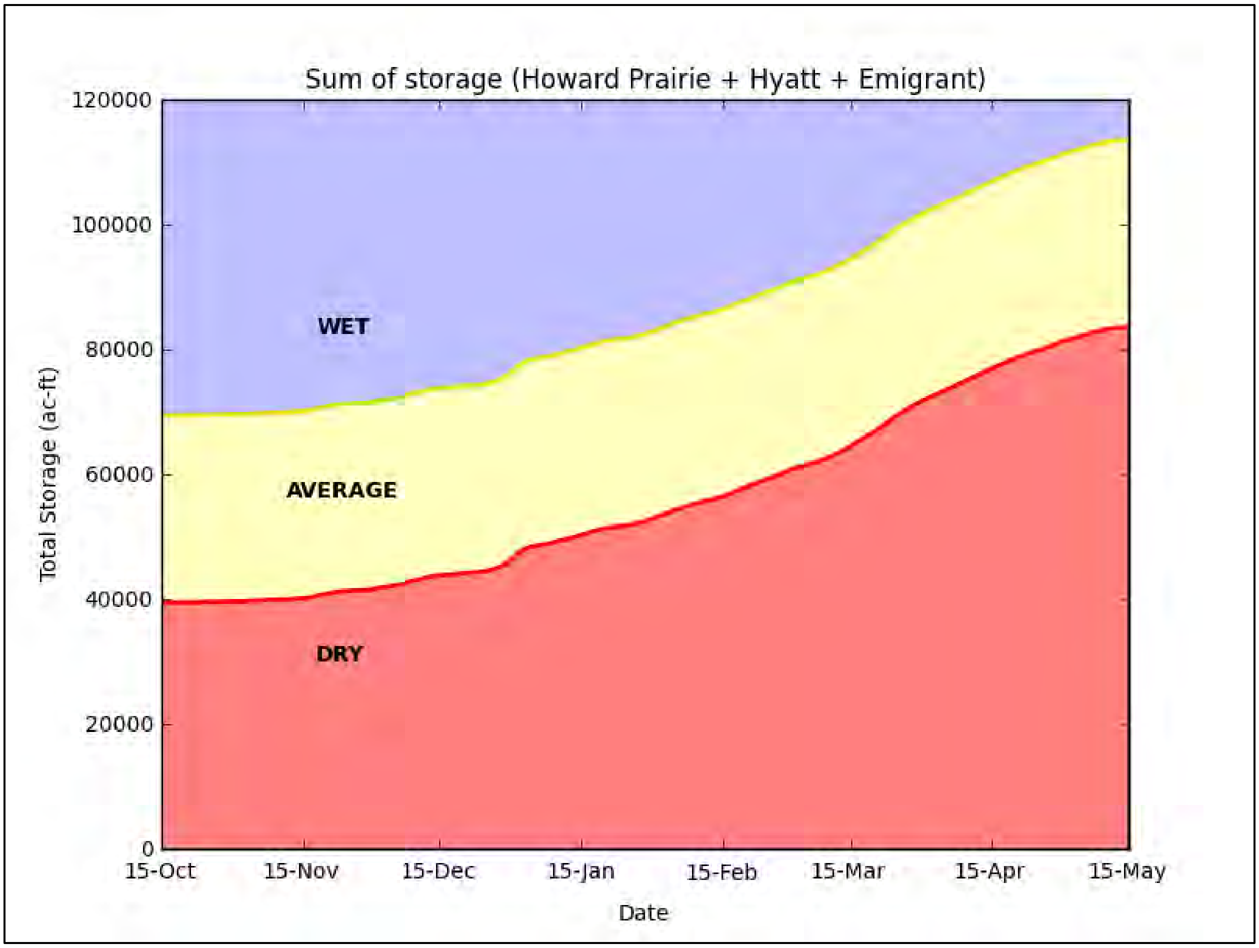


Figure 1. Observed daily average storage conditions ±15,000 acre-feet for water years 1992 through 2010 (yellow shaded region or average region) and the upper boundary for dry conditions (red line) and the lower boundary for wet conditions (yellow line).

Minimum flow requirements for each day of the simulation were determined by the system state for that day. One consequence of this approach is that increases in water demand due to changes in minimum flow targets affect the total supply of water in the reservoirs, and thus the system state. Because the minimum flow targets under a dry system state are lower than under an average or wet system state, higher minimum flow demands under average reservoir conditions can over time paradoxically result in lower instream flows. As the system shifts to a lower system state due to the higher minimum flow demands, since average conditions occurred a greater percent of time in the model. This did not occur in BOR Alternative 1.2, but did occur in NMFS's RPA scenario.

The time each scenario spends in each system state is shown graphically in Figure 2 and percentages provided in Table 3.

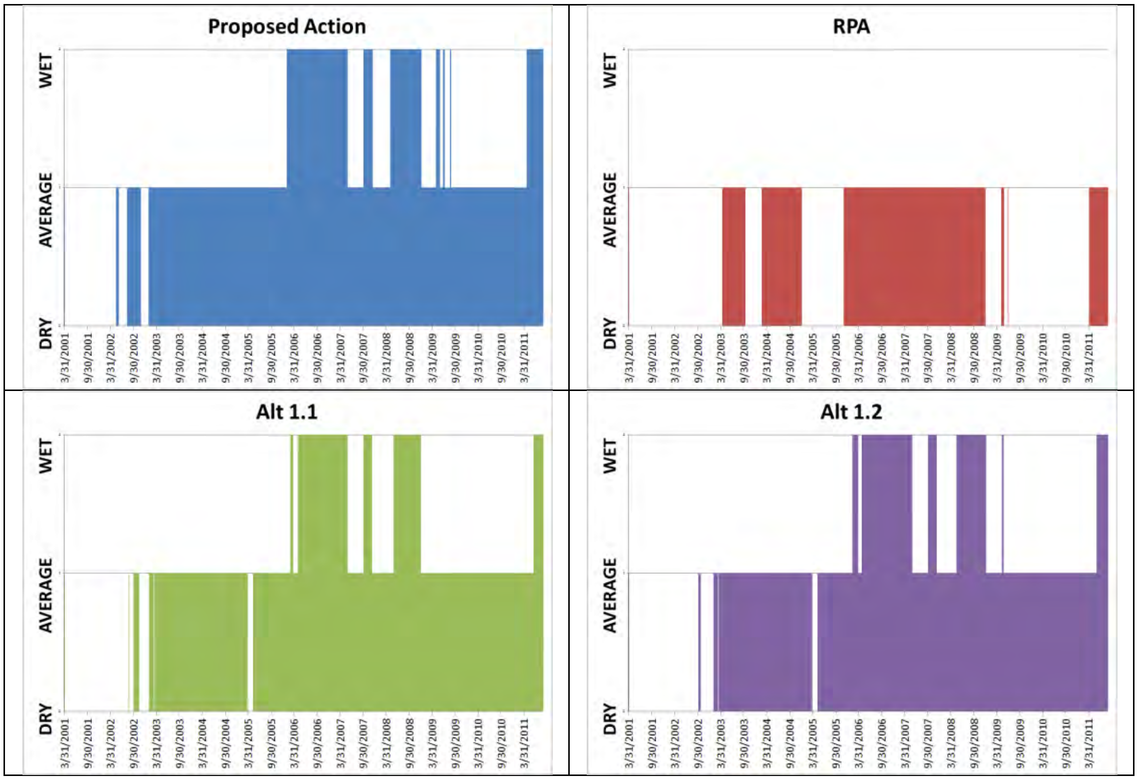


Figure 2. The time each scenario spends in each system state (dry, average, or wet) for the simulation period.

Table 3. Percent of time each scenario spends in each system state for the simulation period

System State/Scenario	Proposed Action	RPA	Alt 1.1	Alt 1.2
Dry	14%	53%	18%	19%
Average	60%	47%	62%	59%
Wet	25%	0%	20%	22%

Minimum Streamflow Requirements

The minimum flow requirements for the Proposed Action scenario are shown in Table 4, for the RPA in Table 5, for Reclamation's Alternative 1.1 in Table 6, and for Reclamation's Alternative 1.2 in Table 7. In the Proposed Action, Alternative 1.1, and 1.2 scenarios a 10 cfs minimum flow is requested at Bear Creek at Medford (MFDO) to act as carriage water to aid the delivery of water throughout Bear Creek. The 10 cfs carriage water is not necessary in the RPA scenario because a minimum flow requirement greater than 10 cfs is already requested at that location.

Minimum flow requests are first met by natural flow and stored water which is already flowing in the reach to meet other demands downstream. If that is not enough, water is released from the reservoirs to meet the request.

Table 4. Proposed Action minimum flow requirements (cfs) by system state. The request at MFDO is not required by the BA, but provides operational carriage water.

Proposed Action (2009 BA)						
	EMI (required)			MFDO (operational)		
Month	dry	average	wet	dry	average	wet
Jan	2	3	6	10	10	10
Feb	2	3	6	10	10	10
Mar	2	3	6	10	10	10
Apr	2	3	6	10	10	10
May	2	3	6	10	10	10
Jun	2	3	6	10	10	10
Jul	2	3	6	10	10	10
Aug	2	3	6	10	10	10
Sept	2	3	6	10	10	10
Oct	2	3	6	10	10	10
Nov	2	3	6	10	10	10
Dec	2	3	6	10	10	10

Table 5. RPA minimum flow requirements (cfs) by system state.

NMFS draft BiOp May 2011 (RPA)												
	EMI			BASO			MFDO			GILO		
Month	dry	average	wet	dry	average	wet	dry	average	wet	dry	average	wet
Jan	2	25	25	30	35	35	50	65	65	25	85	85
Feb	2	20	25	25	30	30	40	65	65	35	85	85
Mar	2	20	25	25	30	30	40	65	65	35	110	110
Apr	2	20	25	25	30	30	35	65	65	60	110	110
May	2	20	25	25	30	30	35	65	65	40	80	80
Jun	2	3	6	15	30	30	20	50	50	30	45	45
Jul	2	3	6	15	25	25	20	40	40	15	30	30
Aug	2	3	6	10	20	20	20	25	25	12	20	20
Sept	2	3	6	7	15	15	20	25	25	12	15	15
Oct	2	3	6	7	15	15	15	25	25	20	30	30
Nov	2	25	25	10	25	25	20	40	40	20	30	30
Dec	2	25	25	15	35	35	40	55	55	25	30	30

Table 6. Reclamation's Alternative 1.1 minimum flow requirements (cfs) by system state. The request at MFDO is not required by Alternative 1.1, but provides operational carriage water.

Alternative 1.1 (ALT1.1)									
	EMI			GILO			MFDO (operational)		
Month	dry	average	wet	dry	average	wet	dry	average	wet
Jan	2	10	12	15	40	40	10	10	10
Feb	2	10	12	20	40	40	10	10	10
Mar	2	10	12	25	70	70	10	10	10
Apr	2	9	12	35	80	80	10	10	10
May	2	9	10	30	70	70	10	10	10
Jun	2	3	6	20	30	30	10	10	10
Jul	2	3	6	15	20	20	10	10	10
Aug	2	3	6	10	15	15	10	10	10
Sept	2	3	6	10	15	15	10	10	10
Oct	2	3	6	10	20	20	10	10	10
Nov	2	6	10	10	20	20	10	10	10
Dec	2	10	12	15	25	25	10	10	10

Table 7. Reclamation's Alternative 1.2 minimum flow requirements (cfs) by system state. A request at MFDO to provide operational water is the same as in Table 6.

Alternative 1.2 (ALT 1.2)												
	EMI			BASO			BCTO			GILO		
Month	dry	average	wet	dry	average	wet	dry	average	wet	dry	average	wet
Jan	2	10	12	-	-	-	-	-	-	15	25	25
Feb	2	10	12	-	-	-	-	-	-	20	25	25
Mar	2	10	12	-	-	-	-	-	-	25	55	55
Apr	2	9	12	25	30	30	30	40	40	40	75	75
May	2	9	10	25	30	30	20	20	20	40	60	60
Jun	2	3	6	15	20	20	10	12	12	15	25	25
Jul	2	3	6	5	12	12	8	10	10	10	15	15
Aug	2	3	6	3	6	6	5	8	8	8	12	12
Sept	2	3	6	3	6	6	5	8	8	8	10	10
Oct	2	3	6	3	8	8	8	12	12	8	10	10
Nov	2	6	10	-	-	-	-	-	-	10	15	15
Dec	2	10	12	-	-	-	-	-	-	15	20	20

Water Rights and Storage Contracts

Under Alternative 1.1, Alternative 1.2, RPA, and Proposed Action scenarios non-project natural flow is diverted in priority to meet diversion requests. Natural flow is measured at the point of diversion at Ashland Lateral (ASLO), East Lateral (EMI QJ), Talent Lateral (TID), Phoenix Canal (PHXO), and Bear Creek Canal (BCCO). Storage rights are natural flow rights used to fill Emigrant, Howard Prairie, and Hyatt Reservoirs. Storage rights compete in priority with other natural flow rights for diversion. Table 8 shows the natural flow rights modeled.

After diversion requests have exhausted the available natural flow, water users rely on the delivery of project stored water (contract water), if water is available in the respective storage account. Stored water is measured at the point of diversion. When water is diverted, it is debited from the user’s storage account. Carryover from year to year is allowed. If a reservoir fails to fill, the shortfall is prorated across all accounts. Therefore, the burden of flood control releases, evaporation, and minimum streamflow requests is shared.

Table 9 shows the storage accounts maintained in the model.

Table 8. Modeled Natural Flow Rights

	Priority Date	***Rate/ Capacity***	***Owner***	***Allowed diversion dates***	***Comments***
Little Butte Creek					
South Fork	1909	100 cfs	MID, RRVID	1Apr - 31Oct	not explicitly modeled; no data are available to determine current diversion rates
Little Butte Creek below confluence	~1800	24 cfs	others	1Apr - 31Oct	
Bear Creek					
	1Mar 1915	60 cfs	MID		Phoenix capacity = 60 cfs
	24Jun 1913	42.5 cfs	RRVID		Jackson St Diversion capacity = 42.5 cfs
	31Jul 1915	28 cfs	TID		Ashland Crk; Neil Crk, point of diversion on Bear Creek
	~1860 - 1888	un-known			not explicitly modeled; no data are available to determine current diversion rates; likely satisfied by return flows; implicitly described in the modeled water supply, but in alternatives with no return flows these rights may not be adequately modeled
Storage Rights					
Emigrant	6Sep 1915	36658 AF	USBR		This includes Hyatt stored water as well as natural flow.
Emigrant	27Jan 1920	40 cfs; 2342 AF	TID		Modeled as additional capacity to the 6Sep1915 USBR right to fill Emigrant because it is included in the 7.39% preferred capacity in the contract
Howard Prairie	6Sep 1915	60600 AF	USBR	1Nov-31May	
South Fork Little Butte Creek	23May 1912	60 cfs	TID	year round	contributes to Howard Prairie
Hyatt	31Jul 1915	16200 AF, 136 cfs	TID	1Nov-31May	Keene Crk water right; 100 cfs of the 136 is also Green Spring Power Plant's right; that 100 cfs is natural flow for Ashland Lateral, but is allowed to be stored and delivered at a later date

Table 9. Modeled Storage Accounts

	share	capacity (acre-feet)	Comments
Howard Prairie, Hyatt and Emigrant combined		**115,800**	
Talent ID preferred	7.3939 %	8,559	provided 'first fill'
Medford ID	7.5151 %	8,698	
Rogue River Valley ID	3.7676 %	4,349	
Talent ID	81.3434 %	94,193	

Irrigation Diversions

Simulated irrigation diversion requests are the same as what was diverted historically at Ashland Lateral (ASLO), East Lateral (EMI QJ), Talent Lateral (TID), Phoenix Canal (PHXO), and Bear Creek Canal (BCCO) Canals. Diversion requests are first met by natural flow rights and then, if that is not enough, by storage contract if available.

Transbasin Diversions

In the model, water is diverted from South Fork Little Butte Creek at South Fork Little Butte Creek Collection Canal (SLBO) and the Dead Indian Collection Canal (DICO) into Howard Prairie Reservoir, but may differ from historical diversions due to the minimum flow request at South Fork Little Butte Creek at Gilkey (GILO).

A 10% channel loss is simulated below Soda Creek at Howard Prairie Delivery Canal (SDCO) and Beaver Creek at Howard Prairie Canal (BCSO) and above Keene Creek Reservoir in the Howard Prairie Delivery Canal year round.

Return Flows

Return flows are surface and subsurface waters which originate from delivery channel losses and irrigation inefficiencies. Return flows return to locations either on the river, in the reservoir, or to neighboring lands. Table 10 and Table 11 show the fractions of diversion assumed to return and the locations where the returns enter the river or reservoir[4]. Each daily return was temporally distributed over a 3 month period.

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[4] The approach used to estimate return flows is described in Appendix A. *Unregulation of Bear and Little Butte Creeks.*

For example, if today is May 20 and ASLO diverts 10 cfs, a total of 4.4 cfs would eventually return to the river (Table 10). Of that 4.4 cfs, 54% or 2.37 cfs would return to the river in the reach above BCAO and below Emigrant Dam (Table 11). The 2.37 cfs would then return over a 3 month period, so that only 0.059 cfs would return today, 0.054 cfs would return tomorrow, and 0.052 cfs would return the next day, etc. The numbers on a daily basis are small, but add up as diversions through the irrigation season contribute daily. Methods to estimate return flows are covered in greater detail in Appendix A.

Table 10. Fraction of diversion that eventually returns to the river. For example, 23% of the water diverted at ASLO in September, eventually returns to the river.

Fraction of Diversion that Eventually Returns to the River					
	ASLO	East Lateral	TALO	PHXO	BCCO
March	0	0	0	0	0
April	0	0	0	0.45	0.45
May	0.44	0.42	0.42	0.45	0.45
June	0.38	0.37	0.37	0.45	0.45
July	0.22	0.15	0.15	0.45	0.45
August	0.21	0.25	0.25	0.45	0.45
September	0.23	0.29	0.29	0.45	0.45
October	0	0	0	0.45	0.45
November	0	0	0	0	0

Table 11. Return locations for the fraction of diversion that eventually returns to the river. For example, of the 23% of water diverted at ASLO in September (see Table 10), 54% of that eventually returns to the river in the reach above BCAO and below EMI and 46% returns directly into Emigrant Reservoir.

Spatial Distribution of the Fraction of Diversion in Table 10		
ASLO	above BCAO and below EMI 0.54	directly into EMI Reservoir 0.46
East Lateral	above PHXO and below BASO 0.62	above TALO, below BCAO 0.38
TALO	above BCTO and below BASO 1	
PHXO	above BCMO and below BJBO 1	
BCCO	above BCMO and below BJBO 1	

Reservoir Operations

Reservoirs fill in priority using the natural flow storage rights in Table 8. Howard Prairie Reservoir also receives transbasin diversion from the South Fork of Little Butte Creek.

Emigrant elevations were limited each day by the flood control rule curve from January 1 through April 30.

Water was released from reservoirs to meet historical diversions, minimum streamflow requests, and system losses, if natural flow did not satisfy these requests. For the Proposed Action scenario, which is most like current operations, this simulation approach produced higher elevations in Emigrant Reservoir than observed in 2001. The effects of this first year advantage carry through the 10 year simulation (see Figure 3).

Reservoir operations were balanced to rely on Howard Prairie to meet the majority of release requests. The first priority was to protect the lowest 17% of Emigrant storage from draft. Next, the lowest 25% of Hyatt and Howard Prairie Reservoirs were protected from draft. Water was released from Howard Prairie first, unless channel capacities and the 25% guideline would have been violated. Then water was released from Hyatt, unless channel capacities and the 25% guideline would have been violated. Lastly, water was released from Emigrant. This approach is not necessarily practiced in real world operations, but was developed during the calibration process.

Reservoir evaporation for Emigrant, Hyatt, Howard Prairie, and Keene Creek Reservoirs was calculated at the end of each day using modeled surface area and pan evaporation.

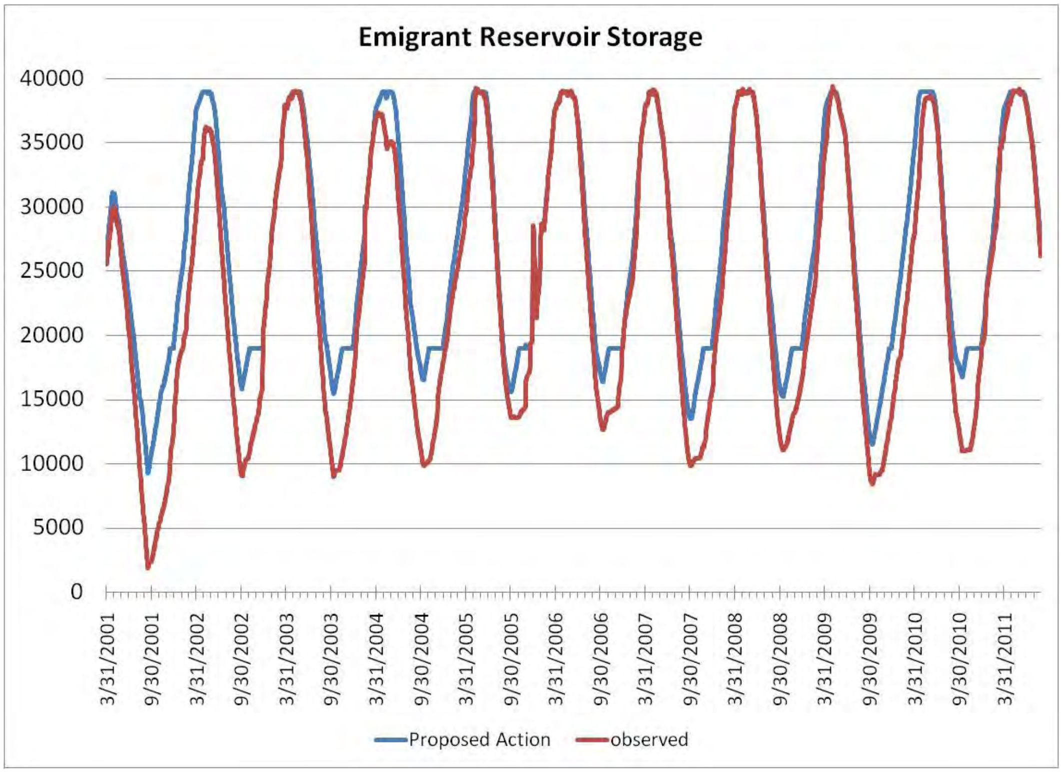


Figure 3. Emigrant Reservoir storage for the Proposed Action scenario compared to observed storage. The knee in the modeled data occurs because the reservoir fills until it meets the rule curve in late November and then passes inflow until the rule curve allows it to fill again on January 1.

Calibration

The model has been calibrated to the available data for observed streamflows, diversions, and reservoir contents[5]. Where data were not available, an attempt was made to estimate the data through correlations with other sources. Appendix B describes the calibration in greater detail.

[5] Graphs demonstrating model calibration are shown in Appendix B. *Model Calibration Graphs.*

RESULTS

In all scenarios, diversion requests and minimum flow requests were fully met, with the exception of the flow requests at South Fork Little Butte Creek at Gilkey (GILO).

Total System Storage

Total simulated system storage for the Proposed Action, RPA, Alternative 1.1, and Alternative 1.2 scenarios is shown in Figure 4.

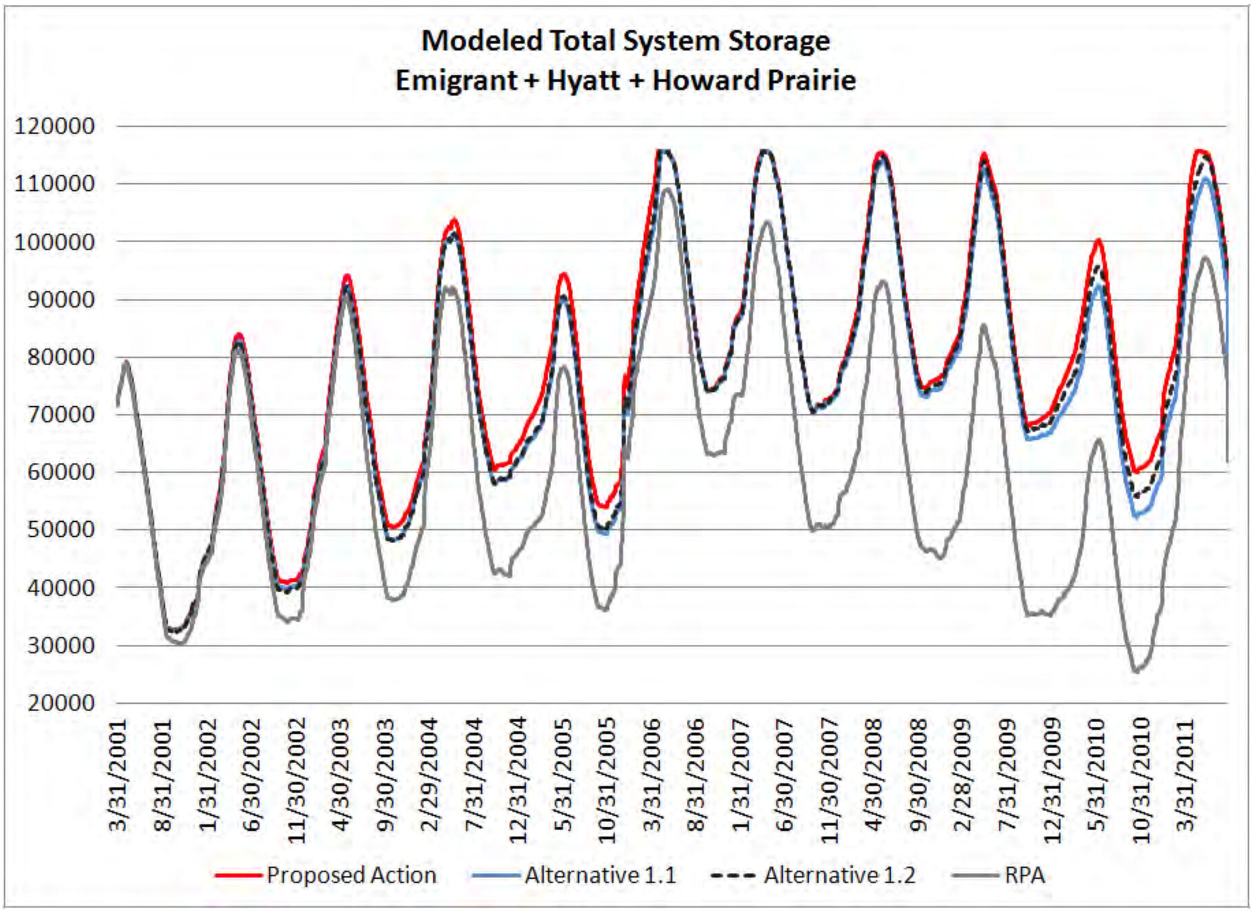
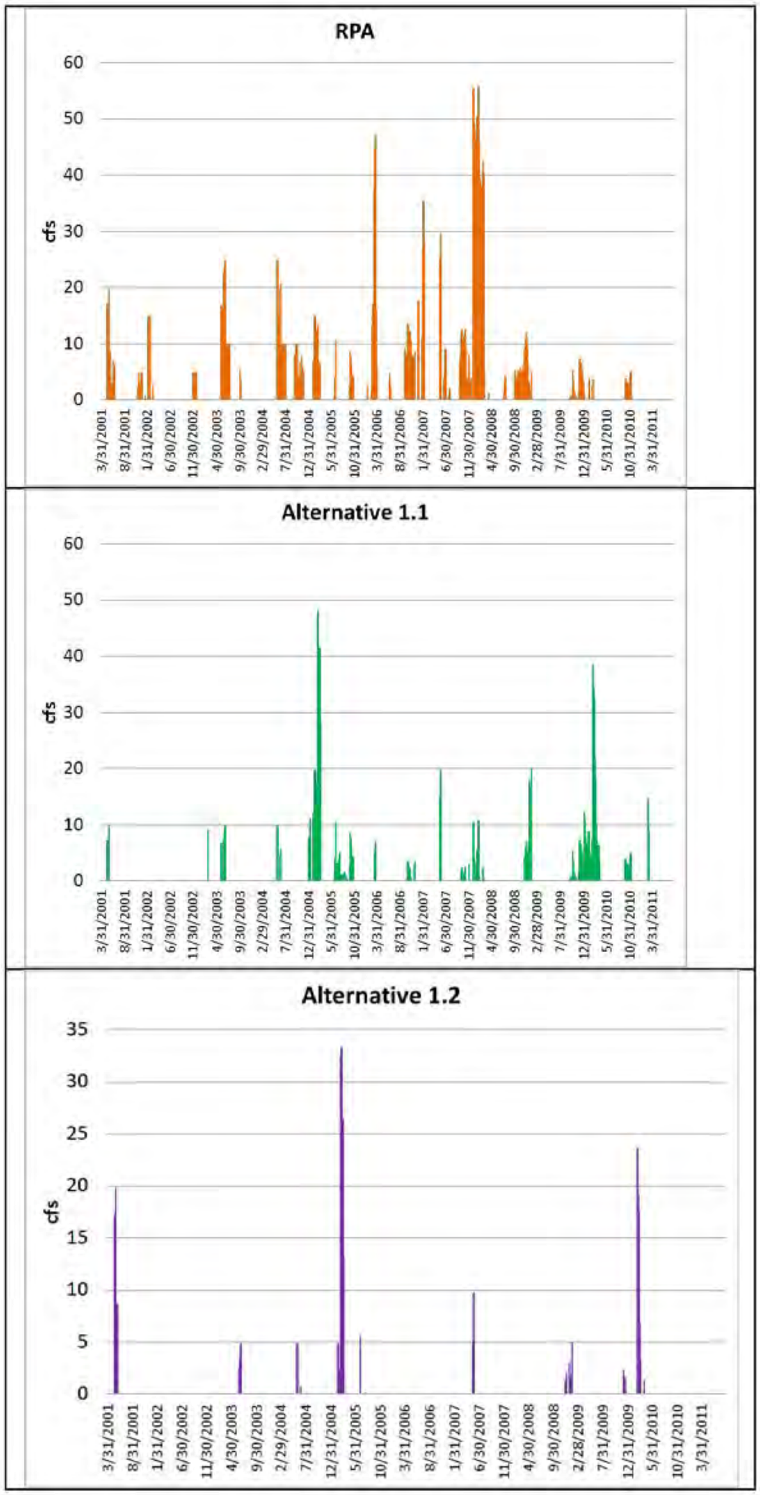


Figure 4. Modeled total system storage for the three action scenarios.

Shortages to Minimum Flow Requests at GILO

Shortages to the minimum flow requests at South Fork Little Butte Creek at Gilkey (GILO) are shown in Table 12. Instream flow requests are only shorted when the natural flow at GILO is less than the flow request.

Table 12. Shortages to the minimum flow requests at South Fork Little Butte Creek at Gilkey (GILO) for RPA, Reclamation's Alternative 1.1 and Alternative 1.2 scenarios. GILO observed discharge data start on 3/28/2005, so simulated values prior to that date are based on inflow estimates to the South Fork of Little Butte Creek watershed.



Appendix A. Unregulation of Bear and Little Butte Creeks

INTRODUCTION

The first step in constructing a river and reservoir simulation model is the development of an unregulated streamflows dataset. Unregulation is the process of removing regulation (or man-made developments) from the observed hydrologic data. An unregulated river can be used as an approximation of the natural river, but the approximation is limited by the availability of measured values for all discharge, reservoir storage, diversion, return flow, and other processes which alter natural hydrology.

The period of study is March 31, 2001 through August 28, 2011. Before 2001 many of the gages necessary to unregulate Bear, Emigrant, and Little Butte Creeks did not exist. Additional gages were installed beginning in 2002 and 2006, therefore missing data needed to be developed for some river reaches to complete the ten year dataset. Limitations of the unregulation are summarized in the final section of this report.

Daily local inflows (also called gains/losses) were calculated independently for the RiverWare and Modsim models of the Rogue Project. Although the methods and results are similar, this paper describes the data and methods used for the Modsim model. Unregulated flows were developed at gage locations by summing local inflows, starting at the head waters. Unregulated flows were developed in a spreadsheet[6], with return flow contributions calculated by Modsim and entered into the spreadsheet.

A tea cup diagram of the Rogue Project with gage locations is shown in Figure 5.

[6] Refer to file: unreg9_with_NegQUs.xlsx

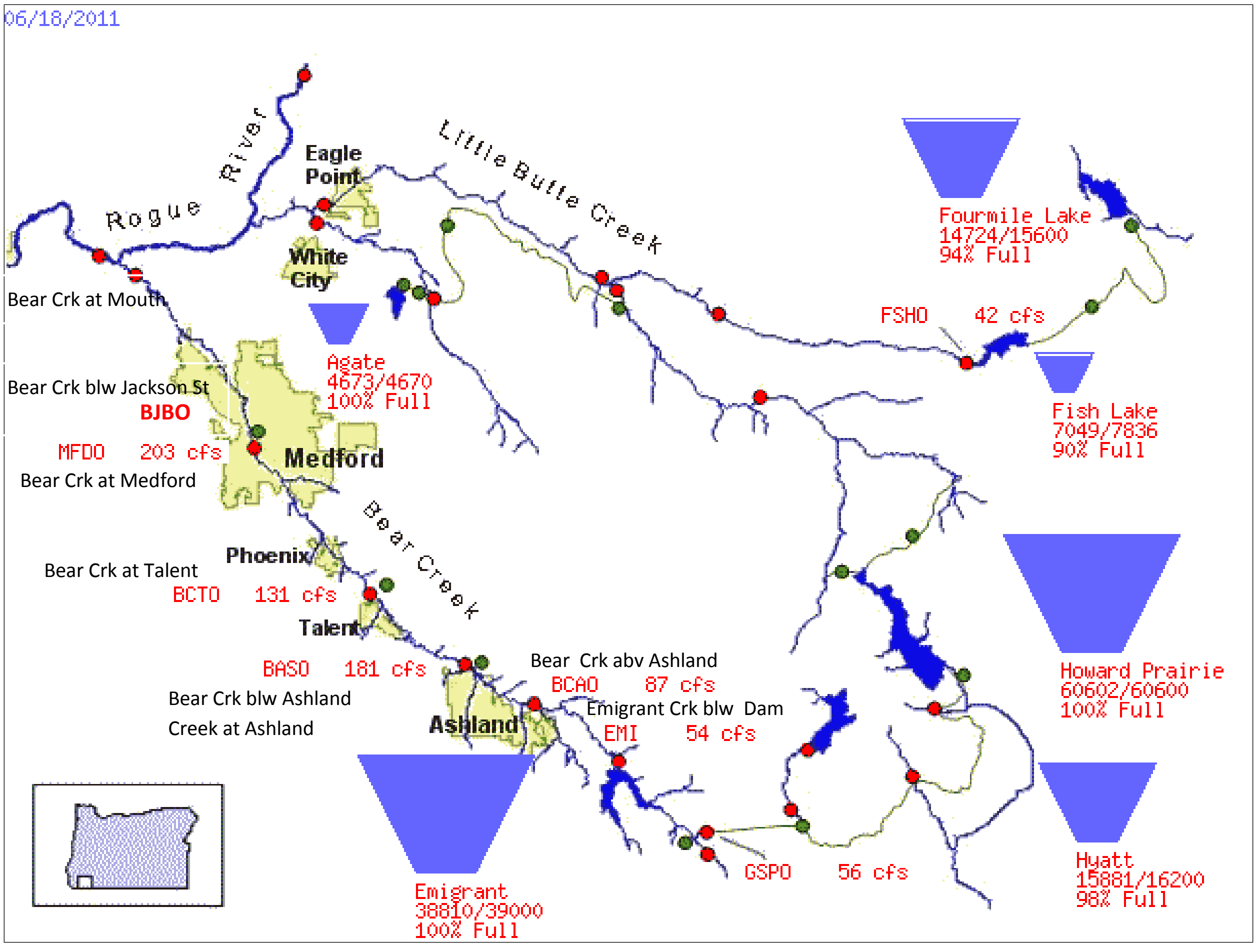


Figure 5. Tea Cup diagram of Rogue Project, showing the gages on Emigrant and Bear Creeks used in the unregulation.

Bear Crk at Medford

METHODS TO CALCULATE DAILY LOCAL INFLOWS

Mass Balance. Daily local inflows were calculated using a mass balance approach (also called a water budget): measured inflows to an upstream gage plus other measured or estimated sources must equal outflows at the next downstream gage plus diversion and other measured or estimated sinks. The differences between the left hand and right hand sides of the equation are the local inflows or losses. Local inflows and losses are intended to represent contributions to the reach from unmeasured creek flows, but also include unmeasured diversion, seepage, surface and subsurface drainage from irrigated lands, groundwater flux, gage error, and travel time.

Measured discharge and reservoir data are available from http://www.usbr.gov/pn/hydromet/.

Measurement locations are shown in Table 13. Measurement start dates are shown if measurements were initiated after March 31, 2001. Refer to the sections in this document Estimated Local Inflows and Missing Local Inflows for information on how data was developed in areas with little historic information.

Table 13. Measured data used in unregulation of Bear, Emigrant, and Little Butte Creeks.

Measurement Location	start date (if later than 3/31/2001)
Reservoir Elevation and Storage	
Howard Prairie Reservoir (HPD AF) acre-feet	
Hyatt Reservoir (HYA AF) acre-feet	
Keene Creek Reservoir (HPCO AF) acre-feet	
Emigrant Lake (EMI AF) acre-feet	
Transbasin Diversion	
South Fork Little Butte Creek Collection Canal (SLBO QJ) cfs	
Dead Indian Collection Canal (DICO QJ) cfs	
Klamath Basin	
Howard Prairie Delivery Canal blw Howard Prairie (HPD QJ) cfs	
Howard Prairie spill (HPD QD) cfs	
Howard Prairie Delivery Canal (HPCO QJ) cfs	
Howard Prairie Delivery Canal Spill (HPCO QD) cfs	
Soda Creek at Howard Prairie Delivery Canal (SDCO QD) cfs	
Beaver Creek at Howard Prairie Canal (BCSO QD) cfs	
Hyatt Dam (HYA QD) cfs	
Green Springs Power Plant near Ashland (GSPO QD) cfs	
Emigrant and Bear Creeks	
Emigrant Crk Abv Green Springs (EGSO QD) cfs	12/16/2002
Emigrant Crk blw EMI (EMI QD) cfs	
Emigrant Crk Spill (EMI QSD and estimated from RiverWare)	
Bear Creek abv Ashland (BCAO) cfs	7/19/2005
Bear Crk blw Ashland Crk (BASO) cfs	
Bear Crk blw Phoenix Diversion at Talent (BCTO) cfs	5/29/2003
Bear Crk at Medford (MFDO QD)	
Bear Creek blw Jackson St Div (BJBO) cfs	7/19/2005
Bear Creek at Mouth below Central Point (BCMO) cfs	7/19/2005
North and South Fork Little Butte Creeks	
North Fork Little Butte Creek at Hiway 140 (NFLO QD) cfs	7/29/2003
South Fork Little Butte Creek at Gilkey (GILO) cfs	3/28/2005
South Fork Little Butte Creek at Mouth (SFLO QD) cfs	3/28/2005
Little Butte Creek (LBCO QD) cfs	5/15/2002
Little Butte Creek blw Eagle Point (LBEO QD) cfs	2/1/2006
Diversions	
Ashland Lateral (ASLO QJ) cfs	
Emigrant Dam Div (EMI QJ) cfs	
Talent Lateral nr Ashland (TALO QJ) cfs	
Phoenix Canal at Talent (PHXO QJ) cfs	
Bear Creek Canal at Medford (BCCO QJ) cfs	
NF Little Butte Creek Canal (NFBO QJ) cfs	
SF Little Butte Creek Canal (SFBO QJ) cfs	5/29/2002

Return Flow Estimates. Return flows are surface and subsurface waters which originate from delivery channel losses and irrigation inefficiencies. Return flows return to locations either on the river, in the reservoir, or to neighboring lands.

Quantities of return flows were originally estimated for the 2003 Biological Opinion using distribution and application efficiencies and irrigated acreage from the now-outdated Water Conservation Plans. Return locations were determined through conversations with the Districts and consideration of surface elevation contours. The 2003 study used monthly data through 1999, but return flow quantities and locations were re-evaluated for this study using the following approach: Initial local inflows were calculated without incorporating return flows. If an initial local inflow peaked or remained high late in the irrigation season or followed a temporal pattern similar to diversions, it was assumed a component of that local inflow was due to return flows. The spatial distribution of returns used in the 2003 study was then adjusted to contribute more or less to each reach, until local inflows achieved the appearance of a more natural runoff pattern. The percentages of diversions which return were kept similar to the 2003 study, with the exception of some reductions during the 2001 irrigation season. Precise return flow calculations are not possible (and somewhat subjective), however this method maintains mass balance in each reach and mass balance for the total system. Table 14 and Table 15 show the fractions of diversion assumed to return and the locations where the returns enter the river or reservoir.

Each daily return was temporally distributed over a 3 month period. The temporal pattern applied works for most soil and subsurface conditions: 4/7 of the return flow returns during the current month, 2/7 during the 2^{nd} month, and 1/7 during the 3^{rd} month. In the absence of better information, this pattern has been consistently applied in models developed for Reclamation's Pacific Northwest Region and elsewhere. The monthly percentages were interpolated and smoothed to develop daily values over a three month period.

For example, using Table 14 and Table 15 and the temporal distribution described above, if today is May 20 and ASLO diverts 10 cfs today, a total of 4.4 cfs would eventually return to the river. Of that 4.4 cfs, 54% or 2.37 cfs would return to the river in the reach above BCAO and below Emigrant Dam (Table 15). Then that 2.37 cfs would return over a 3 month period, so that only 0.059 cfs would return today, 0.054 cfs would return tomorrow, and 0.052 cfs would return the next day, etc. The numbers on a daily basis are small, but add up as diversions through the irrigation season contribute daily.

Table 14. Fraction of diversion that eventually returns to the river. For example, 23% of the water diverted at ASLO in September, eventually returns to the river.

Fraction of Diversion that Eventually Returns to the River					
	ASLO	East Lateral	TALO	PHXO	BCCO
March	0	0	0	0	0
April	0	0	0	0.45	0.45
May	0.44	0.42	0.42	0.45	0.45
June	0.38	0.37	0.37	0.45	0.45
July	0.22	0.15	0.15	0.45	0.45
August	0.21	0.25	0.25	0.45	0.45
September	0.23	0.29	0.29	0.45	0.45
October	0	0	0	0.45	0.45
November	0	0	0	0	0

Table 15. Return locations for the fraction of diversion that eventually returns to the river. For example, of the 23% of the water diverted at ASLO in September (see Table 14), 54% of that eventually returns to the river in the reach above BCAO and below EMI and 46% returns directly into Emigrant Reservoir.

Spatial Distribution of the Fraction of Diversion in Table 14		
ASLO	above BCAO and below EMI 0.54	directly into EMI Reservoir 0.46
East Lateral	above PHXO and below BASO 0.62	above TALO, below BCAO 0.38
TALO	above BCTO and below BASO 1	
PHXO	above BCMO and below BJBO 1	
BCCO	above BCMO and below BJBO 1	

Evaporation. Reservoir evaporation for Emigrant, Hyatt, Howard Prairie, and Keene Creek Reservoirs was calculated for each day using:

evaporation = end-of-day surface area x 0.7 x pan evaporation.

Daily pan evaporation was developed using interpolation and smoothing of average monthly pan evaporation at Medford Experiment Station (http://www.wrcc.dri.edu/htmlfiles/westevap.final.html). Elevation/Capacity/Area curves can be found in Reclamation's Standard Operating Procedures.

Negative Unregulated Reach Flows. The unregulation approach described here produces some negative local inflows (also called losses or negative gains) which may add up to create negative unregulated reach flows. Negative reach gains preserve mass balance and account for reservoir bank storage, reach and reservoir travel time, reservoir wind effects, measurement error, and ungaged diversions and are necessary for accuracy in model development. Travel time may be the most significant contributor to negative reach gains, since the unregulation approach and the subsequent simulation models do not attempt to attenuate or shape local inflows for routing. Although short term negative unregulated flows present a problem for analysts who want to use unregulated flows as an approximation of naturalized flows, the simulation scenarios (such as all those included in the Modeled Scenarios Section p.6 of the main document) do not experience negative reach flows. Figure 6 shows the daily unregulated reach flows below Emigrant Dam and the occurrences of negative unregulated reach flows[7].

[7] All unregulated reach flows are in sheet **'Creek Unreg Details QU (cfs)'** in file unreg9_with_NegQUs.xlsx.

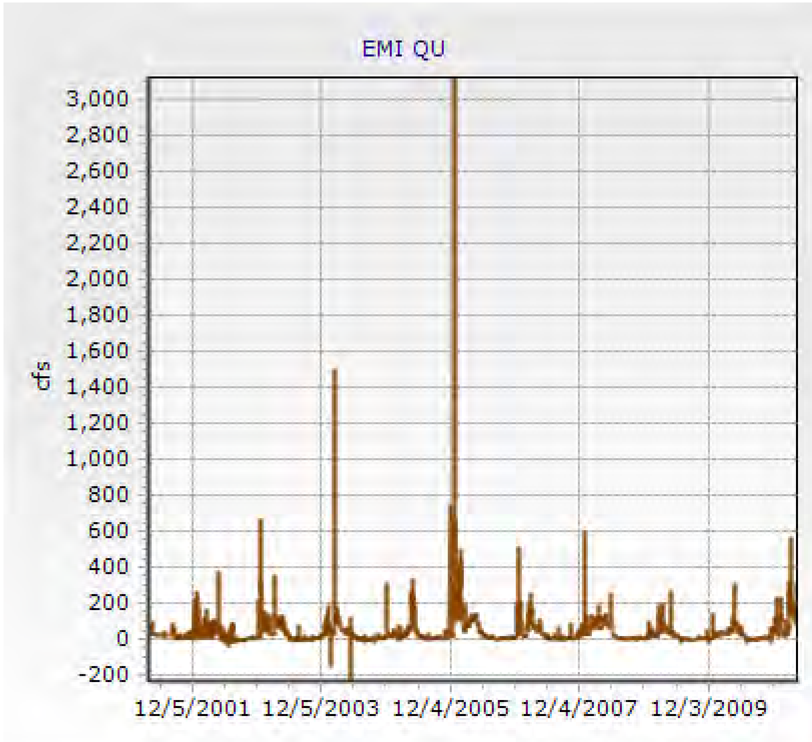


Figure 6. Unregulated streamflow below Emigrant Dam. Unregulated streamflow is not natural flow, but is often used as an approximation of natural flow. Negative values for unregulated flow may create problems for analysts who use unregulated flows as an approximation of natural flow, but do not create problems in simulation of alternatives as they maintain system mass balance.

<u>Estimated Local Inflows for Bear Creek.</u> Local inflows for sub reaches on Bear Creek with incomplete records were estimated by prorating the local inflows from the larger reaches which include them. The river locations affected by these estimates are:

Bear Creek above Ashland (BCAO), prior to July 19, 2005, and
Bear Creek below Phoenix Diversion at Talent (BCTO), prior to May 29, 2003.

The proration ratio used is the median of the daily ratios determined from the period of existing overlapping record. For example, if the existing overlapping record for this study is from July 19, 2005 through April 30, 2011, there are 6 values for August 1 and 6 ratios of the gain for the sub reach over the gain for the larger reach. The median of those 6 ratios is then used to prorate the reach gains for the larger reach prior to July 19, 2005, producing gains for the sub reach.

The proration approach is only an approximation, and if applied to the short period when a complete record exists, it performs poorly. The success of this approximation, however, is that it maintains mass balance for the larger encompassing reach and allows for a continuous simulation.

Missing Local Inflows. Local inflows for the two lower reaches on Bear Creek are incomplete due to missing data and cannot be estimated because there are no measurements further downstream. The river locations affected by missing local inflows are:

Bear Creek below Jackson Street Diversion (BJBO), prior to July 19, 2005, and
Bear Creek at the Mouth (BCMO), prior to July 19, 2005.

Discharge for Green Springs Power Plant. Green Springs Power Plant discharge affects the locals calculated for the Howard Prairie Delivery Canal and the locals entering Emigrant Reservoir. Green Springs measured discharge starts on 7/24/2002, so prior to that, data transcribed from paper records of power production are used.

Estimated Local Inflows for Little Butte Creek. The unregulation of Little Butte Creek and South Fork Little Butte Creek is limited by the lack of data throughout that portion of the system (refer to Figure 7). But, data for nearly the entire period of study exist for the South Fork Little Butte Creek Collection Canal (SLBO), the Dead Indian Canal (DICO), and Little Butte Creek at Lake Creek (LBCO). These locations dominate the water budget.

Caution is advised in using simulated reach flows at South Fork Little Butte Creek at Gilkey (GILO) and South Fork Little Butte Creek at Mouth (SFLO) prior to 3/28/2005 due to missing data. Caution is also advised in using simulated reach flows at Little Butte Creek at Mouth (LBEO) prior to 2/1/2006 due to missing data.

Estimated Local Inflows for South Fork Little Butte Creek at Gilkey. Measured discharge at South Fork Little Butte Creek at Gilkey (GILO) starts on March 28, 2005. Calculated local inflows for the GILO reach prior to this date satisfy only the outflow at DICO, SLBO, SFBO, and LBCO with inflow from NFLO.   After this date, calculated local inflows satisfy the outflow at DICO, SLBO, and GILO and appear to be about 20 cfs greater. Therefore, 20 cfs was entered as an additional gain at GILO prior to March 28, 2005 and the local inflows were recalculated to produce a more natural appearing hydrograph. See Figure 8.

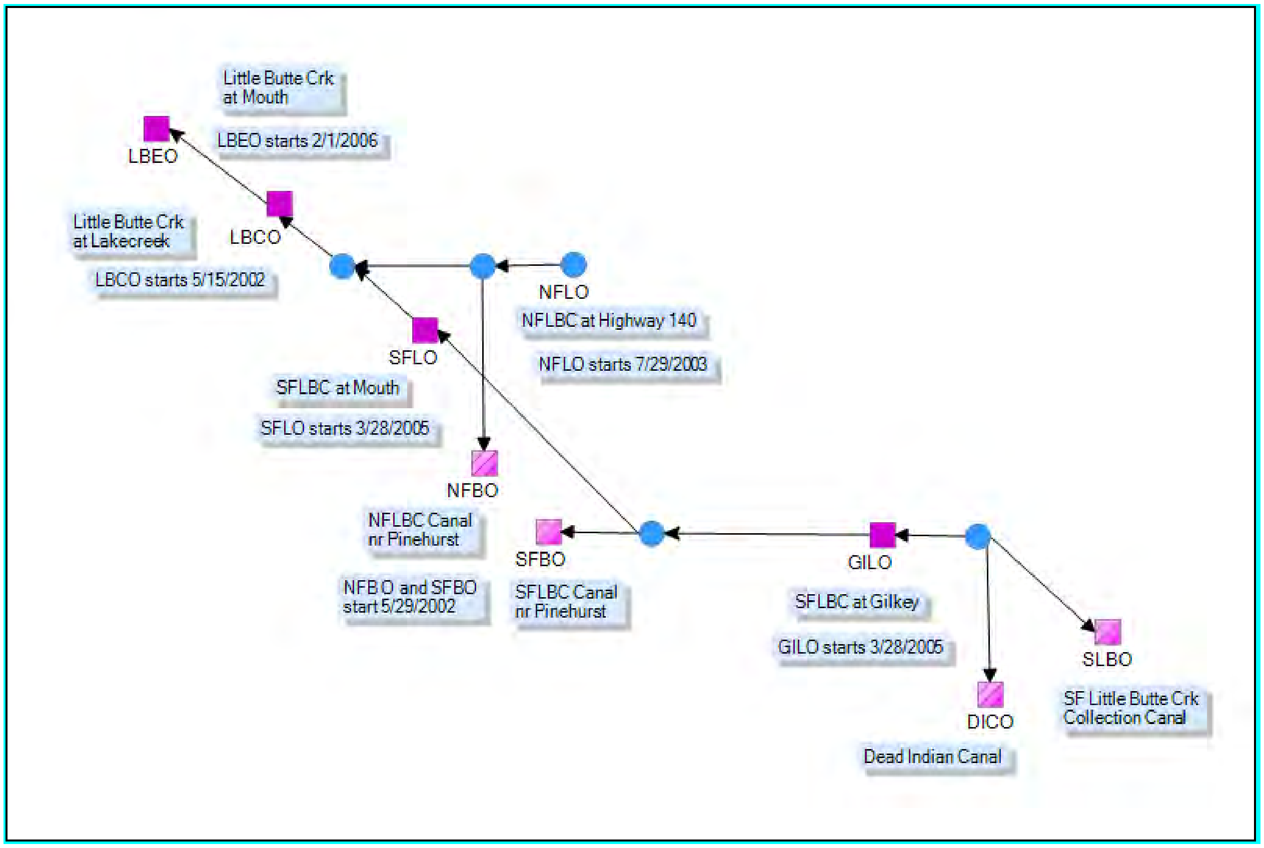


Figure 7. Available streamflow and diversion data for Little Butte Creek and South Fork Little Butte Creek.

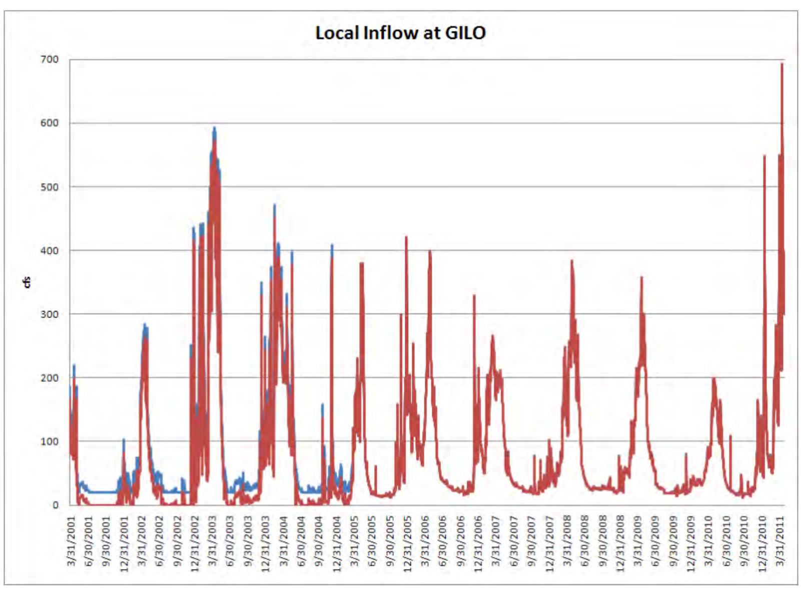


Figure 8. Estimated and calculated local inflows at GILO. Measured discharge at GILO starts on March 28, 2005. Calculated local inflows at GILO are shown in red. Estimated local inflows prior to March 28, 2005, using a 20 cfs baseflow, are shown in blue.

Keene Creek Reservoir. Keene Creek Reservoir is a small reregulating reservoir with a very short period of fill and release, usually about a week. The often daily swing between calculated loss and then gain would usually indicate gage error, but the frequency of gain/loss pairs is so consistent, it appears that the gains and losses primarily reflect a fill and release operation. In addition, the unknown travel time from Hyatt Reservoir and along the Howard Prairie Delivery Canal contribute to the uncertainty of what the calculated locals represent. On average, the daily losses and gains are about 8 cfs. Over the study period, the total calculated losses tend to cancel out the total calculated gains at Keene Creek Reservoir. For this reason, the calculated gains and losses at Keene Creek are omitted in subsequent simulations constructed from the unregulation. In simulation, Keene Creek Reservoir fills from deliveries from Hyatt Reservoir and the Howard Prairie Delivery Canal and releases to Green Springs Power Plant, but is not subject to the calculated gains and losses which overpower the operation of such a small pool. This introduces a small error in the water budget, which is absorbed by the larger reservoirs and which corrects itself within a day or two.

LIMITATIONS OF THE UNREGULATION

The limitations of the unregulation are primarily a function of lack of a complete streamflow and canal withdrawals record. This analysis was done with 10 years of daily data. It would have been desirable to have a longer gaged record in order to compute reach gains, but that record did not exist.

This has little effect on overall results at the major downstream control points because mass balance is preserved when doing the calculations. However, individual gains between the gages with short records listed below should be used with care.

Reach Location	start date
Bear Creek abv Ashland (BCAO)	7/19/2005
Bear Crk blw Phoenix Diversion at Talent (BCTO)	5/29/2003
Bear Creek blw Jackson St Div (BJBO)	7/19/2005
Bear Creek at Mouth below Central Point (BCMO)	7/19/2005
South Fork Little Butte Creek at Gilkey (GILO)	3/28/2005
Little Butte Creek (LBCO QD)	5/15/2002
Little Butte Creek blw Eagle Point (LBEO QD)	2/1/2006

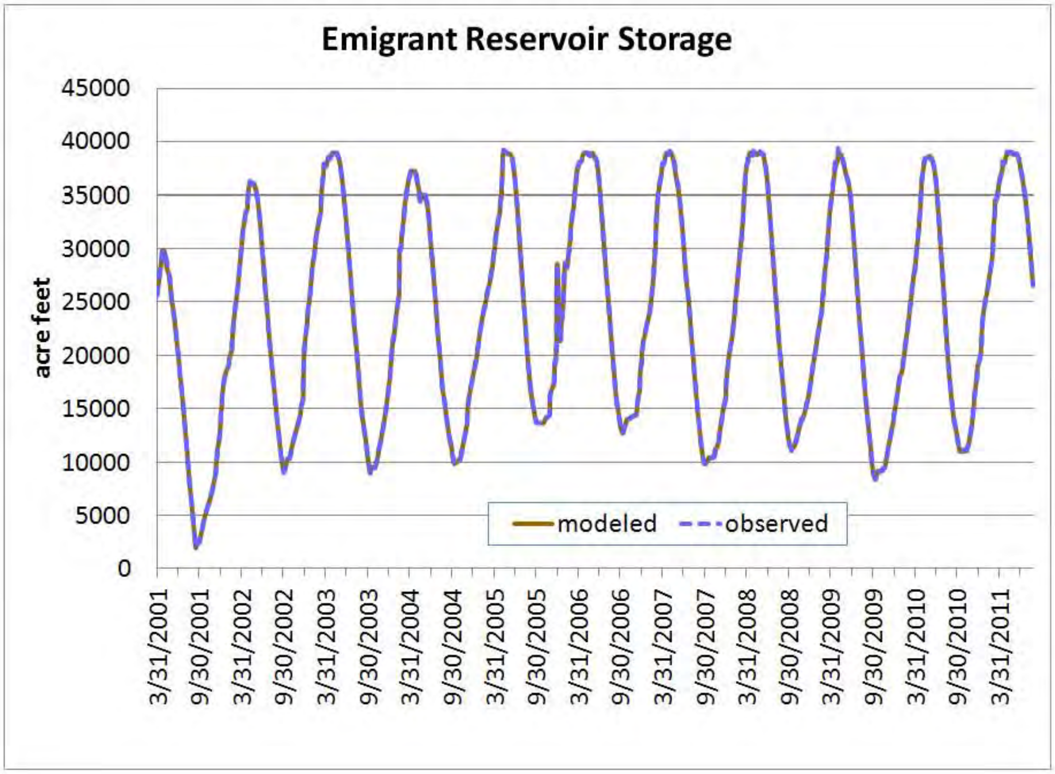
Negative gains exist in the data set, often as a result of computing gains without reach or reservoir routing. For many analyses this is not important because the unregulated flows include an inherent correction for routing and that correction is carried through all subsequent simulations. Although small, the routing correction may need to be revisited if simulated flows and reservoir levels differ significantly from historic values.

Keene Creek Reservoir has a very small storage capacity compared to inflows and outflows. This introduced a small error in the water budget in that reach, which is absorbed by adjacent reservoirs and corrects itself within a day or two.

Appendix B. Calibration for the Regulation Model of Bear and Little Butte Creeks

The calibration model, which is the foundation of the Proposed Action and other scenarios, was constructed and revised as problems were discovered and edits made in the other modeled scenarios.

The calibration model is similar to the Proposed Action in that the same minimum flows are requested at EMI and historic diversions are met. However, the calibration model differs from the Proposed Action in that the 10 cfs carriage water is not requested at MFDO and the reservoir rules draw down Emigrant Reservoir more in August and September to more closely simulate recent historic conditions. It is important to recognize that the Proposed Action simulates reservoir operations which attempt to meet only the minimum streamflow requests, historic diversions, flood control, and historic streamflow losses, with a few additional agreed-upon requests. These Proposed Action operations differ from historic operations for many reasons, including events which are not modeled, such as anticipation of future, but unrealized demands for water, uncertainty in rainfall and runoff forecasts, frozen delivery canals, and human judgment. The calibration model, however, attempts to mimic historic reservoir operations by forcing releases, when necessary, to more closely resemble historic reservoir elevations. The following graphs demonstrate the model calibration.


Emigrant Reservoir Storage
acre feet
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
3/31/2001
9/30/2001
3/31/2002
9/30/2002
3/31/2003
9/30/2003
3/31/2004
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3/31/2009
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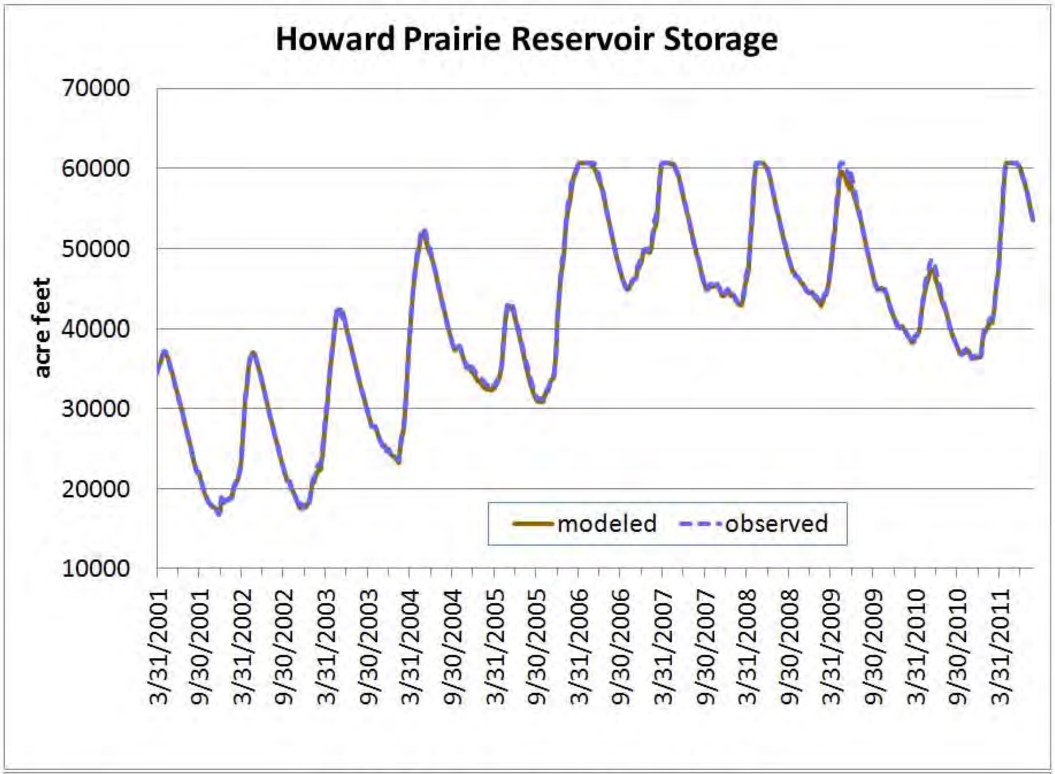
3/31/2010
9/30/2010
3/31/2011
modeled
observed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acre feet
70000
60000
50000
40000
30000
20000
10000
modeled
observed
3/31/2001
9/30/2001
3/31/2002
9/30/2002
3/31/2003
9/30/2003
3/31/2004
9/30/2004
3/31/2005
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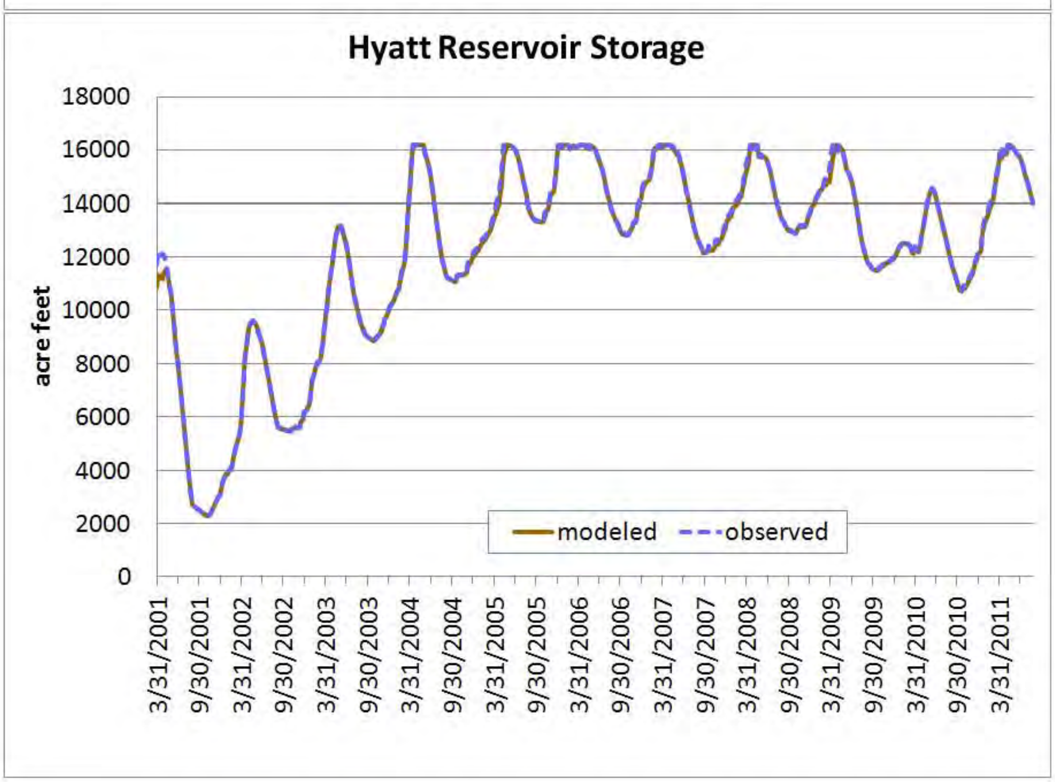
Hyatt Reservoir Storage
acre feet
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16000
14000
12000
10000
8000
6000
4000
2000
0
modeled
observed
3/31/2001
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3/31/2002
9/30/2002
3/31/2003
9/30/2003
3/31/2004
9/30/2004
3/31/2005
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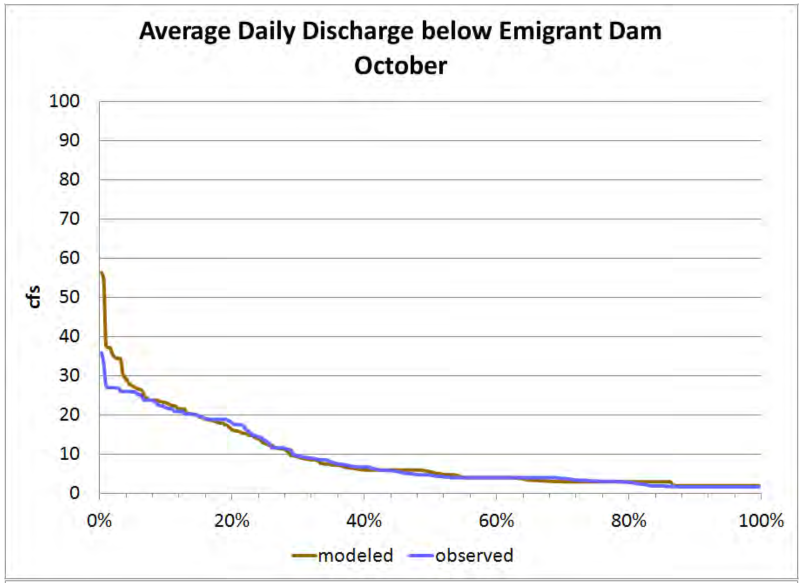
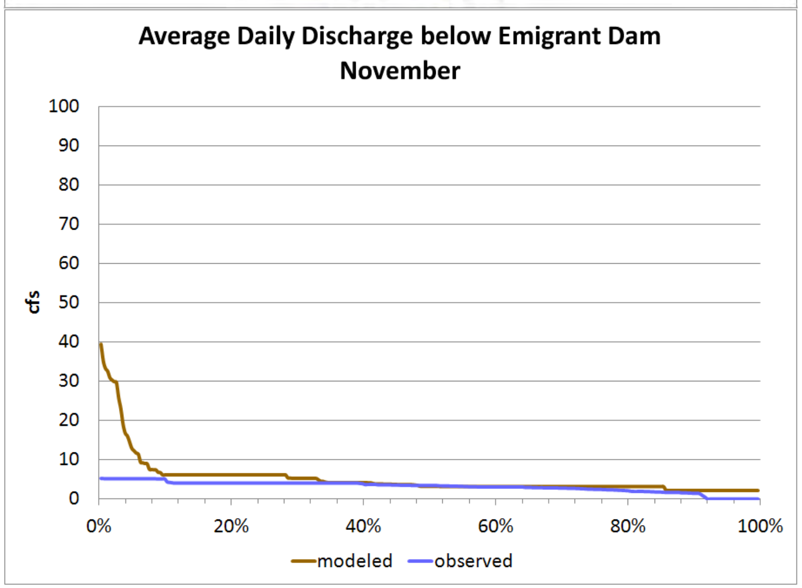
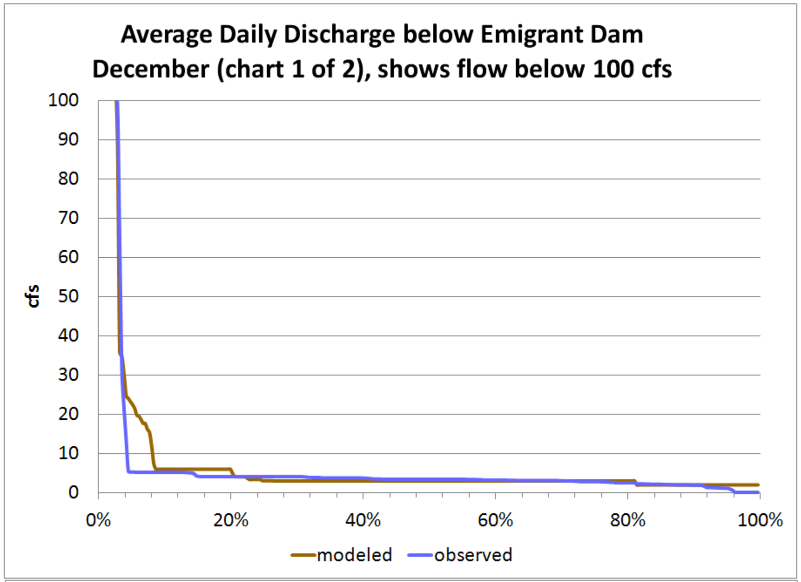
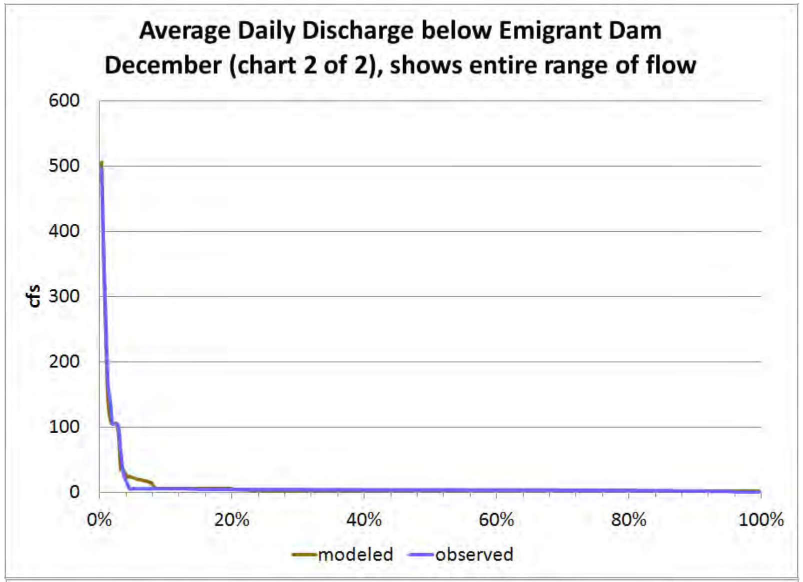
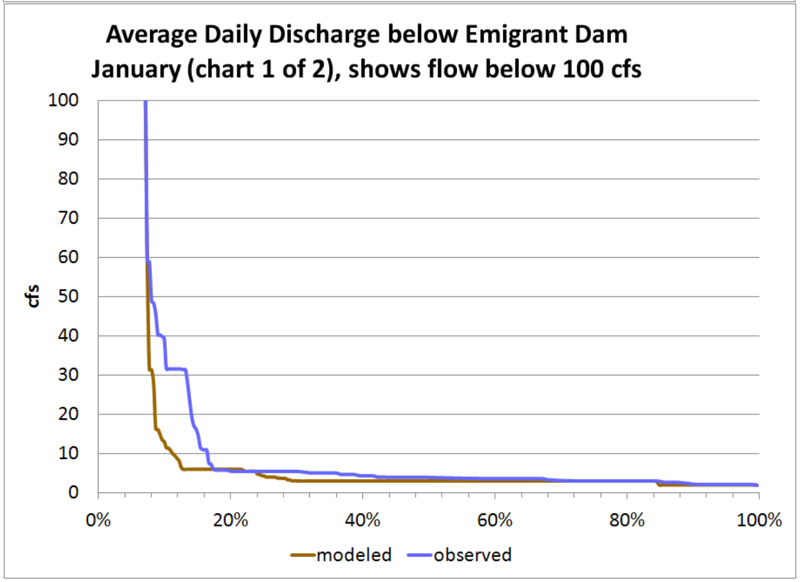


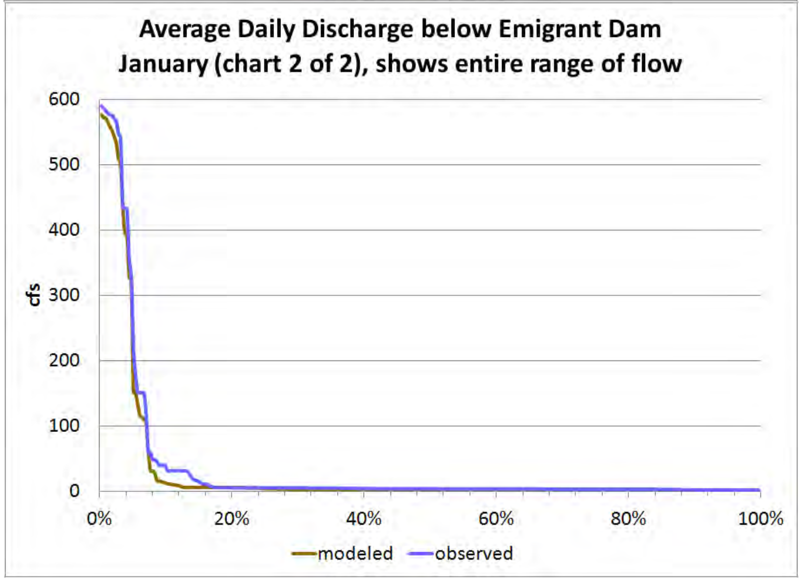


In October and November, modeled values for discharge below Emigrant Dam successfully simulate observed values.

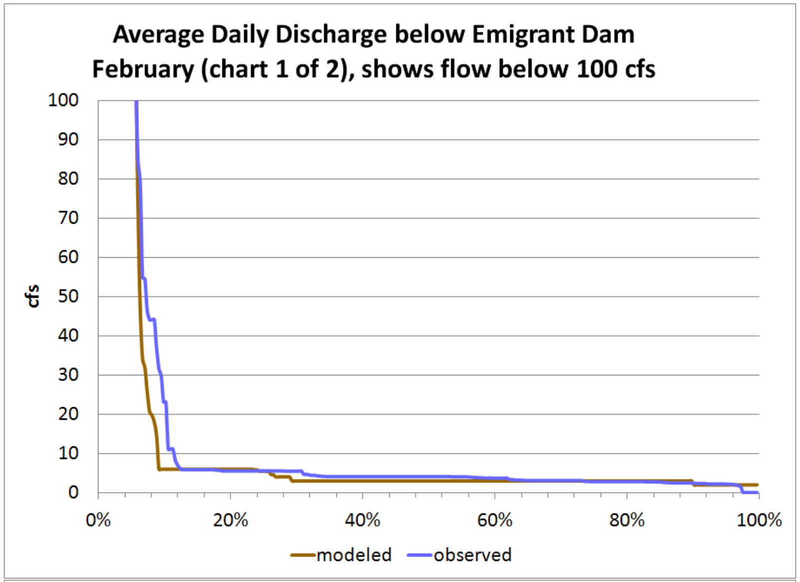


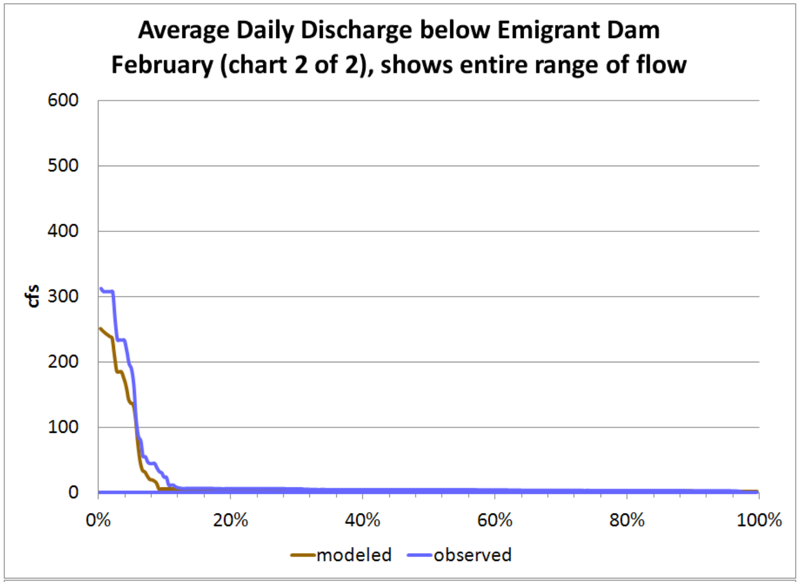


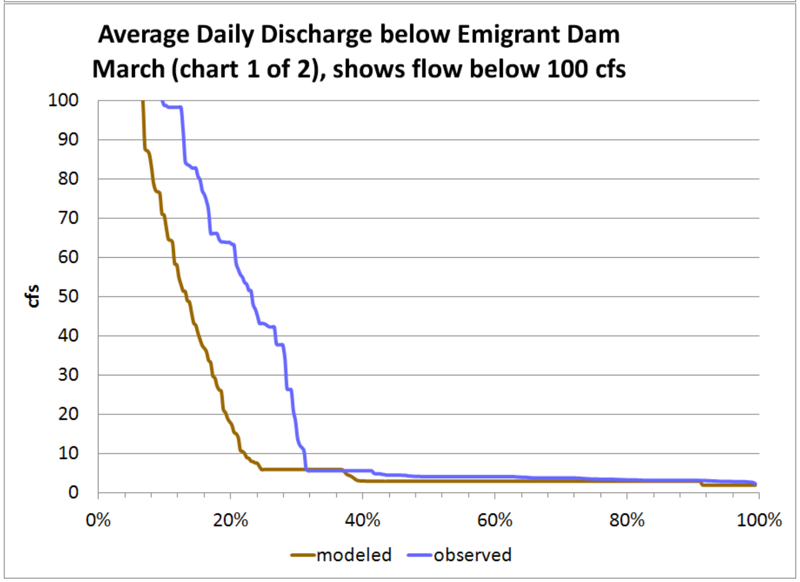


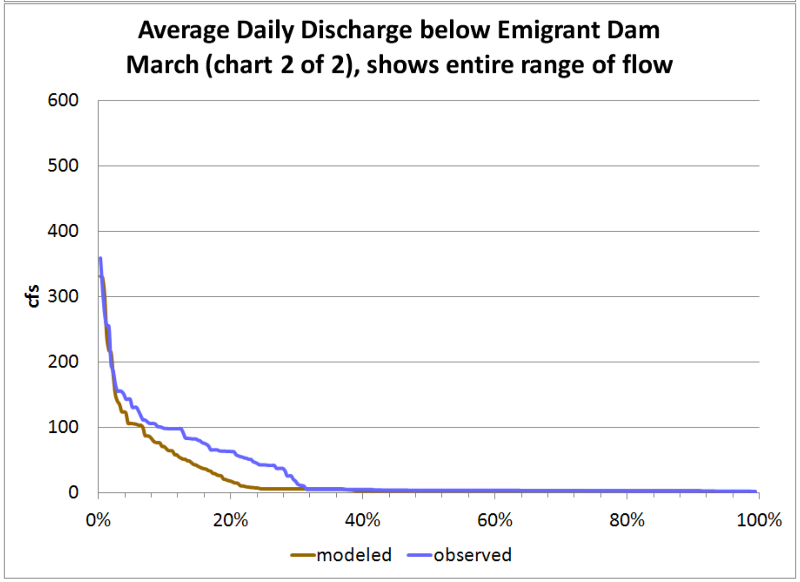


In December and January, modeled values for discharge below Emigrant Dam successfully simulate observed values.

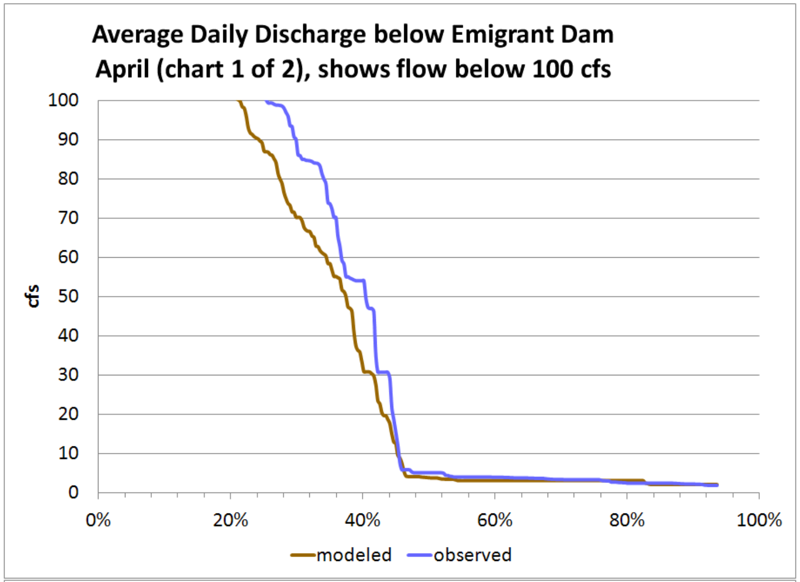


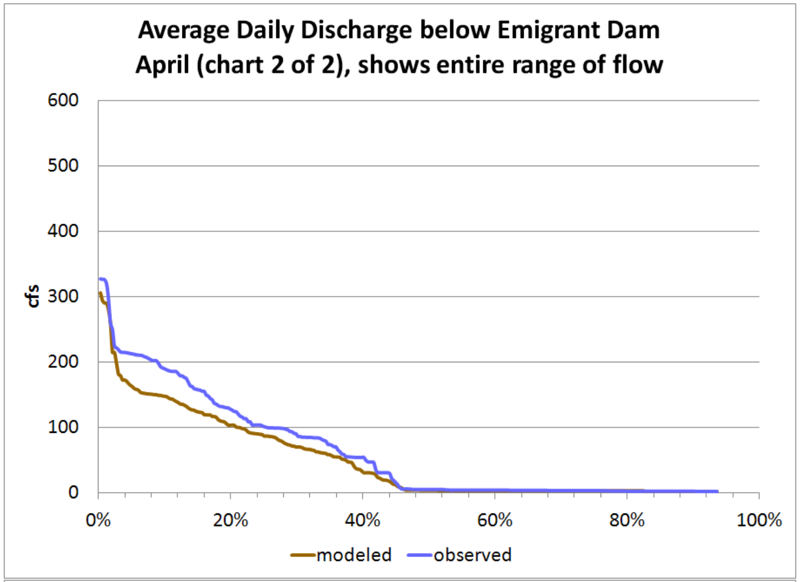


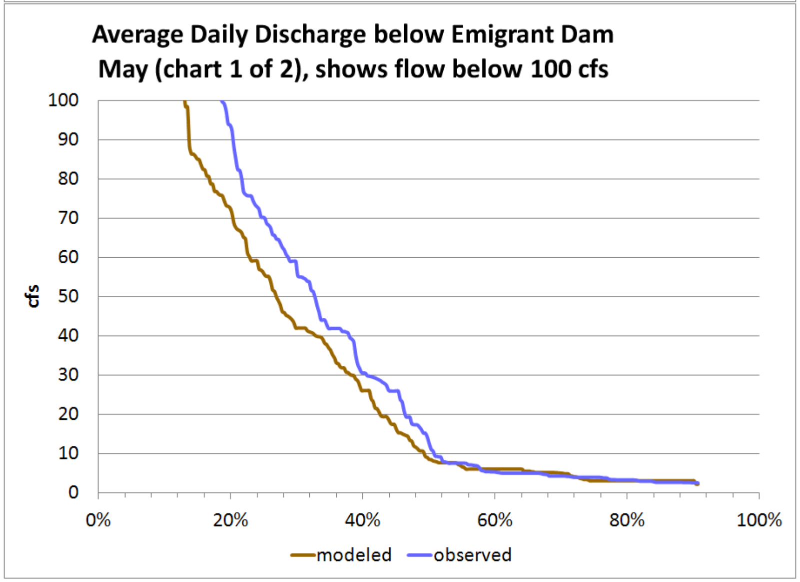


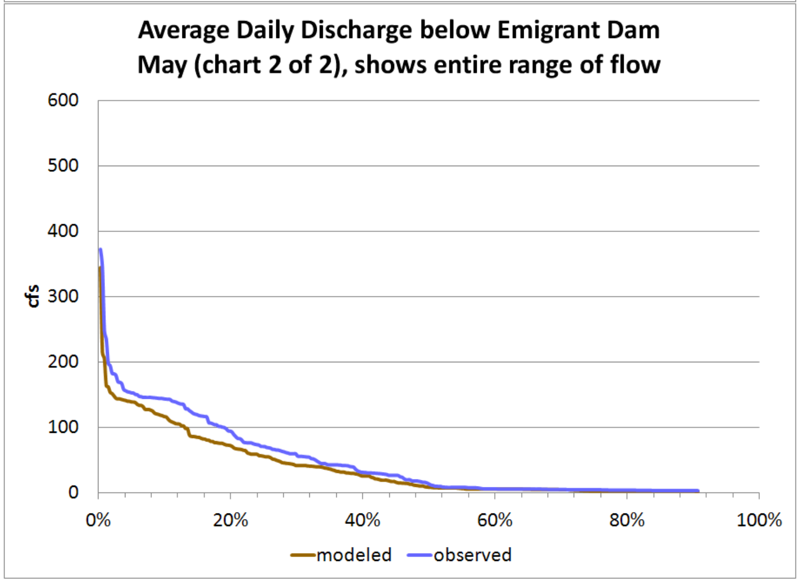


In February, modeled values for discharge below Emigrant Dam successfully simulate observed values. In March, modeled discharge below Emigrant is at times less than observed because the only functions driving releases in the model in March are minimum flow requests below the dam, reservoir rule curves, and unspecified reach losses.

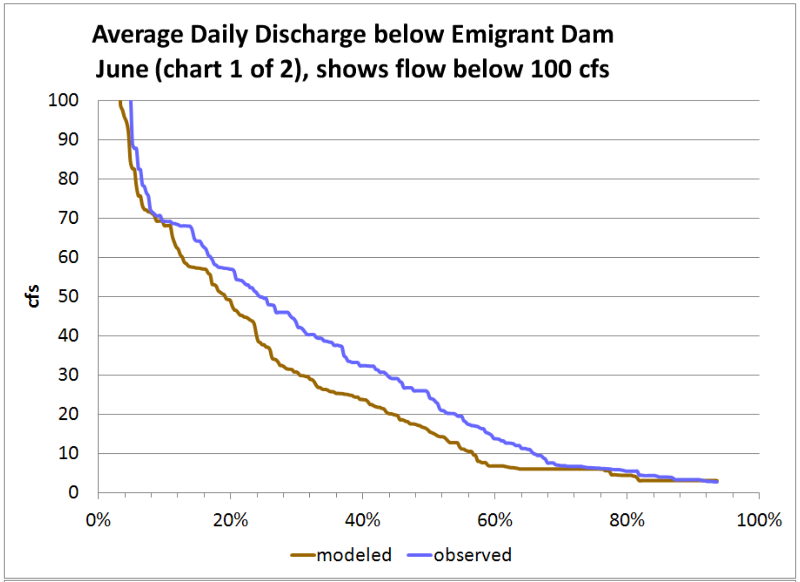


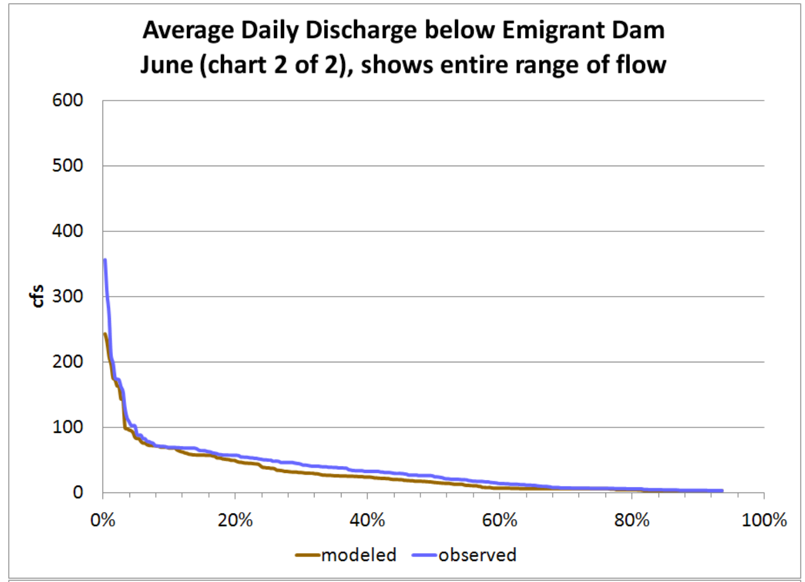


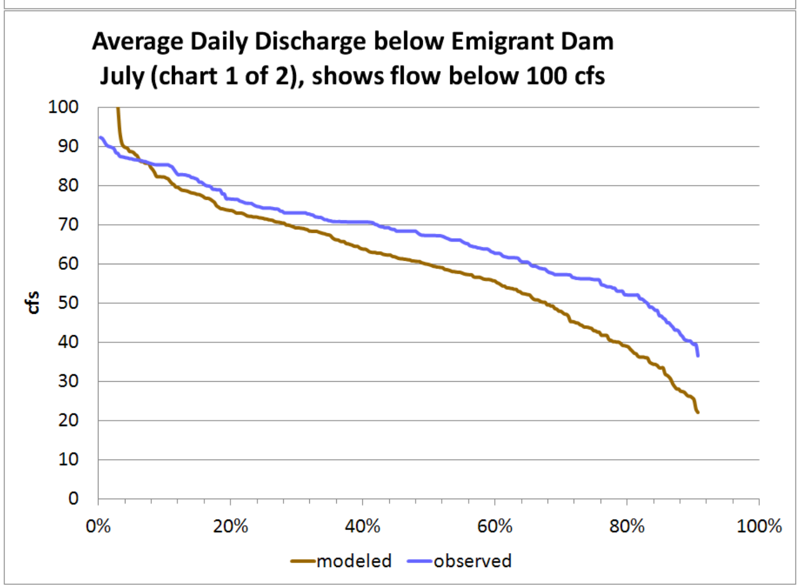


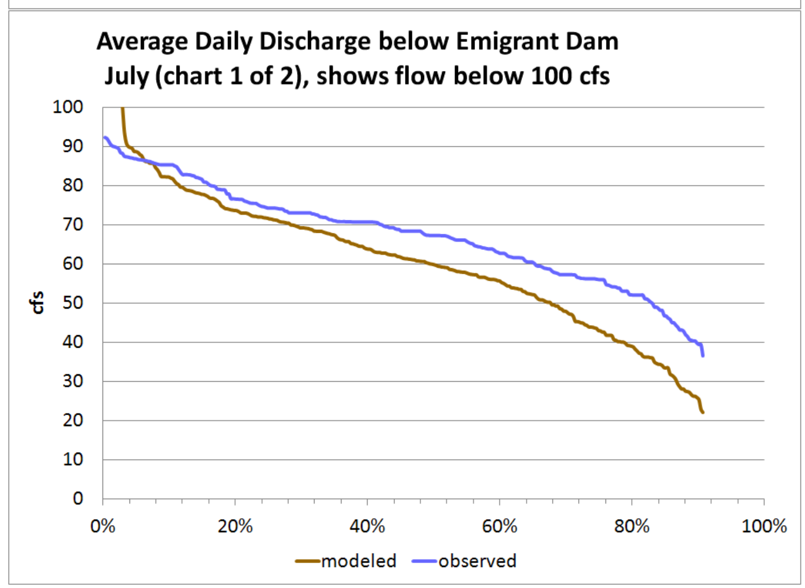


In April and May, modeled discharge below Emigrant is at times less than observed because the only functions driving releases in the model in April and May are the onset of irrigation, minimum flow requests below the dam, reservoir rule curves, and unspecified reach losses.

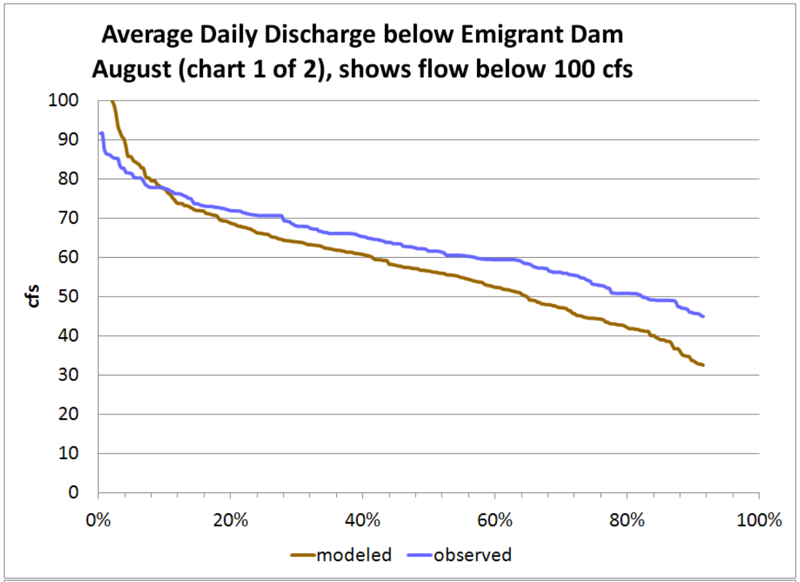


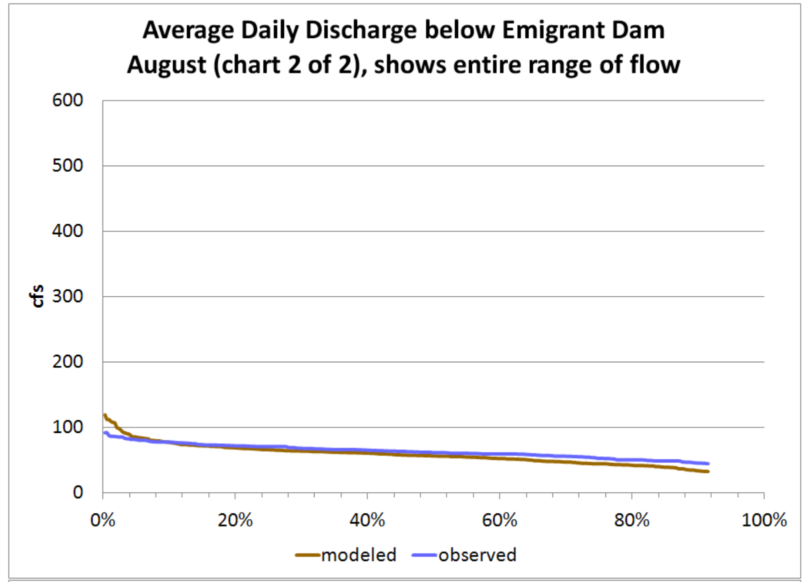


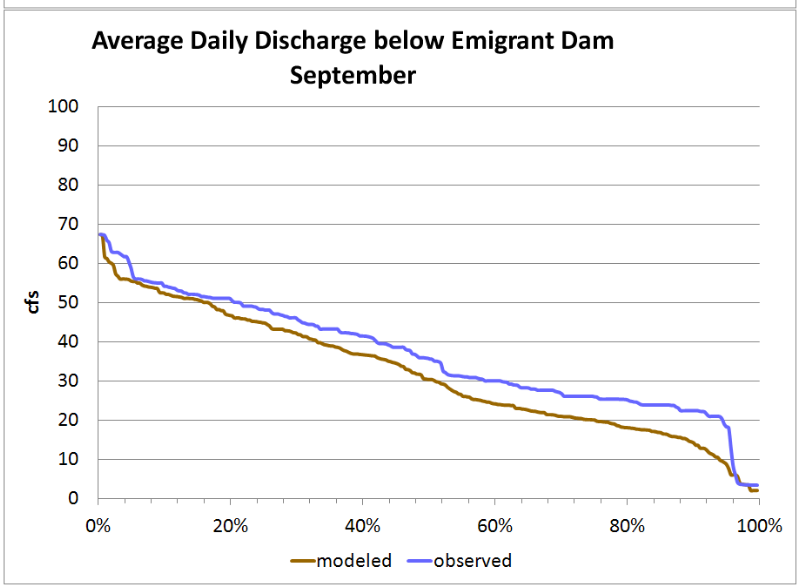


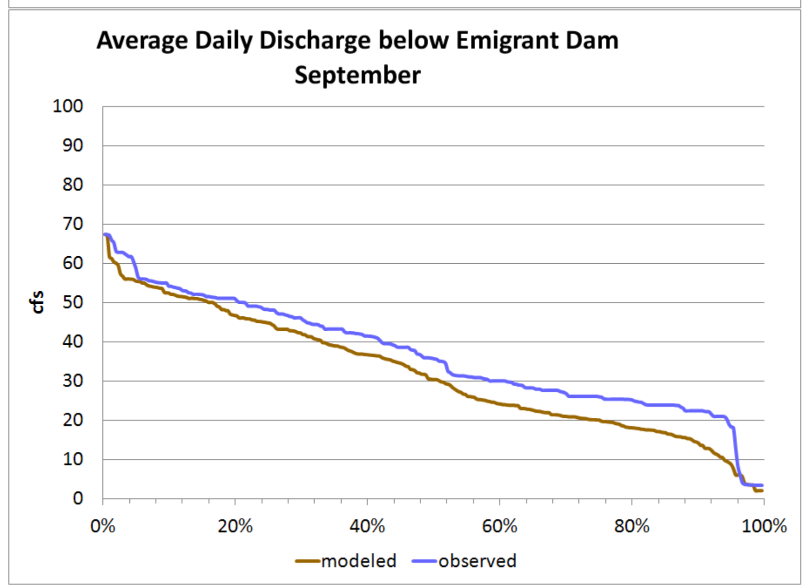


In June and July, modeled discharge below Emigrant is at times less than observed because the only functions driving releases in the model in June and July are the mid season irrigation and unspecified reach losses.









In August and September, modeled discharge below Emigrant is at times less than observed because the only functions driving releases in the model in August and September are the late season irrigation and unspecified reach losses.

Appendix B

RECLAMATION
Managing Water in the West

Biological Analysis of Coho Salmon Production Potential and Habitat Limiting Factors in Rogue River Irrigation Project Streams

Columbia Cascades Area Office
Pacific Northwest Region

U.S. Department of the Interior
Bureau of Reclamation
Columbia-Cascades Area Office
Yakima, Washington

February 2012

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

U.S. Department of the Interior
Bureau of Reclamation
Columbia-Cascades Area Office
Yakima, Washington

February 2012

Biological Analysis of Coho Salmon Production Potential and Habitat Limiting Factors in Rogue River Irrigation Project Streams

prepared by

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U.S. Department of the Interior
Bureau of Reclamation
Columbia-Cascades Area Office
Yakima, Washington

February 2012

Biological Analysis of Coho Salmon Production Potential and Habitat Limiting Factors in Rogue River Irrigation Project Streams

Columbia Cascades Area Office, Yakima, WA

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2/29/12
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Biological Analysis of Coho Salmon Production Potential and Habitat Limiting Factors in Rogue River Irrigation Project Streams

Executive Summary

Production potential for coho salmon smolt and adult life stages were estimated in Emigrant and S.F. Little Butte Creek stream systems, two important stream reaches influenced by the Rogue Irrigation Project, Oregon. These estimates were produced using a commonly utilized habitat limiting factors model for Oregon streams (Nickelson 1998) and based on habitat availability calculations from a Physical Habitat Simulation System habitat model for three different flow scenarios (Without Reclamation, With Reclamation Historic Operations, and With Reclamation Proposed Operations) and coho salmon life stages (adult spawning, juvenile summer rearing, and overwinter parr rearing) within each stream reach. Spawning gravel was found to be sufficiently abundant to produce more coho salmon smolts and adults than the stream systems could sustain at all flow scenarios; thus adult spawning was determined to not be a limiting factor to coho salmon production potential. Availability of summer rearing habitat, while found to be more limiting than spawning habitat, was determined to be sufficiently available under all flow scenarios to fully seed subsequently available winter rearing habitats in both stream reaches. Overwintering habitat availability, therefore, was found to be the ultimate limiting factor to coho salmon smolt and returning adult production potential in both stream reaches.

Potential smolt production estimates for each stream reach were calculated for each flow scenario based upon the availability of the overwintering habitat. Implementation of the Proposed Operations through the winter season produced a potential smolt production estimate that was 85% and 76% of the production potential in the Without Reclamation scenario in the Emigrant Creek and S.F. Little Butte Creek stream reaches, respectively. Adult production estimates under the Proposed Operations, based on winter rearing habitat as the ultimate physical habitat limitation, were found to be 180 to 212 adults for the Emigrant Creek reach and 314 to 412 adult spawners for the S.F. Little Butte Creek reach at long term equilibrium levels.

These results indicate that improvements in the amount and quality of winter rearing habitat in these reaches can be important to increasing the production of smolts and eventual adult returns to these stream reaches. It is cautioned, however, that increases in the amount of winter rearing habitat to address the physical limiting factor would only be effective at actually increasing production when higher densities of juvenile and adult abundance levels are achieved in these stream reaches. The amount of winter rearing habitat that is presently available under Historic Operations, or will be provided under the Proposed Operations, is adequate to support larger numbers of smolts and adults than are currently observed in these systems, particularly Emigrant Creek. Low coho salmon abundance and usage of currently available habitat areas in Emigrant and upper Bear Creek indicates that factors other than physical habitat availability are limiting production. Water quality limitations such as high water temperatures in these and other stream segments of Bear and Little Butte Creeks are suspected of contributing to the limited production potential of coho salmon. The S.F. Little Butte Creek system is likely closer to reaching densities at which habitat would limit production than Emigrant Creek, so it is recommended that habitat restoration actions be focused in this system first. Restoration actions for Emigrant and upper Bear Creek should be focused on long term improvement to winter rearing habitat conditions, but restoration efforts to remove the current major limiting factor; such as elevated water temperature, should be conducted first or concurrent with instream physical habitat restoration in Emigrant Creek.

Introduction

Methods to estimate carrying capacity and to determine the habitat limiting production of fishes are critical to the successful management of sustainable wild salmonid populations. Such methods are needed by fish managers to support habitat protection activities, and to improve habitat enhancement planning. Methods to estimate carrying capacity can also be useful for monitoring the effects of land-use plans and practices on fish populations and habitat. A major shortfall of many habitat restoration projects has been a lack of an adequate understanding of the factors limiting the target population. Consequently, habitat improvement projects have often failed to address the habitat factors that specifically limit fish populations, and as a result, these projects have failed to increase production as intended (Hall and Baker 1982; Nickelson et al. 1992a). Methods to identify habitats that limit salmonid production are therefore necessary for planning and implementation of stream habitat restoration projects and for determining effects of actions that may alter habitat such as irrigation practices related to storage and diversion of water.

In this analysis we estimate the production potential for coho salmon in Rogue Basin streams that are influenced by the operation of the Rogue Irrigation Project. Production potential is the estimated number of coho salmon that might be produced from a population under a particular set of environmental circumstances and habitat availability. The estimate of production potential for coho salmon described here is based on methodologies that have been specifically developed for estimating coho salmon production in coastal and inland stream systems of Oregon and Washington and have been widely used in Pacific Northwest stream systems. This approach has been particularly useful in evaluating the combined effects of flow and temperature on coho salmon smolt capacity estimates (Nickelson 2008) in conjunction with weighted usable area (WUA) estimates of habitat availability from flow-habitat relationship studies (Reclamation 2007).

The ultimate purpose of this document is to develop a habitat limiting factors model that can be used to identify coho salmon potential production that could occur from project affected stream systems under different flow scenarios that are representative of a range of environmental conditions found in stream systems of the upper Rogue Basin in southwest Oregon. The flow scenarios evaluated include Without Reclamation, Historical Operations, and Proposed Operations. The following assessment looks at the habitat conditions that are available for each coho salmon life history stage as a result of flow conditions to estimate which life history stage is most limiting to coho salmon populations. The assessment also looks at the amount of habitat for each life history stage that would be present in each stream reach analyzed under "Without Reclamation" or unregulated conditions for comparative purposes and assesses the physical habitat factor that is most limiting to coho salmon production. The smolt capacity estimates based on modeled habitat changes with flow were then scaled for each reach according to the proportional change in WUA estimates between a new Proposed Operations against a baseline flow condition (Without Reclamation).

This document describes the various potential coho salmon limiting factors and analyzes the physical habitats that could be limiting coho salmon production by life stage in both Emigrant and S.F. Little Butte Creeks under a range of flow conditions. Spawning habitat was analyzed first, followed by summer rearing habitat, then winter habitat. These were analyzed separately and sequentially to determine production potential by life stage. They are then compared and assessed together to determine which factor is most likely to be limiting coho salmon production in these Rogue Basin stream systems.

The specific methods used and the results obtained are described below. These results were compared with potential production assessments, life history specific survival values used, other historical studies conducted in the Rogue Basin and from other basins as appropriate to determine the relative accuracy of the methods used and data obtained.

Conceptual Framework

The habitat model is based on the concept of a habitat "bottleneck" (Hall and Field-Dodgson 1981) that limits the number of individuals of a given species that a stream can support (Figure 1). The model assumes that an environmental bottleneck influences numbers of fish produced through a spatial limitation. This assumption seems to be valid for coho salmon because they have evolved a system of population regulation that results in smolts that achieve a size necessary to survive in the ocean. Thus, before a population becomes so dense that individual size is reduced below this theoretical minimum, which appears to be about 80mm fork-length (FL), inherent mechanisms of population regulation, such as territoriality and dominance-hierarchy (Chapman 1962, Mason and Chapman 1965, Nickelson 1992c) would reduce population abundance.

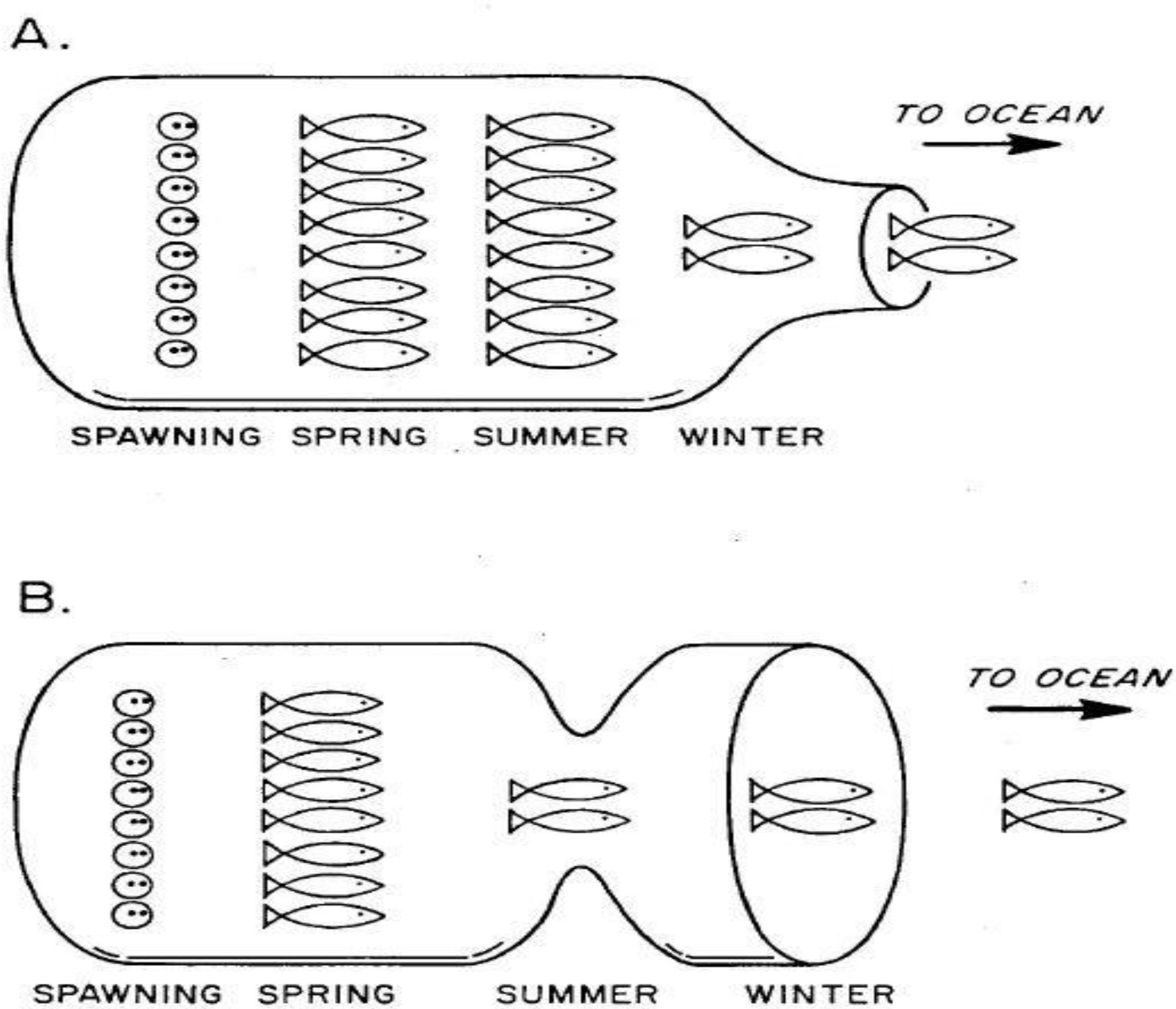

Figure 1. Examples of habitat bottlenecks occurring during (A) the winter, and (B) the summer.

The habitat model identifies the habitat bottleneck by simultaneously comparing the production potential of the stream habitat for each life stage. It estimates the number of individuals that can be supported, projects the population size through time to the smolt stage by using density independent survival rates obtained from the literature. The life stage that results in the lowest potential smolt yield is the critical life stage, and the amount and type of habitat needed by that life stage is the limiting habitat.

The carrying capacity of the stream is the size of a cohort (or year-class) after the bottleneck, minus losses due to density-independent processes occurring between the time of the bottleneck and the time that the fish leave the stream as smolts. Once a bottleneck in habitat availability restricts the size of a cohort, subsequent mortality should be density-independent only because the habitat required by subsequent life stages would, by definition, be in surplus. Subsequent cohorts of coho salmon in Oregon would not result in density dependent mortality on the first cohort because as the second cohort emerges from the gravel, the first cohort is migrating to the ocean (Chapman 1965).

Definitions

The ***carrying capacity*** of a stream for coho salmon is the number of wild smolts produced, as determined by the freshwater life stage most restricted by the limiting habitat.

The ***limiting habitat*** of a stream is that habitat required to support a particular life stage of a given species (in this case coho salmon) that is in the shortest supply relative to habitats required to support other life stages. In this context, the limiting habitat can be considered a limiting factor.

Life stages refer to sequential periods during the freshwater life history of a species, each period with specific habitat requirements. Typically, habitat requirements change as the result of growth or as the result of seasonal environmental changes such as an increase in flow or a decrease in temperature. For this analysis of coho salmon production potential, we recognize four life stages that are dependent on freshwater habitat availability: 1) spawning and incubation, 2) summer parr rearing, 3) winter parr rearing , and 4) smolts. We also recognize an additional life stage, returning adult salmon, which is dependent on marine conditions for survival. In Oregon, coho salmon generally outmigrate as smolts after one year in freshwater (Chapman 1965, Moring and Lantz 1975, Hall et al. 1987) and return as adults 18-months after smolt outmigration (Sandercock 1991).

The ***rearing capacity*** of a particular habitat type is the average density of coho salmon (number/m^2) that would be expected to be supported by a specific habitat type on a seasonal basis, and is specific to a given life stage (Reeves et al. 1989, Nickelson 1992b).

Stream habitat is separated into different ***habitat types*** based on their hydraulic characteristics. We did not perform stream habitat surveys during the summer and winter periods to identify or characterize detailed habitat types as recommended by Bisson et al. (1982), Nickelson (1998), and Nickelson et al. (1992b). Rather, to better fit the situation, we chose habitat types that corresponded to the PHABSIM modeled habitat which were life stage specific. These included three habitat categories which included, 1) spawning/incubation, 2) summer rearing, and 3) winter rearing.

Study Area

The coho salmon production potential assessment described in this analysis is limited to two important reaches of the Bear and Little Butte Creek stream systems. The Emigrant Creek stream reach is approximately 3.5 miles (5.63 km) long and extends from the confluence of Neil Creek and Emigrant Creek upstream to the base of Emigrant Dam. The South Fork Little Butte Creek stream reach is an important spawning and rearing area for coho salmon and extends approximately 16.6 miles (26.72 km) from the confluence of Little Butte Creek upstream to an impassible falls (Figure 2). These reaches are important production areas at the upstream extent of coho salmon distribution in Project-influenced streams, and are reaches that are most affected by Rogue Project water storage or diversions. Although the following analysis focuses on these two discrete stream reaches, the production potential assessment could also be performed for the other stream reaches in Bear Creek and Little Butte Creek to get a complete picture of the total production potential for coho salmon on a watershed scale. A complete production potential analysis that incorporates all of the reaches of the Emigrant and Bear Creek watersheds was not performed for this assessment.

Emigrant Creek downstream of Emigrant dam tends to have more deep water habitat due to the channel being narrower and deeper than the South Fork Little Butte Creek stream channel which is situated in a wider and more open alluvial valley. As a result, there tends to be more pool habitat per 1,000 ft of stream channel in the Emigrant Creek reach than in the S.F. Little Butte Creek stream system (Reclamation 2007). Habitat surveys conducted by the U.S. Forest Service (2002), Oregon Department of Fish and Wildlife (Dambacher 1992, ODFW 1994), Reclamation (2007) and GeoEngineers (2004) confirm that pool habitat is more prevalent in Emigrant and upper Bear Creek than in S.F. Little Butte Creek. These two stream systems also share similar water temperature profiles that are more suitable for supporting coho salmon populations due to their locations in the upper part of their respective watersheds and because of cool water releases from Emigrant Dam in Emigrant and upper Bear Creeks. Stream reaches that are located lower in both watersheds tend to have less suitable rearing conditions for coho salmon due to high water temperatures (>18-20˚C) (Nickelson 2008, Reclamation 2009, NMFS 2012). Photographs showing the relative conditions of both the Emigrant Creek and S.F. Little Butte Creek stream systems are provided for general habitat condition reference (Figures 3 through 6).

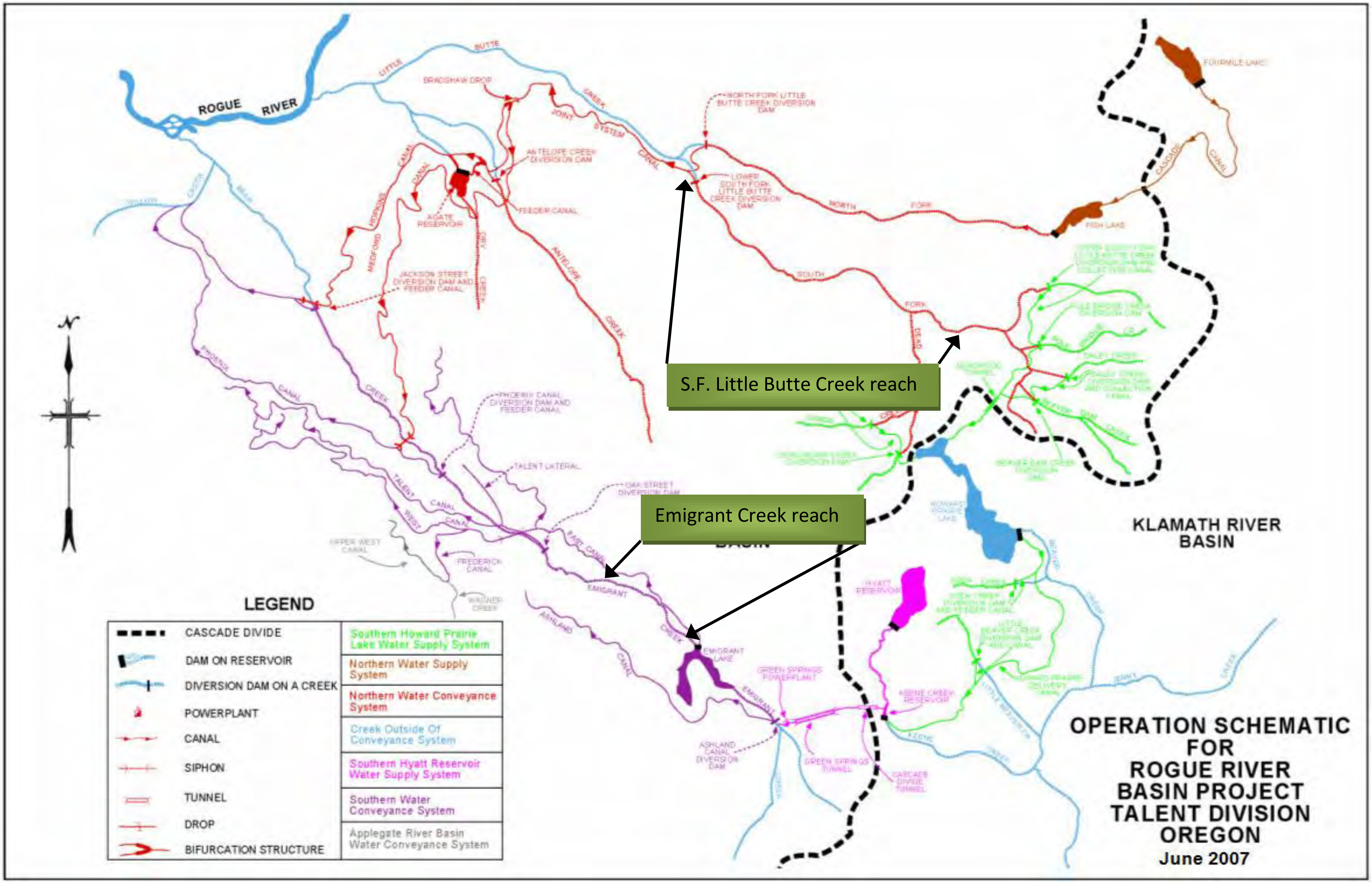

Figure 2. Map showing stream segmentation for Rogue Project instream flow assessment and the 2 reaches analyzed for coho salmon production potential in the Bear and Little Butte Creek watersheds.

Figure 3. Typical habitat units found in the Emigrant Creek reach showing relatively narrow and confined channel morphology**.**

Figure 4. Example of the relatively narrow and confined habitat units found in the Emigrant Creek reach.

Figure 5. Typical habitat units found in the South Fork Little Butte Creek reach showing relatively unconfined channel morphology with fewer pools and more riffle habitat types.

Figure 6. Additional examples of habitat units found in the South Fork Little Butte Creek reach showing relatively unconfined channel morphology with fewer pools and more riffle habitat types.

Habitat Limiting Factors Model and Other Production Potential Estimate Models

Habitat Limiting Factors Model

We used the habitat limiting factor model of Nickelson (1998), hereafter referred to as the habitat model, to identify factors that could be limiting smolt production and to estimate potential carrying capacities for juvenile coho salmon in the subject stream systems. The habitat model uses estimates of available surface area for each habitat type and life stage. Habitat-type specific potential juvenile coho salmon production over three life history stages (spawning/incubation, summer rearing, and winter rearing) were used to estimate seasonal production potential, and estimated available spawning habitat was used to estimate the number of possible redds and potential egg production in each stream reach. Density-independent survival rates obtained from the literature were applied to potential seasonal rearing capacity estimates to generate potential smolt production estimates for each life history stage. These rates were derived from data collected in Oregon streams (Chapman 1965, Reeves et al. 1989, Nickelson et al. 1992a, Nickelson et al. 1992b, Nickelson 1998) and other studies of coho salmon in the Pacific Northwest (McMahon 1983, Baranski 1989, Bradford et al. 1997). Estimates of available surface area by habitat type were identified from stream specific IFIM transects and the resulting PHABSIM habitat model (Reclamation 2007). Weighted Useable Area (WUA) calculations from the PHABSIM model were used as the primary input to the Nickelson (1998) model for this assessment.

Because the production potential estimates and ultimate limiting factors analysis are based on habitat areas that are available under various flow conditions (i.e. without Reclamation condition vs. proposed operation), it is important to explain how the habitat areas used in the analysis were derived. The output from the PHABSIM model was chosen to represent the amount of total habitat available by life stage for the estimation of production potential because the PHABSIM model can efficiently estimate the total amount of habitat that would be available in a stream reach under any particular flow regime. This is particularly important when comparing production estimates between different scenarios as is done for this production potential assessment report. Another important reason for utilizing the PHABSIM model for assessing habitat availability is that the PHABSIM model outputs only estimate habitat areas that are considered to be useable by particular life-history stages of coho salmon. In essence, the PHABSIM model screens all habitat areas based on life stage specific preferences or requirements (e.g. depth, velocity, substrate type, etc.) and reports only the amount of habitat area that meet those criteria. Therefore, the PHABSIM model can be used to directly estimate the total amount of useable habitat by coho salmon life stage. For example, PHABSIM estimates of the amount of summer rearing habitat would only consist of estimated habitat areas that actually meet summer parr rearing criteria. All other habitat areas that do not meet life stage specific habitat preferences or requirements are excluded.

Although this method of habitat estimation may be considered somewhat coarse with a potential to misrepresent the true amount of habitat available for each life stage, the PHABSIM model generates discrete and specific estimates of total habitat area for spawning/incubation, summer rearing, and winter rearing. These habitat availability estimates have been screened by life stage specific preferences and requirements and represent very reasonable estimates of total habitat availability by life stage. Additionally, it should be noted that the PHABSIM modeling criteria were established by a committee of knowledgeable scientists familiar with SONCC coho salmon and Oregon streams. The PHABSIM data was therefore deemed to be an acceptable method for estimating habitat availability by life stage for the limiting factors analysis methods used in this document.

These habitat based methods have been widely used in the Pacific Northwest to estimate coho salmon production potential and have been widely published in the literature. The model used in this document has gone through several iterations since its early development in the 1980's. Portions of this work, including early versions of the habitat model have been published in Reeves et al. (1989), Nickelson et al. (1992b), Nickelson et al. (1992c), and Nickelson (1998). Much of the following description of the habitat model and its application comes from Nickelson (1992b).

The specific life-stage that limits smolt production in the system is the life-stage capable of producing the fewest number of smolts. The underlying assumption of the habitat model is that when a specific habitat is in short supply, a bottleneck exists that may subject a cohort to density-dependent mortality, which may lead to an underseeding of habitats used by subsequent life stages Nickelson (1998). As a result, density-dependent mortality at later life stages may be important in affecting overall productivity.

Typical estimates of production potential are based on measurement of the maximum number of coho salmon smolts that any particular stream systems can produce based on the amount of habitat available. However, to further estimate production potential and carrying capacity in addition to smolt estimates derived from the habitat model, the methods described here also estimate the potential amount of adult escapement that can be sustained by available habitat. This is accomplished by using estimates of maximum smolt production from the habitat model, and back-calculating the number of adult coho salmon needed to fully seed available habitat and to estimate potential production from adult returns. Both measures of production potential, smolt production or adult spawner returns, are heavily dependent on estimates of habitat availability in project influenced streams and would therefore be only as accurate as the habitat data that goes into the habitat model.

The potential adult production of the system was then determined as;

$$\textit{Adult Production} = \textit{maximum smolt capacity} * \textit{SAR}$$

where SAR (Smolt to Adult Return rates) represents the overall out of basin and marine survival rates. A range of SAR values between 1% and 5% were used to represent the range of marine survival rates that have been typically observed for Pacific Northwest salmon species, including coho salmon from Oregon streams. Nickelson (1998) recommended using three different marine survival rates (*SAR* = 3%, 5%, 10%) to represent the range of survival observed in Oregon streams. A 10% SAR rate was not chosen because this was not thought to be representative of SAR rates for inland populations of coho salmon such as the Upper Rogue River (URR) populations. Other researchers have used similar smolt to adult survival estimate ranges with averages around 4% to represent the typical long term survival rate (Bradford et al. 1997, NPCC 2003). SAR rates are considered smolt to adult returns from smolt outmigration from project affected streams to adult return to the same stream.

Bradford model

For comparative purposes, a model developed by Bradford et al. (1997) for Pacific coast salmon was also used to estimate mean coho salmon smolt abundance (Y) based on stream length (X, km) for the selected stream reaches in this analysis as;

$$Log_e(Y) = 6.90 + 0.97Log_e(X)$$

This model predicts smolt abundance using stream length alone as the dominant variable determining production. Marine survival rates of 3% and 4% were applied to the smolt estimates (Y) to estimate the range of estimated adult production potential from the Bradford model. Stream reach length used in the Bradford model for this report was taken from the delineated reach breaks used for the Rogue Basin PHABSIM model and are described in the Rogue River Basin Project Coho Salmon Instream Flow Assessment Report (Reclamation 2007). These stream reach lengths were 5.73 km and 26.72 km respectively, for the Emigrant and S.F. Little Butte Creek stream reaches.

Spawning/Incubation Factors

To address the adult spawning escapement potential of these systems, spawning gravel availability estimates based on extent of stream habitat areas were used to assess the amount of useable spawning gravel to support coho salmon spawning and incubation needs. We estimated the amount of available spawning habitat in the Emigrant and S.F. Little Butte Creek stream reaches based on the total amount of spawning/incubation habitat available from the PHABSIM data for these stream segments. We considered the average size of coho salmon redds and the area recommended for spawning per redd (Burner 1951), then incorporated an average fecundity of 2,500 for coho salmon, estimates of life stage survival rates from Nickelson (1998), Reeves et al. (1989), and others, then estimated the number of spawning females that would be needed to fully and uniformly utilize or seed the estimated amount of spawning habitat available without superimposition of redds. We estimated the number of smolts that could be produced and the number of adults that would return at several smolt to adult return (SAR) rates.

The amount of available spawning habitat that occurs under various flow scenarios is provided below in Table 1 for both the Emigrant Creek and S.F. Little Butte Creek reaches (represented by the EMI and GILO Hydromet gauges, respectively). The three flow scenarios and the amount of Weighted Useable Area (WUA) created from those flow scenarios (from the PHABSIM model) are presented below in Table 1.

The flow scenarios analyzed include 1) the Without Reclamation flow scenario which represents the amount of WUA (ft^2 and m^2) that would reasonably be expected to occur for the entire stream reach in the absence of Reclamation's Rogue Project, 2) the With Reclamation flow scenario that represents the amount of habitat (ft^2 and m^2) that has existed and which currently exists under Historic Operations and 3) the amount of spawning/incubation habitat that is anticipated to occur as a result of implementation of the Proposed Operation as defined in the 2012 Biological Assessment for the Future Operation and Maintenance of the Rogue River Valley Irrigation Project (Reclamation 2012). Comparison of the total amount of WUA spawning/incubation habitat resulting from the three flow scenarios is displayed in Table 1.

Table 1. Amount of Weighted Usable Area (WUA) for the Spawning/Incubation coho salmon life stage in both Emigrant and S.F. Little Butte Creeks under the Without Reclamation, Historical With Reclamation, and the Proposed Operation flow scenarios. Spawning habitat area calculated using the greatest amount of spawning/incubation WUA available in January and February from the 50% exceedence (average) water year condition.

Reach	Flow Scenario	Amount of WUA for Spawning/Incubation from Winter Flows		
		WUA value from PHABSIM (ft^2/1000 ft)	**Total Spawning/Incubation Habitat Area ft^2 converted to (m^2)**	**Percent of Unregulated WUA**
Emigrant Creek (EMI) Total Stream Reach Length = 3.5 miles (5.63 km)	Without Reclamation	10,709 (ft^2/1000 ft)	197,902 ft^2 **(18,385 m^2)**	100%
	With Reclamation (Historic Operations)	2,847 (ft^2/1000 ft)	52,612 ft^2 **(4,887 m^2)**	26%
	With Reclamation (Proposed Operations)	6,397 (ft^2/1000 ft)	118,216 ft^2 **(10,982 m^2)**	60%
S.F. Little Butte Creek (GILO) Total Stream Reach Length = 16.6 miles (26.72 km)	Without Reclamation	8,645 (ft^2/1000 ft)	757,716 ft^2 **(70,392 m^2)**	100%
	With Reclamation (Historic Operations)	7,833 (ft^2/1000 ft)	686,546 ft^2 **(63,780 m^2)**	91%
	With Reclamation (Proposed Operations)	7,403 (ft^2/1000 ft)	648,858 ft^2 **(60,278 m^2)**	85%

Under the Proposed Operations, the amount of spawning/incubation habitat that would be suitable to support coho salmon spawning and incubation requirements totals 10,982 m^2 and 60,278 m^2 for the Emigrant and S.F. Little Butte Creek stream reaches, respectively. These habitat amounts would equate to approximately 60% and 85% of spawning habitat that would exist under the Without Reclamation scenario for these project affected streams. Spawning/incubation habitat areas that are currently being provided in the Emigrant and S.F. Little Butte Creek stream reaches are also shown in Table 1 and amount to 4,887 m^2 for the Emigrant Creek stream reach and 63,780 m^2 for S.F. Little Butte Creek. These areas represent 26% and 91%, respectively, of the spawning habitat area under the Without Reclamation scenario. When habitat under the Proposed Operation is compared to the amount of habitat that is provided under Historic Operations, it is apparent that Proposed Operation flows would result in a significant increase in the amount of usable spawning/incubation habitat that is preferred by adult coho salmon for spawning than is currently being provided for the Emigrant Creek reach. Weighted usable spawning/incubation habitat in the Emigrant Creek reach would increase from 4,887 m^2 currently available to 10,982 m^2 under the Proposed Operation. However, the amount of spawning habitat available under the Proposed Operations in the S.F. Little Butte Creek stream reach would be 15% less than under the Without Reclamation condition.

To evaluate the impact of spawning habitat availability on coho salmon smolt production potential, the estimated number of female spawners needed to fully utilize available spawning habitat was determined for each stream reach and flow scenario. Smolt production potential for each reach and flow scenario was then estimated based on reported literature values for habitat area needed for spawning based on average redd size, average fecundity per female, and average coho salmon egg to smolt survival rates.

Redd size

To estimate the number of redds and therefore the number of spawning female fish that the available habitat could support, it was necessary to assign an average area required for a single spawning pair of salmon to construct and defend a redd. The average size of a coho salmon redd reported by various authors cited in Sandercock (1991) was about 1.5 m^2. Crone and Bond (1976) indicated the average area of gravel disturbed (presumably for a redd) was 2.6 m^2, while Burner (1951) noted an average redd size of 2.8 m^2. Nickelson (1998) estimated an average redd size of 3 m^2 in coastal Oregon streams while Magneson and Gough (2006) indicated an average redd area of 3.6 m^2 in the Klamath Basin of California. Fleming and Gross (1989) reported an equation from Tautz (1977) for estimating redd size:

$$\text{Average redd size} = (FL/31)^2 * 2{,}358\ cm^2 * 4 * 0.7$$

Where FL is the average fork length (tip of nose to center of the fork in the caudal fin measured in cm) of females in the population, 4 is the modal number of nests per redd, 0.7 adjusts for nest overlap, and 2,358 cm^2 is the area used by a 31 cm female during redd construction. We used the average fork length of 69.3 cm for 75 coho salmon captured by angling and reported by Rivers (1963) in the Rogue River and adult size of 64.0 cm at Cole Rivers Hatchery between 2001 and 2010 (David Pease, Cole Rivers Hatchery, personal communication, 2011). This yielded an average redd size of between 2.8 and 3.2 m^2. Averaging the reported and calculated redd sizes yields a redd size of 2.8 m^2. However, salmon have often been observed defending larger areas than are required for just the disturbed area associated with redd development and therefore are believed to require some additional defensible space larger than the redd itself to reproduce successfully. Burner (1951) recommended that the area needed for spawning coho salmon should be about four times the redd size, which based on 2.8 m^2 would be about 10 m^2. In our estimate of production potential, we used 10 m^2 as the area needed for a single female coho salmon to spawn without redd overlap or superimposition.

Fecundity

To estimate the number of juveniles that might be produced from the estimated number of spawning adults the available habitat would support, we needed an estimate of the average fecundity of female coho salmon. Fecundity of adult salmon varies with fish size and latitude (Wydoski and Whitney 2003, Nemeth et al. 2004). Salo and Bayliff (1958; cited in Sandercock 1991) developed a regression equation to predict the number of eggs produced per female based on standard length. Based on the average fork length of 64.0 cm for adult data on both male and female coho salmon at Cole Rivers Hatchery between 2001 and 2010, and using this average in Salo and Bayliff's regression equation;

$$y = -2596 + 84.53x$$

where *y* = number of eggs per female and *x* = standard length (cm) we obtained an average fecundity of 2,814 eggs per female. Nickelson (1998) used a fecundity of 2,500 eggs per female in his coho salmon production model. Substituting 2,500 in Salo and Bayliff's (1958) equation produced a fish standard length of 60.3 cm, which was probably close to the average standard length of the coho salmon measured at Cole Rivers Hatchery since standard length is less than fork length. Thus, it was justified to use Nickelson's fecundity of 2,500 eggs per female in this potential production assessment.

The steps taken to assess the production potential for coho salmon in the Emigrant Creek and S.F. Little Butte Creek stream reaches included estimating the amount of useable spawning gravel from the PHABSIM model that was assumed to be within the suitable range for coho salmon spawning, incorporating information about redd size, calculating the number of spawning female coho salmon needed to fully utilize the habitat, then incorporating average fecundity to calculate the number of eggs those females could produce. Ultimately, an egg to smolt survival rate of 1.5 percent was then used to estimate, the total number of smolts that could be produced. Egg to smolt survival of 1.5 percent was selected based on a range of estimates from the literature. Neave and Wickett (1953 cited in Sandercock 1991) reported egg to smolt survival for British Columbia coho salmon as 1 to 2 percent, Reeves et al. (1989) listed an egg to smolt survival of 0.02 (2 percent), Nickelson (1998) used egg to smolt survival of about 3 percent in his model, and Anderson and Hetrick (2004) estimated egg to smolt survival of 2.1 and 1.7 percent in Kametolook and Clear Creek, Alaska, respectively.

Given the amount of useable habitat for spawning that would be available under the three different flow scenarios presented in Tables 1 and 2, it was estimated that sufficient amounts of spawning habitat were available to accommodate up to 1,838 female spawners in Emigrant Creek and between 6,027 and 7,039 female spawners in the S.F. Little Butte Creek reach. From the estimated 2,500 eggs per female and a 1.5 percent egg to smolt survival, between 18,300 and 68,925 smolts could potentially be produced in Emigrant Creek and the number of smolts that could be produced in the S.F. Little Butte Creek is between 226,012 and 263,962 (Table 2). This assumes that all suitable spawning habitat in both of these reaches is fully and uniformly utilized by spawning coho salmon.

From the estimated number of coho salmon smolts that could potentially be produced given available spawning habitat, we estimated the number of adults returning as SARs from one to five percent. This range of SARs was selected to bracket annual variability expected to occur, those observed both historically and recently, and to be consistent with SAR values of 3-5% and 5% cited by Nickelson (1992b) and Bradford et al. (1997), respectively, for Pacific Coast coho salmon. This range is also inclusive of those reported in the interim objective of the NPCC's 2003 Mainstem Amendment of achieving SARs in the two to six percent range (average four percent) for Snake River and upper Columbia River salmon and steelhead (NPCC 2003). Using SARs from the project affected stream reaches back to the same stream reaches eliminates the need to consider life stage-specific survival during outmigration, residence time in the estuary and ocean and during the adult upstream migration, and harvest in the ocean or lower Rogue River. Table 3 shows potential adult production, by reach, for SAR rates of one to five percent, based on smolts produced from potential adult spawning and 1.5 percent egg to smolt survival.

Table 2. Estimates of the number of potential redds produced, adult female spawners, and potential smolt capacity based on spawning habitat availability at 10 m^2 per redd and 1.5% egg to smolt survival rates under three different flow scenarios.

Reach	Flow Scenario	Spawning Habitat Area (m^2)	Potential no. of redds at 10 m^2 each	No. of females required at one per 10 m^2	Estimated no. of eggs per reach with fecundity of 2,500 eggs/female	No. of smolts produced at 1.5% egg to smolt survival
Emigrant Creek (EMI) Total Stream Reach Length = 3.5 miles (5.63 km)	Without Reclamation	18,385 m^2	1,838	1,838	4,595,000	68,925 smolts
	With Reclamation (Historic Operations)	4,887 m^2	488	488	1,220,000	18,300 smolts
	With Reclamation (Proposed Operations)	10,982 m^2	1,098	1,098	2,745,000	41,175 smolts
S.F. Little Butte Creek (GILO) Total Stream Reach Length = 16.6 miles (26.72 km)	Without Reclamation	70,392 m^2	7,039	7,039	17,597,500	263,962 smolts
	With Reclamation (Historic Operations)	63,780 m^2	6,378	6,378	15,945,000	239,175 smolts
	With Reclamation (Proposed Operations)	60,278 m^2	6,027	6,027	15,067,500	226,012 smolts

Table 3. Number of potential returning adults from smolt production estimates based on available spawning gravel for 3 flow scenarios in Emigrant and S.F. Little Butte Creek stream reaches. Smolt to Adult Return (SAR) rates based on estimates from Bradford et al. (1997) and Nickelson (1992b).

Reach	Flow Scenario	No. of smolts produced	Estimated Adult Return based on SAR				
			1%	2%	3%	4%	5%
Emigrant Creek (EMI) Total Stream Reach Length = 3.5 miles (5.63 km)	Without Reclamation	68,925 smolts	689	1,378	2,067	2,756	3,446
	With Reclamation (Historic Operations)	18,300 smolts	183	366	549	732	915
	With Reclamation (Proposed Operations)	41,175 smolts	412	824	1,235	1,648	2,058
S.F. Little Butte Creek (GILO) Total Stream Reach Length = 16.6 miles (26.72 km)	Without Reclamation	263,962 smolts	2,639	5,279	7,918	10,558	13,198
	With Reclamation (Historic Operations)	239,175 smolts	2,391	4,783	7,175	9,567	11,958
	With Reclamation (Proposed Operations)	226,012 smolts	2,260	4,520	6,780	9,040	11,300

Based on spawning habitat availability, smolt production estimates, and applying SAR rates of between one and five percent, it appears that the amount of spawning habitat under all three flow scenarios is sufficient to produce large numbers of adult coho salmon returns to both the Emigrant Creek and S.F. Little Butte Creek stream reaches. For Emigrant Creek, potential adult returns under the Proposed Operations scenario ranged from 412 to 2,058 adults based on the one and five percent SAR, respectively. Similarly, with implementation of the proposed operation in

S.F. Little Butte Creek an estimated 2,260 to 11,300 adult returns could be produced at SAR rates of one and five percent, respectively.

These estimates indicate that there is sufficient spawning gravel availability under both the Historic Operations and the Proposed Operations flow scenarios to maintain the present 9.2 spawners per Intrinsic Potential (IP) km spawner density requirement. It is also sufficient to support expansion to the 20 spawner per IP km spawner density goal that is required by the SONCC coho salmon Technical Recovery Team to achieve a low risk threshold necessary for SONCC coho salmon to survive and recover (Williams et al. 2008). Reclamation asserts that the amount of spawning habitat provided by the Proposed Operation flows in both Emigrant and S.F. Little Butte Creeks sufficiently allows for additional spawning to occur in excess of that currently occurring. The Proposed Operations flows therefore allow for coho salmon spawning density and adult abundance increases in both stream systems. Based on this adult production potential estimates it is believed that more spawning habitat would be available than can be effectively used by coho salmon spawners in the Bear and Emigrant Creek systems even when URR coho salmon population recovery targets are met.

Of course, these estimates provide an oversimplified example of the amount of redds that could be produced by coho salmon spawners in these reaches, since it is not reasonable to expect that adult coho salmon spawners would use every square foot of available habitat for spawning. However, these examples do illustrate that there are sufficient quantities of available spawning habitat that meet the requirements for successful coho salmon spawning and incubation under both current conditions as well as anticipated future conditions with implementation of Proposed Operations flows to allow for significant numbers of coho salmon spawners in both project affected streams.

Based on the availability of large amounts of usable spawning and incubation habitat that is currently available, which would be increased even more through flow improvements that would be provided in the Proposed Operations plan for both the Emigrant and S.F. Little Butte Creek stream reaches, it is Reclamation's conclusion that sufficient levels of spawning and incubation habitat would be provided by the proposed action to allow for successful spawning and incubation in project affected streams to allow for an adequate potential for recovery of SONCC coho salmon. Based on this information and on the limited number of coho salmon adults that are currently using the Emigrant Creek/upper Bear Creek system, it is determined that spawning habitat is not the limiting factor to coho salmon production.

Although the coho salmon populations in Emigrant/Bear Creek and in the S.F. Little Butte Creeks would be provided increased habitat areas for spawning and incubation through implementation of increased streamflows under the Proposed Operations, Reclamation cautions that coho salmon population abundance would not necessarily increase as a result. As previously stated, the coho salmon population is not currently limited by the lack of spawning habitat in project affected streams. Further increases in amounts of usable spawning habitat are therefore not likely to result in population increases. In addition, even if spawning habitat is ultimately found to be limiting, it could take many years for the additional amount of spawning/incubation habitat created by implementing the Proposed Operations to result in coho salmon abundance increases in the Emigrant Creek reach to take advantage of the available spawning habitat. This is due to the small number of coho salmon that are and have historically been observed in the Bear Creek system, the length of time to rebuild the population in this reach due to its geographic separation from other population centers such as Little Butte Creek, and other factors limiting coho salmon production in lower Bear Creek and within the SONCC ESU in general.

Summer and Overwintering Habitat Factors

Nickelson (1998) noted that overwintering pool habitat in coastal systems is important for juvenile coho salmon, and is the primary bottleneck to coho salmon smolt production, so this could be a factor limiting coho salmon production in this interior system as well (Nickelson et al. 1992b). Similarly, McMahon (1983) and several other authors such as Bustard and Narver (1975), Tschaplinski and Hartman (1983), and Brown and Hartman (1988) noted that the amount of suitable winter habitat may be a factor limiting coho salmon production. However, Baranski (1989) noted that available rearing habitat during the summer low flow period is a limiting factor in Puget Sound coho salmon production in Washington State. These studies indicate that limiting factors can vary by region, stream basin, and individual streams. In order to determine the ultimate limiting factor to coho salmon production in any particular stream system an evaluation must be performed on each of the primary habitat areas available during each coho salmon life stages (i.e. spawning/incubation, summer rearing, winter rearing) that occur on a seasonal basis to identify the factor that restricts production of coho salmon smolts or adults to the greatest extent.

The habitat model uses quantitative data of seasonal habitat availability that include estimates of the surface area of each habitat type as well as an estimate of the quantity of gravel. For each life stage except smolt, the model estimates the potential number of individuals (typically number/m^2) that available habitat in the stream can support (seasonal rearing capacity). This is the sum of the product of the surface area of each habitat type and the potential rearing density for that habitat type.

Juvenile coho salmon exhibit considerable plasticity in behavior and use of habitat (Meehan and Bjornn 1991, Sandercock 1991). During early rearing they utilize riffles and pools in streams, but as water temperatures decrease they move to tributaries, side channels, or deeper pools with some structure for overwintering (Beecher et al. 2002, Shirvell 1994, Chapman 1962, Mason and Chapman 1965, Crone and Bond 1976, Bustard and Narver 1975, McMahon 1983, Brown and Hartman 1988). In some cases they move considerable distances both upstream and downstream from summertime rearing areas to overwintering habitat (Chapman 1965, Tshaplinski and Hartman 1983, Sandercock 1991). Low summertime river flows and elevated water temperatures as well as inadequate quality and quantity of suitable overwintering habitat conditions may be factors limiting coho salmon production. Both of these time periods have been noted as constituting production bottlenecks (Nickelson 1998, Baranski 1989). Production potential estimates must be performed to determine which seasonal period constitutes the limiting factor to coho salmon production based on site specific conditions and habitat availability.

Summer Rearing Habitat Production Potential and Limiting Factors

Summer Rearing Habitat Available

The amount of summer habitat available for supporting coho salmon summer parr was obtained from the PHABSIM model for each of the three flow scenarios analyzed. The PHABSIM model output was provided in ft^2/1000 ft of channel but was subsequently converted to m^2 and summed for the entire reach for ease of calculation in the habitat model. Summer rearing habitat areas for both Emigrant Creek and S.F. Little Butte Creek reaches for all three flow scenarios are provided in Table 4. Summer rearing habitat for Emigrant Creek ranged from 9,653 m^2 for the Without Reclamation scenario to a high of 11,942 m^2 for both the Historic Operation and the Proposed Operation scenario. The increased amount of summer habitat provided by both With Reclamation scenarios over the Without Reclamation scenario is a result of increased operational releases out of Emigrant Dam during the summer months throughout the irrigation season which augments instream flows. Summer rearing habitat increases by about 23% over the Without Reclamation flow condition in the Emigrant Creek stream reach due to these releases (Table 4).

Table 4. Amount of Weighted Usable Area (WUA) for the Summer Rearing coho salmon life stage in both Emigrant and S.F. Little Butte Creeks under the Without Reclamation, Historic Operation, and the Proposed Operation. Summer habitat rearing areas calculated using the July - October average WUA for the 50% exceedence (average) water year condition.

Reach	Flow Scenario	Amount of WUA for Summer Rearing from Summer Flows (June-Oct)		
		WUA value from PHABSIM (ft^2/1000 ft)	**Total Summer Rearing Habitat Area ft^2 converted to (m^2)**	**Percent of Unregulated WUA**
Emigrant Creek (EMI) Total Stream Reach Length = 3.5 miles (5.63 km)	Without Reclamation	5,623 (ft^2/1000 ft)	103,913 ft^2 **(9,653 m^2)**	100%
	With Reclamation (Historic Operations)	6,956 (ft^2/1000 ft)	128,546 ft^2 **(11,942 m^2)**	123%
	With Reclamation (Proposed Operations)	6,956 (ft^2/1000 ft)	128,546 ft^2 **(11,942 m^2)**	123%
S.F. Little Butte Creek (GILO) Total Stream Reach Length = 16.6 miles (26.72 km)	Without Reclamation	2,736 (ft^2/1000 ft)	239,804 ft^2 **(22,278 m^2)**	100%
	With Reclamation (Historic Operations)	2,696 (ft^2/1000 ft)	236,299 ft^2 **(21,952 m^2)**	98%
	With Reclamation (Proposed Operations)	2,696 (ft^2/1000 ft)	236,299 ft^2 **(21,952 m^2)**	98%

For the S.F. Little Butte Creek stream reach, the amount of summer rearing habitat ranges from 22,278 m^2 for the Without Reclamation and 21,952 m^2 for both of the With Reclamation flow scenarios. Both With Reclamation scenarios are slightly reduced from the Without Reclamation flow scenario due to some minor flow diversions in the early and late summer period under the proposed action in the S.F. Little Butte Creek system. With the exception of these minor diversions summer flows are very similar between the Proposed Operations and Without Reclamation scenario because no (or very minor) operations occur in the S.F. Little Butte Creek during the summer months. The difference is about a 2% reduction of flows. The proposed action would provide summer rearing habitat conditions that are essentially identical to the Without Reclamation flow condition.

Summer Habitat Production Potential Estimates

To assess the effects of habitat changes resulting from different flow scenarios on coho salmon smolt production potential from the summer rearing period to smolt stage, we utilized information on typically observed coho salmon summer parr rearing density and density independent survival estimates obtained from the literature. Summer rearing habitat areas obtained from the PHABSIM model were multiplied by summer rearing density estimates of 1.7 parr/m^2 to calculate the summer parr carrying capacity in each stream reach. Summer rearing densities range from 0.1 parr/m^2 for riffle and rapids to 1.7 to 1.8 parr/m^2 for more preferred pool habitats such as lateral scour pools and mid-channel scour pools (Reeves et al. 1989, Nickelson et al. 1992b, Nickelson 1998). Because coho salmon juveniles heavily utilize pool habitats in summer and the PHABSIM summer rearing habitat areas were modeled from conditions found in pool habitats, it was assumed that 1.7 parr/m^2 was an appropriate value to use for determining overall summer pool habitat rearing capacity. Summer parr capacity estimates were then multiplied by density independent survival estimates from the habitat model (0.72; Nickelson 1998) to determine the maximum amount of smolts (carrying capacity) that could be theoretically produced for each reach and flow scenario. Finally, we applied SAR rates from one to five percent to the smolt estimates to determine the range of adult returns that could be produced (Table 5).

Production potential estimates using average rearing density and smolt survival rates from Table 5 indicate that for the Emigrant Creek stream reach a total of 14,616 smolts could have been supported under summer habitat conditions with Historic Operations and would continue to be provided with Proposed Operations. This potential smolt production is an approximately 23% increase over the production potential of 11,815 smolts under the Without Reclamation flow scenario. Conversely, for the S.F. Little Butte Creek stream reach, Proposed Operations would result in summer habitat being reduced by approximately 2% from the Without Reclamation scenario, or a summer rearing production potential decrease from 27,268 smolts to 26,869 smolts. Overall, Proposed Operations would result in a smolt carrying capacity increase of 2,801 smolts within Emigrant Creek stream reach and a decrease of 399 smolts in the S.F. Little Butte Creek stream reach based on summer rearing habitat conditions alone.

Table 5. Coho salmon smolt production potential estimates for Emigrant and S.F. Little Butte Creeks under three flow scenarios based on 1.7 summer parr per m2 rearing densities and survival rates to smolt outmigration of 0.72 (Smolt summer habitat capacity estimates and smolt survival data from Reeves et al. 1989, Nickelson 2008, and Nickelson 1998). Adult return estimates are provided for Smolt to Adult (SAR) rates of one to five percent for each flow scenario.

Reach	**Flow Scenario**	**Summer Rearing Habitat Smolt Production Potential Estimate**			**Estimated Adult Returns based on SAR**				
		Summer Habitat available in reach (m^2)	Carrying Capacity for summer parr at 1.7 parr/m^2	Number of potential smolts at 0.72 survival rate	1%	2%	3%	4%	5%
Emigrant Creek Reach (EMI) Total stream reach length = 3.5 miles (5.63 km)	Without Reclamation	9,653 m^2	16,410 parr	11,815 smolts	118	236	354	472	590
	With Reclamation (Historic Operations)	11,942 m^2	20,301 parr	14,616 smolts	146	292	438	584	730
	With Reclamation (Proposed Operations)	11,942 m^2	20,301 parr	14,616 smolts	146	292	438	584	730
South Fork Little Butte Creek Reach (GILO) Total stream reach length = 16.6 miles (26.72 km)	Without Reclamation	22,278 m^2	37,872 parr	27,268 smolts	272	545	818	1,090	1,363
	With Reclamation (Historic Operations)	21,952 m^2	37,318 parr	26,869 smolts	268	536	806	1,072	1,343
	With Reclamation (Proposed Operation)	21,952 m^2	37,318 parr	26,869 smolts	268	536	806	1,072	1,343

Because estimates of potential coho salmon smolt capacity generated by this method have been shown to be closely related to actual smolt production when summer habitat was fully seeded with juveniles [approximately 1.5-2.0 parr/m^2 of pool habitat; Nickelson et al. (1992b)] it is believed that the smolt production estimates provided here are accurate and within reason.

The affects to adult coho salmon returns based on SAR values between one and five percent mimic those described above with increased adult returns to the Emigrant Creek reach and a slight decrease in adult returns to the S.F. Little Butte Creek reach as indicated in Table 5. Between 146 and 730 adult spawners could be expected to return to Emigrant Creek under the Proposed Operations, compared to 118 to 590 adult returns that were estimated under the Without Reclamation flow scenario using SAR rates of one to five percent, respectively. Increased adult return estimates under the Proposed Operations scenario result from improved production potential due to increases in available summer rearing habitat for the Emigrant Creek stream reach. For the S.F. Little Butte Creek reach, adult returns of between 268 to 1,343 fish could be supported with implementation of the proposed action based on summer rearing habitat smolt production potential estimates and SAR rates of one to five percent. These adult return estimates are similar to those under the Without Reclamation scenario because the summer rearing habitat data upon which these estimates are based differ by only 2% (Table 4 and 5).

Comparison of estimated coho production potential based on summer rearing habitat carrying capacity versus available spawning habitat clearly shows that summer habitat is the more limiting factor to coho production. This is particularly evident when smolt production estimates from all flow scenarios for the S.F. Little Butte Creek reach are compared. Potential smolt production estimates using spawning gravel availability data indicate that between 226,012 to 263,962 smolts can be produced in this reach under Proposed Operations and Without Reclamation flow scenarios, respectively (Table 3). Under these same flow scenarios and using available summer rearing habitat data, smolt production estimates are reduced by an order of magnitude to 26,869 to 27,268 smolts (Table 5).

This analysis reveals that potential production estimates for both coho salmon smolt and adult returns are more limited by the amount of available summer rearing habitat in both the Emigrant Creek and the S.F. Little Butte Creek stream reaches analyzed than from spawning habitat availability. This conclusion is consistent with numerous studies on coho salmon ecology which indicate that space limitations that normally occur during the freshwater rearing phase of the coho salmon life cycle restrict the ultimate production of juveniles and smolts.

Optimum Female Spawner Escapement from Summer Habitat

Another useful method for determining adult production potential in stream systems utilizing summer habitat information is the calculation of optimal female spawner numbers needed to fully utilize the amount of summer rearing habitat. This method was developed to allow for the estimation of the number of female spawners that would be required to produce coho salmon fry and parr to fully seed the available summer rearing habitat in any particular stream system. This method is based on the observation that after spawning, the most restrictive limiting factor for coho salmon juveniles is the amount of available summer rearing habitat available for rearing juveniles. Egg and subsequent fry and parr production from less than the optimum number of females per km would result in insufficient fry or parr to occupy available summer rearing habitat. Conversely, fry or parr produced from more than the optimum number of female spawners per km would result in an overabundance of coho salmon fry to efficiently utilize the amount of available summer rearing habitat. The excess fry from such overproduction would either be lost to density dependent factors such as intraspecific competition due to limited space or interspecific competition from predators within that particular stream reach or be forced to emigrate from the system to downstream areas in search of available summer habitat. This is a common life history strategy that is employed by coho salmon in streams with high production potential (Chapman 1965, Mason and Chapman 1965, Hartman et al. 1969).

The optimum female spawner escapement is a back-calculation method that identifies the amount of summer habitat that is available for occupation by summer fry or parr and then estimates the number of female spawners that could produce the required number of fry to occupy that available habitat. The equation for determining optimum number of female spawners was provided by Reeves et al. 1989 and is as follows:

$$Optimum\ \#\ of\ female\ spawners/km = \frac{Total\ summer\ rearing\ area}{number\ (km)\ (area\ per\ smolt)\ (egg\ to\ smolt\ survival)\ (fecundity)}$$

where,

area per smolt = 2.5 m^2 per smolt
egg-to-smolt survival = 0.02
fecundity = 2500 eggs/female

Utilizing this equation and information available for summer rearing habitat for the Without Reclamation condition obtained from the PHABSIM model for both the Emigrant Creek and S.F. Little Butte Creek stream reaches analyzed (Table 6), indicates the following results on optimum female spawning density to fully utilize available summer rearing habitat.

Emigrant Cr. (5.63 km long) with 9,653 m^2 summer habitat:

$$\frac{9{,}653\ m2}{5.63)(2.5\ m2)(0.02)(2500)} = 13.7\ female\ spawners\ per\ km$$

S.F. Little Butte Creek (26.72 km long) with 22,278 m^2 summer habitat:

$$\frac{22{,}278\ m2}{26.72)(2.5\ m2)(0.02)(2500)} = 6.6\ female\ spawners\ per\ km$$

To obtain the optimum number of adult spawners that can fully seed a stream reach, the number of female spawners per km is multiplied by 2.0 to account for male spawners, assuming a 1-to-1 ratio of females to male spawners, and then this number is multiplied by the number of total km in the stream reach of interest. So, 13.7 female spawners per km in Emigrant Creek (multiplied by 2.0 for males) equates to 27 spawning adults per km, multiplied by 5.63 km for the entire length of the Emigrant Creek stream reach results in 154 total adult spawners needed to fully seed available summer habitat in Emigrant Creek under Without Reclamation flow conditions. Similarly for the S.F. Little Butte Creek reach where summer habitat can support the production from 6.6 females per km, times 2.0 for males equates to 13 adults per km, multiplied by 26.72 km for the S.F. Little Butte Creek stream reach length results in 353 total spawners needed to fully seed available summer habitat in S.F. Little Butte Creek for the Without Reclamation flow scenario.

Table 6. Optimum number of female spawners per km and total number of spawners required to fully seed available summer rearing habitat area for 3 flow scenarios in Emigrant and S.F. Little Butte Creek stream reaches. Method applied according to Reeves et al. (1989).

Reach	Flow Scenario	Optimum Number of Female Spawners and Total Number of Spawners Needed to Fully Seed Available Summer Habitat		
		Summer Habitat available in reach (m^2)	Optimum Number of Female spawners/km to fully seed habitat	Total Number of adult spawners to fully seed available summer rearing habitat
Emigrant Creek Reach (EMI) Total stream reach length = 3.5 miles (5.63 km)	Without Reclamation	9,653 m^2	13.7 females/km	154 adult spawners
	With Reclamation (Historic Operations)	11,942 m^2	17.0 females/km	191 adult spawners
	With Reclamation (Proposed Operations)	11,942 m^2	17.0 females/km	191 adult spawners
South Fork Little Butte Creek Reach (GILO) Total stream reach length = 16.6 miles (26.72 km)	Without Reclamation	22,278 m^2	6.6 females/km	353 adult spawners
	With Reclamation (Historic Operations)	21,952 m^2	6.5 females/km	347 adult spawners
	With Reclamation (Proposed Operations)	21,952 m^2	6.5 females/km	347 adult spawners

Table 6 indicates that summer rearing habitat availability and the optimal number of female spawners needed to fully seed that available habitat increases under the Proposed Operations relative to Without Reclamation in the Emigrant Creek stream reach. This results from more summer rearing habitat being provided during the irrigation season due to increased water releases from Emigrant Dam. The number of total adults that can be supported in this reach therefore increases from 154 adults under the Without Reclamation scenario to 191 adults under the Proposed Operations scenario, which is an increase of approximately 23%. Conversely, summer rearing habitat and the optimum number of female spawners required to fully seed that habitat in the S.F. Little Butte Creek drainage decreases by approximately 2% with Proposed Operations (Table 6). The slight decrease in summer rearing habitat available under the

Proposed Operations amounts to a decrease of approximately 6 adult coho salmon spawners in the entire S.F. Little Butte Creek stream reach.

As was shown earlier in Table 1, there is more than an adequate amount of available spawning habitat to accommodate this level of adult spawning in both the Emigrant and South Fork Little Butte Creek systems. Estimating the amount of female spawners needed to fully seed the available summer rearing habitat available under all three flow scenarios supports the conclusion that spawning habitat is not the limiting factor in either of these project affected stream systems. The availability of summer rearing habitat limits the ability of both smolt and adult production potential when both summer rearing habitat and spawning/incubation habitat are evaluated. Comparisons of Table 5 and Table 6 indicate that substantially less smolt and adult production can occur due to the limitations created by availability of summer rearing habitat in these two stream systems.

Although summer rearing habitat availability appears to limit production of smolts and adult returns when compared against spawning habitat production potential estimates, it is important to note that this limitation occurs under all three flow scenarios, including the Without Reclamation flow condition. Furthermore it is important to also note that under the Proposed Operations the amount of summer habitat available is increased relative to the Without Reclamation condition, and as a result both smolts and adult production potentials are anticipated to be higher than they would be under the Without Reclamation flow scenario when summer rearing habitat the only factor considered. In other words, implementation of the Proposed Operations in the Emigrant Creek stream reach does not remove the ultimate production potential bottleneck created by summer habitat (as will be shown in subsequent sections), however, it does result in improved summer rearing habitat conditions and allows for greater production to occur relative to the Without Reclamation flow scenario in this particular stream reach.

For the S.F. Little Butte Creek stream reach, available summer habitat is slightly reduced with implementation of the Proposed Operations relative to the Without Reclamation condition. As a result, the production potential for both coho salmon smolts and adults are also commensurately reduced by approximately 2% (Table 5 and 6).

Given the amounts of available summer rearing habitat and available spawning habitat for both the Without Reclamation and the Proposed Operations flow scenarios, a SAR rate of between 1% and 2% would be sufficient to provide a sustainable population of smolts and adults for both the Emigrant Creek and S.F. Little Butte Creek stream reaches as indicated by optimum number of spawners to fully seed available summer rearing habitats shown in Table 6.

Bradford et al. (2000) analyzed 14 datasets from Pacific Northwest streams and reported that about 19 spawning females per km, ranging from 4 to 44, were needed to achieve full production capacity for smolts. This was at low spawner abundance. Beidler et al. (1980 cited in Nickelson et al. 1992) noted that at least 25 spawners were needed to seed juvenile rearing habitat in some Oregon coastal streams. Our assessment of production potential indicates that between 13.7 and 17 female fish per km (27 to 34 total adults/km) are needed to fully seed available habitat in the Emigrant Creek stream reach given both Without Reclamation and Proposed Operations habitat availability data. For the S.F. Little Butte Creek stream reach our assessment indicates that only 6.5 to 6.6 females (13 total fish/km) are needed to fully seed available summer habitat areas in the reach analyzed over all flow scenarios.

Estimated adult returns for one to three percent SAR are in the range reported by Bradford et al. (2000). Shaul and Van Alen (2001) reported low average spawner and smolt densities of 5 to 6 females per km in interior basin Alaska streams. Similarly, during the 2004 to 2008 run years, Lewis et al. (2009) estimated an average of 6 coho salmon spawners per mile in the Upper Rogue subbasin (hatchery or wild origin unstated). These authors suggest that low coho salmon densities may be characteristic of interior habitats, similar to, and inclusive of the interior Rogue. The 5 to 6 females per km Shaul and Van Alen (2001) reported compares closely with the low estimate of 6.6 adults per km for 1.7 fish per m^2 of summer rearing habitat used in this assessment at SAR rates of one to two percent estimated here. These reported adult spawner densities from interior stream systems indicate that summer rearing habitat may have a controlling effect on the number of coho salmon smolts and adults that can be produced from any given stream system, even in streams that have large amounts of spawning and incubation habitat.

Winter Rearing Habitat Production Potential and Limiting Factors Analysis

In general for both coastal and inland stream systems there tends to be less winter habitat than summer habitat. This is because coho salmon prefer pools with different characteristics during winter than summer (Chapman 1965, Mason 1976, McMahon 1983, Reeves et al. 1989, Nickelson 1998) and these characteristics tend to be more restricted in physical extent for the winter than summer habitat. Pool habitats that were suitable in summer can become unsuitable due to these changing requirements or preferences. For example, coho salmon winter parr prefer to occupy pool habitat that is larger, deeper, and provides more cover and protection from high flows than they do in the summer (Bustard and Narver 1975). This is typical of coho salmon habitat preferences as they transition from summer habitat to overwintering habitat (Hassler 1987). As a result, there is typically a reduction in the amount of habitat that is considered useable by winter parr over summer parr.

Winter Rearing Habitat Available

The amount of winter habitat available for supporting coho salmon winter parr was obtained from the PHABSIM model for each of the three flow scenarios analyzed. The PHABSIM model output was provided in ft^2/1000 ft of channel but was subsequently converted to m^2 and summed for the entire reach for ease of calculation in the habitat model. Winter rearing habitat areas for both Emigrant Creek and S.F. Little Butte Creek reaches for all three flow scenarios are provided in Table 7.

Winter rearing habitat for Emigrant Creek ranged from 9,506 m^2 for the Without Reclamation scenario to a low of 6,156 m^2 for the Historic Operation flow schedule. The Proposed Operations provides habitat that is approximately intermediate between the high and low values at 8,060 m^2 (Table 7). The amount of winter rearing habitat present under the Proposed Operations would be approximately 15% less than the Without Reclamation flow scenario.

Table 7. Amount of Weighted Usable Area (WUA) for the Winter Rearing coho salmon life stage in both Emigrant and S.F. Little Butte Creeks under the Without Reclamation, Historic Operations, and the Proposed Operations. Winter habitat rearing areas calculated using the January - April average WUA for the 50% exceedence (average) water year condition.

Reach	Flow Scenario	Amount of WUA for Winter Rearing from Winter Flows (November-April)		
		WUA value from PHABSIM (ft^2/1000 ft)	**Total Winter Rearing Habitat Area ft^2 converted to (m^2)**	**Percent of Unregulated WUA**
Emigrant Creek (EMI) Total Stream Reach Length = 3.5 miles (5.63 km)	Without Reclamation	5,537 (ft^2/1000 ft)	102,324 ft^2 **(9,506 m^2)**	100%
	With Reclamation (Historic Operations)	3,586 (ft^2/1000 ft)	66,269 ft^2 **(6,156 m^2)**	65%
	With Reclamation (Proposed Operations)	4,695 (ft^2/1000 ft)	86,763 ft^2 **(8,060 m^2)**	85%
S.F. Little Butte Creek (GILO) Total Stream Reach Length = 16.6 miles (26.72 km)	Without Reclamation	2,260 (ft^2/1000 ft)	198,880 ft^2 **(18,476 m^2)**	100%
	With Reclamation (Historic Operations)	2,025 (ft^2/1000 ft)	178,200 ft^2 **(16,555 m^2)**	89%
	With Reclamation (Proposed Operations)	1,724 (ft^2/1000 ft)	151,712 ft^2 **(14,094 m^2)**	76%

For the S.F. Little Butte Creek stream reach, the amount of winter rearing habitat ranges from a high of 18,476 m^2 for the Without Reclamation flow scenario and 14,094 m^2 with the Proposed Operations. The proposed action flows are slightly reduced from the Without Reclamation flow scenario due to flow diversions in the winter period in this stream reach. These reductions are approximately 24%.

Winter Habitat Production Potential Estimates

From the winter rearing habitat area of pools in the stream reaches analyzed, we calculated the number of juveniles that could be supported by available habitat areas and that could be expected to survive to the following spring to outmigrate as smolts. We utilized information on typically observed coho salmon winter parr rearing density and density independent survival estimates obtained from the literature. Winter rearing habitat areas obtained from the PHABSIM model were multiplied by winter rearing density estimates of 1.8 parr/m^2 to calculate the winter carrying capacity for overwintering parr in each stream reach (Reeves et al. 1989, Nickelson 1998). Similar to summer rearing densities, winter rearing densities vary widely according to habitat type. Typically, suitable winter rearing habitat is in least supply in Oregon coastal streams compared with the other habitat types and thus has a greater potential to limit smolt production in freshwater environments (Nickelson 1992, Nickelson 1998; Reeves et al. 1989). Winter rearing density estimates range from 0.1 parr/m^2 or less for riffle and glide habitats and can approximate 0.6 to 1.8 parr/m^2 for more preferred pool habitats including dammed pools, backwater pools, beaver ponds and alcoves (Nickelson et al. 1992b, Nickelson 1998).

Because coho salmon juveniles heavily utilize these limited and specific types of pool habitats in winter and the PHABSIM winter rearing habitat areas were modeled from conditions found in pool habitats with overwintering characteristics, we estimated the number of smolts that could be produced within each reach based on available winter rearing habitat values from the PHABSIM model. We then assumed that the 1.8 parr/m^2 rearing capacity value obtained from the literature and which has been typically used to estimate wintering capacities was an appropriate value to use for determining overall winter habitat rearing capacity. Available winter parr rearing capacity estimates were then multiplied by a density independent survival estimate of 0.31 from the habitat model (Reeves et al. 1989, Nickelson 2008) to determine the amount of smolts that could be produced for each reach and flow scenario. Finally, from the number of fish expected to survive the winter, we calculated number of fish per km for the total length of each stream reach analyzed for each of the three flow scenarios for comparison and we applied SAR rates from one to five percent to the smolt estimates to determine the range of adult returns that could be produced given these typically observed out of basin survival rates (Table 8).
These values were compared with published values on smolts per km and adults per km.

We estimated that 9,506 m^2 and 18,476 m^2 of pool habitat was present in the two stream reaches analyzed under the Without Reclamation flow scenario (Table 8). If these pools were used as overwintering habitat by juvenile coho salmon at rearing densities of 1.8 winter parr/m^2, we estimated that approximately 5,304 smolts and 10,310 smolts could theoretically be produced in the Emigrant and S.F. Little Butte Creek stream reaches, respectively, under the Without Reclamation flow scenario. Smolt production estimates from winter habitat areas anticipated to be available as calculated from the Proposed Operations for Emigrant and S.F. Little Butte Creek were 4,497 and 7,864 smolts, respectively. These smolt production estimates are reductions in approximately 807 smolts in Emigrant Creek and 2,446 smolts in the S.F. Little Butte Creek reach. These are 15% and 24% reductions respectively from Without Reclamation production levels. For juvenile rearing/overwintering habitat, we conservatively estimated that Emigrant Creek and the S.F. Little Butte Creek reaches analyzed could produce about 4,497 and 7,864 coho salmon smolts respectively, at 1.8 overwinter parr/m^2, or about 798 and 294 smolts per km of total reach area for Emigrant and S.F. Little Butte Creek reaches analyzed.

We also estimated the number of returning adults based on SARs from one to five percent. Based on smolt production potential estimates from Table 8, approximately 53 to 265 adult returns for the Without Reclamation flow scenario and 45 to 224 adult coho salmon would be expected to return under the Proposed Operations flow scenario for the Emigrant Creek reach. For the S.F. Little Butte Creek reach between 103 to 515 and 78 to 393 adults for the Without Reclamation and the Proposed Operations, respectively (Table 8) would be expected.

Smolt and adult coho salmon production estimates that were derived from winter rearing habitat areas available under all three flow scenarios were much less than those calculated based on either amount of spawning habitat available or summer rearing habitat. This indicates that winter rearing habitat is the limiting physical habitat variable that is most likely be the ultimate limiting factor to coho salmon production in the two Rogue River Basin stream reaches analyzed. This conclusion is based on the assumption that the life stage that results in the lowest potential smolt yield is the critical life stage and the amount and type of habitat needed by that life stage is the limiting habitat.

Table 8. Coho salmon smolt production potential estimates for Emigrant and S.F. Little Butte Creeks under three flow scenarios based on 1.8 winter parr per m^2 rearing densities and survival rates to smolt outmigration of 0.31 (Smolt winter habitat capacity estimates and smolt survival data from Reeves et al. 1989, Nickelson 1998, and Nickelson 2008). Adult return estimates are provided for Smolt to Adult (SAR) rates of one to five percent for each flow scenario.

Reach	**Flow Scenario**	**Winter Rearing Habitat Smolt Production Potential Estimate**				**Estimated Adult Returns based on SAR**				
		Winter Habitat available in reach (m^2)	Carrying Capacity for winter parr at 1.8 parr/m^2	Number of potential smolts at 0.31 survival rate	Number of potential smolts per km	1%	2%	3%	4%	5%
Emigrant Creek Reach (EMI)	Without Reclamation	9,506 m^2	17,111 winter parr	5,304 smolts	942	53	106	159	212 (3	265
Total stream reach length = 3.5 miles (5.63 km)	With Reclamation (Historic Operations)	6,156 m^2	11,081 winter parr	3,435 smolts	610	34	68	103	136	171
	With Reclamation (Proposed Operations)	8,060 m^2	14,508 winter parr	4,497 smolts	798	44	90	134	180	224
South Fork Little Butte Creek Reach (GILO)	Without Reclamation	18,476 m^2	33,257 winter parr	10,310 smolts	385	103	206	309	412	515
Total stream reach length = 16.6 miles (26.72 km)	With Reclamation (Historic Operations)	16,555 m^2	29,799 winter parr	9,238 smolts	345	92	184	277	368	461
	With Reclamation (Proposed Operations)	14,094 m^2	25,369 winter parr	7,864 smolts	294	78	157	236	314	~~393~~

Because winter habitat area is the ultimate limiting factor to coho salmon production potential, increases in this limiting habitat variable would eventually be needed to allow for increased production potential in both stream reaches analyzed. Increasing the amount of available winter rearing habitat would relieve the population bottleneck created by this most restricting habitat variable. Although winter rearing habitat is estimated as being the ultimate factor limiting coho salmon production, it is important to note that this habitat would only be the limiting factor at full seeding levels in these creeks. If current rearing densities are less than 1.8 parr/m^2 in all available winter rearing pools then the currently available winter habitat is not being fully utilized and therefore not limiting the population. Systems that have low spawner abundance and therefore low summer and winter parr production tend to not be winter or summer habitat limited. This appears to be the case with Emigrant Creek as very few adults are currently observed to be using this available habitat, and as a result, very few juveniles are observed to be using available habitat areas. The S.F. Little Butte Creek system is likely closer to being winter habitat limited since adult spawning abundance appears to be at levels where winter rearing habitat is being fully utilized. The adult returns calculated from the winter rearing habitat smolt production assuming a 4% SAR rate (Table 8) appear to be very close to those at equilibrium levels from summer rearing habitat (Table 6).

Summary

This coho salmon potential production estimation analysis indicates that based on the availability of physical habitat resulting from Without Reclamation and Proposed Operations flow conditions only, there is a sufficient amount of spawning habitat available to support between 1,648 – 2,756 adult spawners in the 5.63 km long Emigrant Creek stream reach and between 9,040 – 10,558 adult spawners in the 26.72 km long S.F. Little Butte Creek stream reach (Table 9). Estimated production of coho salmon eggs, juveniles and smolts that could be produced from full utilization of currently available spawning habitat indicates that both stream systems can be fully seeded from such spawning levels (Table 9) and that availability of physical spawning gravel habitat areas indicates that spawning habitat is not currently limiting the production of coho salmon in these watersheds. Despite such high potential production estimates for the smolt and adult life stages from fully utilization of spawning habitat by adult fish, these production estimates are not realistic and are not close to the observed smolt production or adult escapements from either of these important stream reaches (ODFW 2005, ODFW 2005a, Lewis et al. 2009). Because there is currently more spawning habitat available than needed to support larger coho salmon populations than are currently observed in these stream systems, any actions to increase the amount of spawning habitat in these systems would not remove a production bottleneck and would not result in increased coho salmon production.

Because of the abundance of available spawning habitat in both project affected stream reaches under the Without Reclamation and Proposed Operations flow scenarios, there exists enough habitat to fully seed these stream reaches with summer fry and parr. Based on an analysis of the total amount of summer rearing habitat available under both flow scenarios (Table 9), it is apparent that the resulting production potential estimates for smolts (11,815 to 14,616 in Emigrant Creek; and 26,869 to 27,268 for S.F. Little Butte Creek) are much less than can be supported by production potentials resulting from available spawning habitat described above. This further indicates that the availability of spawning habitat is not limiting the production potential in either of these stream reaches. Based on the availability of summer rearing habitat and a 4% SAR rate it appears that approximately 472 to 584 adult coho salmon returns could be sustained in the Emigrant Creek stream reach, while approximately 1,072 to 1,090 adults could be sustained in the S.F. Little Butte Creek stream reach.

The estimated smolt outmigrant numbers and returning adult escapements that are based on summer rearing habitat availability data provide more realistic production potential estimates when compared to observed numbers of smolts produced from, or adults returning to, the S.F. Little Butte Creek production area in particular. Production potential estimates resulting from summer habitat limitations also appear to be more representative of the true production potential of these systems when compared to the smolt and adult production estimates from spawning habitat availability data described above. This reflects the realities of space limitation and increased coho salmon mortality that are typically observed during the summer rearing period for these stream obligate species. Initial fry densities resulting from adult spawning are reduced through space limitations and both density dependent and density independent mortality factors that result in lower summer parr densities through the summer period as pool sizes decrease with declining summer streamflow.

In the case of the two stream reaches analyzed for this report, the Proposed Operations provide for either increased production potential in Emigrant Creek compared to the Without Reclamation flow scenario, or for approximately equal production potential in the case of the S.F. Little Butte Creek stream reach, because summer flow operations in Emigrant Creek provide more flow and support more suitable summer habitat conditions. For the S.F. Little Butte Creek stream reach summer production potential estimates for smolts and adults are equal to those for the Without Reclamation flow scenario since little or no operations occur as a result of the Rogue Project during the summer months in S.F. Little Butte Creek system.

Despite the more realistic smolt and adult production estimates that are provided using summer rearing habitat availability data, production potential estimates based on summer habitat availability are still likely to be higher than observed estimates or the true production potential for the stream reaches analyzed because all flow scenarios provide more summer rearing habitat than winter rearing habitat. Assuming that summer habitat is not the ultimate limiting factor to coho salmon smolt production in these stream reaches (see paragraphs below), it is unlikely that increased coho salmon smolt production would occur with further increases in summer rearing habitat. As a result, enhancing habitat to increase the amount of physical summer habitat available for coho salmon in Emigrant or S.F. Little Butte Creeks is not a recommendation at this time unless physical habitat enhancements also result in improved water quality or reduce other stressors known to restrict production potential.

The amount of available summer habitat is maintained at increased levels (for the Emigrant Creek reach) or similar levels (for the S.F. Little Butte Creek reach) to those under the Without Reclamation flow scenario. Summer habitat areas that are available to support summer rearing coho salmon are in greater abundance in each of these stream reaches than for suitable winter rearing habitat. Furthermore, overwinter mortality tends to further reduce coho salmon production in most stream systems when analyses are based on habitat availability alone. Therefore it is likely that summer rearing habitat would not be the ultimate limiting factor to coho salmon production.

Table 9. Comparison of coho salmon production potential estimates using habitat availability for 3 different coho salmon life history stages (adult spawning, summer rearing, and winter rearing) and 3 different flow scenarios. Data is summarized from tables cited earlier in the document. Results from the Bradford model are also presented for comparative purposes for both the Emigrant Creek and S.F. Little Butte Creek stream reaches.

	Spawning Habitat Production Potential Estimate (Data from Tables 2 and 3)			Summer Rearing Production Potential Estimate (Data from Table 5)			Winter Rearing Production Potential Estimate (Data from Table 8)			Bradford Model[1]	
Flow Scenario	No. of eggs produced	No. of smolts	No. of adult returns at 4% SAR rate	No. of summer parr	No. of smolts	No. of adult returns at 4% SAR rate	No. of winter parr	No. of smolts	No. of adult returns at 4% SAR rate	No. of smolts	No. of adult returns using 4% SAR rate
Emigrant Creek Reach (EMI)											
Without Reclamation	4,595,000	68,925	2,756	16,410	11,815	472	17,111	5,304	212	5,304	212
With Reclamation (Historic Operations)	1,220,000	18,300	732	20,301	14,616	584	11,081	3,435	136	- -	- -
With Reclamation (Proposed Operations)	2,745,000	41,175	1,648	20,301	14,616	584	14,508	4,497	180	- -	- -
S.F. Little Butte Creek Reach (GILO)											
Without Reclamation	17,597,500	263,962	10,558	37,872	27,268	1,090	33,257	10,310	412	19,896	796
With Reclamation (Historic Operations)	15,945,000	239,175	9,567	37,318	26,869	1,072	29,799	9,238	368	- -	- -
With Reclamation (Proposed Operations)	15,067,500	226,012	9,040	37,318	26,869	1,072	25,369	7,864	314	- -	- -

[1] -The Bradford model equation is presented earlier in the document and was used to calculate smolt abundance from stream length (km) only. Because stream length does not vary between the 3 flow scenarios presented, the results from the Bradford model are only presented once for each stream reach.

Smolt production estimates using available winter habitat as the driving variable indicate that 5,304 smolts could potentially be produced under Without Reclamation habitat conditions and 4,497 smolts could be produced under the Proposed Operations in the Emigrant Creek watershed (Table 9). Similarly, 10,310 smolts were estimated under the Without Reclamation scenario for S.F. Little Butte Creek with 7,864 smolts being ultimately produced under the Proposed Operations scenario. These potential production estimates based on availability of winter rearing habitat indicate that the proposed action would result in a 15% reduction in the Emigrant Creek smolt capacity estimate and a 24% reduction in smolt capacity estimates in the S.F. Little Butte Creek populations compared to the Without Reclamation flow scenario. If the assumption of a 4% SAR return rate is used, these smolt production estimates indicate that each of these stream systems can support a sustained production of 212 adults and 412 adults for the Emigrant and S.F. Little Butte Creek reaches respectively, at full stream seeding levels under the Without Reclamation flow scenario and could potentially support 180 and 314 adult returns for the same creeks under the Proposed Operations.

Because available winter rearing habitat under both the Without Reclamation and Proposed Operations produced the lowest estimated number of outmigrating smolts and returning adults when compared to estimates for other life history stages (spawning and summer rearing), winter rearing habitat is indicated as being the ultimate limiting factor to coho salmon production in both stream reaches analyzed in this report. Based on a limiting factors analysis of physical habitat availability alone in the two uppermost reaches of the Bear and Little Butte Creek watersheds, it appears that winter rearing habitat is the most limiting physical habitat variable in these stream systems under both the Without Reclamation and the With Reclamation scenarios. The number of smolts estimated in both Emigrant and S.F. Little Butte Creeks from the winter rearing habitat data as well as the estimates of returning adults that were generated from those smolt estimates assuming a 4% SAR rate are considered to be the maximum sustained production potential that these stream systems can theoretically support based on physical habitat data alone.

To provide a check on the ability of these stream systems to ultimately support the level of adult production estimated using winter rearing habitat as the limiting factor (e.g. 180 to 212 returning adults for Emigrant Creek and 314 to 412 returning adults for S.F. Little Butte Creek), the optimum number of spawners needed to fully seed available summer habitat was calculated using methods described by Reeves et al. (1989). Those adult spawner levels were presented and discussed earlier in this document and summarized in Table 6. According to optimum spawner estimates, approximately 154 to 191 adult spawners would be needed to fully utilize the available summer habitat for Emigrant Creek, whereas 347 to 353 would be required in the S.F. Little Butte Creek stream reach. These estimates are based on available summer rearing habitat and correspond well with the estimated number of adult coho salmon spawners that can be sustained over the long term based on the winter rearing habitat limitations and 4% SAR rates.

When these estimates are compared, it appears that a maximum spawner abundance of approximately 212 and 412 coho salmon adults could be supported on a sustained basis under the Without Reclamation flow scenario for the Emigrant and S.F. Little Butte Creek stream reaches, respectively, if winter rearing habitat is the limiting factor. Under the Proposed Operations flow scenario it appears that the maximum sustainable adult coho salmon production estimate would be 180 and 314 adults, respectively, for these same stream systems. Potential production estimates under the Proposed Operations would constitute a reduction in sustained adult production at equilibrium population levels of approximately 32 adult coho salmon in the Emigrant Creek reach and 98 adult coho salmon in the S.F. Little Butte Creek stream reach.

Under the winter habitat limiting factor assumption, the production potential of coho salmon smolts and adults is very comparable to literature sources of coho production potential based on stream length and latitude, and number of spawning fish per mile methods. We feel that the estimate of production potential presented here is reasonable and conservative.

Smolt production estimates using winter rearing as the limiting factor for the Without Reclamation flow scenario agreed exactly with smolt estimates that were obtained from the Bradford Model (5,304 smolts) in the Emigrant Creek reach (Table 9). However, smolt production estimates based on winter rearing habitat for the Without Reclamation flow scenario for the S.F. Little Butte Creek reach (10,310 smolts) were only 50% of the smolt estimate predicted from the Bradford Model (19,896 smolts). The Bradford Model smolt estimate was found to be intermediate between the smolt estimates obtained from the winter rearing and summer rearing habitat availability limiting habitat calculations for the S.F. Little Butte Creek (Table 9).

Sufficient amounts of available and useable habitat for spawning, summer rearing, and winter rearing would exist under the Proposed Operations to support coho salmon in both the Emigrant Creek and S.F. Little Butte Creek systems at greater abundance levels than are currently observed in these stream systems. In summary, sufficient spawning habitat is currently available to support enough adult coho salmon spawners to fully seed available summer rearing habitat found in these two important Rogue Basin stream systems. Similarly, sufficient summer rearing habitat exists under the Without Reclamation and Proposed Operation flow scenarios to provide sufficient summer parr survival and production to fully seed available winter rearing habitat in both stream reaches analyzed. Finally, the amount of winter rearing habitat available under both the Without Reclamation and With Reclamation flow scenarios was found to be the ultimate limiting factor for both the Without Reclamation flow scenario as well as the Proposed Operations flow scenario.

Winter habitat appears to be the limiting factor to coho salmon production at higher spawner abundance levels. However, winter rearing habitat would not limit the population until returning adult coho salmon spawner abundance levels produce enough offspring to fully seed available winter habitat that is presently available. Current adult production levels, especially in the Emigrant/Bear Creek system are insufficient to fully seed the available summer or winter rearing habitat. As a result, winter rearing habitat is not immediately limiting the population and is not acting as the current bottleneck to population productivity at this time. Winter rearing habitat may become limiting, and would likely be the first habitat factor to become limiting, but only at significantly higher adult spawner abundance levels than are currently observed. From this limiting factors analysis in appears that winter rearing habitat would become the limiting factor when spawner abundance surpasses 180 adult spawners in Emigrant Creek and 412 adult spawners in the S.F. Little Butte Creek production area. Until these adult escapement numbers are achieved the current limiting factor to coho salmon production would be adult spawner abundance.

Discussion

This assessment of coho salmon production potential only dealt with mainstem reaches (no tributaries) and only estimated the production potential of habitat areas within the boundaries of each reach: 5.63 km in Emigrant and 26.72 km in S.F. Little Butte Creeks respectively. Substantial spawning and rearing areas are available to coho salmon within major tributaries of these mainstem reaches. However, production potential for coho salmon smolts and adults from these tributary habitat areas were not considered or modeled in this document.

Application of the habitat limiting factors model to Rogue River Basin streams that are influenced by the Rogue Irrigation Project suggests that availability of overwintering habitat limits coho salmon smolt production (Tables 8 and 9) when only physical habitat availability is modeled. Minimum coho salmon adult escapement necessary to fully seed available habitat with juveniles was estimated at approximately 180 to 212 adult coho salmon for the Emigrant Creek reach, while escapements of 314 to 412 were found to fully seed available winter habitat in S.F. Little Butte Creek production area. Smolt to adult return rates of approximately 4 percent would be necessary to produce the minimum number of adults (Table 9) at equilibrium rates of production. This analysis also indicates that there is more summer habitat available than winter habitat in the stream reaches analyzed. This is expected as winter habitat areas decrease in quantity as coho salmon parr and smolt rearing preferences become more stringent over the winter season. However, the amount of smolt production from winter habitat is sufficient to produce enough adult returns at 4% SAR rates to fully utilize the available summer habitat in both reaches analyzed. These stream systems seem to therefore be in equilibrium with the proper balance of summer and winter habitat areas to produce a sustained population when physical habitat conditions are evaluated alone.

Both the Nickelson and the Bradford models appear to provide reasonable estimates of coho salmon production for low gradient systems. The Nickelson (1998) and Bradford et al. (1997) models both yielded similar estimates of smolt production, and Anderson and Hetrick (2004) found that the model of Bradford et al. (1997) closely approximated smolt production estimated from the intensive habitat inventory model (Nickelson 1998) for streams on the Alaska Peninsula. The production estimates for the Emigrant Creek reach from the habitat model was exactly predicted by the Bradford et al. (1997) model prediction that was based on stream length only (Table 9) for the Without Reclamation flow scenario. However, the Bradford et al. (1997) model significantly overestimated the smolt and adult potential production that was calculated from the habitat model of Nickelson in the S.F. Little Butte Creek reach that was based on the assumption of a winter habitat limiting factor. Bradford et al. (1997) reported that stream length was useful in predicting mean smolt abundance, and that streams between 48 to 50 °N latitude were most productive, with those between 46 to 48 °N latitude somewhat less so. The Rogue River Basin streams that are the subject of this report are situated at about 42.25 °N latitude and would therefore fall within the extreme southern portion of the coho salmon range where productivity would be expected to be reduced overall.

Bradford et al. (1997) related $\log_e$ mean coho salmon smolt abundance to $\log_e$ stream length (km). From this equation we calculated that the 5.63 km Emigrant Creek reach and the 26.72 km S.F. Little Butte Creek stream reach could potentially produce 5,304 smolts and 212 adults and 19,896 coho salmon smolts and 796 adults, respectively. For the Emigrant Creek reach the Bradford model estimate equated quite well and was consistent with the winter rearing habitat limiting factor production levels and adult return values using the 4% SAR rate which were, 5,304 smolts and 212 adult returns (Table 9). For the S.F. Little Butte Creek production potential estimates, however, the Bradford model produced smolt capacity and adult return prediction results that were intermediate between the summer rearing and winter rearing production potential estimates. The high estimate for smolt production using the Bradford model in the S.F. Little Butte Creek reach could be explained by the fact that the S.F. Little Butte Creek system is dominated by larger percentages of riffle and glide habitat and smaller proportions of pool habitat that is favored by coho salmon juveniles. Since the Bradford model predicts smolt production based on stream length only, it would tend to overestimate smolt production on stream systems with fewer pool areas per mile of stream similar to the S.F. Little Butte Creek.

Smolt and adult production estimates based on spawning habitat availability indicate that the S.F. Little Butte Creek stream reach produces about 5 times more smolts and adults then are produced in Emigrant Creek. This is to be expected since the S.F. Little Butte Creek reach is approximately 5 times longer (26.72 km) then the Emigrant Creek stream reach (5.63 km) and has comparable amounts of spawning habitat as measured by PHABSIM WUA values per 1,000 ft of stream length. Conversely, total coho salmon smolt estimates from the S.F. Little Butte Creek reach are only 2 times as high as smolt estimates from the Emigrant Creek reach for both summer and winter habitat estimates, despite the S.F. Little Butte Creek being 5 times longer in reach length. This is because both summer and winter habitat areas (ft^2 per 1,000 ft of stream channel) are much lower in the S.F. Little Butte Creek reach than in Emigrant Creek. These smolt estimates and WUA habitat values indicate that pool habitat is not as prevalent per 1,000 ft of stream in the S.F. Little Butte Creek reach as in the Emigrant Creek reach. This observation is consistent with habitat survey data for these creeks that show higher percentages of riffle habitat and lower amounts of pool habitats in the S.F. Little Butte Creek reach then are found in the Emigrant Creek stream reach.

Although the estimate of 10,310 smolts from the overwintering rearing habitat estimation method for the S.F. Little Butte Creek population appears to be substantially lower than available data on actual smolt outmigration from the basin (18,800 smolts), they do compare very favorably with the 2004 estimate of 10,000+ presmolts estimated prior to 2004 by Vogt (2004). The estimate of 10,310 smolts derived from this analysis actually compares favorably with the more recent observed estimate of 18,800 smolts when all other coho salmon production areas in the Little Butte Creek watershed are considered. The S.F. Little Butte Creek estimate represents production from only a portion of the entire basin production. The ODFW estimate of 18,800 smolts includes the estimate of the entire basin, including production from the North Fork and mainstem Little Butte Creeks as well. For instance, Nickelson (2008) predicted that the North Fork of Little Butte Creek had the highest potential for smolt capacity for the entire Little Butte Creek watershed. Therefore it can be expected that these estimates for S.F. Little Butte Creek in combination with other production areas in Little Butte Creek could account for the 18,800 smolt production estimate of the ODFW (2004) or the higher estimates produced by other studies.

Regarding effects on Little Butte Creek, the Rogue Project diverts water from the upper watershed and transfers those flows to the Bear Creek Watershed. The effects of the diversions on annual coho salmon production are not obvious. ODFW annual fish trapping efforts indicate Little Butte Creek consistently produces more than 10,000 pre-smolts per year, and is the most productive watershed in the Upper Rogue for coho salmon, representing about 77% of the total annual production of URR pre-smolts (Vogt, 2004). In terms of pre-smolt production per stream mile, Little Butte Creek produced 200 or more pre-smolts per mile in 6 out of 7 years of trapping (between 1998 to 2004), with three of those years resulting in over 600 smolts per mile produced. Results presented from ODFW smolt trapping estimates compare favorably with habitat limiting factor estimates presented in this report. Under smolt production estimates produced for this report for the S.F. Little Butte Creek stream reach approximately 10,310 smolts were estimated based on Without Reclamation flow scenario, with 7,864 smolts being produced under the Proposed Operations. These smolt estimates translate into 385 and 294 smolts per mile, respectively, for these various flow scenarios (Table 8).

The SONCC ESU Technical Recovery Team (TRT) that was convened by NOAA Fisheries to establish recovery criteria for the Oregon and Northern California Coast Recovery Domain observed that coho salmon production in the URR was currently at approximately 9.2 to 9.8 spawners/Intrinsic Potential km (IP km). The TRT further concluded that approximately 20 spawners/IP km was required for the URR coho salmon population to be meet the low risk of extinction threshold necessary to survive and recover (Williams et al 2006, Williams et al. 2008). Multiplying the estimated current (9.2 spawners/IP km) and required spawner density (20 spawners/IP km) by the amount of accessible habitat in these two stream reaches (5.63 km in Emigrant and 26.72 km in S.F. Little Butte Creek) gives escapement numbers of 51 (current) and 112 (required) in the Emigrant Creek reach, and 245 (current) and 534 (required) spawners to meet recovery threshold levels in the S.F. Little Butte Creek stream reaches. The adult production potential estimates produced from this assessment of 180 to 212 adults in Emigrant Creek and 314 to 412 adult returns at long term equilibrium levels in S.F. Little Butte Creek indicate that there is sufficient habitat under all flow scenarios modeled in the Emigrant Creek reach to meet the TRT recovery target for spawner density of 20 spawners/IP km. For the S.F. Little Butte Creek stream reach there appears to be a sufficient amount of habitat to support the current spawning density of 9.2 fish/IP km and allow for increases in spawning density. Using the adult production capacity estimate of 412 total spawners at equilibrium levels, a maximum spawner density of only 15.5 adults/IP km (412 adults/26.72 km) could possibly be met over the long term. Even using available habitat under the Without Reclamation flow scenario, there appears to be an insufficient amount of habitat to allow for establishment of recovery target spawning densities identified by Williams et al. (2008) in the S.F. Little Butte Creek stream reach.

We believe that the long term equilibrium adult production estimates obtained from this assessment are conservative and accurate. The estimate of 412 spawners that was calculated for the S.F. Little Butte Creek population using the smolt estimate and an SAR rate of 4% for the Without Reclamation flow scenario (Table 8 and 9) is very similar to those observed during adult spawner estimates performed in 1949-55 by the U.S. Fish and Wildlife Service (USFWS 1955) and by adult production estimates from Rivers (1963). These estimates were based on direct observations of returning adult spawners to the Little Butte Creek watershed prior to construction of the enlarged Emigrant Dam and Reclamation presence in the basin. The observed estimate of 500 adults utilizing habitat in S.F. Little Butte Creek over a 10-year average period as reported by the U.S. Fish and Wildlife Service (1955) and Rivers (1963) indicates that the adult production potential estimates methods in this report are accurate and are representative of actual production potential capabilities of the S.F. Little Butte Creeks system. The USFWS report also indicated that up to 1,000 adult coho salmon spawners were observed to use S.F. Little Butte Creek in a year with excellent returns to the entire basin (1949) indicating that in years with above average escapement more spawners may use spawning habitat than long term equilibrium numbers can support.

The production potential estimates for adult spawners estimated for this assessment (180 to 212 adult coho salmon for Emigrant Creek, and 314 to 412 adults for S.F. Little Butte Creek) reflect abundance numbers that were based on the maximum sustained production at long term equilibrium levels from available physical habitat areas within each reach. It is important to note that these predicted long term equilibrium production numbers are not necessarily the maximum number of adult spawners that could use these reaches in any given year. As indicated by the amount of spawning habitat available, and years when observed spawner abundance was higher than predicted equilibrium production levels (e.g. 1949 with 1,000 adult returns as described above), it is likely that in years with above average escapement levels in the entire Rogue Basin that larger numbers of spawners could occur in these project affected stream reaches then predicted from this assessment. As described earlier there is a sufficient amount of physical habitat to support several thousand spawners in these reaches (Tables 1-3). However, as shown in this assessment there are insufficient amounts of subsequent rearing habitat to support either summer and winter rearing life stages for this amount of spawning, regardless of flow scenario analyzed. As a result, any excess spawning above the long term equilibrium escapement levels predicted from this assessment are not likely to result in smolt production increases because of summer habitat limitations, and most importantly, winter habitat limitations which would ultimately determine the amount of coho salmon smolt production potential and long term sustainable adult returns to these watersheds.

Coho salmon fry and juvenile production occurring from adult spawning in excess of the long term equilibrium escapement numbers may still contribute to overall watershed smolt production levels. This can occur because coho salmon have evolved a strategy of downstream dispersal of fry and parr to utilize available rearing areas if they are fully utilized from areas with excess spawning (Brown and Hartman 1988, Chapman 1962, Chapman 1965, Mason and Chapman 1965, Mason 1976, Nickelson et al. 1992b). Juvenile coho salmon likely would move seasonally within the Bear and S.F. Little Butte Creek watersheds to find suitable habitat as both flow and water temperatures change, but also when rearing densities exceed available rearing habitat in original spawning areas, or as fish grow through time (Chapman 1962, Mason and Chapman 1965). If excess fry are produced in a fully seeded system, some fry may be forced downstream away from the spawning and early rearing area due to territorial behavior of the fish (Ruggles 1966 cited in Sandercock 1991), crowding, or changing environmental conditions (Mason 1976). This movement would redistribute rearing juvenile coho salmon into areas of the river where habitat might be less suitable. Conversely, habitat away from spawning and early rearing habitat may be more structurally complex and support a larger or more diverse and abundant food base (Sandercock 1991).

Coho salmon juvenile surveys performed in the Upper Rogue River subbasin (ODFW 2005a) confirmed presence and varying levels of abundance in Little Butte, Big Butte, Evans, Trail, Elk, and Antelope creeks (Figure 7). Most high density rearing occurs in the upper watersheds and often immediately below public land that supplies cool water. Densities of juvenile coho salmon throughout the Upper Rogue River population vary by location (Figure 7). Most of the juvenile coho salmon observed recently were in the headwater areas of Little and Big Butte creeks, Elk Creek, Trail Creek, and Evans Creek. Historically, Bear Creek had more than 25 miles of estimated high IP habitat; however, no juvenile coho salmon were observed during summer sampling (Figure 7), likely due to high water temperatures and habitat degradation in this highly urbanized watershed. Coho salmon juveniles have been captured sporadically and in very low densities in the Bear Creek mainstem and tributaries (ODFW 2005 and Reclamation 2000), indicating some juveniles are present in this watershed at least during times of year with lower temperatures. Juvenile coho salmon were documented in Larson Creek (VanDyke 2006a) and Military Slough (VanDyke 2006b), both in the Bear Creek watershed, during sampling with hoop traps from November 2005 to March 2006. During the 2004 to 2008 run years, on average about 17 percent of sites were occupied by wild adult coho salmon with an estimated average of 6 spawners per mile in the Upper Rogue subbasin (hatchery or wild origin unstated) (Lewis et al. 2009).

The two reaches analyzed for this production potential estimate provide suitable spawning, summer rearing, and winter rearing habitat and based on the analysis of habitat area are likely able to produce coho salmon in the numbers presented here. Although the Emigrant Creek production estimates presented in this report are considered to be accurate as they compare favorably with other estimation methods (e.g. Bradford Model) and are calculated using readily observed habitat data for pool habitat, they are not supported by the level of observed adult spawning or juvenile rearing data from this reach. We believe that this is not a function of lack of accuracy in the modeled estimates for juvenile rearing or adult returns. Rather the disagreement between estimated numbers and observed numbers in Emigrant Creek is a reflection of other limiting factors in the lower basin that are preventing the full production potential from occurring in the upper reaches of Bear and Emigrant Creeks. Some of these other factors would be elevated water temperatures from riparian zone development, extremely variable flow events from rapid run-off due to high levels of development, and high nutrient and sediment loads from human activities in the watershed.

Although spawning numbers are not accurately tracked or well documented in Emigrant Creek it is clear that adult or juvenile coho salmon are not using the habitat areas that are currently available. Presently, abundance of SONCC coho salmon is depressed in the Bear Creek watershed. Smolt trapping surveys have demonstrated few coho salmon are being produced in the watershed (Figure 7) and adult carcass and redd surveys have been discontinued due to low spawner abundance in Bear Creek. Other important factors such as warm water temperatures in the summer would likely displace young coho salmon downstream for rearing and may preclude successful summer rearing in most reaches. Based on some limited information that indicated high summertime water temperatures, we suspect that actual production in this reach would be lower. For example, high water temperatures that are sufficiently elevated in the lower Bear Creek watershed to have high mortality for coho salmon juveniles are known to occur. Several authors have noted the presence of high water temperatures as being the ultimate limiting factor to coho salmon production in Bear Creek (Bredikin et al. 2006, RVCOG 2001, Reclamation 2009, Williams et al. 2006).

Most recently, Nickelson (2008) performed a smolt capacity estimate for many streams within the Oregon portion of the SONCC ESU, including Bear Creek, and concluded that despite the presence of available habitat in this stream system that coho salmon production levels were ultimately limited by high water temperatures. This was noted in unregulated, natural-flowing streams. Nickelson (2008) recommended that water temperatures be reduced in affected watersheds before other habitat restoration actions are pursued due to the limitations to production that water temperatures present. This recommendation is consistent with other authors who evaluate both physical and biological habitat limiting factors and present methods for identification of limiting factors (Reeves et al. 1989).

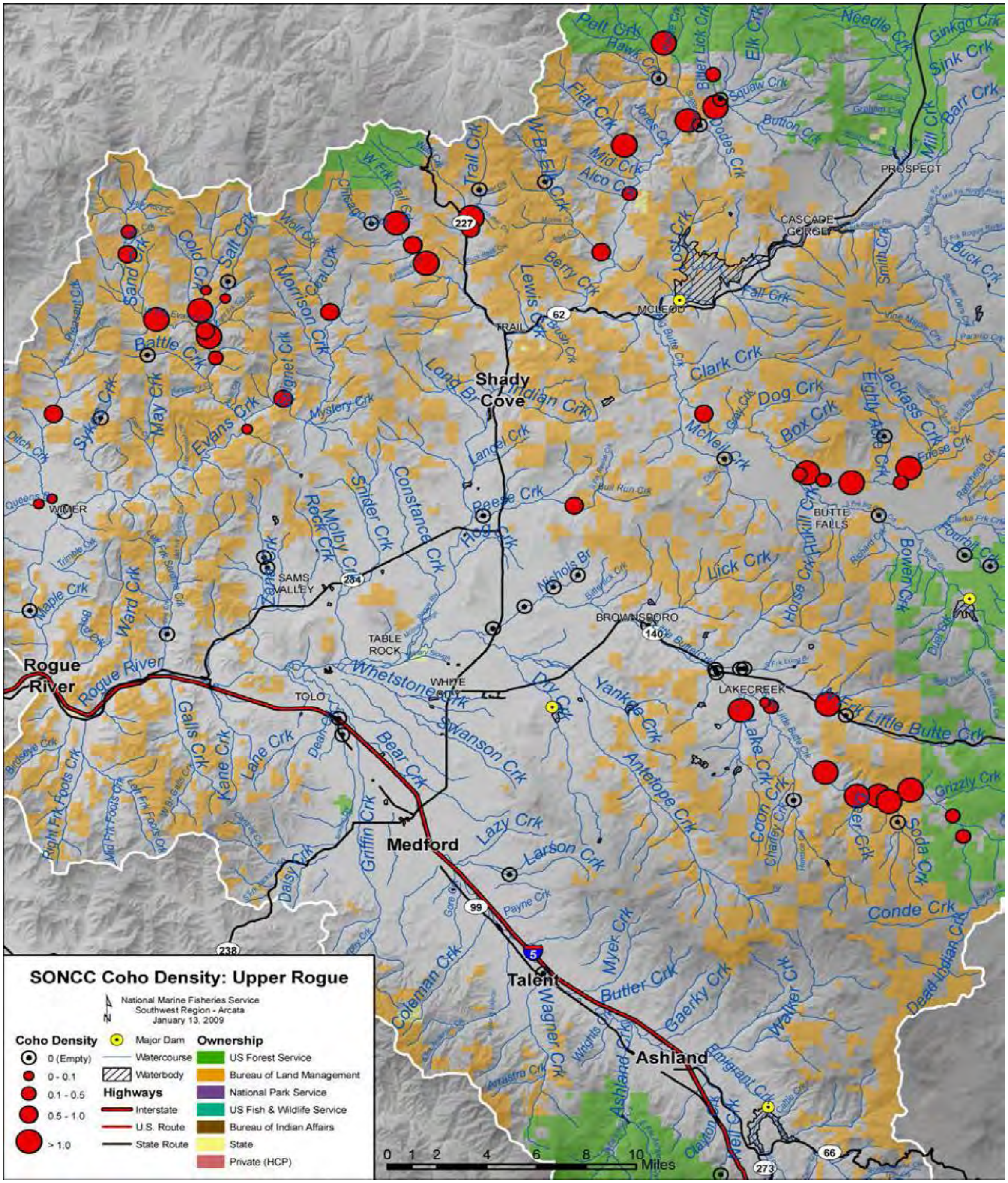

Figure 7. Upper Rogue River juvenile coho salmon survey results from 1998 to 2004. Map shows density of fish per square meter. The highest densities were located in upper watershed areas, and coho salmon were absent in lower reaches of all tributaries and at all stations in Bear Creek ODFW (2005a).

Ocean Conditions

Ocean conditions are known to be important in determining survival and production rates for Oregon and California coho salmon stocks (e.g. Beamish and Bouillon 1993; Francis and Hare 1994; Hare and Francis 1995; Gargett 1997; Mantua et al. 1997; Hare et al. 1999; Beamish et al. 1999; Beamish et al. 2000, Peterson et al. 2006; Nickelson 2007). Effects of ocean conditions are also recognized for SONCC coho salmon survival (ODFW 1989; NMFS 2007; Cramer Fish Science, 2008).

Ocean conditions appear to be the most important factor determining the abundance of URR coho salmon spawner abundance considering wild adult fish from the URR correlated with hatchery returns, pre-smolt production levels did not relate to adult returns, and that main stem Rogue River flows did not relate to adult returns (ODFW 1989). This finding is consistent with results of a recent life cycle model prepared for Klamath Basin coho salmon (Cramer Fish Sciences, 2008), and conclusions of ODFW (1982), Nickelson (1998), andODFW (2005).

Freshwater Effects

Regarding freshwater habitat effects on URR coho salmon, temperature may be the most important limiting factor. Nickelson (2008) estimated coho salmon smolt capacity for streams in the Rogue River Basin, and many streams in the URR population area were found to be critically limited by summer water temperatures. Ambient air temperatures occurring in the Upper Rogue River Sub-Basin, especially in the Rogue Valley (Bear Creek Watershed and lower Little Butte Creek Watershed), heat several area stream reaches above levels tolerable for juvenile coho salmon and other native fishes (e.g. Rivers 1963; Dambacher et al. 1991; ODEQ 2007). Although land use practices may have increased summer temperatures in some cases, coho salmon survival in certain stream reaches in the Upper Rogue River Sub-Basin have most likely always been limited by summer water temperatures (Agrawal et al., 2005). Stream flow and water temperature should therefore be evaluated comprehensively in order to understand the overall effects of the Project on coho salmon as well as the overall efficacy of any stream habitat enhancement treatments.

Little Butte and Bear Creeks currently offer more productive habitat than can be effectively seeded by returning adults. Recently three larger impoundments have been removed from the Rogue River basin and sufficient time has not passed to demonstrate results related to increased adult returns. Gold Hill (2008), Savage Rapids (2009), and Gold Ray (2010) dams have been removed downstream of the Project and will likely have a substantial influence on adult returns in the near future. Monitoring is underway and is necessary to determine how returning adults distribute in the upper Rogue River Basin in response to dam removal.

Reclamation's Rogue Project was completed between 1958 and 1962, and as described above, affects the URR habitat in Little Butte Creek and Bear Creek watersheds. In summer, the project cools ambient water temperatures in lower Emigrant Creek and upper Bear Creek through delivery of stored reservoir water (Horsburgh, 2007). However, Horsburgh (2007) found no relationship between flow levels in Bear Creek and water temperatures below Oak Street Diversion dam suggesting that thermal loading occurring downstream of the reservoir negates any benefits provided by the cool water inputs and supplemental flows provided by the Reclamation project. ODEQ (2007) found that thermal loading in Bear Creek Watershed is driven primarily by solar inputs. The water temperature data collected on project affected stream reaches suggest that maximum summertime water temperatures sometimes exceed the preferred range for rearing coho salmon, but did not approach the lethal temperature. This warm water flowing downstream contributes to increased river water temperature. A few locations of groundwater upwelling have been identified, but the flow from these, even though they may have a localized cooling effect on the river, is apparently insufficient to offset the larger effect of warm water from the lower reaches of Bear and Little Butte Creeks. In winter, Reclamation's project primarily reduces stream flows along Emigrant Creek (Piaskowski et al., 2008), which comprises about 3% of streams accessible to coho salmon (Nickelson, 2008). Water storage in Emigrant reservoir in winter also reduces the magnitude of high flow events in Emigrant and Bear creeks (Piaskowski et al., 2008).

Since 2003, Reclamation and the Rogue River Irrigators have been working through extremely complex issues of water management as they relate to the Endangered Species Act consultation. The Project involves many water rights issues, has limited controls, and a relatively short period of record of stream gauge data, that has hampered several analyses needed to make proper decisions on how to structure the future operation of the Project to benefit SONCC coho salmon. Even though these challenges exist, Reclamation and the irrigators have advanced several operational changes to provide benefits to fisheries resources in the interim. Specifically, the Project has been and currently is operated with ramping protocols in mind and a commitment to avoid extreme river flow alterations at critical times for fish habitat. When possible, the Project has also operated with elevated minimum instream flows to stabilize and supplement fish habitat.

Water conservation measures, retirement of select diversions, and overall system improvements have continued to be made by the irrigation districts to improve the efficiency of water use from the Project and to help alleviate negative pressures on fisheries resources. Combined with an expanded education program, the interim habitat conditions during ESA consultation have continued to improve over time with the Districts providing the recommended minimum instream flows throughout the 2011/2012 winter season.

Reclamation's proposed action would involve habitat restoration actions to increase the amount of winter rearing habitat to support improved adult spawner abundances over time. Instream restoration actions involving placement of large wood structural components would be targeted at increasing the amount and quality of winter rearing habitat. If winter rearing habitat is limiting, the increased amount of habitat created by these instream structures would sequentially remove the production bottlenecks caused by limitations in this most limiting habitat element. However, as mentioned previously, these habitat restoration actions would not increase production until adult abundance in these reaches increases to the point that available rearing habitat becomes limiting. This adult production level was estimated to be about 180 adult coho salmon in Emigrant Creek and 314 adult coho salmon in the S.F. Little Butte Creek stream reach under the Proposed Operations scenario and 412 adult coho salmon in the S.F. Little Butte Creek system and 212 adult coho salmon in the Emigrant Creek stream reach as habitat levels that are anticipated under the Without Reclamation flow scenario.

Recommendations

Based on a review of Bear Creek watershed hydrology, there are other factors in addition to stream flow and water temperature that may be important to consider in analyzing the effects of the Project on coho salmon. These include: spawning substrate distribution and availability, availability of juvenile coho salmon preferred rearing habitat (e.g. thermal refuges in summer, volume of pools, distribution and quantities of large wood debris and off-channel stream habitat), and peak flows relative to bedload movements that may affect coho salmon egg and alevin in-gravel survival.

Measures of production potential, smolt production or adult spawner returns, are heavily dependent on estimates of habitat conditions in project affected streams and would therefore be only as accurate as the habitat data that goes into the habitat model. The production potential estimates could be conducted again using actual stream survey data on both summer and winter habitat availability in both Emigrant and S.F. Little Butte Creeks. Using the most accurate and readily available data from stream specific habitat surveys that are conducted on a seasonal basis is recommended by Bisson et al. (1982) and Nickelson (1998) to obtain the most accurate results for use in the habitat model. As a result, it would be advisable to conduct more intensive habitat surveys during both the summer and winter rearing seasons in both the Emigrant/Bear Creek and S.F. Little Butte Creek watersheds to obtain the most accurate stream habitat data possible. At a minimum these habitat surveys could serve as a check to ensure that the habitat data obtained from the PHABSIM model is within reason and acceptable for use in the habitat model.

Production in these streams could ultimately be improved by increasing the physical habitat area for the most limiting life stage, but first adult spawners need to be increased to fully seed rearing habitats. For coho salmon an additional means of improving potential production is to encourage spawning in areas with good spawning habitat and allow for fry and juvenile dispersal to currently available but underutilized rearing habitats. The primary need/action to increase production in these stream systems would be to improve adult spawner abundance to take advantage of available spawning gravel and habitat to produce the number of fry and parr to fully seed available summer rearing habitat that is currently underutilized or underseeded. As adult escapement reaches levels where summer and winter rearing habitat become fully seeded, then increasing summer parr abundance would provide an adequate supply of parr to move into available winter rearing habitat. Finally, as winter rearing habitat becomes inundated at high adult abundance levels, winter rearing habitat would ultimately limit the population as this habitat would be in highest demand.

An emphasis should be placed on enhancing instream habitat conditions where intrinsic conditions provide the greatest opportunity for coho salmon rearing and survival. Cool water temperatures coming from tributaries of Bear Creek originating from the higher elevations of the Siskiyou Mountains (inclusive of Neil Creek to Coleman Creek) may provide the most favorable coho salmon rearing habitat in the watershed (Nickelson 2008). Summer conditions along tributaries of Bear Creek should be assessed for opportunities for improving juvenile coho salmon access and rearing habitat. This approach addresses what appears to be the most critical factor limiting coho salmon production in the Bear Creek Watershed at this time, high summer water temperatures.

For Emigrant and upper Bear Creek, continued work on winter habitat improvement is recommended. However, restoration efforts should focus on actions that would improve the current limiting factor which apparently is high water temperatures in the lower Bear Creek watershed. The local communities (Cities of Ashland and Medford) have adopted specific action plans to address thermal loading in Bear Creek and are embarking on an aggressive plan to install riparian plantings along up to 8 miles of Bear Creek shoreline. Additional elements of habitat improvement within the Bear and Little Butte Creek basins should be carefully documented and evaluated to monitor treatment success.

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Appendix C

Emigrant Creek Habitat Uplift Analysis

A Synthesis of Two Models (PHABSIM and HEC-RAS) to Quantify LWD Habitat Value

Rogue River Project ESA Consultation.
Medford, Oregon

for

Bureau of Reclamation

February 28, 2012

GeoEngineers
Earth Science + Technology

Emigrant Creek Habitat Uplift Analysis

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Rogue River Project ESA Consultation
Medford, Oregon

for
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Emigrant Creek Habitat Uplift Analysis
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Rogue River Project ESA Consultation
Medford, Oregon

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INTRODUCTION AND PURPOSE

GeoEngineers, Inc. (GeoEngineers) was retained by the Bureau of Reclamation (Reclamation) through a contract with the Talent Irrigation District to quantify the habitat improvement potential of wood based, in-stream habitat structures in Emigrant Creek. The purpose of this analysis is to evaluate the feasibility of non-flow based habitat enhancement methods to help meet the habitat objectives requested by the National Marine Fisheries Service (NMFS) in South Fork Little Butte Creek and Emigrant/Bear Creeks during the Rogue River Project ESA consultation (Figure 1). Specifically, the enhancement of Southern Oregon/Northern California Coasts (SONCC) coho salmon (*Oncorhynchus kisutch*) habitat in Emigrant Creek was evaluated through the strategic placement of multiple types of common large woody debris (LWD) structures.

In its Draft Biological Opinion (NMFS 2011), NMFS identified in-stream and riparian habitat improvements as one of three Reasonable and Prudent Alternatives (RPA's) to reduce the effects of the Proposed Action on SONCC coho salmon. To mitigate for the lack of instream wood in Emigrant, Bear, and Little Butte Creeks, NMFS provided general targets for wood density, size, and reach locations of in-stream habitat structures. Recognizing that adding LWD to streams causes a change in channel morphology known to be beneficial to fish, the challenge of this work was to derive a practical method to quantify habitat improvement resulting from LWD additions. The effort presented in this report was developed to quantify the habitat uplift potential of in-stream habitat structures and to provide Reclamation with a science-based approach to plan, design, implement, and evaluate reach and basin scale habitat improvements in the Project Area.

An innovative approach was developed for this analysis which combined two common modeling tools, the United States Geological Survey (USGS) Physical Habitat Simulation System Software (PHABSIM) and the United States Army Corps of Engineers Hydrologic Engineering Centers River Analysis System (HEC-RAS) model. The original PHABSIM model for Emigrant Creek was developed by Reclamation as part of the 2007 Rogue River Basin Project Coho Salmon Instream Flow Assessment (Sutton 2007). While PHABSIM is a suitable tool to quantify existing and available habitat conditions, and is used to predict changes in habitat associated with alternative flow regimes, it is not used to predict changes in habitat associated with physical (channel) changes. The application presented here was developed in response to collaborative efforts between NMFS, Reclamation, and the Rogue Basin Watershed Users Council (RBWUC) during ESA consultation with the intent to provide a tool to use in habitat planning that enables a quantifiable measurement of non-flow based habitat uplift.

For this "proposed" conditions analysis, GeoEngineers developed a HEC-RAS model of the Emigrant Creek PHABSIM reach, calibrated the HEC-RAS model to observed hydraulic conditions, and utilized HEC-RAS hydraulic output data to calculate Weighted Usable Area (WUA) in a spreadsheet based format. Upon demonstrating that the spreadsheet based HEC-RAS/PHABSIM analysis (RAS-SIM) provided WUA results within 2% of Reclamations PHABSIM files, we modified the HEC-RAS geometry files to simulate the installation of three different types of LWD habitat structures, and analyzed the effects of each structure independently. The hydraulic output from the proposed conditions HEC-RAS files was used to calculate WUA in the RAS-SIM spreadsheets utilizing the same method established by Reclamation in 2007, with the results providing a quantitative evaluation of the post-habitat enhancement channel conditions.

Time and data constraints prevented applying this approach to the entire Bear Creek and South Fork Little Butte Creek watersheds. Emigrant Creek was selected as the sample reach at which to apply this procedure to illustrate how the process and relationships work and how the habitat enhancement features can contribute to overall habitat quantity and quality improvements, as measured by WUA for a range of streamflow volumes. The development of an effective procedure that can be improved, expanded, and applied further to additional reaches in South Fork Little Butte and Bear Creeks is an important outcome of this effort. This report summarizes the assumptions, methods, and results of the analyses that were completed to quantify the potential habitat uplift produced from the installation of properly designed and sited in-stream LWD structures.

METHODS

Geomorphic Assessment & Conceptual Enhancement Plan for Emigrant Creek

A desktop geomorphic assessment was conducted of Emigrant Creek between Bounds Pond and the Neil Creek confluence to evaluate historical channel morphology and to assist in the development of in-stream habitat improvement concepts.

Aerial photos of Emigrant Creek were purchased from the University of Oregon for the years 1939, 1952, 1967, and 1994; a 2009 aerial was provided via Bing Maps (Appendix A). Photos were scanned, ortho-rectified, and loaded into a GIS database. Changes in channel location, planform, and geometry were evaluated by comparing the photos sequentially and assessing channel changes relative to significant land use changes, such as flood events, dam building, and urban development. The results of the aerial photo analysis demonstrate a simplification of the Emigrant Creek channel that has occurred over time, with a reduction in multi-threaded channels, channel confinement, and a reduction of in-channel woody structure.

The combined effects of timber harvest, urbanization, agriculture, dam building, and floodplain development have led to lack of transport and presence of large wood in Bear and Emigrant Creeks. The straightening and simplification of streams has reduced the amount of slow, cool edgewater habitats where coho salmon fry and juveniles thrive (ODEQ 2008). Beaver have been greatly reduced in this watershed along with the pools they create (ODFW 2005). Channelization of Emigrant and Bear Creeks has disconnected them from much of their floodplain, reducing the physical processes that form coho salmon habitat. These processes include side channel formation, accumulation of large wood jams, formation of slower water velocities, and formation of pools. Downcutting due to channel confinement is also evident in Emigrant Creek. Regional studies (Spence et al 1996) found that downcutting can alter riparian area soil moisture, inhibiting recovery of riparian forests. All of these observed geomorphic changes have had a cumulative effect over time of reducing the quality of available coho habitat within the Emigrant Creek system, and in particular led to degradation in the presence of in-stream wood and the potential supply of riparian based large wood.

The physical and biological benefits of LWD habitat structures are well documented (Abbe and Montgomery 1996, Beechie and Sibley, 1997, McHenry et al 2001, Wondzell and Bisson 2003, Pess et al 2007, McHenry et al 2007). This analysis is focused on evaluating the potential habitat uplift provided by restoring large woody debris structures to Emigrant Creek. The locations and types of the particular LWD habitat structures analyzed for habitat uplift in Emigrant Creek are conceptual, though they are based on a review of aerial photos (Appendix A) and site photos (Sutton2007); future habitat planning efforts will require detailed site inventories along with a comprehensive geomorphic overlay to develop appropriate final designs to allow construction of these habitat features. The cumulative habitat and geomorphic benefits of the woody structures evaluated in this study cannot be fully modeled in HEC-RAS or PHABSIM, and much of the potential habitat lift provided by these structures will go unaccounted for in the quantitative modeling process described below.

Build and Calibrate HEC-RAS Open Channel Hydraulics Model to Original PHABSIM Files

Reclamation provided to GeoEngineers the original PHABSIM model files, field notes, and supplemental spreadsheet data used in the development of the Rogue River Basin Project Coho Salmon Instream Flow Assessment (Sutton 2007). Reclamation developed the Emigrant Creek PHABSIM study using three observed and measured discharge volumes: 8-, 38- and 64 cubic feet per second (cfs). Each discharge volume has a corresponding depth, velocity, and water surface elevation dataset associated with each transect, measured by the user at user defined stationing (intervals) across each transect. The Emigrant Creek PHABSIM model consists of 10 transects over a 334 feet channel length.

GeoEngineers developed a HEC-RAS model of the Emigrant Creek PHABSIM reach by extracting stream channel survey data from the PHABSIM cross section editor, and supplemented by spreadsheet data (field notes) provided by Reclamation’s lead investigator (Ron Sutton). Boundary conditions used for the HEC-RAS model are based on known water surface elevations at the upstream (Transect 10) and downstream (Transect 1) boundaries for the 3 calibrated flow volumes of 8, 38, and 64 cfs. GeoEngineers developed a unique geometry file for each of the three calibration flows. The HEC-RAS models were calibrated by simultaneously matching the PHABSIM simulated water surface elevation and corresponding velocity profile at each transect along the Emigrant Creek reach. Stream tubes or roughness zones were created in HEC-RAS based on the horizontal stations measured in the field by Reclamation and adjusted simultaneously to match the water surface and velocity profile in the PHABSIM model. Existing conditions HEC-RAS output is presented in Appendix B.

Upon completion of model calibration, GeoEngineers was able to accurately simulate the hydraulic conditions that were measured in the field during the PHABSIM field data collection process. This hydraulic calibration process is a key step in the RAS-SIM process to ensure that similar physical criteria are being evaluated in RAS-SIM as were evaluated and measured in the field during PHABSIM data collection.

Calibrate HEC-RAS Based WUA Analysis to PHABSIM WUA Analysis

Upon hydraulic calibration of the HEC-RAS models to the PHABSIM depth and velocity output, GeoEngineers developed a spreadsheet based tool to analyze the PHABSIM WUA algorithms using hydraulic data exported from HEC-RAS. PHABSIM calculates habitat area in weighted usable area (WUA) through an algorithm that evaluates depth, velocity, and cover compared to suitability indices developed during the Instream Flow Incremental Methodology (IFIM) process (Sutton 2007). Reclamation developed a method to calculate WUA as follows:

Equation 1: ***Weighted Usable Area (WUA) = (Area*Composite Suitability Factor)****, where*

*Composite Suitability Factor (CSF) = Geometric Mean (Velocity Suitability Index*Depth Suitability Index)*Cover Suitability Index*

WUA is calculated per transect, and each transect area is normalized depending on the prevalence of each Mesohabitat unit (pool, riffle or glide) in a process described in the 2007 report. The normalization process is completed in order to take the 334 foot Emigrant Creek PHABSIM study reach, consisting of 10 transects, and apply the results more broadly to a 1,440 foot reach of Emigrant Creek in which reach scale Mesohabitat unit proportions were evaluated, normalized to weighted useable area units measured in square feet of habitat per 1,000 feet of stream channel. GeoEngineers used the same normalization process and Mesohabitat unit proportions shown in Table 5 of the Reclamation report (Sutton 2007).

Calibration efforts were focused on the lower flow scenarios, given the minimum flow targets provided by Reclamation, shown in Table 1 below. WUA calibration was performed at 2 and 10 cfs, to encompass the complete range of minimum flows proposed for the low and median hydrologic conditions, when streamflow is most limiting to habitat and in-stream wood structures will provide the greatest uplift. Calibration was completed for both summer and winter rearing habitat suitability; however, since winter rearing habitat is commonly the limiting factor to coho production final wood volumes will likely depend on winter rearing uplift potential. Winter rearing habitat analyses are used in Appendix B to demonstrate the analytical process and results of this effort.

TABLE 1. MINIMUM FLOW TARGETS BELOW EMIGRANT RESERVOIR (AT EMI GAUGE), FOR LOW, MEDIAN, AND HIGH RESERVOIR STORAGE CONDITIONS, IN CUBIC FEET PER SECOND (CFS)

Month	Low	Median	High
October	2	3	6
November	2	6	10
December	2	10	12
January	2	10	12
February	2	10	12
March	2	10	12
April	2	9	12
May	2	9	10
June	2	3	6
July	2	3	6
August	2	3	6
September	2	3	6

Appendix C-1 demonstrates the stepwise process used to calibrate RAS-SIM WUA results to the original PHABSIM results for the 2 cfs run, winter rearing habitat suitability. Step 1 of the RAS-SIM calibration is to import the hydraulic data from HEC-RAS into an Excel template for 9 of the 10 transects. Although there are a total of 10 transects used in the PHABSIM analysis, Transect 5 was used solely for modeling of the hydraulic control and WUA is not evaluated at that transect. Step 2 is the interpolation of HEC-RAS velocity and depth values to the stations (horizontal units) established by Reclamation for each transect. Step 3 calculates the WUA by using a lookup function to establish the depth, suitability, and cover index values for each station, applying Equation 1, and totaling the wetted area and WUA per transect. Step 4 is the summary page, which aggregates the WUA from each transect and weights each transect according to the Mesohabitat unit proportions.

Calibration runs were completed for 2 and 10 cfs, for both summer and winter rearing conditions. Results are shown in Table 2, presenting a comparison of both total wetted area and total WUA for the GeoEngineers RAS-SIM and the Reclamation PHABSIM. Area and WUA data from PHABSIM comes from Table D-1 (Sutton 2007).

TABLE 2. RAS-SIM CALIBRATION RESULTS

	PHABSIM (Sutton 2007)		RAS-SIM (GeoEngineers 2012)		Comparison RAS SIM as % of PHABSIM	
Calibration Run	**Total Area (ft^2)/1000 ft**	**WUA (ft^2)/1000 ft**	**Total Area (ft^2)/1000 ft**	**WUA (ft^2)/1000 ft**	**Total Area (ft^2)/1000 ft**	**WUA (ft^2)/1000 ft**
Winter Rearing 2 cfs	22,446	3,274	23,655	3,244	105%	99%
Winter Rearing 10 cfs	28,217	4,695	29,065	4,705	103%	100%
Summer Rearing 2 cfs	22,446	5,252	24,342	5,146	108%	98%
Summer Rearing 10 cfs	28,217	7,076	29,065	7,100	103%	100%

The average wetted area calculation using RAS-SIM is within 5% of PHABSIM (except for summer rearing at the 2 cfs calibration flow which is within 8% of PHABSIM values) and the average WUA calculation using RAS-SIM is within 2% of PHABSIM, for all modeled conditions. Following this successful calibration procedure, the HEC-RAS and RAS-SIM models were considered calibrated and ready to apply to proposed conditions scenarios.

Build Proposed Conditions Model

The purpose of the analysis is to determine the habitat uplift potential of three types of singular structures designed and installed within the 334 foot reach of Emigrant Creek evaluated for the PHABSIM analysis. In addition, the analytical results may be used to guide habitat enhancement planning for the greater reach of Emigrant Creek from Bounds Pond to the Neil Creek confluence. Upon HEC-RAS and RAS-SIM model calibration, GeoEngineers developed three different proposed conditions models in HEC-RAS to simulate the presence of three common types of in-stream habitat structures:

- Bar Apex type log jams (Figure 2): Bar apex log jams are created in the middle of a channel to split flow, increase channel length and depth, form pools, and provide cover for fish. Apex jams simulate a log jam that develops naturally when a key piece is transported and deposited mid channel and recruits smaller wood over time, forming a larger jam that can influence channel dynamics and habitat. Bar apex type structures in Emigrant Creek could be expected to include between 5 and 10 pieces of LWD, between 12 and 24 inches diameter (DBH), and 15 to 25 ft in length.
- Barb type log jams (Figure 3): Barb type jams are bank-based log jams, often designed to provide both habitat uplift and bank stability. Barb jams create lateral scour holes, form pools, and provide cover along stream banks, where they are designed to simulate a fallen tree that stays along the bank and recruits floating wood over time. Barb type structures in Emigrant Creek could be expected to include between 5 and 10 pieces of LWD, between 12 and 24 inches diameter (DBH), and 15 to 25 ft in length.
- Cross channel type wood structures (Figure 4): Cross channel structures are smaller structures placed at narrower channel locations, and simulate one or multiple logs buried or embedded into the substrate, and creating a small grade control, which forms a scour pool downstream, sorting sediment and creating habitat. Cross channel structures in Emigrant Creek could be expected to include 2 pieces of LWD, between 12 and 24 inches diameter (DBH), and 15 to 25 ft in length.

Each structure was independently evaluated to determine the range of habitat uplift potential provided by a variety of in-stream structures likely to be applied during habitat improvements in the Bear, Emigrant, and Little Butte Creek watersheds. Analyses were completed for all three structures, winter and summer rearing, at 2 and 10 cfs, for a total of 12 proposed modeled conditions. No effort was made to assess the combined habitat interaction of these proposed structures within the simulation model.

Design Concepts

Based on geomorphic and site review, GeoEngineers developed restoration concepts to properly place each of the three structure types in the most appropriate location. This design process was conceptual and based solely on a desktop evaluation. A more robust design process must be employed prior to ultimate siting, design, and installation of wood structures. However, within the context of the RAS-SIM analysis, each structure was appropriately placed and sized based on their unique attributes and functions and the selected in-stream location.

The intent of this report is not to provide details on the design, application, and benefits of large wood in streams; these issues are well documented elsewhere. The intent of this report is to demonstrate a process through which the WUA uplift of a proposed habitat structure can be evaluated using a HEC-RAS based PHABSIM analysis.

HEC-RAS

The three proposed conditions models are presented in Appendix B. Habitat structures were inserted as obstructions into the existing conditions geometry files at the locations determined most appropriate based on the geomorphic site review. Pool depths around and adjacent to the structures were manually adjusted to reflect the anticipated channel response based on observed pool morphology in similar nearby systems such as Neil Creek (USFS 2001), Ashland Creek (USFS 2000), and Upper Emigrant Creek (ODFW 2012). Proposed conditions adjustments allow the HEC-RAS model to predict the hydraulic changes resulting from LWD installations in the local geological and geomorphic conditions in the vicinity of the proposed activity, thereby generating the most representative results.

A minimum number of transects were added to the HEC-RAS models to depict the full extent of each structure and to accurately capture the resulting pool formation. Each of the newly developed proposed conditions HEC-RAS models contains only one habitat structure (of the three described above) to allow for the isolated evaluation of a single habitat enhancement treatment. Upon completion of the proposed conditions models, each condition was simulated for flows of 2 and 10 cfs. HEC-RAS calculates the proposed conditions depths and velocities at the same intervals as was done for the existing conditions models. Upon review of model output, depth and velocity values are exported from HEC-RAS for application into the RAS-SIM spreadsheets.

RAS-SIM

Appendix C-2 and C-3 present the RAS-SIM analysis for the Apex and Barb type habitat structures, at 2 cfs, for the winter rearing life history stage. The stepwise process described for the existing conditions calibration was replicated for the proposed conditions. In Step 1, the proposed conditions depth and velocity values are imported from HEC-RAS. The proposed conditions generally maintain the same river stationing and roughness values as the existing conditions. Hydraulic changes occur as depth and velocity values within each transect and the overall reach respond to the presence of the habitat structure and channel adjustments. Step 2 is an interpolation from HEC-RAS stationing to PHABSIM stationing and is completed as was done during existing conditions calibration. It should be noted that the reason this step is necessary is because HEC-RAS has a limit on the number and distribution of horizontal stationing, whereas PHABSIM stationing is based on user preference as determined in the field. Step 2 is necessary to create stationing, and weighting per station, in the exact same way as originally developed in the field during PHABSIM data collection.

COVER

Step 3 calculates WUA per station and per transect. Step 3 uses a look up function to pull depth, velocity, and cover indices from the Data Reference Tables, and then apply Equation 1 to calculate WUA. In each proposed condition, cover codes were modified to reflect changes in bed material and presence of and proximity to wood according to the criteria established in the IFIM process (Sutton 2007, Appendix D). Cover codes were modified using a very conservative approach, only adjusting cover within transects and stations within direct physical influence of the proposed structures. The cumulative effects of habitat enhancement on channel morphology, sediment transport and deposition, and riparian area recovery were not predicted and cover codes at transects not directly within the physical influence of the structure were not adjusted from the original PHABSIM files.

MESOHABITAT UNITS

The Mesohabitat units are adjusted for the proposed conditions between Steps 3 and 4. Step 4 aggregates the WUA per transect according to the Mesohabitat unit and normalizes the results to square feet per 1,000 foot according to the process established by Reclamation in 2007. The

Mesohabitat unit categorizes each transect as glide, riffle, or pool. The original units (existing conditions) were established in the field by Reclamation and reviewed during the IFIM process. Proposed conditions Mesohabitat units were adjusted to reflect the morphologic shift expected from the presence of woody structures (i.e., riffle or glide to pools).

Upon adjusting cover codes and Mesohabitat units to reflect proposed conditions, WUA is calculated in Step 4. Results for the existing and proposed conditions RAS-SIM analyses are discussed below.

RESULTS

Tables 3 and 4 present the results of the RAS-SIM analysis for the 16 conditions evaluated for this study. For the Emigrant Creek PHABSIM study reach, GeoEngineers developed RAS-SIM based weighted usable area (WUA) for the existing conditions (calibrated to within 2% of Reclamation's 2007 values) and three proposed conditions at 2 and 10 cfs, for both winter and summer juvenile rearing habitat suitability. The data is presented both in absolute WUA habitat area values and as uplift from the existing condition in area and percentage increase. Proposed conditions results demonstrate the WUA uplift estimated for a single habitat enhancement structure, comprised of multiple individual pieces of wood. The existing conditions WUA establishes the baseline values from which each type of LWD structure may be compared to derive an uplift factor.

TABLE 3. WUA RESULTS FOR EMIGRANT CREEK EXISTING AND PROPOSED CONDITIONS (IN FT^2/1,000 FT)

	Winter Rearing		Summer Rearing	
	2 cfs	**10 cfs**	**2 cfs**	**10 cfs**
Existing Conditions	3,244[1]	4,705[1]	5,146[1]	7,100[1]
Bar Apex Jam	4,145	5,372	6,092	7,861
Barb Type Jam	4,657	6,455	6,429	8,568
Cross Channel Structure	4,088	5,687	6,339	8,600

Notes:

[1]Existing conditions WUA values used from the RAS-SIM results, rather than PHABSIM results, to maintain consistency for uplift analysis.

TABLE 4. WUA UPLIFT PER PROPOSED CONDITION, IN AREA (FT²/1,000 FT) AND PERCENT OF EXISTING CONDITION

	Winter Rearing		Summer Rearing	
	2 cfs	10 cfs	2 cfs	10 cfs
Bar Apex Jam	901 ft²/1000 ft (+28%)	667 ft²/1000 ft (+14%)	946 ft²/1000 ft (+18%)	761 ft²/1000 ft (+11%)
Barb Type Jam	1413 ft²/1000 ft (+44%)	1750 ft²/1000 ft (+37%)	1283 ft²/1000 ft (+25%)	1469 ft²/1000 ft (+21%)
Cross Channel Structure	844 ft²/1000 ft (+26%)	982 ft²/1000 ft (+21%)	1193 ft²/1000 ft (+23%)	1501 ft²/1000 ft (+21%)

CONCLUSIONS

Results of this unique application of two commonly used models in river science demonstrates that summer and winter rearing habitat for SONCC coho can be accurately measured, predicted and quantified to obtain substantial increases in fish habitat with effective placement of LWD structures. This is especially important in flow-limited or regulated streams such as Emigrant Creek where natural conditions no longer exist and habitat management is necessary to optimize fish production potential. The results of this pilot study can be considered an example of what is possible through a more robust technical planning and design process. The data and time limitations on this study were significant, but the results show extreme progress, and clearly demonstrate that in-stream habitat enhancement can increase WUA per unit discharge. This process can be applied more broadly throughout the Project area during planning, design, and monitoring of habitat enhancement activities to quantitatively evaluate degraded SONCC coho habitat and the anticipated benefits of proposed design alternatives.

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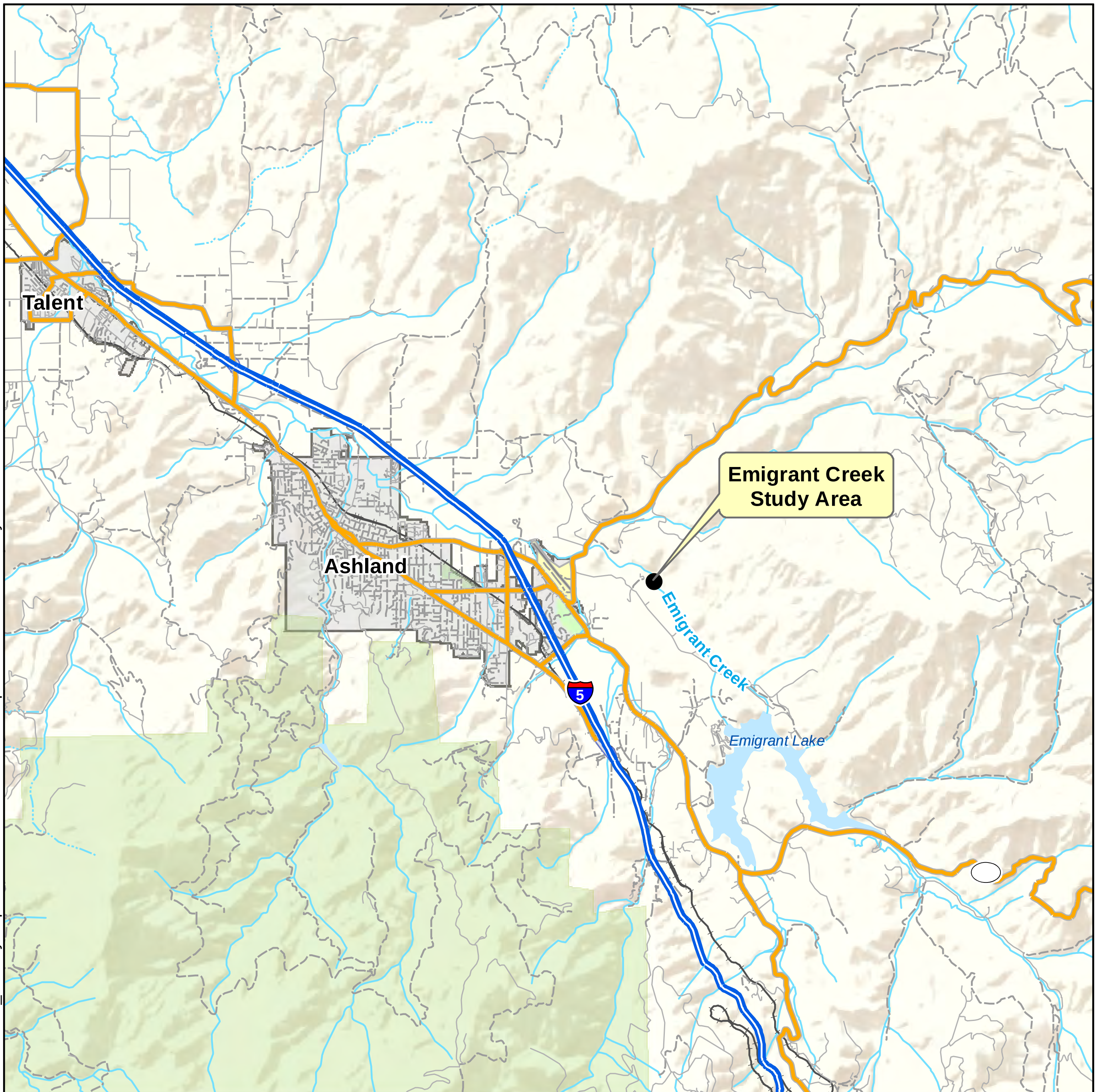
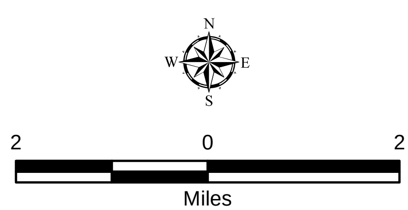
I





Notes:
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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
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Data Sources: ESRI Data & Maps

Projection: NAD 1983 UTM Zone 10N

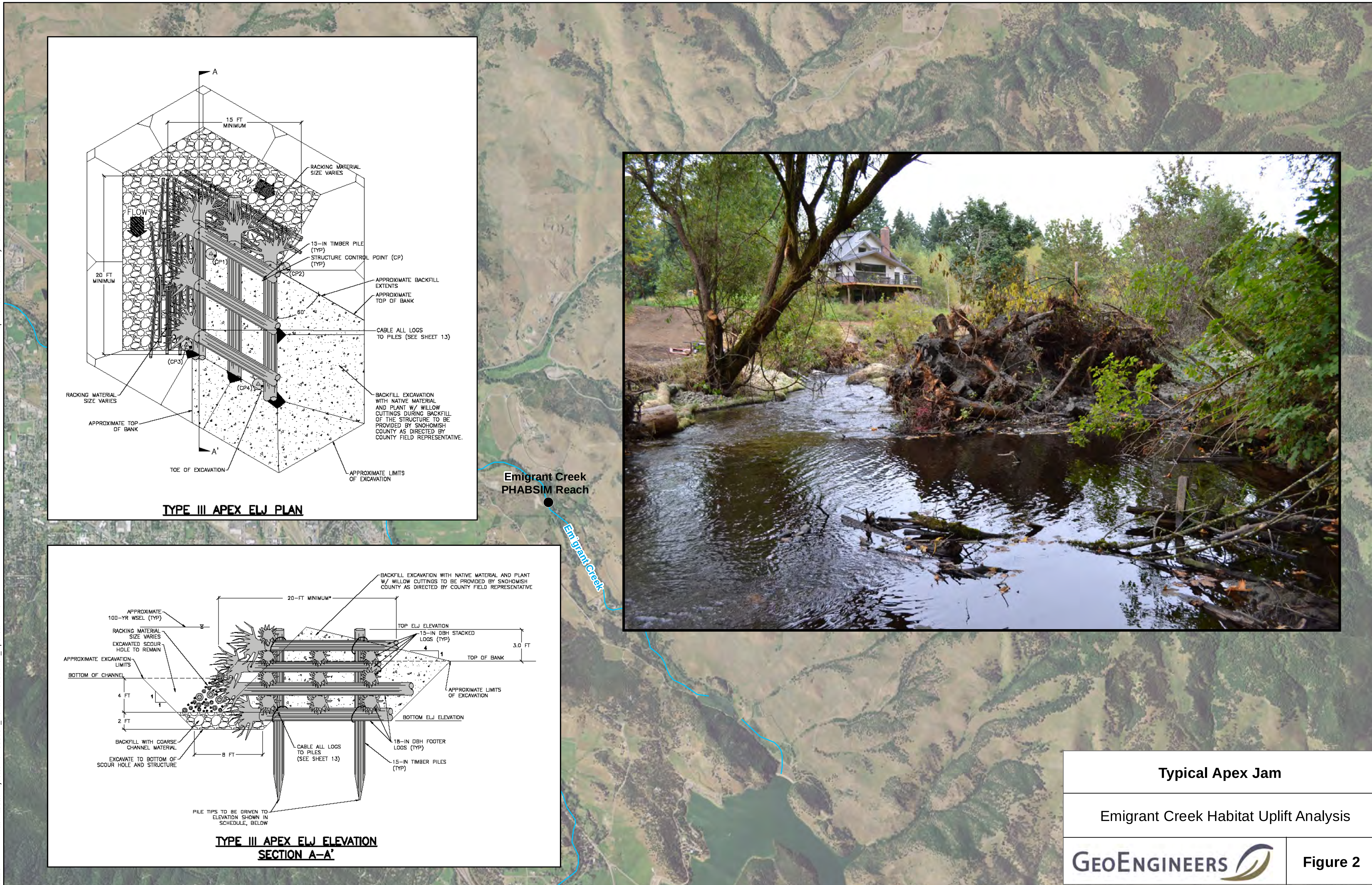
Vicinity Map

Emigrant Creek Habitat Uplift Analysis

GEOENGINEERS

Figure 1

Seattle Path: \\sea\Projects\11\1188300102_Aerials\1188300102_VicinityMap.mxd Map Revised: 13 February 2012 amanza



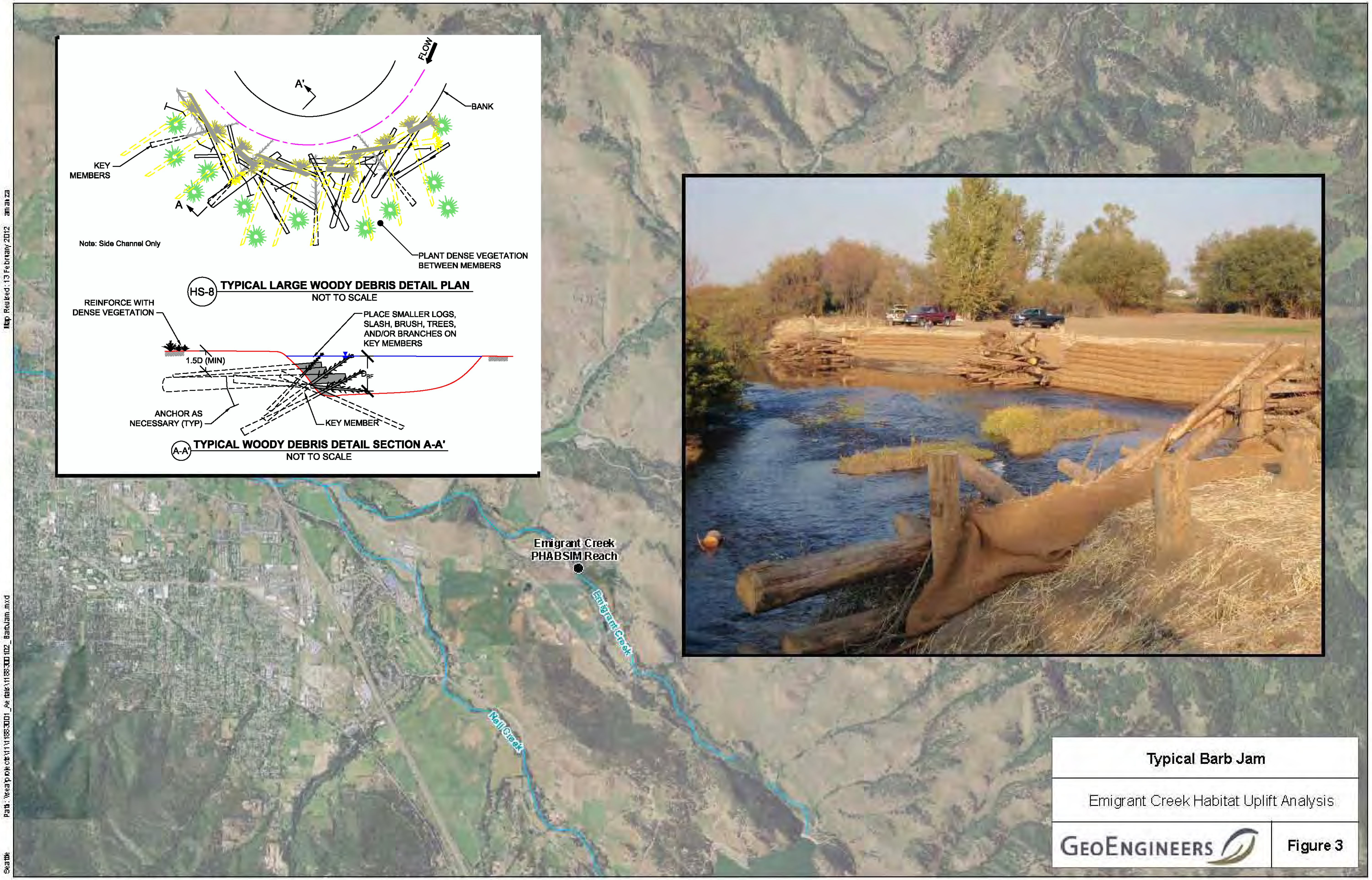
Typical Apex Jam

Emigrant Creek Habitat Uplift Analysis

GEOENGINEERS

Figure 2

Seattle Path: \\seal\Projects\11\11883001_Aerials\1188300102_ApexJam.mxd Map Revised: 13 February 2012 amanza

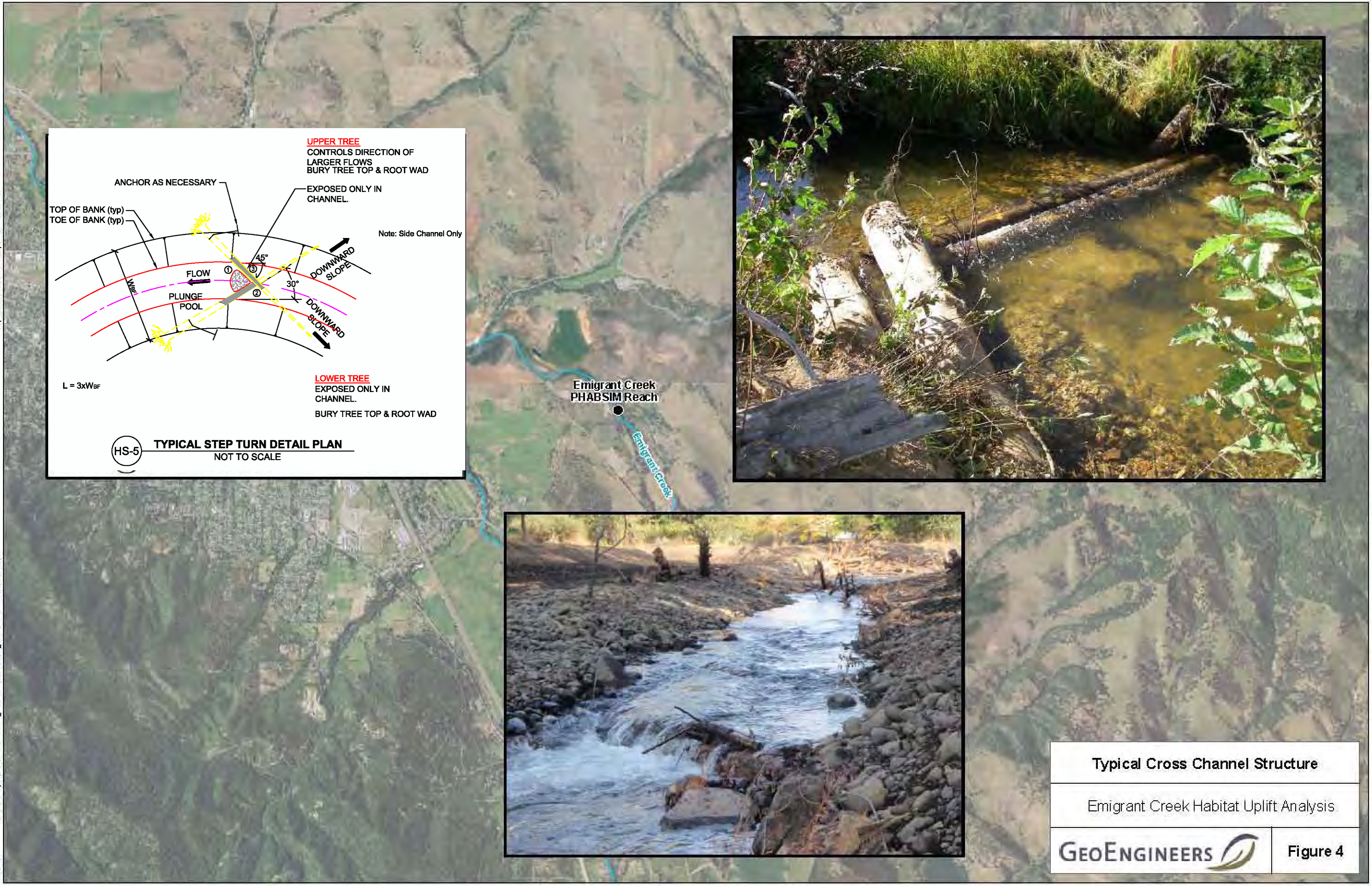


Typical Barb Jam

Emigrant Creek Habitat Uplift Analysis

GeoEngineers

Figure 3



Typical Cross Channel Structure

Emigrant Creek Habitat Uplift Analysis

GeoEngineers — **Figure 4**

Map Revised: 13 February 2012

I

APPENDIX A
Emigrant Creek Study Area Historical Aerial Photos

Data Source: NAIP Aerial Imagery, 2009.
University of Oregon Map & Aerial Photography Library.

Notes:
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1952 Aerial Photo - Emigrant Creek

Emigrant Creek Habitat Uplift Analysis

GeoEngineers

Figure A1

Seattle: Path: \projects\1\11188001_Aerials\BCAD_EMI_StudyArea.mxd Map Revised: 13 February 2012 amanza

800 0 800

Feet

N W E S

1967 Aerial Photo - Emigrant Creek

Emigrant Creek Habitat Uplift Analysis

GeoEngineers

Figure A2

Data Source: NAIP Aerial Imagery, 2009.
University of Oregon Map & Aerial Photography Library.

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Seattle Path: \\sea\projects\11\11683001_Aerials\8CAO_EMI_StudyArea.mxd Map Revised: 13 February 2012 amaiza

Data Source: NAIP Aerial Imagery, 2009.
University of Oregon Map & Aerial Photography Library.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

1994 Aerial Photo - Emigrant Creek

Emigrant Creek Habitat Uplift Analysis

GEOENGINEERS

Figure A3

Seattle Path: \\ea\projects\1\11183001_Aerial\CAD_EMI_StudyArea.mxd Map Revised: 13 February 2012 amaiza

800 0 800

Feet

N W E S

Data Source: NAIP Aerial Imagery, 2009.
University of Oregon Map & Aerial Photography Library.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

2009 Aerial Photo - Emigrant Creek

Emigrant Creek Habitat Uplift Analysis

GeoEngineers

Figure A4

Seattle: Path: \\sea\projects\11\11883001_Aerials\BCAO_EMI_StudyArea.mxd Map Revised: 13 February 2012 amanza

APPENDIX B
HEC-RAS Report, Existing and Proposed Conditions

Existing Conditions

Existing Conditions
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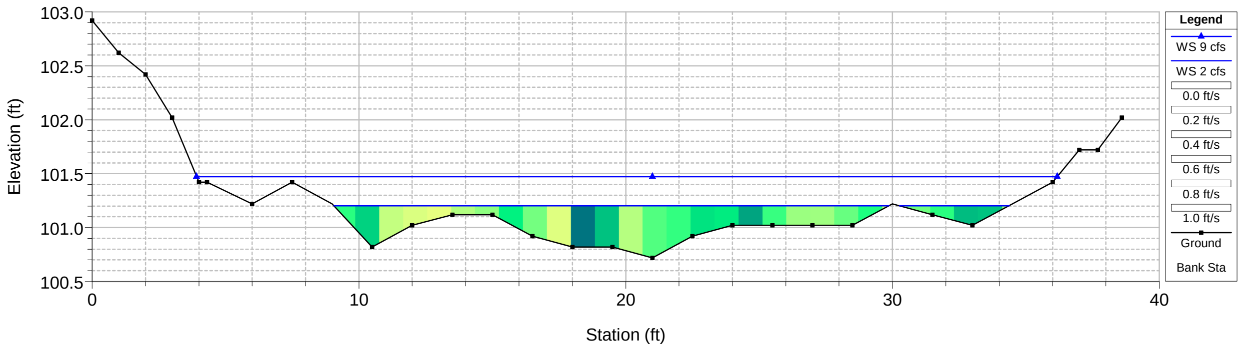

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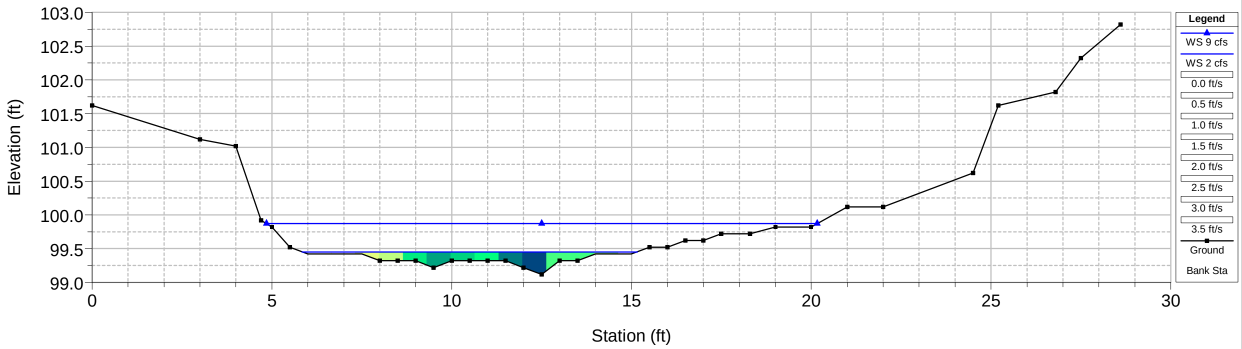

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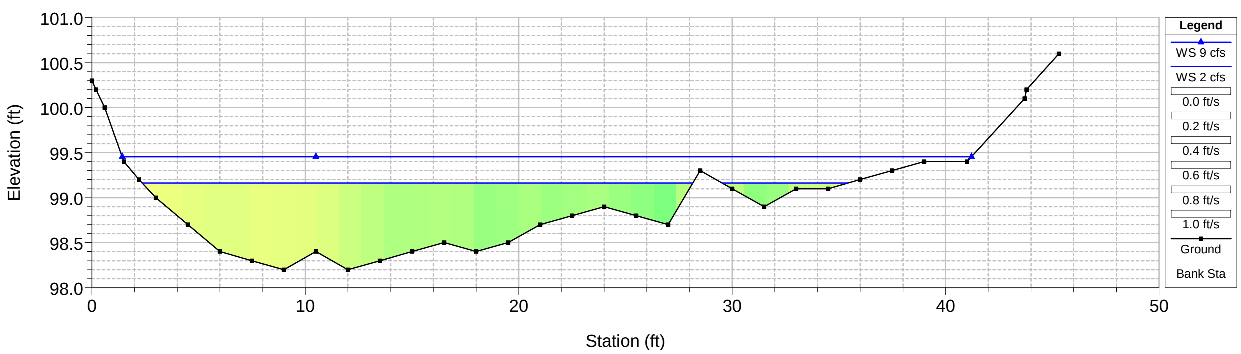

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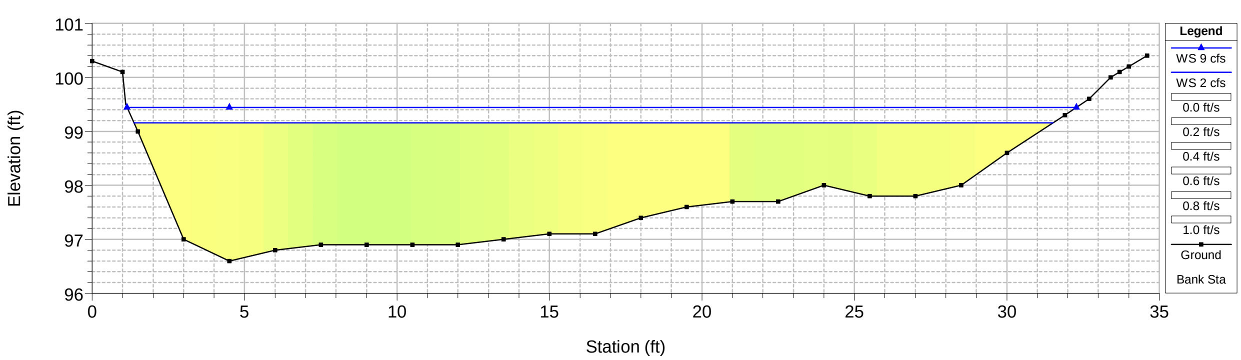

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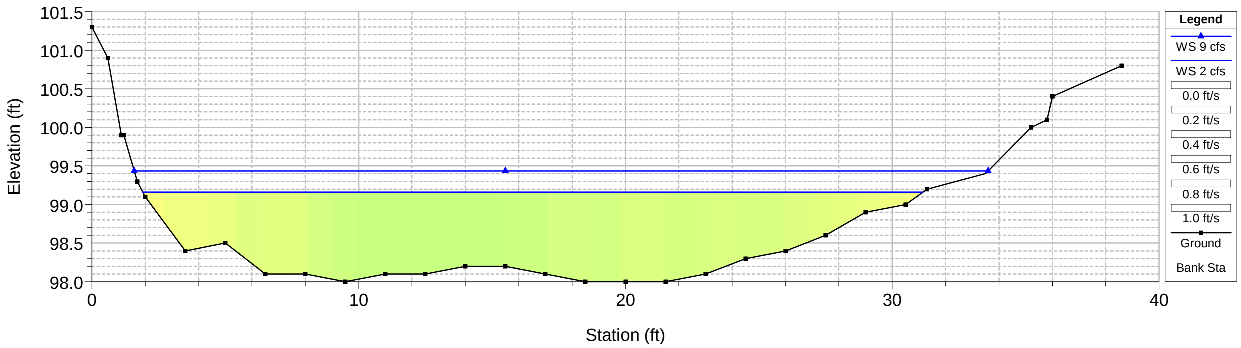

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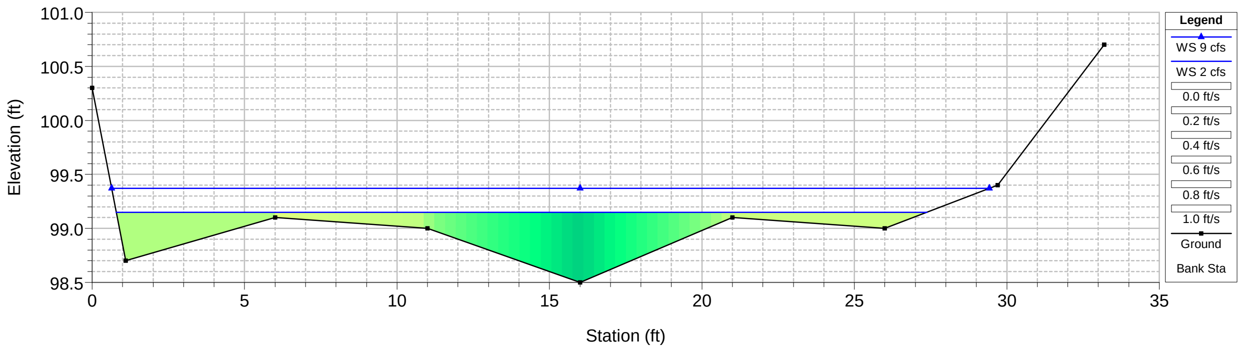

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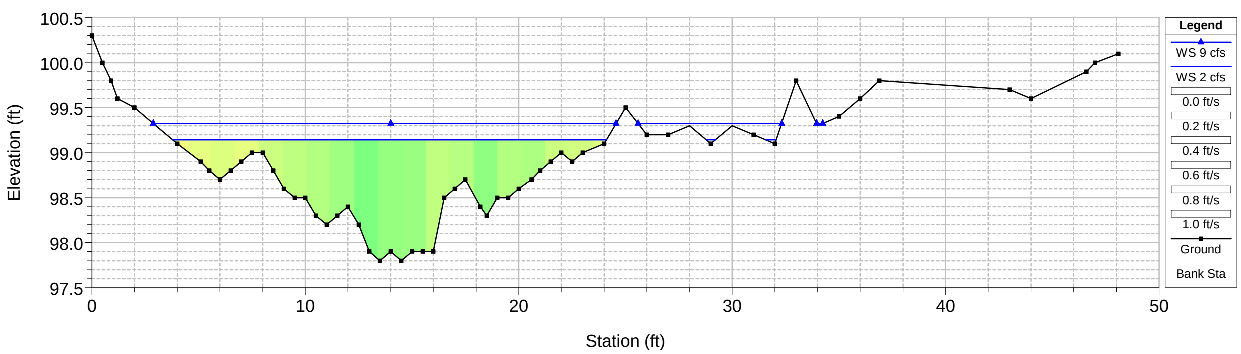

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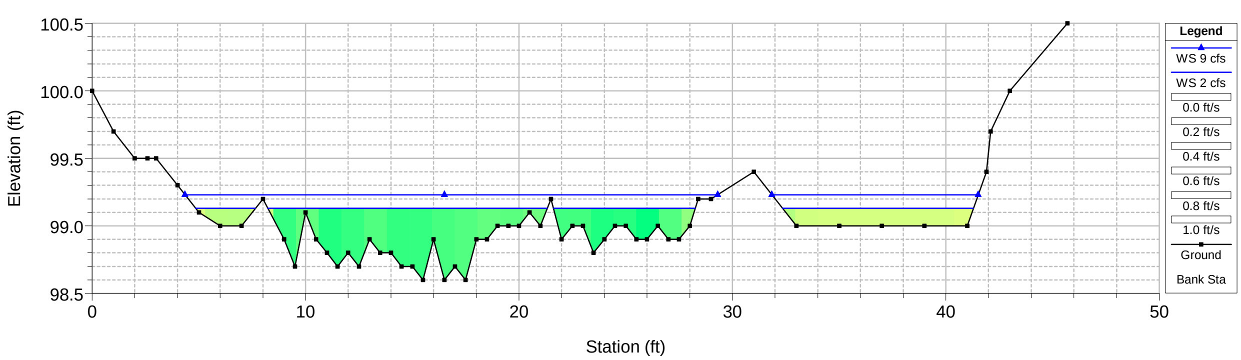

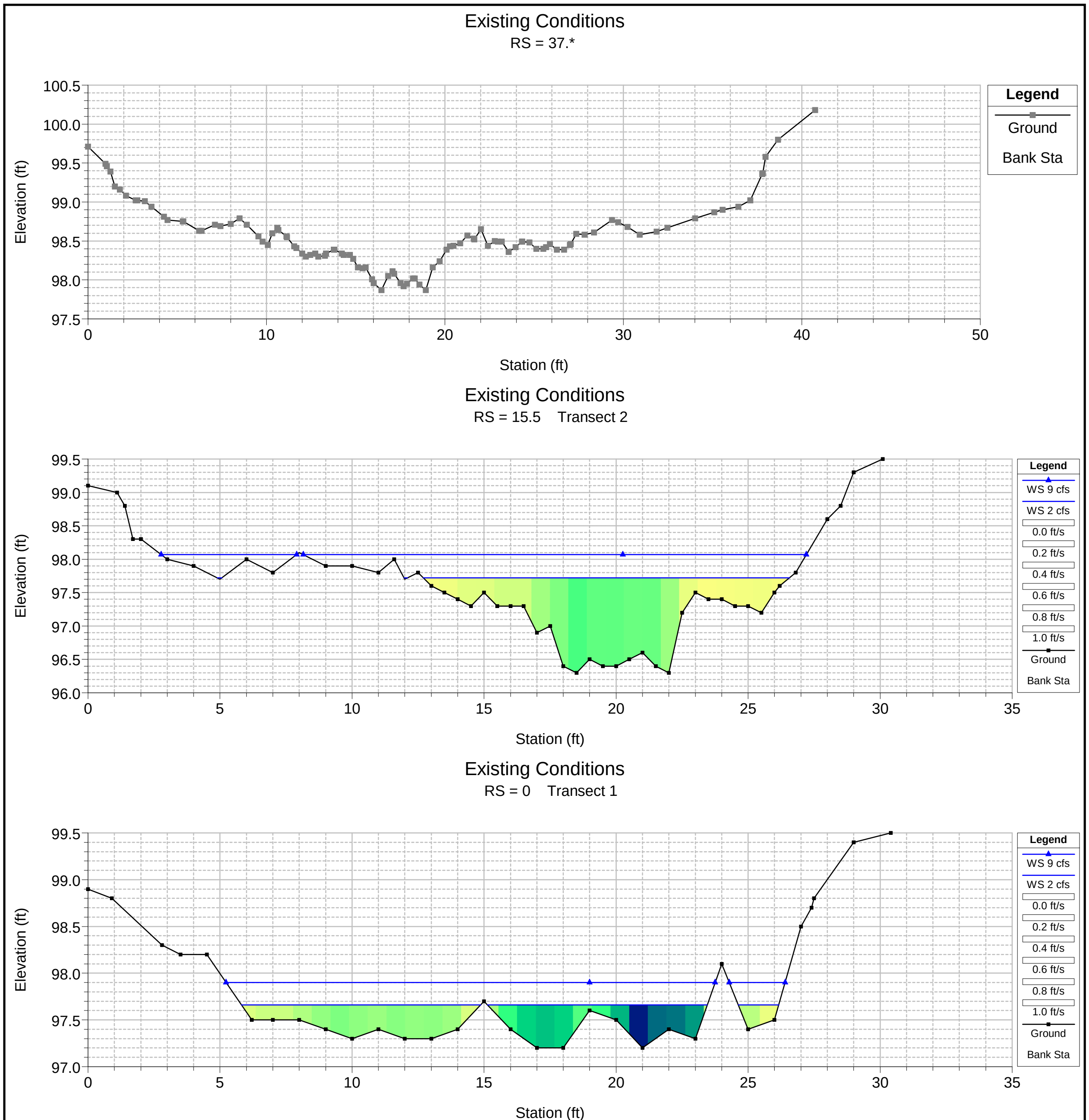
Existing Conditions
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Elevation (ft)
Station (ft)
Legend
Ground
Bank Sta
Existing Conditions
RS = 15.5 Transect 2
Elevation (ft)
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta
Existing Conditions
RS = 0 Transect 1
Elevation (ft)
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
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0.8 ft/s
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Ground
Bank Sta

Proposed Apex Jam

Apex Type Jam
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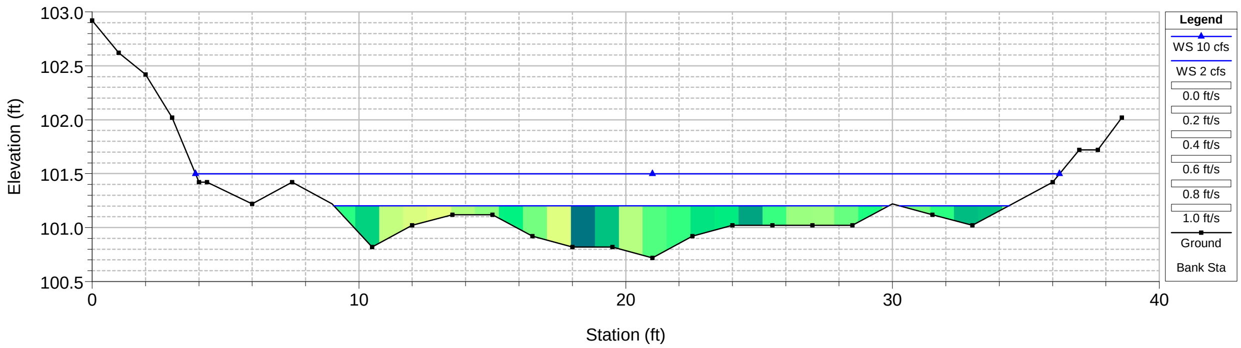

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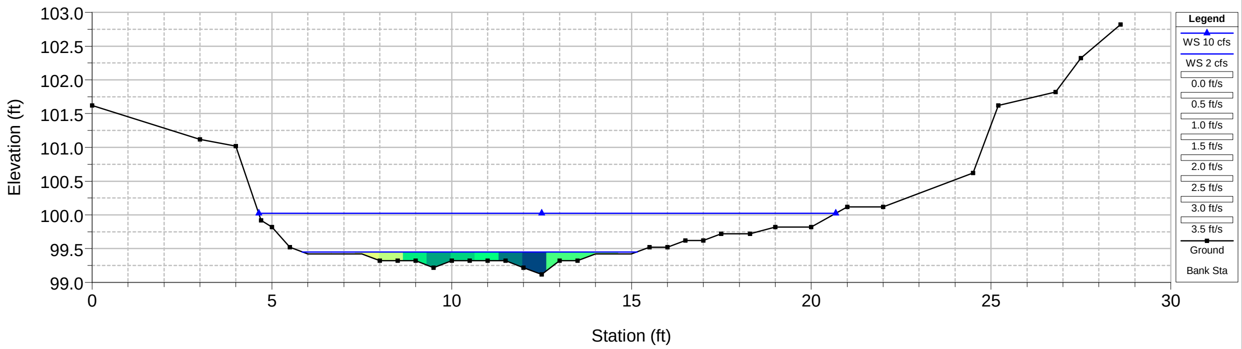

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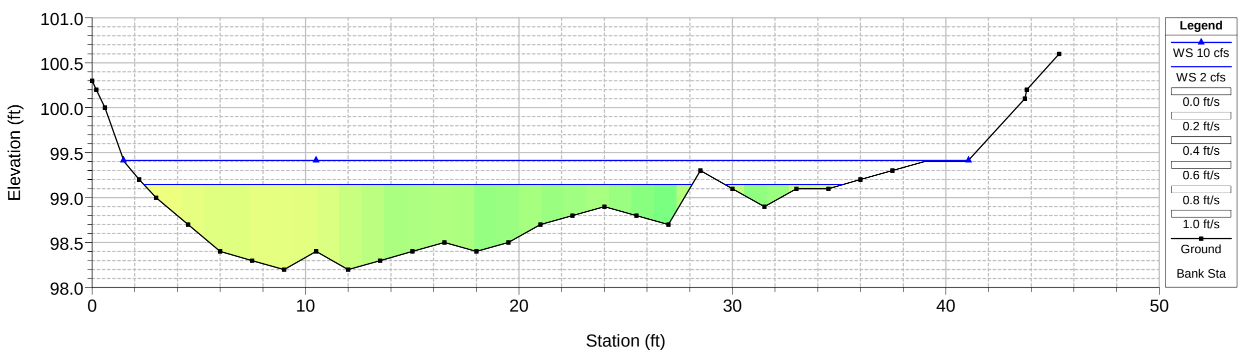

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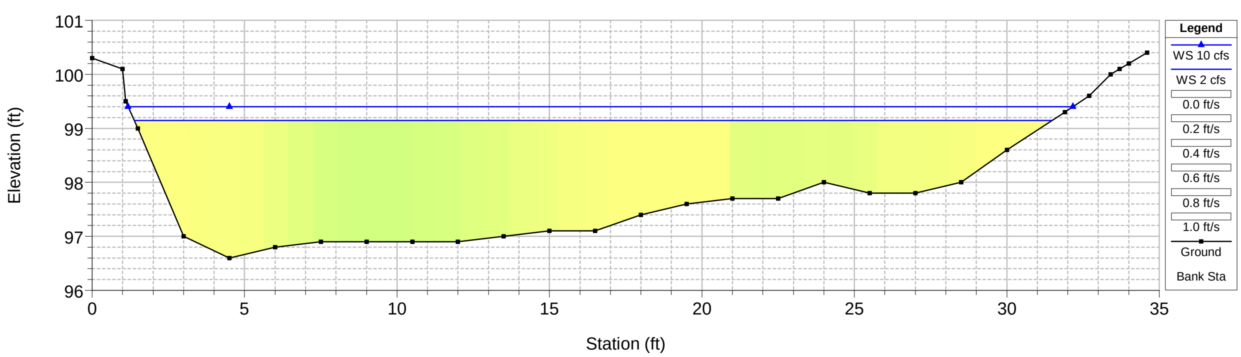

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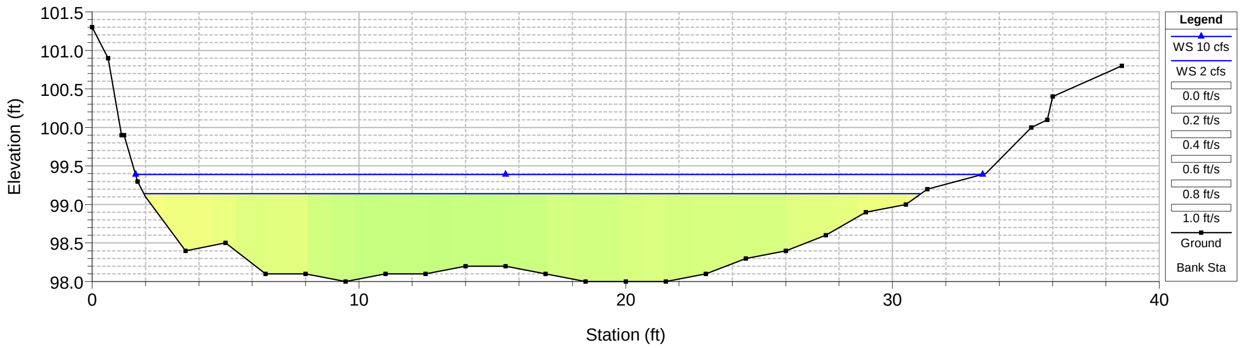

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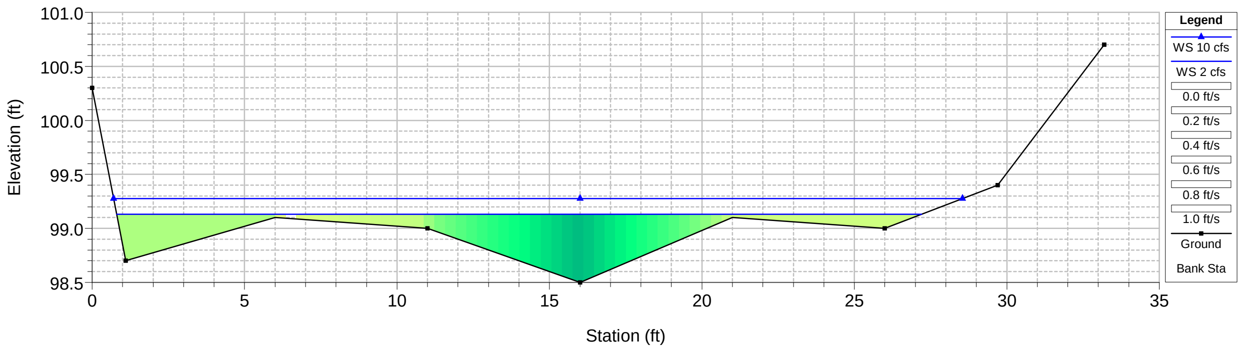

Apex Type Jam

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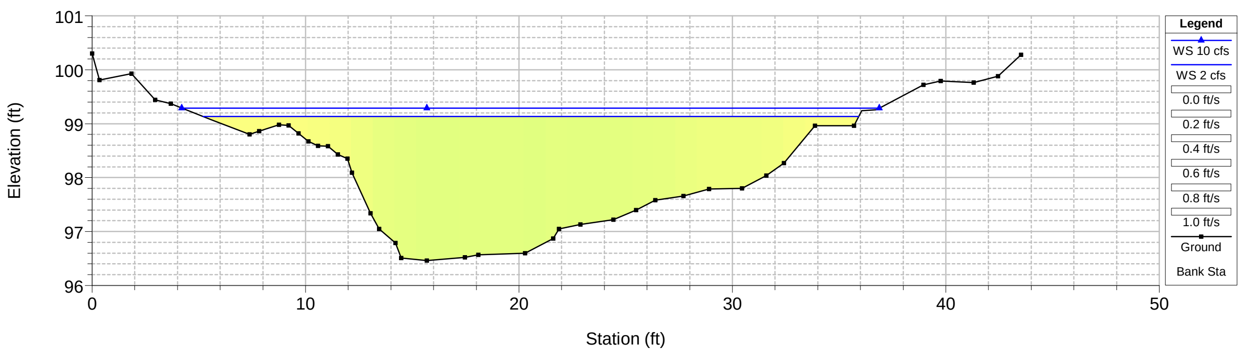

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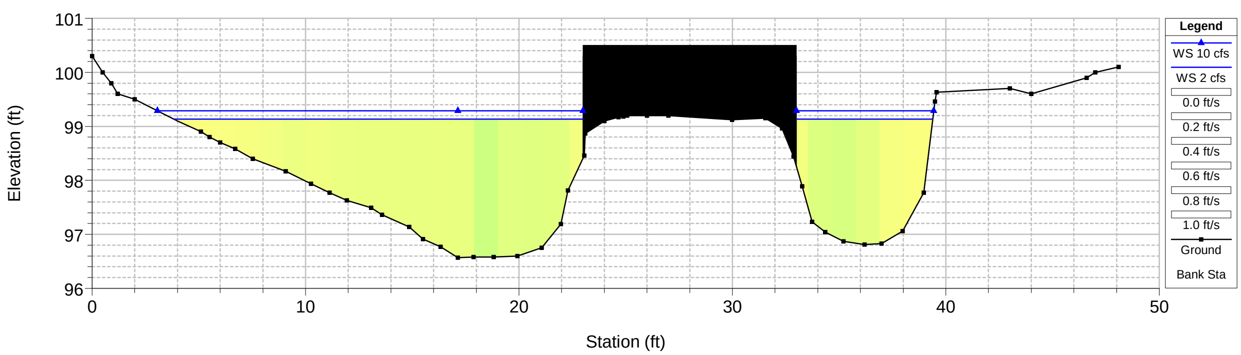

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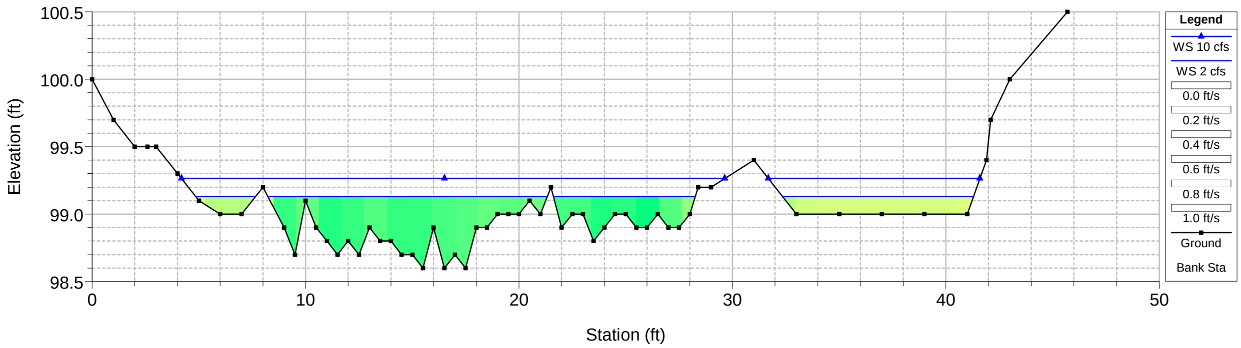

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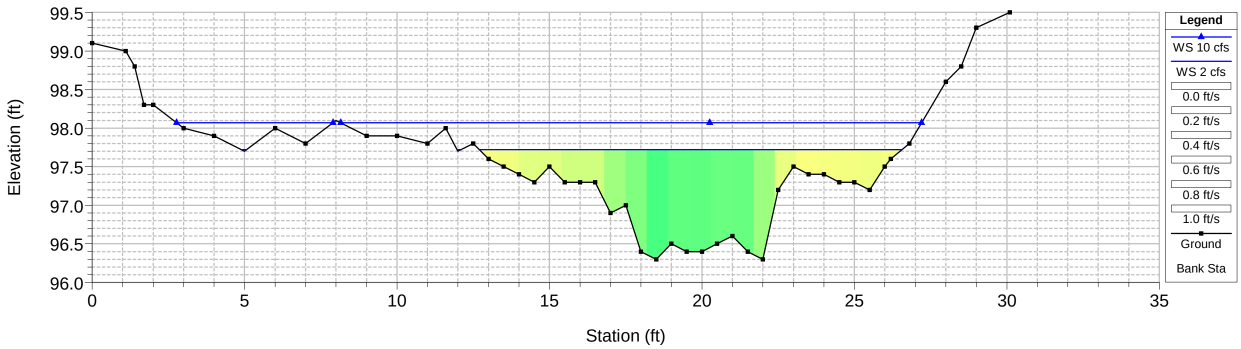

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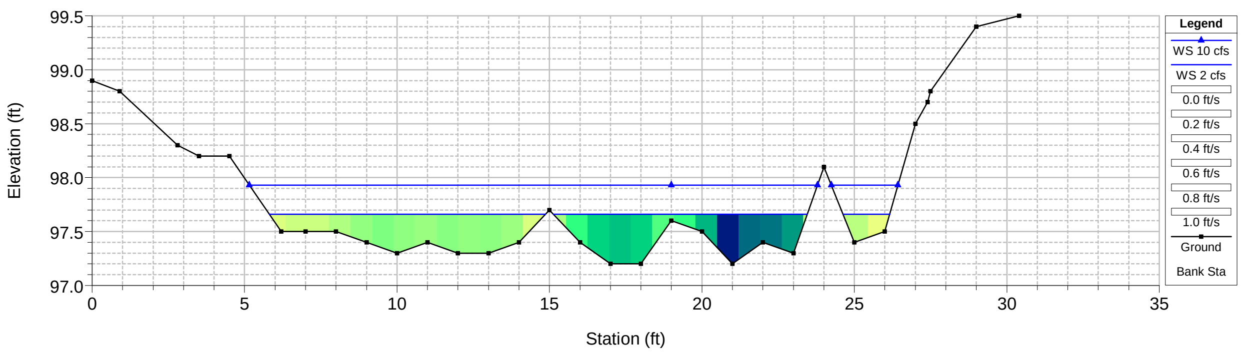
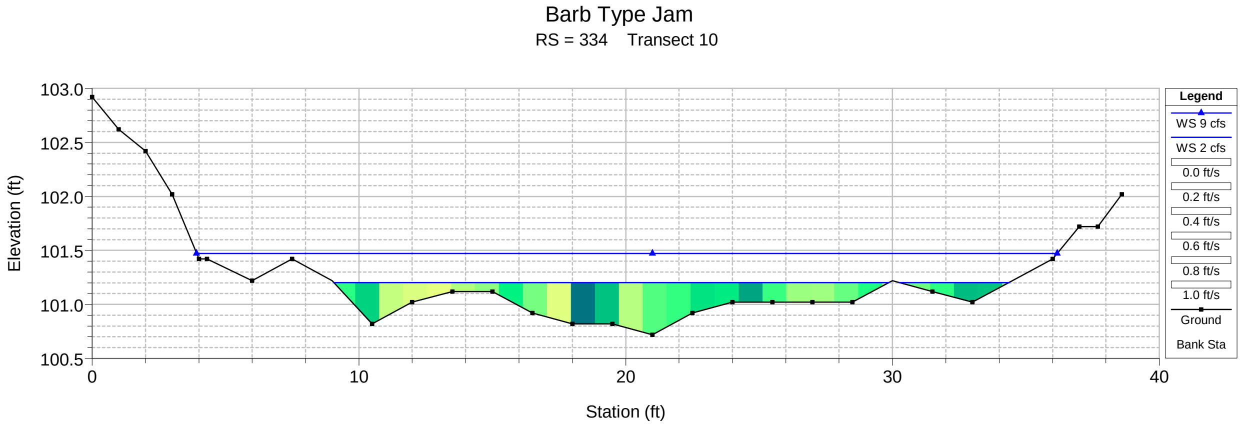
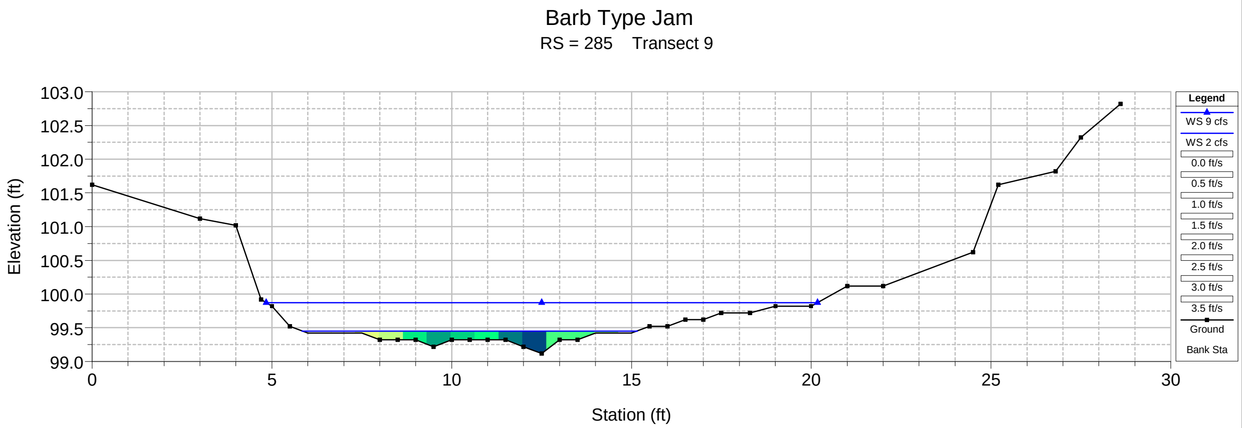
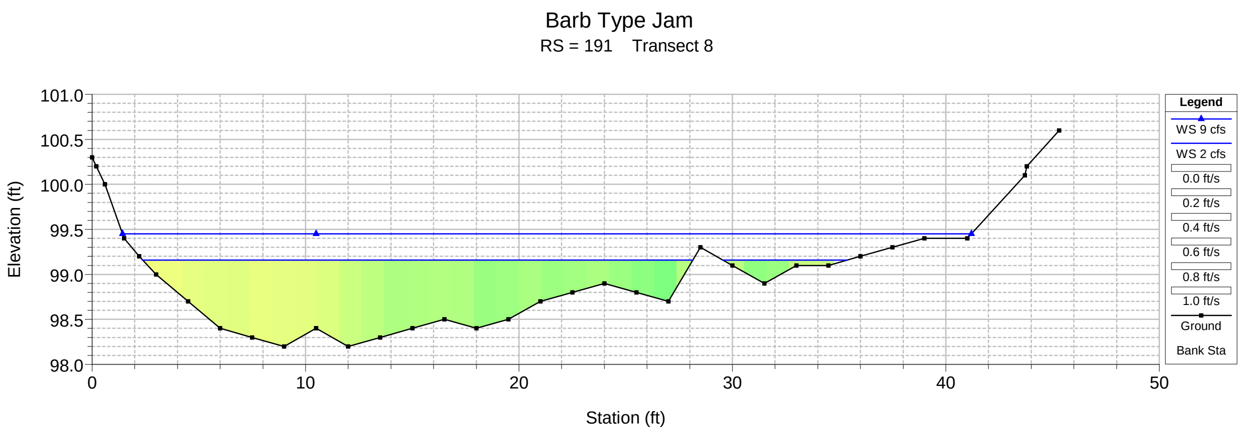
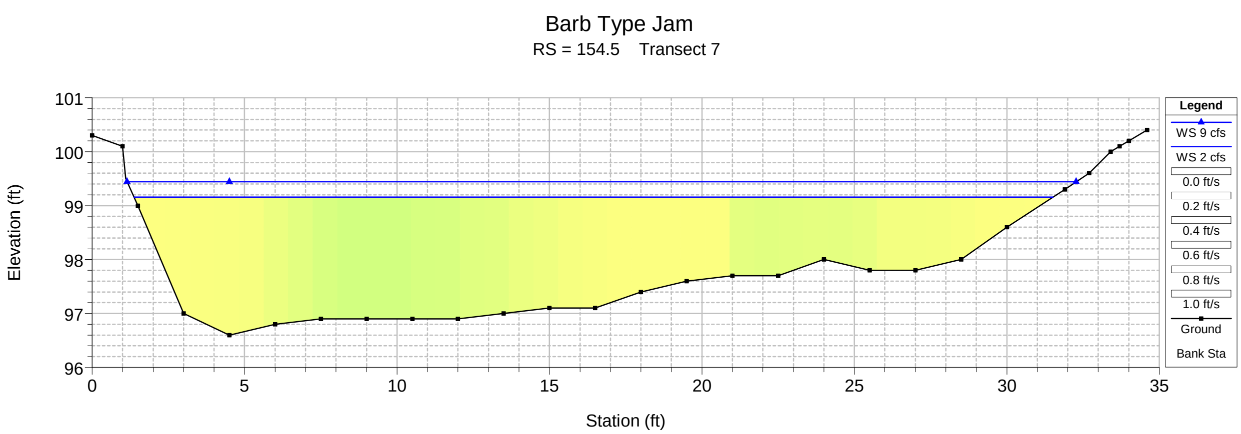


Proposed Barb Jam


Barb Type Jam
RS = 334 Transect 10
Elevation (ft)
103.0
102.5
102.0
101.5
101.0
100.5
0
10
20
30
40
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta

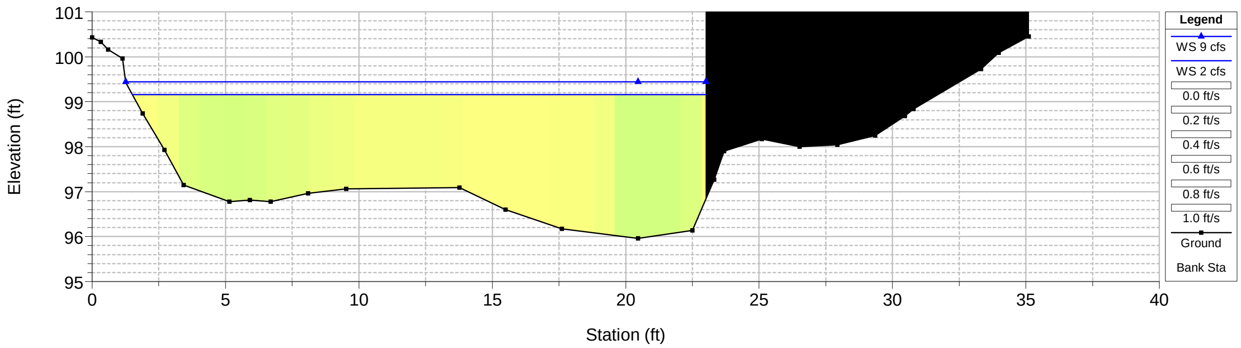

Barb Type Jam
RS = 285 Transect 9
Elevation (ft)
103.0
102.5
102.0
101.5
101.0
100.5
100.0
99.5
99.0
0
5
10
15
20
25
30
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
3.5 ft/s
Ground
Bank Sta


Barb Type Jam
RS = 191 Transect 8
Elevation (ft)
101.0
100.5
100.0
99.5
99.0
98.5
98.0
0
10
20
30
40
50
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta


Barb Type Jam
RS = 154.5 Transect 7
Elevation (ft)
101
100
99
98
97
96
0
5
10
15
20
25
30
35
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta

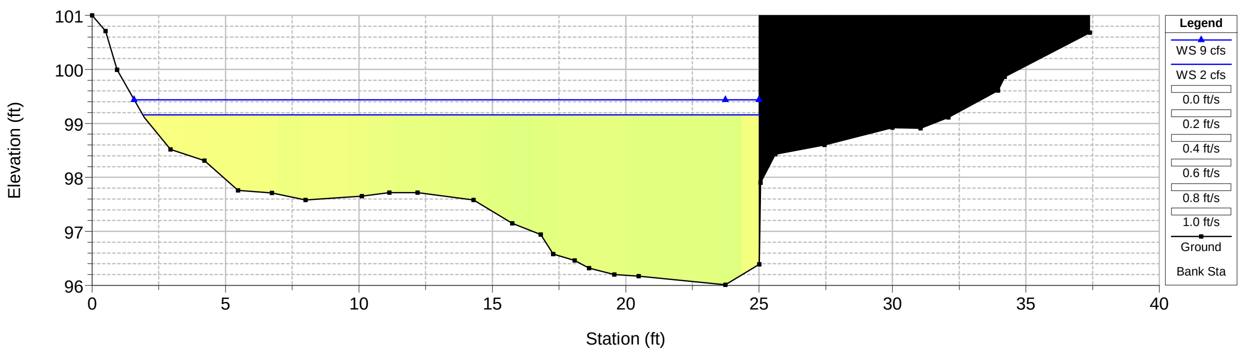
Barb Type Jam

RS = 150. STRUCTURE UPPER



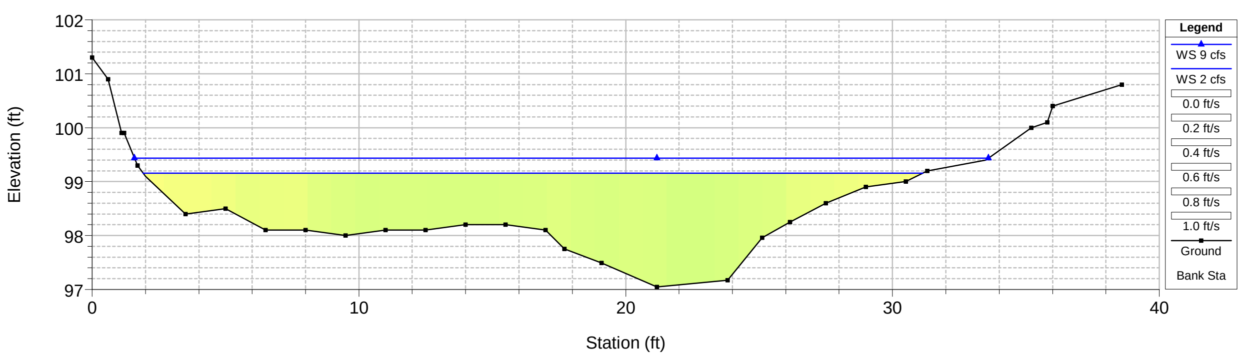
Barb Type Jam

RS = 130. STRUCTURE LOWER



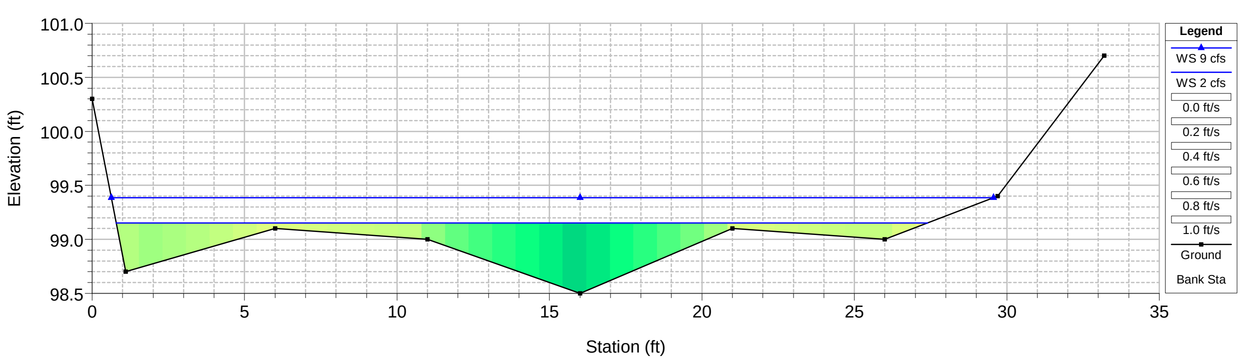
Barb Type Jam

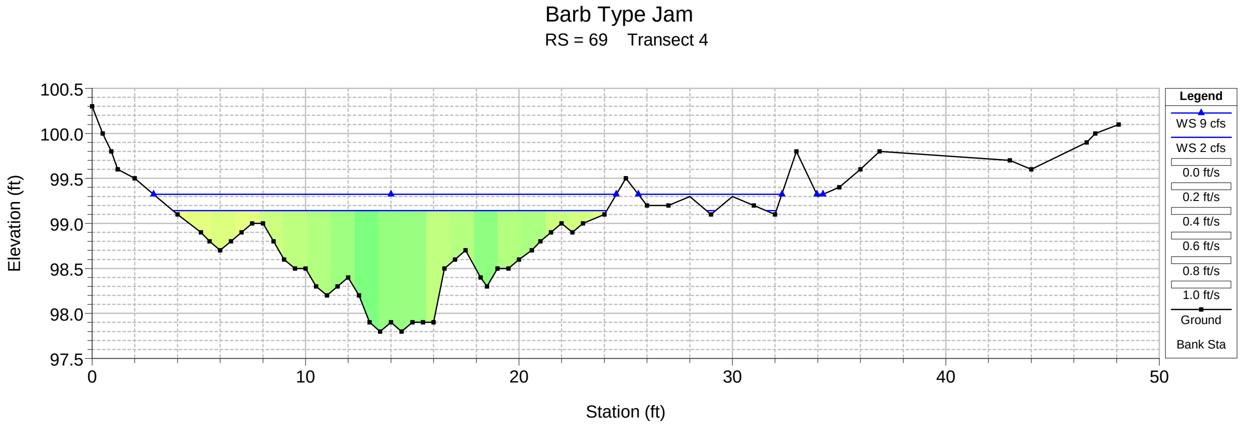
RS = 119.5 Transect 6

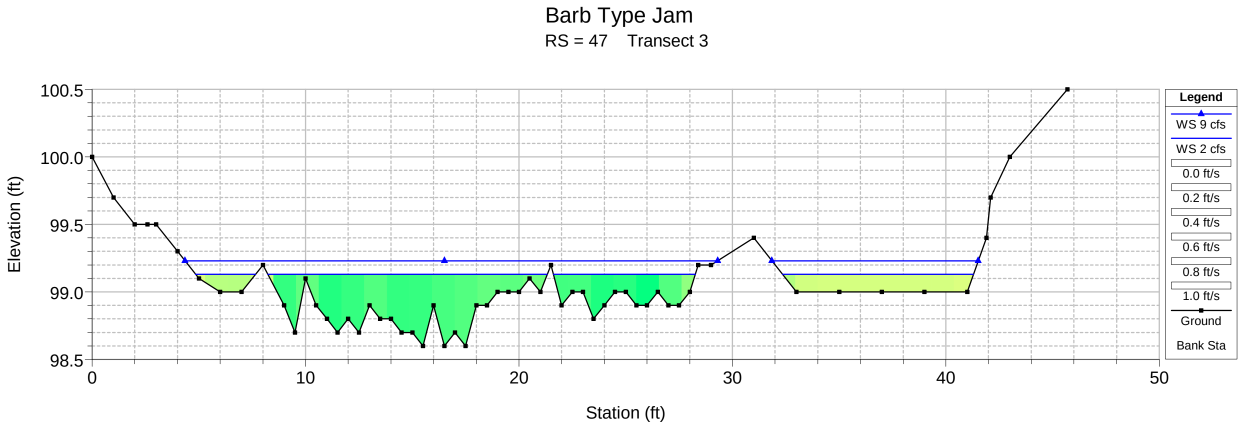


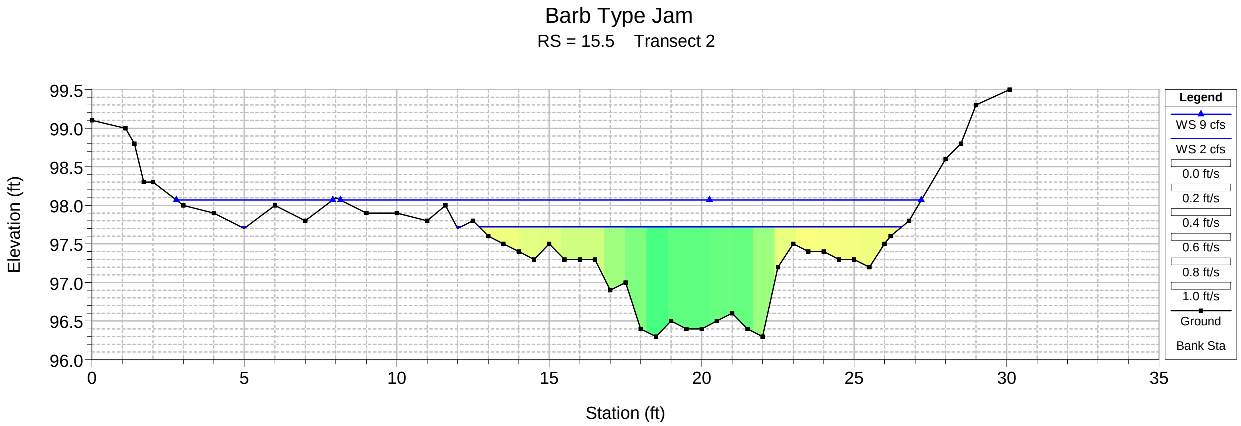
Barb Type Jam

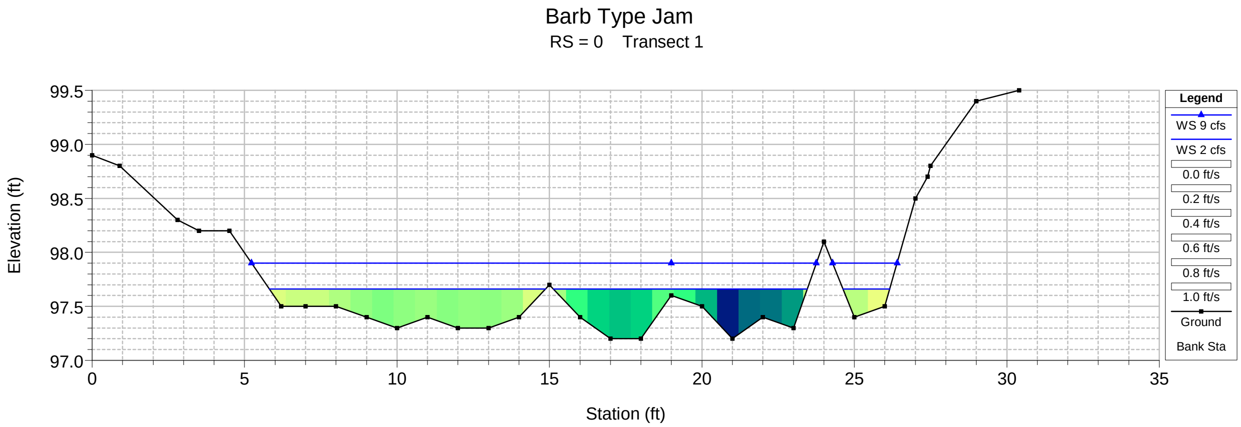
RS = 95 Transect 5




Barb Type Jam
RS = 69 Transect 4
Elevation (ft)
100.5
100.0
99.5
99.0
98.5
98.0
97.5
0
10
20
30
40
50
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta


Barb Type Jam
RS = 47 Transect 3
Elevation (ft)
100.5
100.0
99.5
99.0
98.5
0
10
20
30
40
50
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta

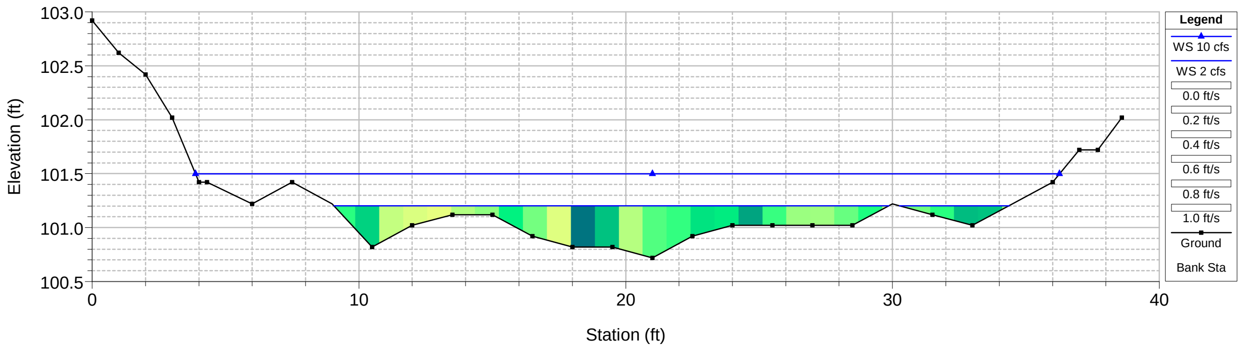

Barb Type Jam
RS = 15.5 Transect 2
Elevation (ft)
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
0
5
10
15
20
25
30
35
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta


Barb Type Jam
RS = 0 Transect 1
Elevation (ft)
99.5
99.0
98.5
98.0
97.5
97.0
0
5
10
15
20
25
30
35
Station (ft)
Legend
WS 9 cfs
WS 2 cfs
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta

Proposed Cross Channel

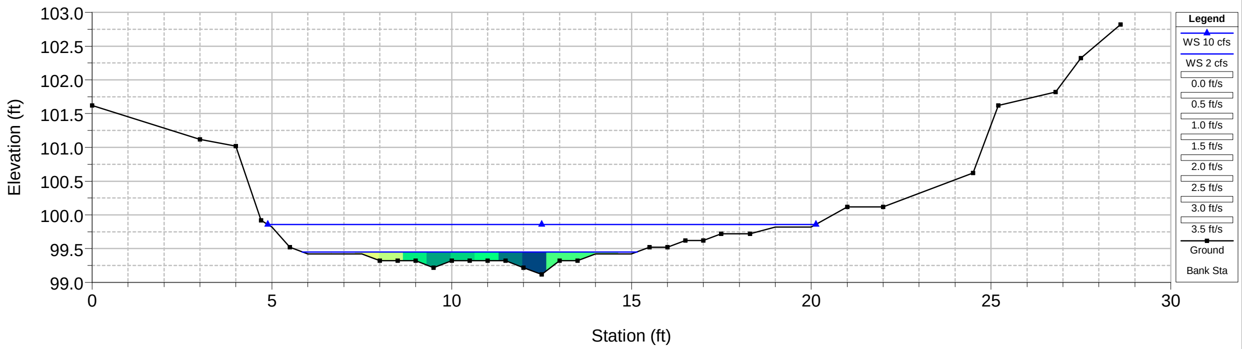
Cross Channel Structure

RS = 334 Transect 10



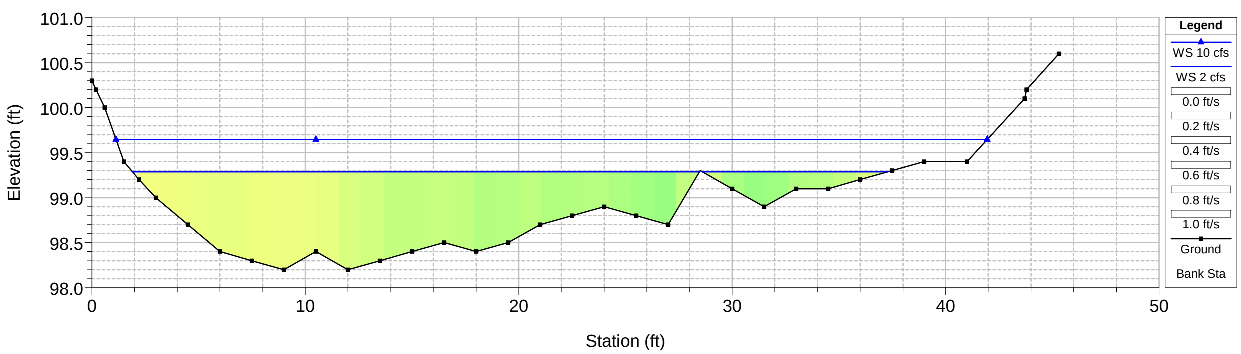
Cross Channel Structure

RS = 285 Transect 9



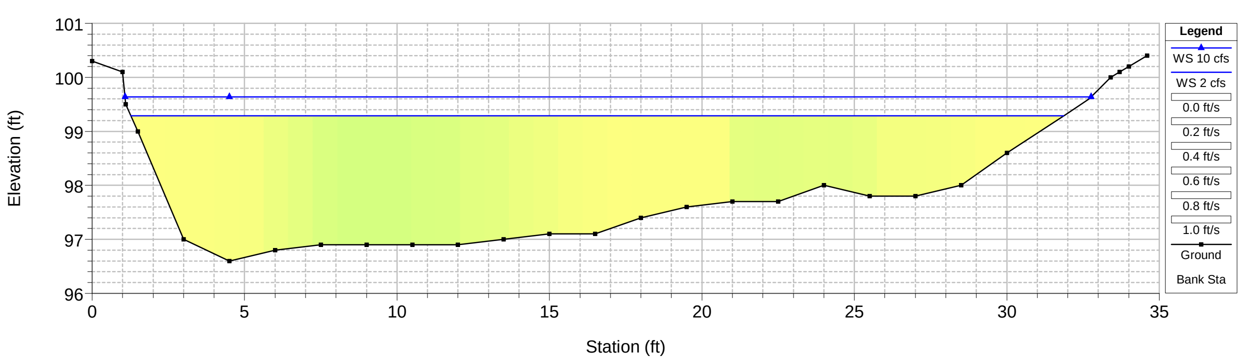
Cross Channel Structure

RS = 191 Transect 8



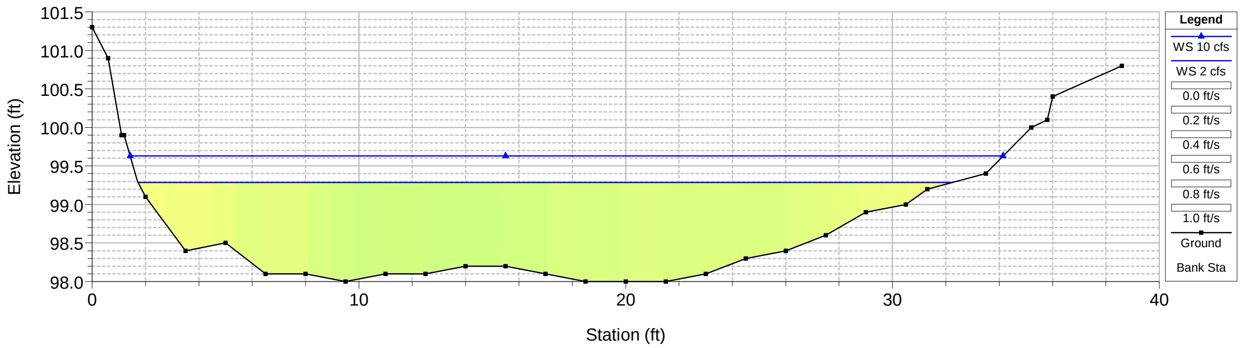
Cross Channel Structure

RS = 154.5 Transect 7



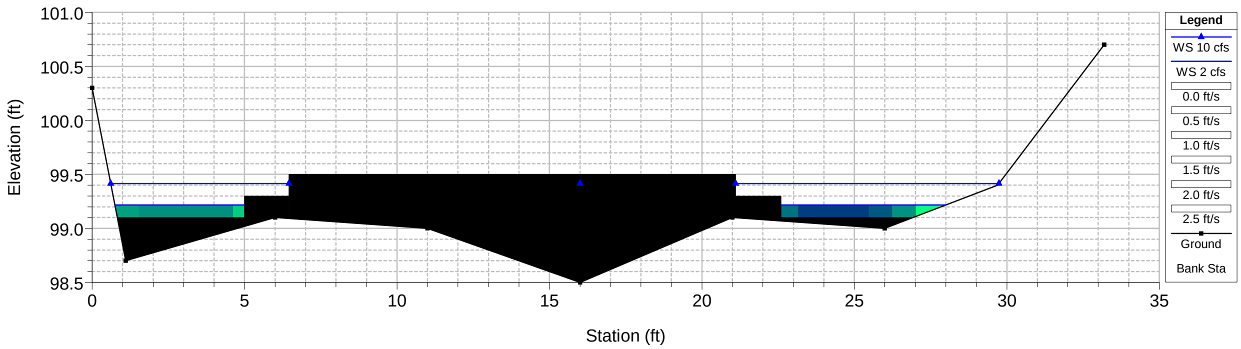
Cross Channel Structure

RS = 119.5 Transect 6



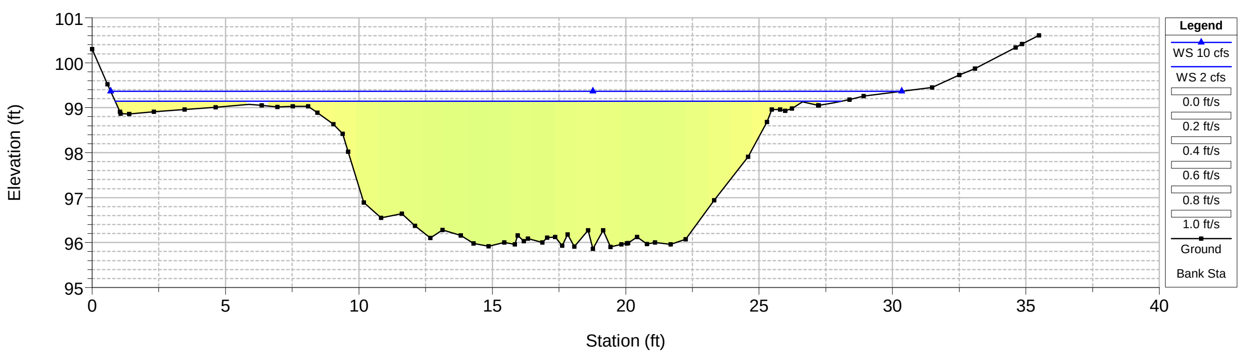
Cross Channel Structure

RS = 95 Transect 5



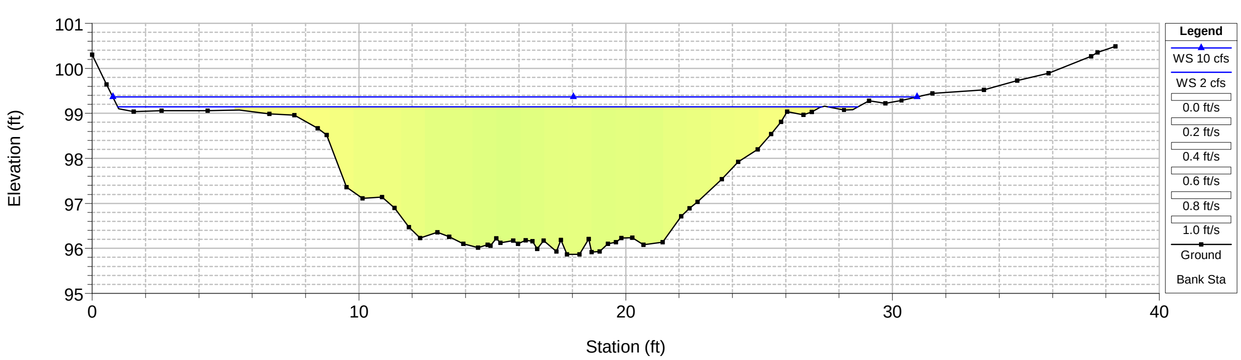
Cross Channel Structure

RS = 91. NEW POOL UPPER

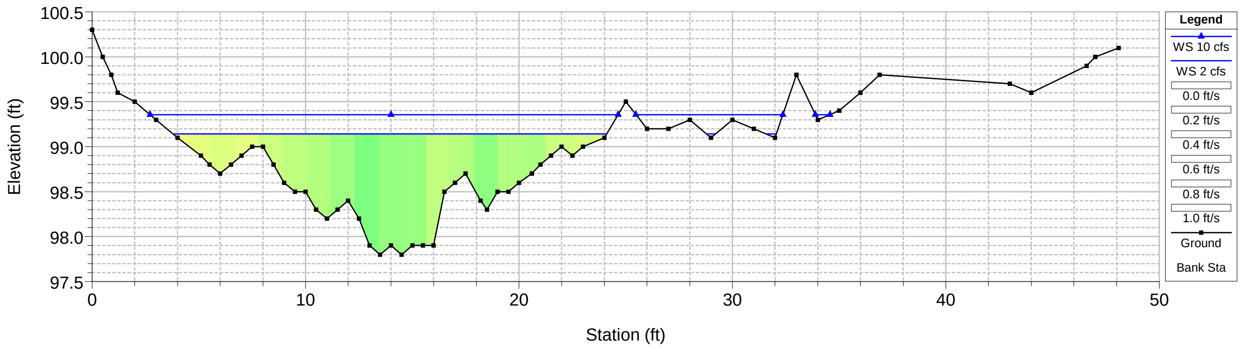


Cross Channel Structure

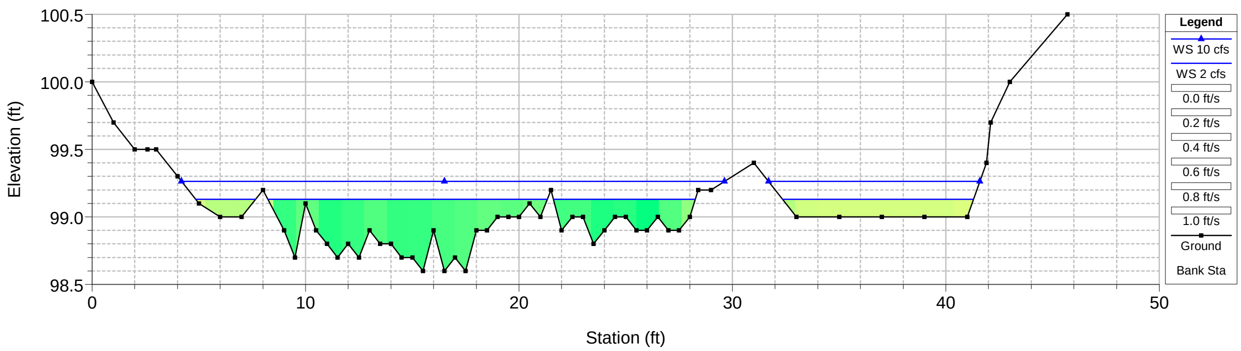
RS = 86. NEW POOL LOWER



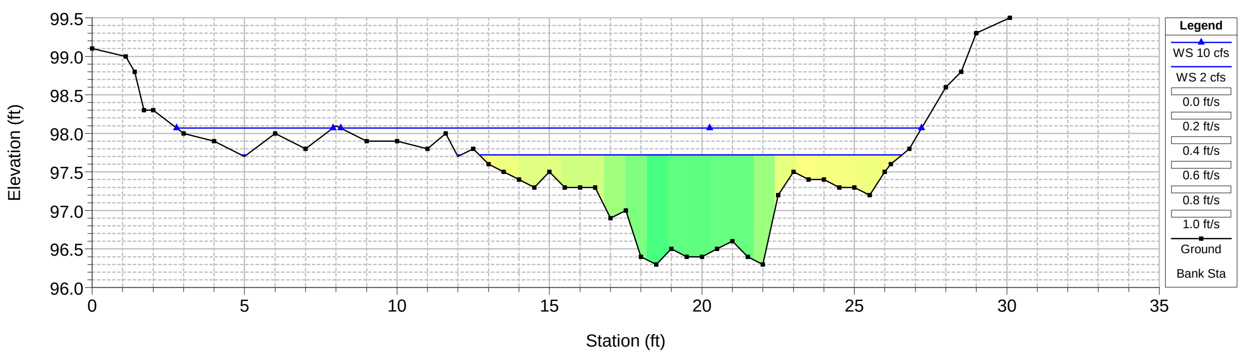
Cross Channel Structure
RS = 69 Transect 4



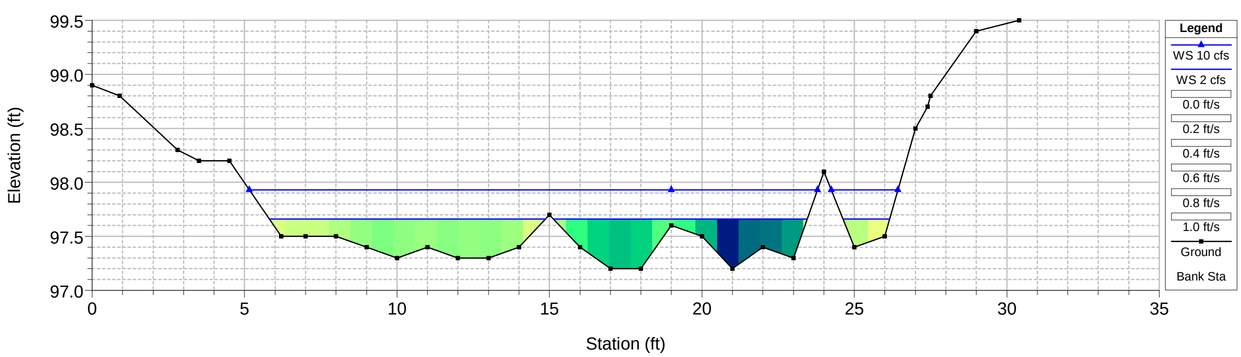
Cross Channel Structure
RS = 47 Transect 3



Cross Channel Structure
RS = 15.5 Transect 2



Cross Channel Structure
RS = 0 Transect 1



Appendix C
RAS-SIM Calculations

C-1
Existing Conditions

Weighted Usable Area Analysis Transect 1 - Glide Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	5.7	6.4	0.10	0.07	6.0
2.0	6.4	7.1	0.16	0.10	6.7
3.0	7.1	7.8	0.16	0.10	7.4
4.0	7.8	8.5	0.18	0.16	8.1
5.0	8.5	9.2	0.24	0.21	8.8
6.0	9.2	9.9	0.31	0.25	9.5
7.0	9.9	10.6	0.33	0.22	10.3
8.0	10.6	11.3	0.28	0.20	11.0
9.0	11.3	12.0	0.33	0.23	11.7
10.0	12.0	12.7	0.36	0.21	12.4
11.0	12.7	13.4	0.35	0.22	13.1
12.0	13.4	14.1	0.28	0.19	13.8
13.0	14.1	14.9	0.11	0.07	14.5
14.0	14.9	15.6	0.06	0.17	15.2
15.0	15.6	16.3	0.23	0.41	15.9
16.0	16.3	17.0	0.38	0.58	16.6
17.0	17.0	17.7	0.46	0.62	17.3
18.0	17.7	18.4	0.42	0.59	18.0
19.0	18.4	19.1	0.17	0.34	18.7
20.0	19.1	19.8	0.10	0.41	19.4
21.0	19.8	20.5	0.21	0.64	20.2
22.0	20.5	21.2	0.40	0.95	20.9
23.0	21.2	21.9	0.35	0.79	21.6
24.0	21.9	22.6	0.29	0.77	22.3
25.0	22.6	23.3	0.29	0.70	23.0
26.0	23.3	24.0	0.05	0.14	23.7
27.0	24.0	24.7	0.04	0.13	24.4
28.0	24.7	25.5	0.21	0.14	25.1
29.0	25.5	26.2	0.16	0.04	25.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9	150.30
0.9	2	
2.8	9	
3.5	9	
4.5	9	
6.2	2	
7.0	2	
8.0	2	
9.0	2	
10.0	2	
11.0	2	
12.0	0	
13.0	0	
14.0	0	
15.0	0	
16.0	0	
17.0	0	
18.0	0	
19.0	0	
20.0	3	
21.0	3	
22.0	3	
23.0	3	
24.0	3	
25.0	3	
26.0	3	
27.0	3	
27.4	3	
27.5	3	
29.0	3	
30.4	3	

Table 3
Velocity Suitability Index

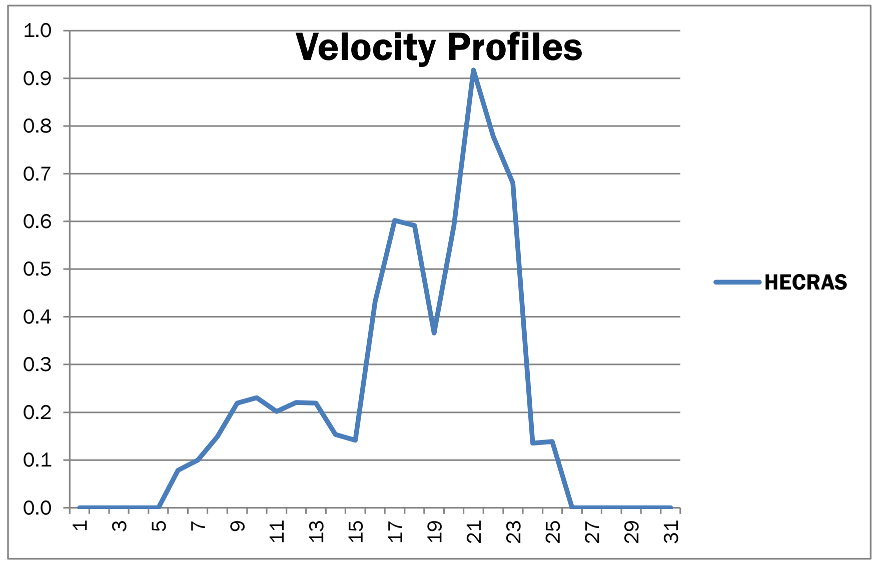
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.0	0.0
0.9	0.0	0.0
2.8	0.0	0.0
3.5	0.0	0.0
4.5	0.0	0.0
6.2	0.1	0.1
7.0	0.1	0.2
8.0	0.1	0.2
9.0	0.2	0.3
10.0	0.2	0.3
11.0	0.2	0.3
12.0	0.2	0.3
13.0	0.2	0.4
14.0	0.2	0.2
15.0	0.1	0.1
16.0	0.4	0.3
17.0	0.6	0.4
18.0	0.6	0.4
19.0	0.4	0.1
20.0	0.6	0.2
21.0	0.9	0.4
22.0	0.8	0.3
23.0	0.7	0.3
24.0	0.1	0.0
25.0	0.1	0.2
26.0	0.0	0.0
27.0	0.0	0.0
27.4	0.0	0.0
27.5	0.0	0.0
29.0	0.0	0.0
30.4	0.0	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
120.2	1.00	0.06	0.70	0.17	20.1
150.3	1.00	0.09	0.70	0.21	31.7
150.3	1.00	0.10	0.70	0.22	32.9
150.3	1.00	0.15	0.70	0.27	41.0
150.3	1.00	0.20	0.70	0.31	47.0
150.3	1.00	0.17	0.05	0.02	3.1
150.3	1.00	0.21	0.05	0.02	3.5
150.3	1.00	0.22	0.05	0.02	3.5
150.3	1.00	0.13	0.05	0.02	2.7
150.3	1.00	0.04	0.05	0.01	1.4
150.3	1.00	0.15	0.05	0.02	2.9
150.3	0.92	0.27	0.05	0.02	3.7
150.3	0.93	0.27	0.05	0.02	3.7
150.3	1.00	0.08	1.00	0.28	41.7
150.3	0.93	0.10	1.00	0.31	46.8
150.3	0.67	0.24	1.00	0.40	60.4
150.3	0.78	0.19	1.00	0.39	58.4
150.3	0.86	0.17	1.00	0.38	57.7
150.3	1.00	0.02	1.00	0.14	21.3
150.3	1.00	0.10	1.00	0.32	48.5
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 2,975.9				Total Weighted Usable Area:	531.9

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 2 - Glide Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	4.9	5.6	0.0	0.0	5.3
2.0	5.6	6.3			6.0
3.0	6.3	7.0			6.7
4.0	7.0	7.7			7.4
5.0	7.7	8.4			8.1
6.0	8.4	9.1			8.8
7.0	9.1	9.8			9.5
8.0	9.8	10.5			10.2
9.0	10.5	11.2			10.9
10.0	11.2	11.9			11.6
11.0	11.9	12.6	0.0	0.0	12.3
12.0	12.6	13.3	0.1	0.0	13.0
13.0	13.3	14.0	0.3	0.0	13.7
14.0	14.0	14.7	0.4	0.1	14.4
15.0	14.7	15.4	0.3	0.1	15.1
16.0	15.4	16.1	0.4	0.1	15.8
17.0	16.1	16.8	0.5	0.1	16.5
18.0	16.8	17.5	0.8	0.2	17.2
19.0	17.5	18.2	1.1	0.3	17.9
20.0	18.2	18.9	1.4	0.4	18.6
21.0	18.9	19.6	1.3	0.3	19.3
22.0	19.6	20.3	1.3	0.3	20.0
23.0	20.3	21.0	1.2	0.3	20.7
24.0	21.0	21.7	1.3	0.3	21.4
25.0	21.7	22.4	1.2	0.2	22.1
26.0	22.4	23.1	0.4	0.0	22.8
27.0	23.1	23.8	0.3	0.0	23.5
28.0	23.8	24.5	0.4	0.0	24.2
29.0	24.5	25.2	0.4	0.0	24.9
30.0	25.2	25.9	0.4	0.0	25.6
31.0	25.9	26.6	0.1	0.0	26.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9	150.30
1.1	9	
1.4	9	
1.7	9	
2.0	9	
3.0	9	
4.0	2	
5.0	2	
6.0	2	
7.0	0	
8.0	0	
9.0	0	
10.0	0	
11.0	0	
11.6	0	
12.0	0	
12.5	0	
13.0	10	
13.5	10	
14.0	10	
14.5	10	
15.0	10	
15.5	10	
16.0	10	
16.5	10	
17.0	10	
17.5	10	
18.0	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.5	10	
21.0	10	
21.5	10	
22.0	10	
22.5	10	
23.0	10	
23.5	10	
24.0	10	
24.5	10	
25.0	10	
25.5	0	
26.0	10	
26.2	10	
26.8	10	
28.0	9	
28.5	9	
29.0	9	
30.1	9	

Table 3
Velocity Suitability Index

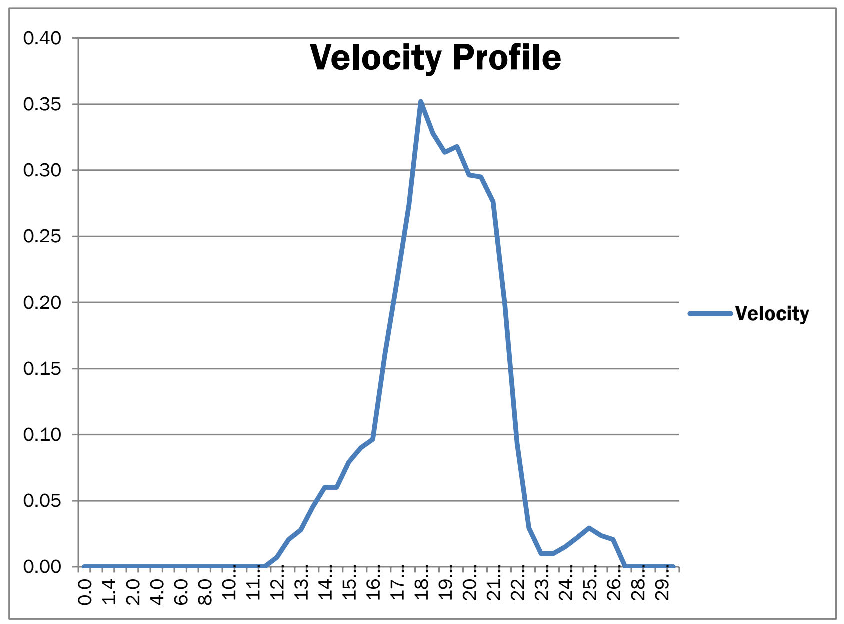
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.1	0.00	0.0
1.4	0.00	0.0
1.7	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.0	0.00	0.0
6.0	0.00	0.0
7.0	0.00	0.0
8.0	0.00	0.0
9.0	0.00	0.0
10.0	0.00	0.0
11.0	0.00	0.0
11.6	0.00	0.0
12.0	0.00	0.0
12.5	0.01	0.0
13.0	0.02	0.1
13.5	0.03	0.2
14.0	0.05	0.3
14.5	0.06	0.4
15.0	0.06	0.3
15.5	0.08	0.4
16.0	0.09	0.4
16.5	0.10	0.5
17.0	0.16	0.7
17.5	0.22	0.9
18.0	0.27	1.2
18.5	0.35	1.3
19.0	0.33	1.3
19.5	0.31	1.3
20.0	0.32	1.3
20.5	0.30	1.2
21.0	0.30	1.2
21.5	0.28	1.2
22.0	0.20	1.2
22.5	0.09	0.7
23.0	0.03	0.4
23.5	0.01	0.3
24.0	0.01	0.3
24.5	0.02	0.4
25.0	0.02	0.4
25.5	0.03	0.4
26.0	0.02	0.2
26.2	0.02	0.1
26.8	0.00	0.0
28.0	0.00	0.0
28.5	0.00	0.0
29.0	0.00	0.0
30.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitaibity	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
60.1	1.00	0.00	0.05	0.00	0.0
75.2	1.00	0.00	0.05	0.00	0.0
75.2	1.00	0.02	0.10	0.01	1.1
75.2	1.00	0.06	0.10	0.03	1.9
75.2	1.00	0.12	0.10	0.04	2.7
75.2	1.00	0.19	0.10	0.04	3.2
75.2	1.00	0.22	0.10	0.05	3.5
75.2	1.00	0.18	0.10	0.04	3.2
75.2	1.00	0.23	0.10	0.05	3.6
75.2	1.00	0.27	0.10	0.05	3.9
75.2	1.00	0.31	0.10	0.06	4.2
75.2	1.00	0.45	0.10	0.07	5.0
75.2	1.00	0.61	0.10	0.08	5.9
75.2	1.00	0.77	0.10	0.09	6.6
75.2	1.00	0.89	0.10	0.09	7.1
75.2	1.00	0.86	0.10	0.09	7.0
75.2	1.00	0.85	0.10	0.09	6.9
75.2	1.00	0.86	0.10	0.09	7.0
75.2	1.00	0.80	0.10	0.09	6.7
75.2	1.00	0.80	0.10	0.09	6.7
75.2	1.00	0.82	0.10	0.09	6.8
75.2	1.00	0.80	0.10	0.09	6.7
75.2	1.00	0.44	0.10	0.07	5.0
75.2	1.00	0.22	0.10	0.05	3.5
75.2	1.00	0.19	0.10	0.04	3.2
75.2	1.00	0.21	0.10	0.05	3.5
75.2	1.00	0.25	0.10	0.05	3.7
75.2	1.00	0.27	0.05	0.03	2.0
75.2	1.00	0.27	0.10	0.05	3.9
30.1	1.00	0.14	0.10	0.04	1.1
90.2	1.00	0.08	0.10	0.03	2.5
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 2,285				Total Weighted Usable Area:	128

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 3 - Riffle Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	4.3	5.3	0.0	0.1	4.8
2.0	5.3	6.4	0.1	0.1	5.8
3.0	6.4	7.4	0.1	0.1	6.9
4.0	7.4	8.5	0.0	0.1	8.0
5.0	8.5	9.6	0.3	0.4	9.0
6.0	9.6	10.6	0.2	0.3	10.1
7.0	10.6	11.7	0.4	0.4	11.2
8.0	11.7	12.8	0.4	0.4	12.2
9.0	12.8	13.8	0.3	0.3	13.3
10.0	13.8	14.9	0.4	0.4	14.4
11.0	14.9	15.9	0.4	0.4	15.4
12.0	15.9	17.0	0.4	0.4	16.5
13.0	17.0	18.1	0.4	0.3	17.5
14.0	18.1	19.1	0.2	0.3	18.6
15.0	19.1	20.2	0.1	0.3	19.7
16.0	20.2	21.3	0.1	0.3	20.7
17.0	21.3	22.3	0.1	0.4	21.8
18.0	22.3	23.4	0.2	0.4	22.9
19.0	23.4	24.4	0.2	0.5	23.9
20.0	24.4	25.5	0.2	0.4	25.0
21.0	25.5	26.6	0.2	0.5	26.0
22.0	26.6	27.6	0.2	0.3	27.1
23.0	27.6	28.7	0.1	0.2	28.2
24.0	28.7	29.8			29.2
25.0	29.8	30.8			30.3
26.0	30.8	31.9			31.4
27.0	31.9	33.0	0.1	0.2	32.4
28.0	33.0	34.0	0.1	0.1	33.5
29.0	34.0	35.1	0.1	0.1	34.5
30.0	35.1	36.1	0.1	0.1	35.6
31.0	36.1	37.2	0.1	0.1	36.7
32.0	37.2	38.3	0.1	0.1	37.7
33.0	38.3	39.3	0.1	0.1	38.8
34.0	39.3	40.4	0.1	0.1	39.9
35.0	40.4	41.5	0.1	0.1	40.9

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	5	98.00
1.0	5	
2.0	5	
2.6	5	
3.0	5	
4.0	5	
5.0	5	
6.0	2	
7.0	0	
8.0	0	
9.0	0	
9.5	0	
10.0	0	
10.5	0	
11.0	0	
11.5	0	
12.0	0	
12.5	0	
13.0	0	
13.5	0	
14.0	0	
14.5	0	
15.0	10	
15.5	10	
16.0	10	
16.5	10	
17.0	10	
17.5	10	
18.0	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.5	10	
21.0	10	
21.5	10	
22.0	10	
22.5	10	
23.0	10	
23.5	0	
24.0	0	
24.5	0	
25.0	0	
25.5	0	
26.0	0	
26.5	0	
27.0	0	
27.5	0	
28.0	0	
28.4	0	
29.0	0	
31.0	0	
33.0	0	
35.0	1	
37.0	1	
39.0	1	
41.0	9	
41.9	8	
42.1	8	
43.0	8	
45.7	2	

Table 3
Velocity Suitability Index

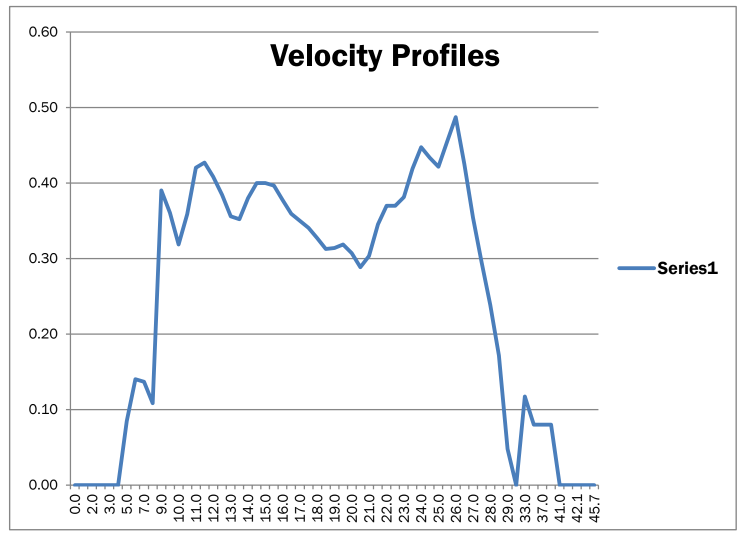
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.0	0.00	0.0
2.0	0.00	0.0
2.6	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.0	0.08	0.1
6.0	0.14	0.1
7.0	0.14	0.1
8.0	0.11	0.0
9.0	0.39	0.2
9.5	0.36	0.2
10.0	0.32	0.2
10.5	0.36	0.2
11.0	0.42	0.3
11.5	0.43	0.4
12.0	0.41	0.4
12.5	0.38	0.3
13.0	0.36	0.3
13.5	0.35	0.3
14.0	0.38	0.4
14.5	0.40	0.4
15.0	0.40	0.4
15.5	0.40	0.4
16.0	0.38	0.4
16.5	0.36	0.4
17.0	0.35	0.4
17.5	0.34	0.4
18.0	0.33	0.3
18.5	0.31	0.2
19.0	0.31	0.2
19.5	0.32	0.1
20.0	0.31	0.1
20.5	0.29	0.1
21.0	0.30	0.1
21.5	0.35	0.1
22.0	0.37	0.1
22.5	0.37	0.2
23.0	0.38	0.2
23.5	0.42	0.2
24.0	0.45	0.2
24.5	0.43	0.2
25.0	0.42	0.2
25.5	0.45	0.2
26.0	0.49	0.2
26.5	0.42	0.2
27.0	0.35	0.2
27.5	0.29	0.2
28.0	0.24	0.1
28.4	0.17	0.1
29.0	0.05	0.0
31.0	0.00	0.0
33.0	0.12	0.1
35.0	0.08	0.1
37.0	0.08	0.1
39.0	0.08	0.1
41.0	0.00	0.0
41.9	0.00	0.0
42.1	0.00	0.0
43.0	0.00	0.0
45.7	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabity	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
98.0	1.00	0.03	0.70	0.11	10.8
98.0	1.00	0.06	0.05	0.01	1.2
98.0	1.00	0.05	0.05	0.01	1.1
98.0	1.00	0.02	0.05	0.01	0.6
49.0	1.00	0.15	0.05	0.02	0.9
49.0	1.00	0.12	0.05	0.02	0.9
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.15	0.05	0.02	0.9
49.0	1.00	0.21	0.05	0.02	1.1
49.0	1.00	0.23	0.05	0.02	1.2
49.0	1.00	0.23	0.05	0.02	1.2
49.0	1.00	0.21	0.05	0.02	1.1
49.0	1.00	0.19	0.05	0.02	1.1
49.0	1.00	0.19	0.05	0.02	1.1
49.0	1.00	0.22	0.05	0.02	1.1
49.0	1.00	0.25	0.10	0.05	2.4
49.0	1.00	0.27	0.10	0.05	2.5
49.0	1.00	0.27	0.10	0.05	2.6
49.0	1.00	0.27	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.19	0.10	0.04	2.1
49.0	1.00	0.12	0.10	0.04	1.7
49.0	1.00	0.09	0.10	0.03	1.5
49.0	1.00	0.07	0.10	0.03	1.3
49.0	1.00	0.06	0.10	0.02	1.2
49.0	1.00	0.04	0.10	0.02	1.0
49.0	1.00	0.04	0.10	0.02	1.0
49.0	1.00	0.06	0.10	0.03	1.2
49.0	1.00	0.08	0.10	0.03	1.4
49.0	1.00	0.08	0.10	0.03	1.4
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.14	0.05	0.02	0.9
49.0	1.00	0.11	0.05	0.02	0.8
49.0	1.00	0.08	0.05	0.01	0.7
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.11	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.10	0.05	0.02	0.8
39.2	1.00	0.07	0.05	0.01	0.5
58.8	1.00	0.05	0.05	0.01	0.6
196.0	1.00	0.01	0.05	0.01	1.0
0.0	1.00	0.00	0.05	0.00	0.0
196.0	1.00	0.05	1.00	0.21	41.6
196.0	1.00	0.07	1.00	0.27	52.0
196.0	1.00	0.07	1.00	0.27	52.0
196.0	1.00	0.07	0.50	0.13	26.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 3,332				Total Weighted Usable Area:	238

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

Weighted Usable Area Analysis Transect 4 - Glide Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	3.4	4.5	0.1	0.0	3.9
2.0	4.5	5.6	0.2	0.1	5.0
3.0	5.6	6.7	0.4	0.1	6.2
4.0	6.7	7.8	0.2	0.1	7.3
5.0	7.8	9.0	0.3	0.1	8.4
6.0	9.0	10.1	0.6	0.1	9.5
7.0	10.1	11.2	0.8	0.2	10.6
8.0	11.2	12.3	0.8	0.2	11.7
9.0	12.3	13.4	1.1	0.3	12.9
10.0	13.4	14.5	1.3	0.2	14.0
11.0	14.5	15.7	1.3	0.2	15.1
12.0	15.7	16.8	1.0	0.1	16.2
13.0	16.8	17.9	0.5	0.1	17.3
14.0	17.9	19.0	0.7	0.2	18.5
15.0	19.0	20.1	0.6	0.2	19.6
16.0	20.1	21.3	0.4	0.2	20.7
17.0	21.3	22.4	0.2	0.1	21.8
18.0	22.4	23.5	0.2	0.1	22.9
19.0	23.5	24.6	0.1	0.1	24.1
20.0	24.6	25.7			25.2
21.0	25.7	26.9			26.3
22.0	26.9	28.0			27.4
23.0	28.0	29.1	0.0	0.0	28.5
24.0	29.1	30.2	0.0	0.0	29.6
25.0	30.2	31.3			30.8
26.0	31.3	32.4	0.0	0.0	31.9

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9	150.30
0.5	9	
0.9	9	
1.2	9	
2.0	9	
3.0	8	
4.0	8	
5.1	9	
5.5	9	
6.0	9	
6.5	9	
7.0	9	
7.5	0	
8.0	0	
8.5	0	
9.0	0	
9.5	0	
10.0	0	
10.5	0	
11.0	0	
11.5	0	
12.0	0	
12.5	0	
13.0	0	
13.5	0	
14.0	0	
14.5	0	
15.0	0	
15.5	0	
16.0	0	
16.5	10	
17.0	10	
17.5	10	
18.2	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.6	10	
21.0	10	
21.5	0	
22.0	0	
22.5	0	
23.0	0	
24.0	0	
25.0	0	
26.0	0	
27.0	8	
28.0	8	
29.0	8	
30.0	8	
31.0	8	
32.0	8	
33.0	8	
34.0	8	
35.0	8	
36.0	8	
36.9	8	
43.0	8	
44.0	8	
46.6	8	
47.0	8	
48.1	8	

Table 3
Velocity Suitability Index

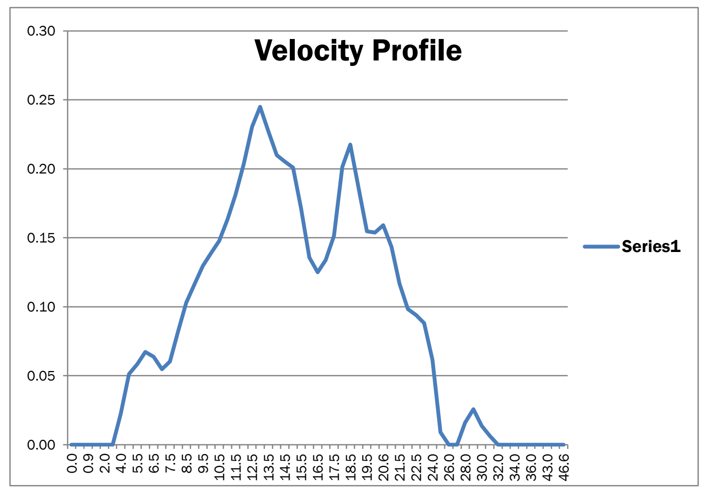
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.5	0.00	0.0
0.9	0.00	0.0
1.2	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.02	0.1
5.1	0.05	0.2
5.5	0.06	0.3
6.0	0.07	0.4
6.5	0.06	0.3
7.0	0.05	0.2
7.5	0.06	0.2
8.0	0.08	0.3
8.5	0.10	0.3
9.0	0.12	0.5
9.5	0.13	0.6
10.0	0.14	0.7
10.5	0.15	0.8
11.0	0.16	0.8
11.5	0.18	0.8
12.0	0.20	0.9
12.5	0.23	1.0
13.0	0.25	1.2
13.5	0.23	1.2
14.0	0.21	1.3
14.5	0.21	1.3
15.0	0.20	1.3
15.5	0.17	1.1
16.0	0.14	1.0
16.5	0.13	0.8
17.0	0.13	0.7
17.5	0.15	0.6
18.2	0.20	0.7
18.5	0.22	0.7
19.0	0.19	0.7
19.5	0.15	0.6
20.0	0.15	0.5
20.6	0.16	0.4
21.0	0.14	0.4
21.5	0.12	0.3
22.0	0.10	0.2
22.5	0.09	0.2
23.0	0.09	0.2
24.0	0.06	0.1
25.0	0.01	0.0
26.0	0.00	0.0
27.0	0.00	0.0
28.0	0.02	0.0
29.0	0.03	0.0
30.0	0.01	0.0
31.0	0.01	0.0
32.0	0.00	0.0
33.0	0.00	0.0
34.0	0.00	0.0
35.0	0.00	0.0
36.0	0.00	0.0
36.9	0.00	0.0
43.0	0.00	0.0
44.0	0.00	0.0
46.6	0.00	0.0
47.0	0.00	0.0
48.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
165.3	1.00	0.04	0.50	0.10	16.5
60.1	1.00	0.15	0.50	0.19	11.4
75.2	1.00	0.18	0.50	0.21	15.9
75.2	1.00	0.23	0.50	0.24	17.9
75.2	1.00	0.20	0.50	0.22	16.8
75.2	1.00	0.15	0.05	0.02	1.4
75.2	1.00	0.13	0.05	0.02	1.4
75.2	1.00	0.16	0.05	0.02	1.5
75.2	1.00	0.21	0.05	0.02	1.7
75.2	1.00	0.30	0.05	0.03	2.1
75.2	1.00	0.40	0.05	0.03	2.4
75.2	1.00	0.46	0.05	0.03	2.6
75.2	1.00	0.53	0.05	0.04	2.7
75.2	1.00	0.55	0.05	0.04	2.8
75.2	1.00	0.54	0.05	0.04	2.8
75.2	1.00	0.59	0.05	0.04	2.9
75.2	1.00	0.67	0.05	0.04	3.1
75.2	1.00	0.76	0.05	0.04	3.3
75.2	1.00	0.81	0.05	0.05	3.4
75.2	1.00	0.86	0.05	0.05	3.5
75.2	1.00	0.85	0.05	0.05	3.5
75.2	1.00	0.84	0.05	0.05	3.4
75.2	1.00	0.76	0.05	0.04	3.3
75.2	1.00	0.67	0.10	0.08	6.1
75.2	1.00	0.55	0.10	0.07	5.6
75.2	1.00	0.42	0.10	0.07	4.9
105.2	1.00	0.36	0.10	0.06	6.3
45.1	1.00	0.44	0.10	0.07	3.0
75.2	1.00	0.48	0.10	0.07	5.2
75.2	1.00	0.44	0.10	0.07	5.0
75.2	1.00	0.40	0.10	0.06	4.7
90.2	1.00	0.34	0.10	0.06	5.3
60.1	1.00	0.27	0.10	0.05	3.1
75.2	1.00	0.22	0.05	0.02	1.8
75.2	1.00	0.15	0.05	0.02	1.5
75.2	1.00	0.11	0.05	0.02	1.3
75.2	1.00	0.10	0.05	0.02	1.2
150.3	1.00	0.08	0.05	0.01	2.2
150.3	1.00	0.03	0.05	0.01	1.3
150.3	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
150.3	1.00	0.01	0.40	0.03	4.3
150.3	1.00	0.01	0.40	0.03	4.3
150.3	1.00	0.00	0.40	0.00	0.0
150.3	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 3,908				Total Weighted Usable Area:	193

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 6 - Pool Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	1.8	2.7	0.2	0.0	2.2
2.0	2.7	3.6	0.6	0.0	3.1
3.0	3.6	4.5	0.7	0.0	4.0
4.0	4.5	5.4	0.7	0.0	4.9
5.0	5.4	6.3	0.9	0.1	5.8
6.0	6.3	7.2	1.1	0.1	6.7
7.0	7.2	8.1	1.1	0.1	7.6
8.0	8.1	9.0	1.1	0.1	8.5
9.0	9.0	9.9	1.1	0.1	9.4
10.0	9.9	10.8	1.1	0.1	10.3
11.0	10.8	11.7	1.1	0.1	11.2
12.0	11.7	12.6	1.1	0.1	12.1
13.0	12.6	13.5	1.0	0.1	13.0
14.0	13.5	14.4	1.0	0.1	13.9
15.0	14.4	15.3	1.0	0.1	14.8
16.0	15.3	16.2	1.0	0.1	15.7
17.0	16.2	17.1	1.0	0.1	16.6
18.0	17.1	18.0	1.1	0.1	17.5
19.0	18.0	18.9	1.2	0.1	18.4
20.0	18.9	19.8	1.2	0.1	19.3
21.0	19.8	20.7	1.2	0.1	20.2
22.0	20.7	21.5	1.2	0.1	21.1
23.0	21.5	22.4	1.1	0.1	22.0
24.0	22.4	23.3	1.1	0.1	22.9
25.0	23.3	24.2	1.0	0.1	23.8
26.0	24.2	25.1	0.9	0.1	24.7
27.0	25.1	26.0	0.8	0.1	25.6
28.0	26.0	26.9	0.7	0.1	26.5
29.0	26.9	27.8	0.6	0.1	27.4
30.0	27.8	28.7	0.4	0.1	28.3
31.0	28.7	29.6	0.3	0.0	29.2
32.0	29.6	30.5	0.2	0.0	30.1
33.0	30.5	31.4	0.1	0.0	31.0

Step 1

Table 2
Cover Codes from Sutton

Station (ft)	Cover	Reach Length (feet)
0.6	9	
1.1	9	
1.2	9	
1.7	9	
2.0	9	
3.5	5	
5.0	5	
6.5	5	
8.0	0	
9.5	0	
11.0	0	
12.5	0	
14.0	0	
15.5	0	
17.0	0	
18.5	0	
20.0	0	
21.5	0	
23.0	0	
24.5	0	
26.0	0	
27.5	0	
29.0	0	
30.5	1	
31.3	1	
33.5	9	
35.2	9	
35.8	9	
36.0	9	
38.6	9	

Table 3
Velocity Suitability Index

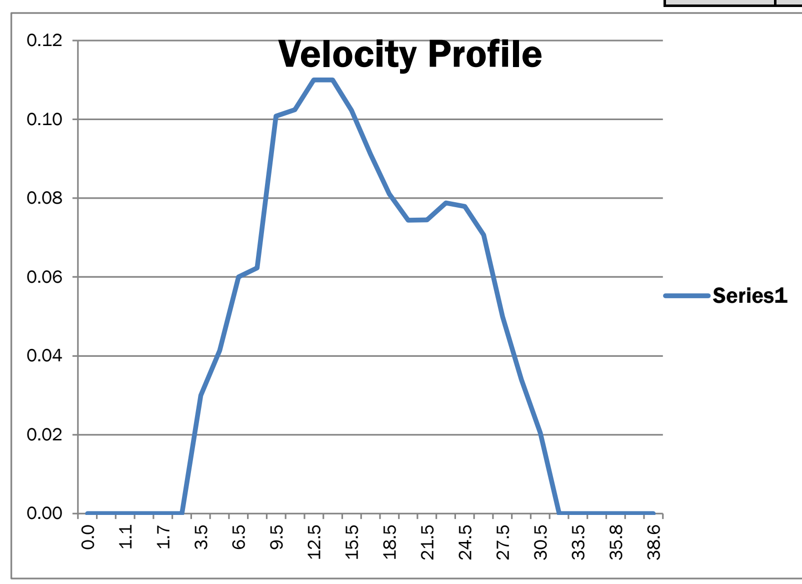
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.6	0.00	0.0
1.1	0.00	0.0
1.2	0.00	0.0
1.7	0.00	0.0
2.0	0.00	0.0
3.5	0.03	0.6
5.0	0.04	0.7
6.5	0.06	1.0
8.0	0.06	1.1
9.5	0.10	1.1
11.0	0.10	1.1
12.5	0.11	1.0
14.0	0.11	1.0
15.5	0.10	1.0
17.0	0.09	1.1
18.5	0.08	1.2
20.0	0.07	1.2
21.5	0.07	1.1
23.0	0.08	1.0
24.5	0.08	0.9
26.0	0.07	0.7
27.5	0.05	0.5
29.0	0.03	0.3
30.5	0.02	0.1
31.3	0.00	0.0
33.5	0.00	0.0
35.2	0.00	0.0
35.8	0.00	0.0
36.0	0.00	0.0
38.6	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
117.0	1.00	0.42	1.00	0.65	75.5
117.0	1.00	0.46	1.00	0.68	79.1
117.0	1.00	0.66	0.05	0.04	4.8
117.0	1.00	0.71	0.05	0.04	4.9
117.0	1.00	0.75	0.05	0.04	5.1
117.0	1.00	0.70	0.05	0.04	4.9
117.0	1.00	0.69	0.05	0.04	4.9
117.0	1.00	0.63	0.05	0.04	4.7
117.0	1.00	0.64	0.05	0.04	4.7
117.0	1.00	0.69	0.05	0.04	4.9
117.0	1.00	0.76	0.05	0.04	5.1
117.0	1.00	0.76	0.05	0.04	5.1
117.0	1.00	0.76	0.05	0.04	5.1
117.0	1.00	0.69	0.05	0.04	4.9
117.0	1.00	0.57	0.05	0.04	4.4
117.0	1.00	0.48	0.05	0.03	4.1
117.0	1.00	0.35	0.05	0.03	3.5
117.0	1.00	0.17	1.00	0.41	47.6
62.4	1.00	0.07	1.00	0.27	16.6
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 2,168				Total Weighted Usable Area:	290

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input (green)

user criterion (grey)

Weighted Usable Area Analysis Transect 7 - Pool Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	0.8	1.6	0.2	0.0	1.2
2.0	1.6	2.4	0.8	0.0	2.0
3.0	2.4	3.2	1.9	0.0	2.8
4.0	3.2	4.0	2.3	0.0	3.6
5.0	4.0	4.8	2.5	0.0	4.4
6.0	4.8	5.6	2.5	0.0	5.2
7.0	5.6	6.4	2.4	0.0	6.0
8.0	6.4	7.2	2.3	0.1	6.8
9.0	7.2	8.1	2.3	0.1	7.6
10.0	8.1	8.9	2.3	0.1	8.5
11.0	8.9	9.7	2.3	0.1	9.3
12.0	9.7	10.5	2.3	0.1	10.1
13.0	10.5	11.3	2.3	0.1	10.9
14.0	11.3	12.1	2.3	0.1	11.7
15.0	12.1	12.9	2.2	0.1	12.5
16.0	12.9	13.7	2.2	0.1	13.3
17.0	13.7	14.5	2.1	0.0	14.1
18.0	14.5	15.3	2.1	0.0	14.9
19.0	15.3	16.1	2.1	0.0	15.7
20.0	16.1	16.9	2.0	0.0	16.5
21.0	16.9	17.7	1.9	0.0	17.3
22.0	17.7	18.5	1.8	0.0	18.1
23.0	18.5	19.3	1.6	0.0	18.9
24.0	19.3	20.1	1.6	0.0	19.7
25.0	20.1	20.9	1.5	0.0	20.5
26.0	20.9	21.7	1.5	0.1	21.3
27.0	21.7	22.5	1.5	0.1	22.1
28.0	22.5	23.3	1.4	0.1	22.9
29.0	23.3	24.1	1.2	0.1	23.7
30.0	24.1	24.9	1.2	0.1	24.5
31.0	24.9	25.8	1.3	0.0	25.3
32.0	25.8	26.6	1.4	0.0	26.2
33.0	26.6	27.4	1.4	0.0	27.0
34.0	27.4	28.2	1.3	0.0	27.8
35.0	28.2	29.0	1.1	0.0	28.6
36.0	29.0	29.8	0.8	0.0	29.4
37.0	29.8	30.6	0.5	0.0	30.2
38.0	30.6	31.4	0.2	0.0	31.0
39.0	31.4	32.2	0.0	0.0	31.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9	78.00
1.0	3	
1.1	3	
1.5	3	
3.0	3	
4.5	3	
6.0	3	
7.5	3	
9.0	3	
10.5	0	
12.0	0	
13.5	0	
15.0	0	
16.5	0	
18.0	0	
19.5	0	
21.0	0	
22.5	0	
24.0	0	
25.5	0	
27.0	0	
28.5	2	
30.0	2	
31.9	2	
32.7	9	
33.4	9	
33.7	9	
34.0	9	
34.6	9	

Table 3
Velocity Suitability Index

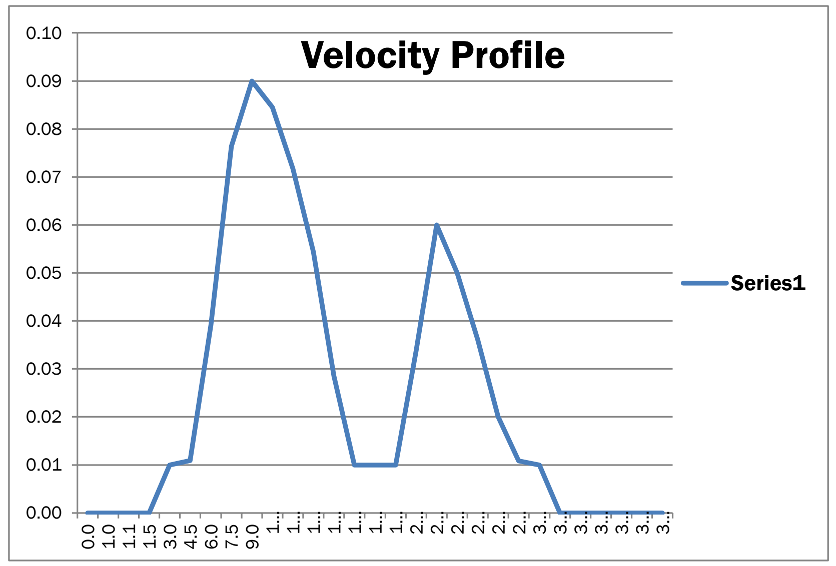
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.0	0.00	0.0
1.1	0.00	0.0
1.5	0.00	0.4
3.0	0.01	2.0
4.5	0.01	2.5
6.0	0.04	2.4
7.5	0.08	2.3
9.0	0.09	2.3
10.5	0.08	2.3
12.0	0.07	2.2
13.5	0.05	2.2
15.0	0.03	2.1
16.5	0.01	2.0
18.0	0.01	1.8
19.5	0.01	1.6
21.0	0.03	1.5
22.5	0.06	1.4
24.0	0.05	1.2
25.5	0.04	1.3
27.0	0.02	1.3
28.5	0.01	1.1
30.0	0.01	0.6
31.9	0.00	0.0
32.7	0.00	0.0
33.4	0.00	0.0
33.7	0.00	0.0
34.0	0.00	0.0
34.6	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

(ft^2)	Index	Index	Suitabilty	Factor	Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
117.0	1.00	0.25	1.00	0.50	58.9
117.0	1.00	1.00	1.00	1.00	117.0
117.0	1.00	1.00	1.00	1.00	117.0
117.0	1.00	1.00	1.00	1.00	117.0
117.0	1.00	1.00	1.00	1.00	117.0
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	1.00	0.05	0.05	5.9
117.0	1.00	0.98	0.05	0.05	5.8
117.0	1.00	0.94	0.05	0.05	5.7
117.0	1.00	0.81	0.05	0.05	5.3
117.0	1.00	0.88	0.05	0.05	5.5
117.0	1.00	0.89	0.70	0.66	77.3
117.0	1.00	0.75	0.70	0.61	70.9
148.2	1.00	0.36	0.70	0.42	62.4
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 2,371				Total Weighted Usable Area:	807

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 8 - Riffle Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	2.1	3.2	0.1	0.0	2.6
2.0	3.2	4.2	0.3	0.0	3.7
3.0	4.2	5.3	0.5	0.1	4.7
4.0	5.3	6.3	0.7	0.1	5.8
5.0	6.3	7.4	0.8	0.1	6.8
6.0	7.4	8.4	0.9	0.1	7.9
7.0	8.4	9.5	0.9	0.1	9.0
8.0	9.5	10.5	0.8	0.1	10.0
9.0	10.5	11.6	0.8	0.1	11.1
10.0	11.6	12.6	0.9	0.1	12.1
11.0	12.6	13.7	0.9	0.1	13.2
12.0	13.7	14.8	0.8	0.2	14.2
13.0	14.8	15.8	0.7	0.2	15.3
14.0	15.8	16.9	0.7	0.2	16.3
15.0	16.9	17.9	0.7	0.2	17.4
16.0	17.9	19.0	0.7	0.2	18.4
17.0	19.0	20.0	0.7	0.2	19.5
18.0	20.0	21.1	0.5	0.2	20.5
19.0	21.1	22.1	0.4	0.2	21.6
20.0	22.1	23.2	0.4	0.2	22.7
21.0	23.2	24.2	0.3	0.2	23.7
22.0	24.2	25.3	0.3	0.2	24.8
23.0	25.3	26.3	0.4	0.2	25.8
24.0	26.3	27.4	0.4	0.3	26.9
25.0	27.4	28.4	0.2	0.1	27.9
26.0	28.4	29.5			29.0
27.0	29.5	30.6	0.1	0.1	30.0
28.0	30.6	31.6	0.2	0.2	31.1
29.0	31.6	32.7	0.2	0.2	32.1
30.0	32.7	33.7	0.1	0.1	33.2
31.0	33.7	34.8	0.1	0.1	34.2
32.0	34.8	35.8	0.0	0.1	35.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9	98.00
0.2	9	
0.6	9	
1.5	9	
2.2	2	
3.0	5	
4.5	5	
6.0	5	
7.5	5	
9.0	5	
10.5	5	
12.0	0	
13.5	0	
15.0	0	
16.5	0	
18.0	0	
19.5	10	
21.0	10	
22.5	10	
24.0	10	
25.5	10	
27.0	0	
28.5	0	
30.0	0	
31.5	0	
33.0	0	
34.5	0	
36.0	0	
37.5	0	
39.0	0	
41.0	2	
43.7	10	
43.8	10	
45.3	9	

Table 3
Velocity Suitability Index

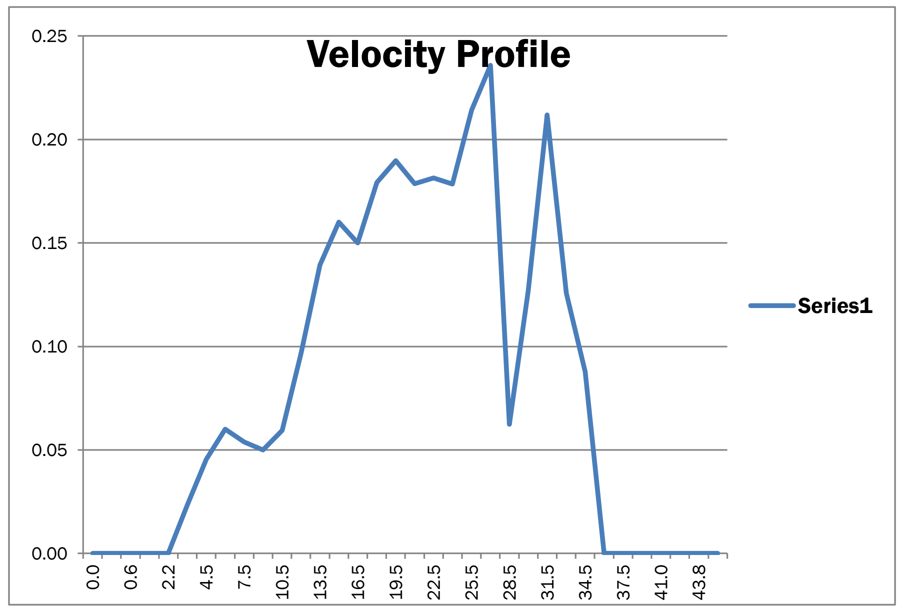
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
0.2	0.00	0.00
0.6	0.00	0.00
1.5	0.00	0.00
2.2	0.00	0.00
3.0	0.02	0.17
4.5	0.05	0.46
6.0	0.06	0.73
7.5	0.05	0.86
9.0	0.05	0.94
10.5	0.06	0.83
12.0	0.10	0.93
13.5	0.14	0.86
15.0	0.16	0.76
16.5	0.15	0.69
18.0	0.18	0.73
19.5	0.19	0.65
21.0	0.18	0.48
22.5	0.18	0.36
24.0	0.18	0.29
25.5	0.21	0.36
27.0	0.24	0.39
28.5	0.06	0.07
30.0	0.13	0.07
31.5	0.21	0.19
33.0	0.13	0.09
34.5	0.09	0.05
36.0	0.00	0.00
37.5	0.00	0.00
39.0	0.00	0.00
41.0	0.00	0.00
43.7	0.00	0.00
43.8	0.00	0.00
45.3	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
147.0	1.00	0.09	1.00	0.30	44.3
147.0	1.00	0.29	1.00	0.54	79.7
147.0	1.00	0.48	1.00	0.69	101.6
147.0	1.00	0.57	1.00	0.75	110.6
147.0	1.00	0.61	1.00	0.78	115.1
147.0	1.00	0.55	1.00	0.74	108.6
147.0	1.00	0.61	0.05	0.04	5.7
147.0	1.00	0.56	0.05	0.04	5.5
147.0	1.00	0.49	0.05	0.04	5.2
147.0	1.00	0.44	0.05	0.03	4.9
147.0	1.00	0.47	0.05	0.03	5.0
147.0	1.00	0.42	0.10	0.06	9.5
147.0	1.00	0.30	0.10	0.05	8.1
147.0	1.00	0.22	0.10	0.05	6.9
147.0	1.00	0.17	0.10	0.04	6.1
147.0	1.00	0.22	0.10	0.05	6.9
147.0	1.00	0.24	0.05	0.02	3.6
147.0	1.00	0.03	0.05	0.01	1.3
147.0	1.00	0.03	0.05	0.01	1.3
147.0	1.00	0.11	0.05	0.02	2.4
147.0	1.00	0.04	0.05	0.01	1.5
147.0	1.00	0.03	0.05	0.01	1.2
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
Total Area: 3,234				Total Weighted Usable Area:	635

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 9 - Riffle Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	5.3	6.0	0.0	0.0	5.7
2.0	6.0	6.7	0.0	0.0	6.3
3.0	6.7	7.3	0.0	0.1	7.0
4.0	7.3	8.0	0.1	0.2	7.7
5.0	8.0	8.7	0.1	0.4	8.3
6.0	8.7	9.3	0.2	1.9	9.0
7.0	9.3	10.0	0.2	2.4	9.6
8.0	10.0	10.6	0.1	2.1	10.3
9.0	10.6	11.3	0.1	1.8	11.0
10.0	11.3	12.0	0.2	2.7	11.6
11.0	12.0	12.6	0.3	3.0	12.3
12.0	12.6	13.3	0.2	1.3	13.0
13.0	13.3	14.0	0.1	1.3	13.6
14.0	14.0	14.6	0.0	0.7	14.3
15.0	14.6	15.3	0.0	0.6	15.0

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	3	98.00
3.0	3	
4.0	3	
4.7	3	
5.0	3	
5.5	3	
6.0	3	
6.5	3	
7.0	3	
7.5	0	
8.0	0	
8.5	0	
9.0	0	
9.5	0	
10.0	0	
10.5	0	
11.0	0	
11.5	0	
12.0	0	
12.5	0	
13.0	0	
13.5	0	
14.0	0	
14.5	0	
15.0	0	
15.5	0	
16.0	0	
16.5	0	
17.0	0	
17.5	0	
18.3	0	
19.0	0	
20.0	0	
21.0	0	
22.0	3	
24.5	3	
25.2	3	
26.8	3	
27.5	3	
28.6	3	

Table 3
Velocity Suitability Index

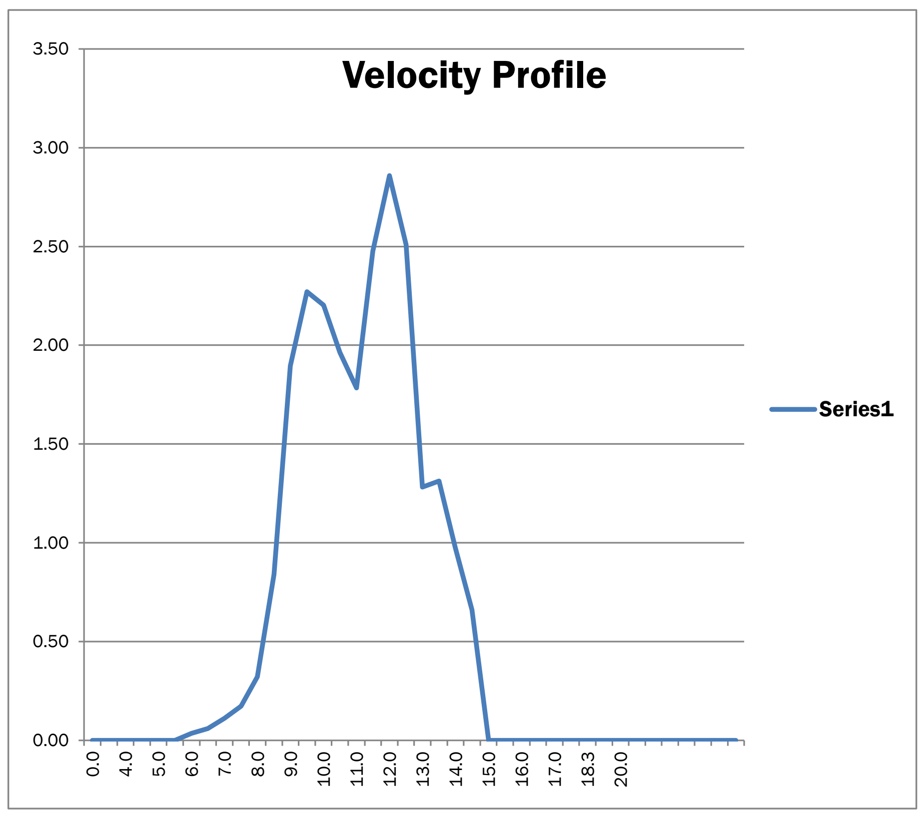
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
3.0	0.00	0.00
4.0	0.00	0.00
4.7	0.00	0.00
5.0	0.00	0.00
5.5	0.00	0.00
6.0	0.04	0.02
6.5	0.06	0.03
7.0	0.11	0.03
7.5	0.17	0.06
8.0	0.32	0.10
8.5	0.84	0.14
9.0	1.90	0.15
9.5	2.27	0.18
10.0	2.20	0.16
10.5	1.96	0.13
11.0	1.78	0.13
11.5	2.48	0.16
12.0	2.86	0.23
12.5	2.51	0.25
13.0	1.28	0.17
13.5	1.31	0.11
14.0	0.97	0.06
14.5	0.66	0.03
15.0	0.00	0.00
15.5	0.00	0.00
16.0	0.00	0.00
16.5	0.00	0.00
17.0	0.00	0.00
17.5	0.00	0.00
18.3	0.00	0.00
19.0	0.00	0.00
20.0	0.00	0.00
21.0	0.00	0.00
22.0	0.00	0.00
24.5	0.00	0.00
25.2	0.00	0.00
26.8	0.00	0.00
27.5	0.00	0.00
28.6	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
49.0	1.00	0.01	1.00	0.10	4.9
49.0	1.00	0.02	1.00	0.12	6.0
49.0	1.00	0.02	1.00	0.12	6.0
49.0	1.00	0.03	0.05	0.01	0.4
49.0	1.00	0.05	0.05	0.01	0.5
49.0	0.73	0.07	0.05	0.01	0.6
49.0	0.06	0.08	0.05	0.00	0.2
49.0	0.04	0.10	0.05	0.00	0.2
49.0	0.04	0.08	0.05	0.00	0.1
49.0	0.05	0.07	0.05	0.00	0.2
49.0	0.07	0.07	0.05	0.00	0.2
49.0	0.03	0.09	0.05	0.00	0.1
49.0	0.02	0.14	0.05	0.00	0.1
49.0	0.03	0.15	0.05	0.00	0.2
49.0	0.32	0.09	0.05	0.01	0.4
49.0	0.29	0.06	0.05	0.01	0.3
49.0	0.62	0.03	0.05	0.01	0.3
49.0	0.88	0.02	0.05	0.01	0.3
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 882				Total Weighted Usable Area:	21

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 10 - Riffle Reach
Existing Conditions Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	9.0	9.9	0.1	0.4	9.4
2.0	9.9	10.8	0.3	0.6	10.3
3.0	10.8	11.7	0.3	0.1	11.2
4.0	11.7	12.6	0.2	0.1	12.1
5.0	12.6	13.5	0.1	0.1	13.0
6.0	13.5	14.4	0.1	0.2	13.9
7.0	14.4	15.3	0.1	0.2	14.8
8.0	15.3	16.2	0.2	0.5	15.7
9.0	16.2	17.1	0.3	0.3	16.6
10.0	17.1	18.0	0.4	0.1	17.5
11.0	18.0	18.9	0.4	0.8	18.4
12.0	18.9	19.8	0.4	0.6	19.3
13.0	19.8	20.7	0.4	0.1	20.2
14.0	20.7	21.5	0.5	0.3	21.1
15.0	21.5	22.4	0.4	0.4	22.0
16.0	22.4	23.3	0.3	0.6	22.9
17.0	23.3	24.2	0.2	0.5	23.8
18.0	24.2	25.1	0.2	0.7	24.7
19.0	25.1	26.0	0.2	0.4	25.6
20.0	26.0	26.9	0.2	0.2	26.5
21.0	26.9	27.8	0.2	0.2	27.4
22.0	27.8	28.7	0.2	0.3	28.3
23.0	28.7	29.6	0.1	0.5	29.2
24.0	29.6	30.5	0.0	0.1	30.1
25.0	30.5	31.4	0.1	0.3	31.0
26.0	31.4	32.3	0.1	0.4	31.9
27.0	32.3	33.2	0.2	0.6	32.8
28.0	33.2	34.1	0.1	0.6	33.7
29.0	34.1	35.0	0.0	0.2	34.6

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9	98.00
1.0	9	
2.0	9	
3.0	9	
4.0	9	
4.3	9	
6.0	9	
7.5	9	
9.0	9	
10.5	3	
12.0	3	
13.5	3	
15.0	3	
16.5	3	
18.0	3	
19.5	3	
21.0	0	
22.5	0	
24.0	0	
25.5	0	
27.0	0	
28.5	0	
30.0	0	
31.5	0	
33.0	0	
34.5	0	
36.0	5	
37.0	5	
37.7	5	
38.6	5	

Table 3
Velocity Suitability Index

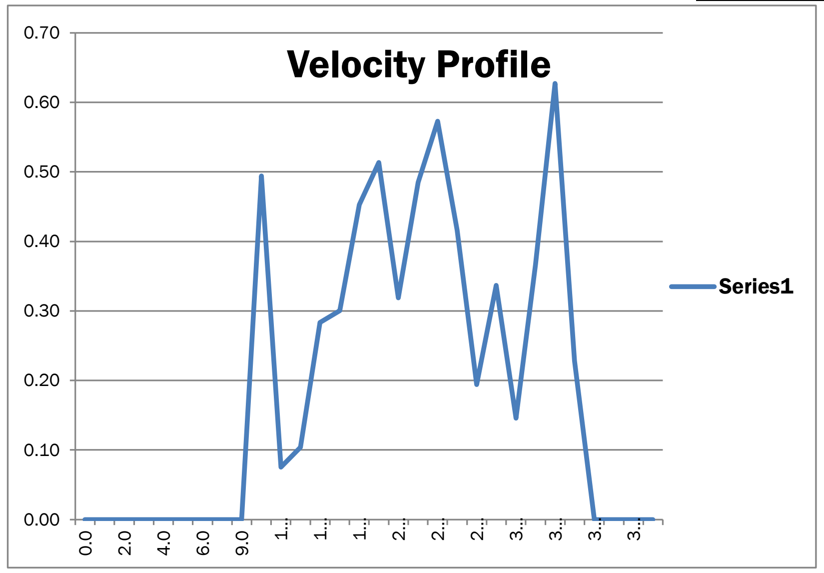
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0	0.05
1	1.00
2	0.70
3	1.00
4	1.00
5	1.00
6	0.05
7	0.30
8	0.40
9	0.50
10	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
1.0	0.00	0.00
2.0	0.00	0.00
3.0	0.00	0.00
4.0	0.00	0.00
4.3	0.00	0.00
6.0	0.00	0.00
7.5	0.00	0.00
9.0	0.00	0.00
10.5	0.49	0.31
12.0	0.08	0.19
13.5	0.10	0.09
15.0	0.28	0.11
16.5	0.30	0.28
18.0	0.45	0.37
19.5	0.51	0.40
21.0	0.32	0.46
22.5	0.49	0.30
24.0	0.57	0.20
25.5	0.42	0.18
27.0	0.19	0.18
28.5	0.34	0.16
30.0	0.15	0.02
31.5	0.37	0.09
33.0	0.63	0.14
34.5	0.23	0.02
36.0	0.00	0.00
37.0	0.00	0.00
37.7	0.00	0.00
38.6	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
147.0	1.00	0.19	1.00	0.44	64.5
147.0	1.00	0.11	1.00	0.33	49.0
147.0	1.00	0.05	1.00	0.21	31.2
147.0	1.00	0.05	1.00	0.22	32.9
147.0	1.00	0.17	1.00	0.41	59.8
147.0	1.00	0.23	1.00	0.48	69.9
147.0	0.99	0.25	1.00	0.49	72.7
147.0	1.00	0.29	0.05	0.03	3.9
147.0	1.00	0.18	0.05	0.02	3.1
147.0	0.94	0.11	0.05	0.02	2.4
147.0	1.00	0.10	0.05	0.02	2.3
147.0	1.00	0.10	0.05	0.02	2.3
147.0	1.00	0.08	0.05	0.01	2.1
147.0	1.00	0.01	0.05	0.00	0.5
147.0	1.00	0.04	0.05	0.01	1.5
147.0	0.90	0.08	0.05	0.01	1.9
147.0	1.00	0.01	0.05	0.01	0.7
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 2,499				Total Weighted Usable Area:	401

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

Existing Conditions
Flow Rate: 2 cfs
Winter Rearing Total Weighted Usable Area Calculations

Transect	River Station	River Station Difference	Total Area	Weighted Usable Area
1.0	0	0	2,976	532
2.0	16	16	2,285	128
3.0	47	32	3,332	238
4.0	69	22	3,908	193
5.0	95	26		
6.0	120	25	2,168	290
7.0	155	35	2,371	807
8.0	191	37	3,234	635
9.0	285	94	882	21
10.0	334	49	2,499	401
	Total	**334**	**23,655**	**3,244**

Sutton's WUA (Table D-1)	
Total Area	**Weighted Usable Area**
22,446	3,274

Percent Difference (Sutton/RAS-SIM)	
Total Area	**Weighted Usable Area**
-5.4%	-0.9%

Step 4

C-2
Proposed Apex Jam

Weighted Usable Area Analysis Transect 1 - Glide Reach
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	5.7	6.4	0.10	0.07	6.0
2.0	6.4	7.1	0.16	0.10	6.7
3.0	7.1	7.8	0.16	0.10	7.4
4.0	7.8	8.5	0.18	0.16	8.1
5.0	8.5	9.2	0.24	0.21	8.8
6.0	9.2	9.9	0.31	0.25	9.5
7.0	9.9	10.6	0.33	0.22	10.3
8.0	10.6	11.3	0.28	0.20	11.0
9.0	11.3	12.0	0.33	0.23	11.7
10.0	12.0	12.7	0.36	0.21	12.4
11.0	12.7	13.4	0.35	0.22	13.1
12.0	13.4	14.1	0.28	0.19	13.8
13.0	14.1	14.9	0.11	0.07	14.5
14.0	14.9	15.6	0.06	0.17	15.2
15.0	15.6	16.3	0.23	0.41	15.9
16.0	16.3	17.0	0.38	0.58	16.6
17.0	17.0	17.7	0.46	0.62	17.3
18.0	17.7	18.4	0.42	0.59	18.0
19.0	18.4	19.1	0.17	0.34	18.7
20.0	19.1	19.8	0.10	0.41	19.4
21.0	19.8	20.5	0.21	0.64	20.2
22.0	20.5	21.2	0.40	0.95	20.9
23.0	21.2	21.9	0.35	0.79	21.6
24.0	21.9	22.6	0.29	0.77	22.3
25.0	22.6	23.3	0.29	0.70	23.0
26.0	23.3	24.0	0.05	0.14	23.7
27.0	24.0	24.7	0.04	0.13	24.4
28.0	24.7	25.5	0.21	0.14	25.1
29.0	25.5	26.2	0.16	0.04	25.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9.0	213.54
0.9	2.0	
2.8	9.0	
3.5	9.0	
4.5	9.0	
6.2	2.0	
7.0	2.0	
8.0	2.0	
9.0	2.0	
10.0	2.0	
11.0	2.0	
12.0	0.0	
13.0	0.0	
14.0	0.0	
15.0	0.0	
16.0	0.0	
17.0	0.0	
18.0	0.0	
19.0	0.0	
20.0	3.0	
21.0	3.0	
22.0	3.0	
23.0	3.0	
24.0	3.0	
25.0	3.0	
26.0	3.0	
27.0	3.0	
27.4	3.0	
27.5	3.0	
29.0	3.0	
30.4	3.0	

Table 3
Velocity Suitability Index

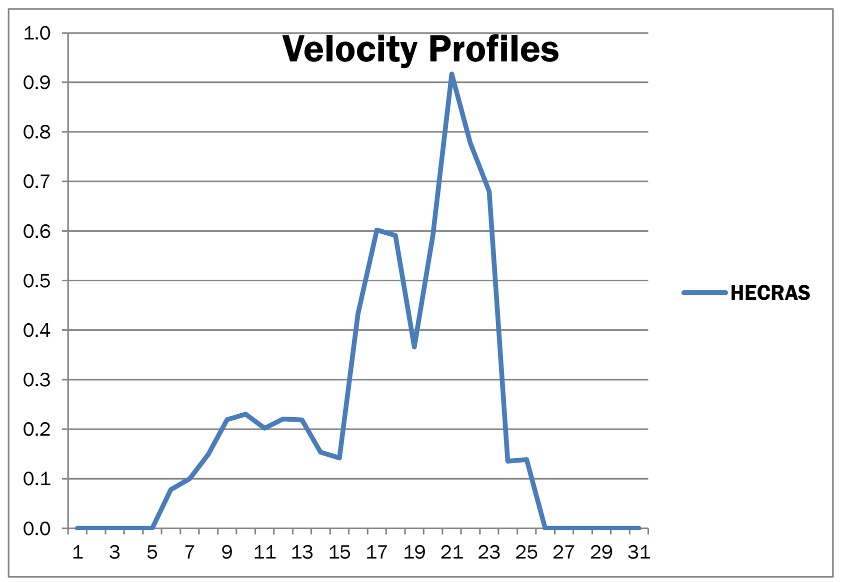
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.0	0.0
0.9	0.0	0.0
2.8	0.0	0.0
3.5	0.0	0.0
4.5	0.0	0.0
6.2	0.1	0.1
7.0	0.1	0.2
8.0	0.1	0.2
9.0	0.2	0.3
10.0	0.2	0.3
11.0	0.2	0.3
12.0	0.2	0.3
13.0	0.2	0.4
14.0	0.2	0.2
15.0	0.1	0.1
16.0	0.4	0.3
17.0	0.6	0.4
18.0	0.6	0.4
19.0	0.4	0.1
20.0	0.6	0.2
21.0	0.9	0.4
22.0	0.8	0.3
23.0	0.7	0.3
24.0	0.1	0.0
25.0	0.1	0.2
26.0	0.0	0.0
27.0	0.0	0.0
27.4	0.0	0.0
27.5	0.0	0.0
29.0	0.0	0.0
30.4	0.0	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
170.8	1.00	0.06	0.70	0.17	28.5
213.5	1.00	0.09	0.70	0.21	45.0
213.5	1.00	0.10	0.70	0.22	46.7
213.5	1.00	0.15	0.70	0.27	58.2
213.5	1.00	0.20	0.70	0.31	66.7
213.5	1.00	0.17	0.05	0.02	4.4
213.5	1.00	0.21	0.05	0.02	4.9
213.5	1.00	0.22	0.05	0.02	5.0
213.5	1.00	0.13	0.05	0.02	3.9
213.5	1.00	0.04	0.05	0.01	2.0
213.5	1.00	0.15	0.05	0.02	4.2
213.5	0.92	0.27	0.05	0.02	5.3
213.5	0.93	0.27	0.05	0.02	5.3
213.5	1.00	0.08	1.00	0.28	59.3
213.5	0.93	0.10	1.00	0.31	66.4
213.5	0.67	0.24	1.00	0.40	85.8
213.5	0.78	0.19	1.00	0.39	83.0
213.5	0.86	0.17	1.00	0.38	82.0
213.5	1.00	0.02	1.00	0.14	30.2
213.5	1.00	0.10	1.00	0.32	69.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area					
4228.1				Total Weighted Usable:	755.7

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

(green)	user input
(grey)	user criterion

Weighted Usable Area Analysis Transect 2 - Glide Reach
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	4.9	5.6	0.0	0.0	5.3
2.0	5.6	6.3			6.0
3.0	6.3	7.0			6.7
4.0	7.0	7.7			7.4
5.0	7.7	8.4			8.1
6.0	8.4	9.1			8.8
7.0	9.1	9.8			9.5
8.0	9.8	10.5			10.2
9.0	10.5	11.2			10.9
10.0	11.2	11.9			11.6
11.0	11.9	12.6	0.0	0.0	12.3
12.0	12.6	13.3	0.1	0.0	13.0
13.0	13.3	14.0	0.3	0.0	13.7
14.0	14.0	14.7	0.4	0.1	14.4
15.0	14.7	15.4	0.3	0.1	15.1
16.0	15.4	16.1	0.4	0.1	15.8
17.0	16.1	16.8	0.5	0.1	16.5
18.0	16.8	17.5	0.8	0.2	17.2
19.0	17.5	18.2	1.1	0.3	17.9
20.0	18.2	18.9	1.4	0.4	18.6
21.0	18.9	19.6	1.3	0.3	19.3
22.0	19.6	20.3	1.3	0.3	20.0
23.0	20.3	21.0	1.2	0.3	20.7
24.0	21.0	21.7	1.3	0.3	21.4
25.0	21.7	22.4	1.2	0.2	22.1
26.0	22.4	23.1	0.4	0.0	22.8
27.0	23.1	23.8	0.3	0.0	23.5
28.0	23.8	24.5	0.4	0.0	24.2
29.0	24.5	25.2	0.4	0.0	24.9
30.0	25.2	25.9	0.4	0.0	25.6
31.0	25.9	26.6	0.1	0.0	26.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	213.54
1.1	9	
1.4	9	
1.7	9	
2.0	9	
3.0	9	
4.0	2	
5.0	2	
6.0	2	
7.0	0	
8.0	0	
9.0	0	
10.0	0	
11.0	0	
11.6	0	
12.0	0	
12.5	0	
13.0	10	
13.5	10	
14.0	10	
14.5	10	
15.0	10	
15.5	10	
16.0	10	
16.5	10	
17.0	10	
17.5	10	
18.0	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.5	10	
21.0	10	
21.5	10	
22.0	10	
22.5	10	
23.0	10	
23.5	10	
24.0	10	
24.5	10	
25.0	10	
25.5	0	
26.0	10	
26.2	10	
26.8	10	
28.0	9	
28.5	9	
29.0	9	
30.1	9	

Table 3
Velocity Suitability Index

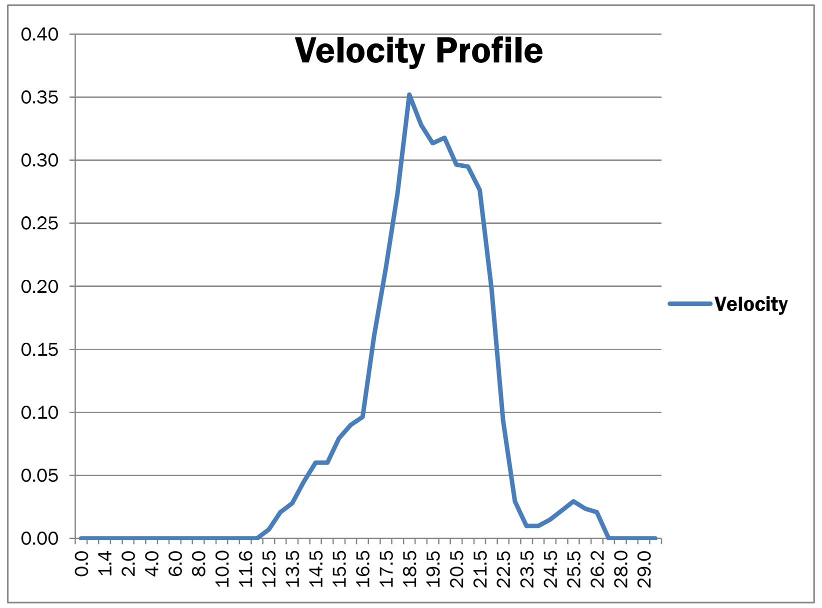
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.1	0.00	0.0
1.4	0.00	0.0
1.7	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.0	0.00	0.0
6.0	0.00	0.0
7.0	0.00	0.0
8.0	0.00	0.0
9.0	0.00	0.0
10.0	0.00	0.0
11.0	0.00	0.0
11.6	0.00	0.0
12.0	0.00	0.0
12.5	0.01	0.0
13.0	0.02	0.1
13.5	0.03	0.2
14.0	0.05	0.3
14.5	0.06	0.4
15.0	0.06	0.3
15.5	0.08	0.4
16.0	0.09	0.4
16.5	0.10	0.5
17.0	0.16	0.7
17.5	0.22	0.9
18.0	0.27	1.2
18.5	0.35	1.3
19.0	0.33	1.3
19.5	0.31	1.3
20.0	0.32	1.3
20.5	0.30	1.2
21.0	0.30	1.2
21.5	0.28	1.2
22.0	0.20	1.2
22.5	0.09	0.7
23.0	0.03	0.4
23.5	0.01	0.3
24.0	0.01	0.3
24.5	0.02	0.4
25.0	0.02	0.4
25.5	0.03	0.4
26.0	0.02	0.2
26.2	0.02	0.1
26.8	0.00	0.0
28.0	0.00	0.0
28.5	0.00	0.0
29.0	0.00	0.0
30.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
85.4	1.00	0.00	0.05	0.00	0.0
106.8	1.00	0.00	0.05	0.00	0.0
106.8	1.00	0.02	0.10	0.01	1.5
106.8	1.00	0.06	0.10	0.03	2.7
106.8	1.00	0.12	0.10	0.04	3.8
106.8	1.00	0.19	0.10	0.04	4.6
106.8	1.00	0.22	0.10	0.05	5.0
106.8	1.00	0.18	0.10	0.04	4.5
106.8	1.00	0.23	0.10	0.05	5.2
106.8	1.00	0.27	0.10	0.05	5.6
106.8	1.00	0.31	0.10	0.06	6.0
106.8	1.00	0.45	0.10	0.07	7.2
106.8	1.00	0.61	0.10	0.08	8.4
106.8	1.00	0.77	0.10	0.09	9.4
106.8	1.00	0.89	0.10	0.09	10.1
106.8	1.00	0.86	0.10	0.09	9.9
106.8	1.00	0.85	0.10	0.09	9.8
106.8	1.00	0.86	0.10	0.09	9.9
106.8	1.00	0.80	0.10	0.09	9.6
106.8	1.00	0.80	0.10	0.09	9.6
106.8	1.00	0.82	0.10	0.09	9.6
106.8	1.00	0.80	0.10	0.09	9.5
106.8	1.00	0.44	0.10	0.07	7.1
106.8	1.00	0.22	0.10	0.05	5.0
106.8	1.00	0.19	0.10	0.04	4.6
106.8	1.00	0.21	0.10	0.05	4.9
106.8	1.00	0.25	0.10	0.05	5.3
106.8	1.00	0.27	0.05	0.03	2.8
106.8	1.00	0.27	0.10	0.05	5.6
42.7	1.00	0.14	0.10	0.04	1.6
128.1	1.00	0.08	0.10	0.03	3.6
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 3,246				Total Weighted Usable Area:	182

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

(green)	user input
(grey)	user criterion

Weighted Usable Area Analysis Transect 3 - Riffle Reach
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	4.3	5.3	0.0	0.1	4.8
2.0	5.3	6.4	0.1	0.1	5.8
3.0	6.4	7.4	0.1	0.1	6.9
4.0	7.4	8.5	0.0	0.1	8.0
5.0	8.5	9.6	0.3	0.4	9.0
6.0	9.6	10.6	0.2	0.3	10.1
7.0	10.6	11.7	0.4	0.4	11.2
8.0	11.7	12.8	0.4	0.4	12.2
9.0	12.8	13.8	0.3	0.3	13.3
10.0	13.8	14.9	0.4	0.4	14.4
11.0	14.9	15.9	0.4	0.4	15.4
12.0	15.9	17.0	0.4	0.4	16.5
13.0	17.0	18.1	0.4	0.3	17.5
14.0	18.1	19.1	0.2	0.3	18.6
15.0	19.1	20.2	0.1	0.3	19.7
16.0	20.2	21.3	0.1	0.3	20.7
17.0	21.3	22.3	0.1	0.4	21.8
18.0	22.3	23.4	0.2	0.4	22.9
19.0	23.4	24.4	0.2	0.5	23.9
20.0	24.4	25.5	0.2	0.4	25.0
21.0	25.5	26.6	0.2	0.5	26.0
22.0	26.6	27.6	0.2	0.3	27.1
23.0	27.6	28.7	0.1	0.2	28.2
24.0	28.7	29.8			29.2
25.0	29.8	30.8			30.3
26.0	30.8	31.9			31.4
27.0	31.9	33.0	0.1	0.2	32.4
28.0	33.0	34.0	0.1	0.1	33.5
29.0	34.0	35.1	0.1	0.1	34.5
30.0	35.1	36.1	0.1	0.1	35.6
31.0	36.1	37.2	0.1	0.1	36.7
32.0	37.2	38.3	0.1	0.1	37.7
33.0	38.3	39.3	0.1	0.1	38.8
34.0	39.3	40.4	0.1	0.1	39.9
35.0	40.4	41.5	0.1	0.1	40.9

Step 1

Table 2
Cover Codes from Sutton

1.0	5
2.0	5
2.6	5
3.0	5
4.0	5
5.0	5
6.0	2
7.0	0
8.0	0
9.0	0
9.5	0
10.0	0
10.5	0
11.0	0
11.5	0
12.0	0
12.5	0
13.0	0
13.5	0
14.0	0
14.5	0
15.0	10
15.5	10
16.0	10
16.5	10
17.0	10
17.5	10
18.0	10
18.5	10
19.0	10
19.5	10
20.0	10
20.5	10
21.0	10
21.5	10
22.0	10
22.5	10
23.0	10
23.5	0
24.0	0
24.5	0
25.0	0
25.5	0
26.0	0
26.5	0
27.0	0
27.5	0
28.0	0
28.4	0
29.0	0
31.0	0
33.0	0
35.0	1
37.0	1
39.0	1
41.0	9
41.9	8
42.1	8
43.0	8
45.7	2

Table 3
Velocity Suitability Index

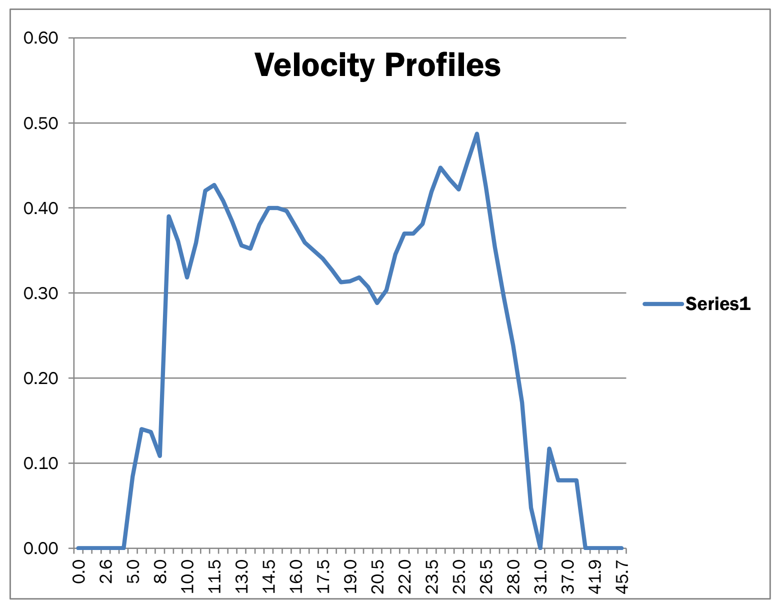
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

ata Interpolation at Specified Stations		
ation ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.0	0.00	0.0
2.0	0.00	0.0
2.6	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.0	0.08	0.1
6.0	0.14	0.1
7.0	0.14	0.1
8.0	0.11	0.0
9.0	0.39	0.2
9.5	0.36	0.2
10.0	0.32	0.2
10.5	0.36	0.2
11.0	0.42	0.3
11.5	0.43	0.4
12.0	0.41	0.4
12.5	0.38	0.3
13.0	0.36	0.3
13.5	0.35	0.3
14.0	0.38	0.4
14.5	0.40	0.4
15.0	0.40	0.4
15.5	0.40	0.4
16.0	0.38	0.4
16.5	0.36	0.4
17.0	0.35	0.4
17.5	0.34	0.4
18.0	0.33	0.3
18.5	0.31	0.2
19.0	0.31	0.2
19.5	0.32	0.1
20.0	0.31	0.1
20.5	0.29	0.1
21.0	0.30	0.1
21.5	0.35	0.1
22.0	0.37	0.1
22.5	0.37	0.2
23.0	0.38	0.2
23.5	0.42	0.2
24.0	0.45	0.2
24.5	0.43	0.2
25.0	0.42	0.2
25.5	0.45	0.2
26.0	0.49	0.2
26.5	0.42	0.2
27.0	0.35	0.2
27.5	0.29	0.2
28.0	0.24	0.1
28.4	0.17	0.1
29.0	0.05	0.0
31.0	0.00	0.0
33.0	0.12	0.1
35.0	0.08	0.1
37.0	0.08	0.1
39.0	0.08	0.1
41.0	0.00	0.0
41.9	0.00	0.0
42.1	0.00	0.0
43.0	0.00	0.0
45.7	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
98.1	1.00	0.03	0.70	0.11	10.9
98.1	1.00	0.06	0.05	0.01	1.2
98.1	1.00	0.05	0.05	0.01	1.1
98.1	1.00	0.02	0.05	0.01	0.6
49.0	1.00	0.15	0.05	0.02	0.9
49.0	1.00	0.12	0.05	0.02	0.9
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.15	0.05	0.02	0.9
49.0	1.00	0.21	0.05	0.02	1.1
49.0	1.00	0.23	0.05	0.02	1.2
49.0	1.00	0.23	0.05	0.02	1.2
49.0	1.00	0.21	0.05	0.02	1.1
49.0	1.00	0.19	0.05	0.02	1.1
49.0	1.00	0.19	0.05	0.02	1.1
49.0	1.00	0.22	0.05	0.02	1.1
49.0	1.00	0.25	0.10	0.05	2.4
49.0	1.00	0.27	0.10	0.05	2.5
49.0	1.00	0.27	0.10	0.05	2.6
49.0	1.00	0.27	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.19	0.10	0.04	2.2
49.0	1.00	0.12	0.10	0.04	1.7
49.0	1.00	0.09	0.10	0.03	1.5
49.0	1.00	0.07	0.10	0.03	1.3
49.0	1.00	0.06	0.10	0.02	1.2
49.0	1.00	0.04	0.10	0.02	1.0
49.0	1.00	0.04	0.10	0.02	1.0
49.0	1.00	0.06	0.10	0.03	1.2
49.0	1.00	0.08	0.10	0.03	1.4
49.0	1.00	0.08	0.10	0.03	1.4
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.14	0.05	0.02	0.9
49.0	1.00	0.11	0.05	0.02	0.8
49.0	1.00	0.08	0.05	0.01	0.7
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.11	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.10	0.05	0.02	0.8
39.2	1.00	0.07	0.05	0.01	0.5
58.9	1.00	0.05	0.05	0.01	0.6
196.2	1.00	0.01	0.05	0.01	1.0
0.0	1.00	0.00	0.05	0.00	0.0
196.2	1.00	0.05	1.00	0.21	41.6
196.2	1.00	0.07	1.00	0.27	52.0
196.2	1.00	0.07	1.00	0.27	52.0
196.2	1.00	0.07	0.50	0.13	26.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 3,335				Total Weighted Usable Area:	238

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input
user criterion

Weighted Usable Area Analysis Transect 4 - New Pool
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	3.4	4.5	0.1	0.0	3.9
2.0	4.5	5.6	0.2	0.0	5.0
3.0	5.6	6.7	0.5	0.0	6.2
4.0	6.7	7.8	0.7	0.0	7.3
5.0	7.8	9.0	0.9	0.0	8.4
6.0	9.0	10.1	1.1	0.0	9.5
7.0	10.1	11.2	1.3	0.0	10.6
8.0	11.2	12.3	1.5	0.0	11.7
9.0	12.3	13.4	1.6	0.0	12.9
10.0	13.4	14.5	1.8	0.0	14.0
11.0	14.5	15.7	2.1	0.0	15.1
12.0	15.7	16.8	2.4	0.0	16.2
13.0	16.8	17.9	2.5	0.1	17.3
14.0	17.9	19.0	2.6	0.1	18.5
15.0	19.0	20.1	2.5	0.1	19.6
16.0	20.1	21.3	2.4	0.1	20.7
17.0	21.3	22.4	1.9	0.1	21.8
18.0	22.4	23.5	1.0	0.0	22.9
19.0	23.5	24.6			24.1
20.0	24.6	25.7			25.2
21.0	25.7	26.9			26.3
22.0	26.9	28.0			27.4
23.0	28.0	29.1			28.5
24.0	29.1	30.2			29.6
25.0	30.2	31.3			30.8
26.0	31.3	32.4			31.9
27.0	32.4	33.6	1.3	0.0	33.0
28.0	33.6	34.7	2.0	0.1	34.1
29.0	34.7	35.8	2.3	0.1	35.2
30.0	35.8	36.9	2.3	0.1	36.4
31.0	36.9	38.0	2.2	0.0	37.5
32.0	38.0	39.2	1.6	0.0	38.6
33.0	39.2	40.3	0.4	0.0	39.7

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	45.14
0.5	9	
0.9	9	
1.2	9	
2.0	9	
3.0	8	
4.0	8	
5.1	9	
5.5	9	
6.0	10	
6.5	10	
7.0	10	
7.5	10	
8.0	10	
8.5	10	
9.0	10	
9.5	10	
10.0	10	
10.5	10	
11.0	10	
11.5	10	
12.0	10	
12.5	10	
13.0	10	
13.5	10	
14.0	10	
14.5	10	
15.0	10	
15.5	10	
16.0	10	
16.5	10	
17.0	10	
17.5	10	
18.2	10	
18.5	10	
19.0	10	
19.5	10	
20.0	4	
20.6	4	
21.0	4	
21.5	4	
22.0	4	
22.5	4	
23.0	4	
24.0	4	
25.0	4	
26.0	4	
27.0	4	
28.0	4	
29.0	4	
30.0	4	
31.0	4	
32.0	4	
33.0	4	
34.0	4	
35.0	4	
36.0	10	
36.9	10	
43.0	8	
44.0	8	
46.6	8	
47.0	8	
48.1	8	

Table 3
Velocity Suitability Index

Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1

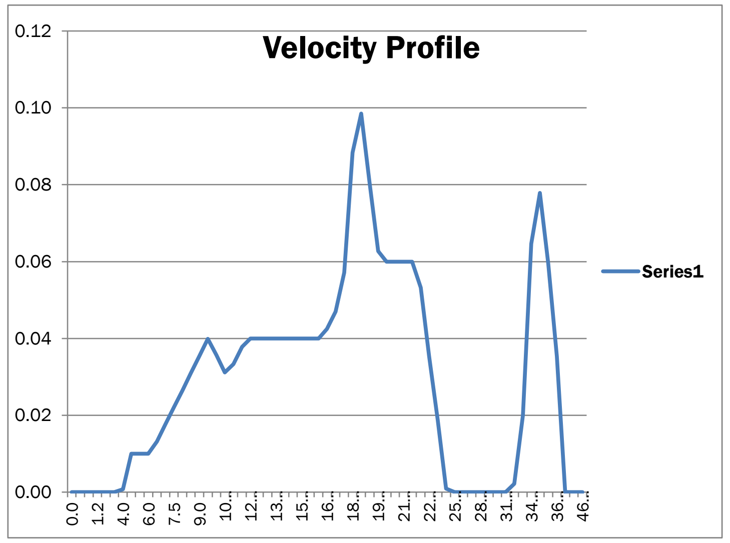


Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.5	0.00	0.0
0.9	0.00	0.0
1.2	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.1
5.1	0.01	0.2
5.5	0.01	0.3
6.0	0.01	0.4
6.5	0.01	0.5
7.0	0.02	0.6
7.5	0.02	0.7
8.0	0.03	0.8
8.5	0.03	0.9
9.0	0.04	1.0
9.5	0.04	1.0
10.0	0.04	1.1
10.5	0.03	1.2
11.0	0.03	1.3
11.5	0.04	1.4
12.0	0.04	1.5
12.5	0.04	1.6
13.0	0.04	1.6
13.5	0.04	1.7
14.0	0.04	1.8
14.5	0.04	2.0
15.0	0.04	2.1
15.5	0.04	2.2
16.0	0.04	2.3
16.5	0.04	2.4
17.0	0.05	2.5
17.5	0.06	2.5
18.2	0.09	2.5
18.5	0.10	2.5
19.0	0.08	2.5
19.5	0.06	2.5
20.0	0.06	2.5
20.6	0.06	2.4
21.0	0.06	2.3
21.5	0.06	2.1
22.0	0.05	1.8
22.5	0.04	1.3
23.0	0.02	0.9
24.0	0.00	0.0
25.0	0.00	0.0
26.0	0.00	0.0
27.0	0.00	0.0
28.0	0.00	0.0
29.0	0.00	0.0
30.0	0.00	0.0
31.0	0.00	0.0
32.0	0.00	0.1
33.0	0.02	1.3
34.0	0.06	1.9
35.0	0.08	2.2
36.0	0.06	2.3
36.9	0.04	2.3
43.0	0.00	0.0
44.0	0.00	0.0
46.6	0.00	0.0
47.0	0.00	0.0
48.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
49.7	1.00	0.04	0.50	0.09	4.6
18.1	1.00	0.15	0.50	0.19	3.4
22.6	1.00	0.20	0.10	0.04	1.0
22.6	1.00	0.27	0.10	0.05	1.2
22.6	1.00	0.34	0.10	0.06	1.3
22.6	1.00	0.40	0.10	0.06	1.4
22.6	1.00	0.46	0.10	0.07	1.5
22.6	1.00	0.52	0.10	0.07	1.6
22.6	1.00	0.57	0.10	0.08	1.7
22.6	1.00	0.63	0.10	0.08	1.8
22.6	1.00	0.69	0.10	0.08	1.9
22.6	1.00	0.76	0.10	0.09	2.0
22.6	1.00	0.82	0.10	0.09	2.0
22.6	1.00	0.88	0.10	0.09	2.1
22.6	1.00	0.95	0.10	0.10	2.2
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
31.6	1.00	1.00	0.10	0.10	3.2
13.5	1.00	1.00	0.10	0.10	1.4
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	1.00	1.00	22.6
27.1	1.00	1.00	1.00	1.00	27.1
18.1	1.00	1.00	1.00	1.00	18.1
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	0.89	1.00	0.94	21.3
45.1	1.00	0.61	1.00	0.78	35.2
45.1	1.00	0.02	1.00	0.14	6.4
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
45.1	1.00	0.07	1.00	0.27	12.0
45.1	1.00	0.83	1.00	0.91	41.1
45.1	1.00	1.00	1.00	1.00	45.1
45.1	1.00	1.00	0.10	0.10	4.5
40.6	1.00	1.00	0.10	0.10	4.1
275.3	1.00	1.00	0.40	0.40	110.1
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 1,444				Total Weighted Usable Area:	479

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

(green)	user input
(grey)	user criterion

GeoEngineers

Weighted Usable Area Analysis New Transect - Pool
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	5.1	6.1	0.1	0.0	5.6
2.0	6.1	7.1	0.2	0.0	6.6
3.0	7.1	8.1	0.3	0.0	7.6
4.0	8.1	9.1	0.2	0.0	8.6
5.0	9.1	10.1	0.3	0.0	9.6
6.0	10.1	11.1	0.5	0.0	10.6
7.0	11.1	12.2	0.7	0.0	11.6
8.0	12.2	13.2	1.5	0.0	12.7
9.0	13.2	14.2	2.1	0.1	13.7
10.0	14.2	15.2	2.6	0.1	14.7
11.0	15.2	16.2	2.7	0.1	15.7
12.0	16.2	17.2	2.6	0.1	16.7
13.0	17.2	18.2	2.6	0.1	17.7
14.0	18.2	19.2	2.6	0.1	18.7
15.0	19.2	20.2	2.5	0.1	19.7
16.0	20.2	21.3	2.4	0.1	20.7
17.0	21.3	22.3	2.2	0.1	21.8
18.0	22.3	23.3	2.0	0.1	22.8
19.0	23.3	24.3	2.0	0.1	23.8
20.0	24.3	25.3	1.9	0.1	24.8
21.0	25.3	26.3	1.7	0.1	25.8
22.0	26.3	27.3	1.5	0.1	26.8
23.0	27.3	28.3	1.5	0.0	27.8
24.0	28.3	29.4	1.4	0.0	28.8
25.0	29.4	30.4	1.3	0.0	29.9
26.0	30.4	31.4	1.2	0.0	30.9
27.0	31.4	32.4	1.0	0.0	31.9
28.0	32.4	33.4	0.6	0.0	32.9
29.0	33.4	34.4	0.2	0.0	33.9
30.0	34.4	35.4	0.2	0.0	34.9
31.0	35.4	36.4	0.1	0.0	35.9

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	45.14
0.5	9	
0.9	9	
1.2	10	
2.0	10	
3.0	10	
4.0	10	
5.1	10	
5.5	10	
6.0	10	
6.5	10	
7.0	10	
7.5	10	
8.0	10	
8.5	10	
9.0	10	
9.5	10	
10.0	10	
10.5	10	
11.0	10	
11.5	10	
12.0	10	
12.5	10	
13.0	10	
13.5	10	
14.0	1	
14.5	1	
15.0	1	
15.5	1	
16.0	1	
16.5	1	
17.0	1	
17.5	10	
18.2	10	
18.5	10	
19.0	10	
19.5	10	
20.0	4	
20.6	4	
21.0	4	
21.5	4	
22.0	4	
22.5	4	
23.0	4	
24.0	4	
25.0	4	
26.0	4	
27.0	4	
28.0	4	
29.0	4	
30.0	4	
31.0	4	
32.0	4	
33.0	4	
34.0	4	
35.0	4	
36.0	4	
36.9	10	
43.0	8	
44.0	8	
46.6	8	
47.0	8	
48.1	8	

Table 3
Velocity Suitability Index

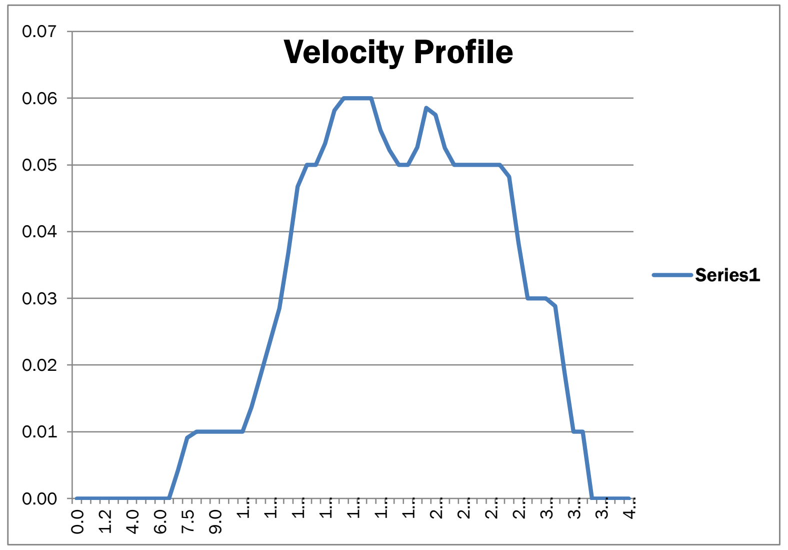
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.5	0.00	0.0
0.9	0.00	0.0
1.2	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.1	0.00	0.0
5.5	0.00	0.0
6.0	0.00	0.1
6.5	0.00	0.2
7.0	0.00	0.2
7.5	0.01	0.3
8.0	0.01	0.2
8.5	0.01	0.2
9.0	0.01	0.2
9.5	0.01	0.3
10.0	0.01	0.4
10.5	0.01	0.5
11.0	0.01	0.6
11.5	0.02	0.7
12.0	0.02	1.0
12.5	0.03	1.3
13.0	0.04	1.7
13.5	0.05	2.0
14.0	0.05	2.3
14.5	0.05	2.5
15.0	0.05	2.6
15.5	0.06	2.6
16.0	0.06	2.7
16.5	0.06	2.6
17.0	0.06	2.6
17.5	0.06	2.6
18.2	0.06	2.6
18.5	0.05	2.6
19.0	0.05	2.5
19.5	0.05	2.5
20.0	0.05	2.5
20.6	0.06	2.5
21.0	0.06	2.4
21.5	0.05	2.2
22.0	0.05	2.1
22.5	0.05	2.1
23.0	0.05	2.0
24.0	0.05	1.9
25.0	0.05	1.8
26.0	0.05	1.6
27.0	0.05	1.5
28.0	0.04	1.4
29.0	0.03	1.4
30.0	0.03	1.3
31.0	0.03	1.2
32.0	0.03	1.0
33.0	0.02	0.6
34.0	0.01	0.2
35.0	0.01	0.2
36.0	0.00	0.0
36.9	0.00	0.0
43.0	0.00	0.0
44.0	0.00	0.0
46.6	0.00	0.0
47.0	0.00	0.0
48.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
22.6	1.00	0.07	0.10	0.03	0.6
22.6	1.00	0.11	0.10	0.03	0.8
22.6	1.00	0.15	0.10	0.04	0.9
22.6	1.00	0.17	0.10	0.04	0.9
22.6	1.00	0.15	0.10	0.04	0.9
22.6	1.00	0.11	0.10	0.03	0.8
22.6	1.00	0.13	0.10	0.04	0.8
22.6	1.00	0.17	0.10	0.04	0.9
22.6	1.00	0.24	0.10	0.05	1.1
22.6	1.00	0.32	0.10	0.06	1.3
22.6	1.00	0.39	0.10	0.06	1.4
22.6	1.00	0.46	0.10	0.07	1.5
22.6	1.00	0.65	0.10	0.08	1.8
22.6	1.00	0.89	0.10	0.09	2.1
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
31.6	1.00	1.00	0.10	0.10	3.2
13.5	1.00	1.00	0.10	0.10	1.4
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
22.6	1.00	1.00	0.10	0.10	2.3
27.1	1.00	1.00	1.00	1.00	27.1
18.1	1.00	1.00	1.00	1.00	18.1
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
22.6	1.00	1.00	1.00	1.00	22.6
45.1	1.00	1.00	1.00	1.00	45.1
45.1	1.00	1.00	1.00	1.00	45.1
45.1	1.00	1.00	1.00	1.00	45.1
45.1	1.00	1.00	1.00	1.00	45.1
45.1	1.00	1.00	1.00	1.00	45.1
45.1	1.00	0.96	1.00	0.98	44.2
45.1	1.00	0.90	1.00	0.95	42.8
45.1	1.00	0.88	1.00	0.94	42.3
45.1	1.00	0.80	1.00	0.89	40.3
45.1	1.00	0.63	1.00	0.80	35.9
45.1	1.00	0.38	1.00	0.61	27.7
45.1	1.00	0.12	1.00	0.35	15.9
45.1	1.00	0.09	1.00	0.30	13.6
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
Total Area: 1,354				Total Weighted Usable Area:	813

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 6 - Pool
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	1.8	2.7	0.2	0.0	2.2
2.0	2.7	3.6	0.6	0.0	3.1
3.0	3.6	4.5	0.7	0.0	4.0
4.0	4.5	5.4	0.7	0.0	4.9
5.0	5.4	6.3	0.9	0.1	5.8
6.0	6.3	7.2	1.0	0.1	6.7
7.0	7.2	8.1	1.0	0.1	7.6
8.0	8.1	9.0	1.1	0.1	8.5
9.0	9.0	9.9	1.1	0.1	9.4
10.0	9.9	10.8	1.1	0.1	10.3
11.0	10.8	11.7	1.0	0.1	11.2
12.0	11.7	12.6	1.0	0.1	12.1
13.0	12.6	13.5	1.0	0.1	13.0
14.0	13.5	14.4	1.0	0.1	13.9
15.0	14.4	15.3	0.9	0.1	14.8
16.0	15.3	16.2	1.0	0.1	15.7
17.0	16.2	17.1	1.0	0.1	16.6
18.0	17.1	18.0	1.1	0.1	17.5
19.0	18.0	18.9	1.1	0.1	18.4
20.0	18.9	19.8	1.1	0.1	19.3
21.0	19.8	20.7	1.1	0.1	20.2
22.0	20.7	21.5	1.1	0.1	21.1
23.0	21.5	22.4	1.1	0.1	22.0
24.0	22.4	23.3	1.1	0.1	22.9
25.0	23.3	24.2	0.9	0.1	23.8
26.0	24.2	25.1	0.8	0.1	24.7
27.0	25.1	26.0	0.8	0.1	25.6
28.0	26.0	26.9	0.7	0.1	26.5
29.0	26.9	27.8	0.6	0.1	27.4
30.0	27.8	28.7	0.4	0.1	28.3
31.0	28.7	29.6	0.2	0.0	29.2
32.0	29.6	30.5	0.2	0.0	30.1
33.0	30.5	31.4	0.1	0.0	31.0

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	45.14
0.6	9	
1.1	9	
1.2	9	
1.7	9	
2.0	9	
3.5	5	
5.0	5	
6.5	5	
8.0	0	
9.5	0	
11.0	0	
12.5	0	
14.0	0	
15.5	0	
17.0	0	
18.5	0	
20.0	0	
21.5	0	
23.0	0	
24.5	0	
26.0	0	
27.5	0	
29.0	0	
30.5	1	
31.3	1	
33.5	9	
35.2	9	
35.8	9	
36.0	9	
38.6	9	

Table 3
Velocity Suitability Index

Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1

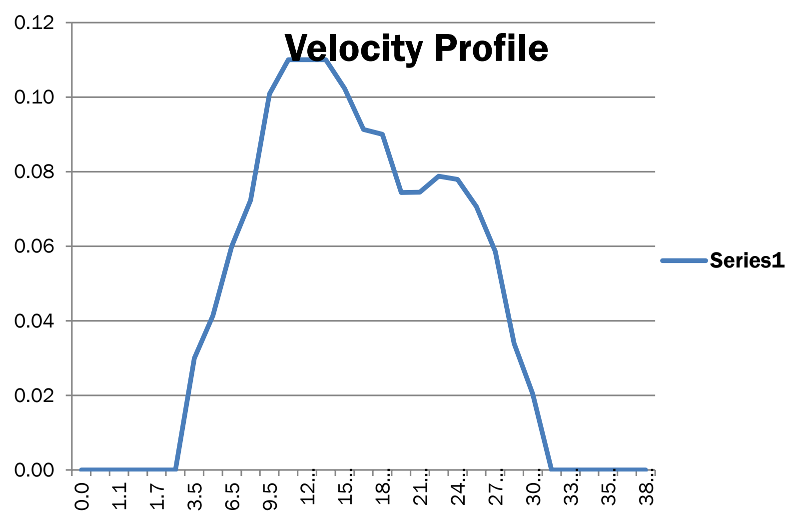


Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.6	0.00	0.0
1.1	0.00	0.0
1.2	0.00	0.0
1.7	0.00	0.0
2.0	0.00	0.0
3.5	0.03	0.6
5.0	0.04	0.7
6.5	0.06	1.0
8.0	0.07	1.1
9.5	0.10	1.1
11.0	0.11	1.1
12.5	0.11	1.0
14.0	0.11	0.9
15.5	0.10	1.0
17.0	0.09	1.0
18.5	0.09	1.1
20.0	0.07	1.1
21.5	0.07	1.1
23.0	0.08	1.0
24.5	0.08	0.9
26.0	0.07	0.7
27.5	0.06	0.5
29.0	0.03	0.3
30.5	0.02	0.1
31.3	0.00	0.0
33.5	0.00	0.0
35.2	0.00	0.0
35.8	0.00	0.0
36.0	0.00	0.0
38.6	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
67.7	1.00	0.40	1.00	0.63	43.0
67.7	1.00	0.44	1.00	0.67	45.1
67.7	1.00	0.65	0.05	0.04	2.7
67.7	1.00	0.69	0.05	0.04	2.8
67.7	1.00	0.74	0.05	0.04	2.9
67.7	1.00	0.69	0.05	0.04	2.8
67.7	1.00	0.67	0.05	0.04	2.8
67.7	1.00	0.62	0.05	0.04	2.7
67.7	1.00	0.63	0.05	0.04	2.7
67.7	1.00	0.69	0.05	0.04	2.8
67.7	1.00	0.75	0.05	0.04	2.9
67.7	1.00	0.75	0.05	0.04	2.9
67.7	1.00	0.74	0.05	0.04	2.9
67.7	1.00	0.68	0.05	0.04	2.8
67.7	1.00	0.56	0.05	0.04	2.5
67.7	1.00	0.47	0.05	0.03	2.3
67.7	1.00	0.34	0.05	0.03	2.0
67.7	1.00	0.16	1.00	0.40	27.0
36.1	1.00	0.06	1.00	0.25	9.1
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 1,255				Total Weighted Usable Area:	165

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 7 - Pool
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	0.8	1.6	0.1	0.0	1.2
2.0	1.6	2.4	0.8	0.0	2.0
3.0	2.4	3.2	1.9	0.0	2.8
4.0	3.2	4.0	2.3	0.0	3.6
5.0	4.0	4.8	2.5	0.0	4.4
6.0	4.8	5.6	2.5	0.0	5.2
7.0	5.6	6.4	2.4	0.0	6.0
8.0	6.4	7.2	2.3	0.1	6.8
9.0	7.2	8.1	2.3	0.1	7.6
10.0	8.1	8.9	2.2	0.1	8.5
11.0	8.9	9.7	2.2	0.1	9.3
12.0	9.7	10.5	2.2	0.1	10.1
13.0	10.5	11.3	2.2	0.1	10.9
14.0	11.3	12.1	2.2	0.1	11.7
15.0	12.1	12.9	2.2	0.1	12.5
16.0	12.9	13.7	2.2	0.1	13.3
17.0	13.7	14.5	2.1	0.0	14.1
18.0	14.5	15.3	2.1	0.0	14.9
19.0	15.3	16.1	2.0	0.0	15.7
20.0	16.1	16.9	2.0	0.0	16.5
21.0	16.9	17.7	1.9	0.0	17.3
22.0	17.7	18.5	1.7	0.0	18.1
23.0	18.5	19.3	1.6	0.0	18.9
24.0	19.3	20.1	1.5	0.0	19.7
25.0	20.1	20.9	1.5	0.0	20.5
26.0	20.9	21.7	1.4	0.1	21.3
27.0	21.7	22.5	1.4	0.1	22.1
28.0	22.5	23.3	1.4	0.1	22.9
29.0	23.3	24.1	1.2	0.1	23.7
30.0	24.1	24.9	1.2	0.1	24.5
31.0	24.9	25.8	1.3	0.0	25.3
32.0	25.8	26.6	1.3	0.0	26.2
33.0	26.6	27.4	1.3	0.0	27.0
34.0	27.4	28.2	1.2	0.0	27.8
35.0	28.2	29.0	1.1	0.0	28.6
36.0	29.0	29.8	0.8	0.0	29.4
37.0	29.8	30.6	0.5	0.0	30.2
38.0	30.6	31.4	0.2	0.0	31.0
39.0	31.4	32.2	0.0	0.0	31.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	45.14
1.0	3	
1.1	3	
1.5	3	
3.0	3	
4.5	3	
6.0	3	
7.5	3	
9.0	3	
10.5	0	
12.0	0	
13.5	0	
15.0	0	
16.5	0	
18.0	0	
19.5	0	
21.0	0	
22.5	0	
24.0	0	
25.5	0	
27.0	0	
28.5	2	
30.0	2	
31.9	2	
32.7	9	
33.4	9	
33.7	9	
34.0	9	
34.6	9	

Table 3
Velocity Suitability Index

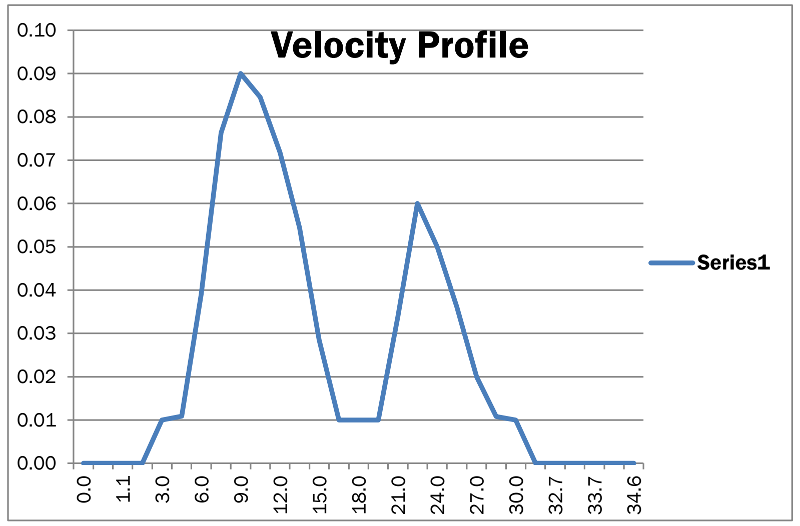
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.0	0.00	0.0
1.1	0.00	0.0
1.5	0.00	0.4
3.0	0.01	2.0
4.5	0.01	2.5
6.0	0.04	2.4
7.5	0.08	2.3
9.0	0.09	2.2
10.5	0.08	2.2
12.0	0.07	2.2
13.5	0.05	2.1
15.0	0.03	2.0
16.5	0.01	2.0
18.0	0.01	1.7
19.5	0.01	1.6
21.0	0.03	1.5
22.5	0.06	1.4
24.0	0.05	1.2
25.5	0.04	1.3
27.0	0.02	1.3
28.5	0.01	1.1
30.0	0.01	0.5
31.9	0.00	0.0
32.7	0.00	0.0
33.4	0.00	0.0
33.7	0.00	0.0
34.0	0.00	0.0
34.6	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
67.7	1.00	0.25	1.00	0.50	33.6
67.7	1.00	1.00	1.00	1.00	67.7
67.7	1.00	1.00	1.00	1.00	67.7
67.7	1.00	1.00	1.00	1.00	67.7
67.7	1.00	1.00	1.00	1.00	67.7
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	1.00	0.05	0.05	3.4
67.7	1.00	0.97	0.05	0.05	3.3
67.7	1.00	0.93	0.05	0.05	3.3
67.7	1.00	0.80	0.05	0.04	3.0
67.7	1.00	0.88	0.05	0.05	3.2
67.7	1.00	0.88	0.70	0.66	44.4
67.7	1.00	0.74	0.70	0.60	40.6
85.8	1.00	0.35	0.70	0.41	35.4
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 1,372				Total Weighted Usable Area:	465

Step 3

Notes:
*Spreadsheet is for Winter Rearing WUA Calculations Only
user input
user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 8 - Riffle Reach
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	2.1	3.2	0.1	0.0	2.6
2.0	3.2	4.2	0.3	0.0	3.7
3.0	4.2	5.3	0.5	0.1	4.7
4.0	5.3	6.3	0.7	0.1	5.8
5.0	6.3	7.4	0.8	0.1	6.8
6.0	7.4	8.4	0.9	0.1	7.9
7.0	8.4	9.5	0.9	0.1	9.0
8.0	9.5	10.5	0.8	0.1	10.0
9.0	10.5	11.6	0.8	0.1	11.1
10.0	11.6	12.6	0.9	0.1	12.1
11.0	12.6	13.7	0.9	0.1	13.2
12.0	13.7	14.8	0.8	0.2	14.2
13.0	14.8	15.8	0.7	0.2	15.3
14.0	15.8	16.9	0.7	0.2	16.3
15.0	16.9	17.9	0.7	0.2	17.4
16.0	17.9	19.0	0.7	0.2	18.4
17.0	19.0	20.0	0.6	0.2	19.5
18.0	20.0	21.1	0.5	0.2	20.5
19.0	21.1	22.1	0.4	0.2	21.6
20.0	22.1	23.2	0.3	0.2	22.7
21.0	23.2	24.2	0.3	0.2	23.7
22.0	24.2	25.3	0.3	0.2	24.8
23.0	25.3	26.3	0.4	0.2	25.8
24.0	26.3	27.4	0.4	0.3	26.9
25.0	27.4	28.4	0.1	0.1	27.9
26.0	28.4	29.5			29.0
27.0	29.5	30.6	0.1	0.1	30.0
28.0	30.6	31.6	0.2	0.2	31.1
29.0	31.6	32.7	0.2	0.2	32.1
30.0	32.7	33.7	0.1	0.1	33.2
31.0	33.7	34.8	0.0	0.1	34.2
32.0	34.8	35.8	0.0	0.0	35.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	98.09
0.2	9	
0.6	9	
1.5	9	
2.2	2	
3.0	5	
4.5	5	
6.0	5	
7.5	5	
9.0	5	
10.5	5	
12.0	0	
13.5	0	
15.0	0	
16.5	0	
18.0	0	
19.5	10	
21.0	10	
22.5	10	
24.0	10	
25.5	10	
27.0	0	
28.5	0	
30.0	0	
31.5	0	
33.0	0	
34.5	0	
36.0	0	
37.5	0	
39.0	0	
41.0	2	
43.7	10	
43.8	10	
45.3	9	

Table 3
Velocity Suitability Index

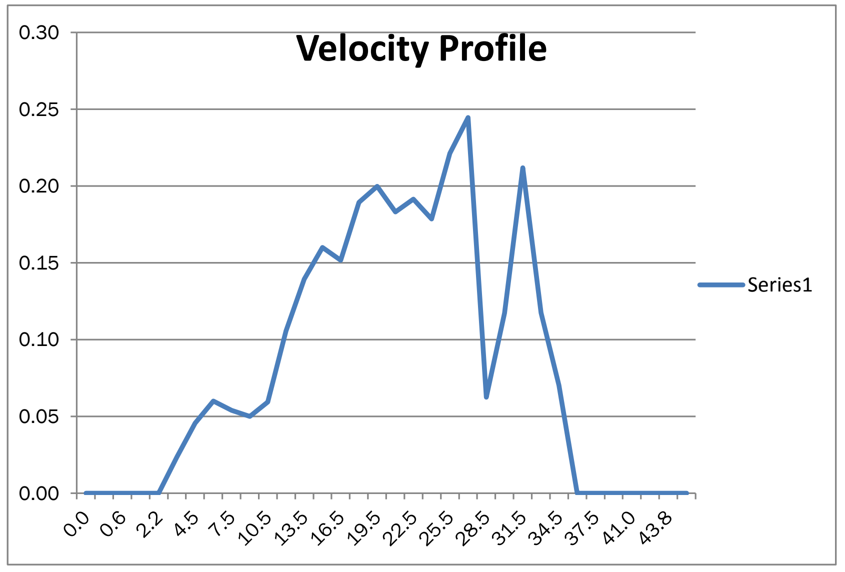
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
0.2	0.00	0.00
0.6	0.00	0.00
1.5	0.00	0.00
2.2	0.00	0.00
3.0	0.02	0.16
4.5	0.05	0.44
6.0	0.06	0.72
7.5	0.05	0.84
9.0	0.05	0.92
10.5	0.06	0.81
12.0	0.11	0.91
13.5	0.14	0.85
15.0	0.16	0.75
16.5	0.15	0.67
18.0	0.19	0.71
19.5	0.20	0.64
21.0	0.18	0.46
22.5	0.19	0.34
24.0	0.18	0.28
25.5	0.22	0.34
27.0	0.24	0.37
28.5	0.06	0.06
30.0	0.12	0.06
31.5	0.21	0.18
33.0	0.12	0.07
34.5	0.07	0.03
36.0	0.00	0.00
37.5	0.00	0.00
39.0	0.00	0.00
41.0	0.00	0.00
43.7	0.00	0.00
43.8	0.00	0.00
45.3	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
147.1	1.00	0.08	1.00	0.29	42.6
147.1	1.00	0.28	1.00	0.53	78.0
147.1	1.00	0.46	1.00	0.68	100.2
147.1	1.00	0.55	1.00	0.74	109.3
147.1	1.00	0.60	1.00	0.77	113.9
147.1	1.00	0.53	1.00	0.73	107.3
147.1	1.00	0.59	0.05	0.04	5.7
147.1	1.00	0.55	0.05	0.04	5.5
147.1	1.00	0.48	0.05	0.03	5.1
147.1	1.00	0.43	0.05	0.03	4.8
147.1	1.00	0.46	0.05	0.03	5.0
147.1	1.00	0.41	0.10	0.06	9.4
147.1	1.00	0.29	0.10	0.05	8.0
147.1	1.00	0.21	0.10	0.05	6.7
147.1	1.00	0.17	0.10	0.04	6.0
147.1	1.00	0.21	0.10	0.05	6.7
147.1	1.00	0.23	0.05	0.02	3.5
147.1	1.00	0.03	0.05	0.01	1.3
147.1	1.00	0.03	0.05	0.01	1.2
147.1	1.00	0.10	0.05	0.02	2.3
147.1	1.00	0.03	0.05	0.01	1.3
147.1	1.00	0.02	0.05	0.01	0.9
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
Total Area: 3,237				Total Weighted Usable Area:	625

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 9 - Riffle Reach
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	5.3	6.0	0.0	0.0	5.7
2.0	6.0	6.7	0.0	0.0	6.3
3.0	6.7	7.3	0.0	0.1	7.0
4.0	7.3	8.0	0.1	0.2	7.7
5.0	8.0	8.7	0.1	0.4	8.3
6.0	8.7	9.3	0.2	1.9	9.0
7.0	9.3	10.0	0.2	2.4	9.6
8.0	10.0	10.6	0.1	2.1	10.3
9.0	10.6	11.3	0.1	1.8	11.0
10.0	11.3	12.0	0.2	2.7	11.6
11.0	12.0	12.6	0.3	3.0	12.3
12.0	12.6	13.3	0.2	1.3	13.0
13.0	13.3	14.0	0.1	1.3	13.6
14.0	14.0	14.6	0.0	0.7	14.3
15.0	14.6	15.3	0.0	0.6	15.0

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	3	98.09
3.0	3	
4.0	3	
4.7	3	
5.0	3	
5.5	3	
6.0	3	
6.5	3	
7.0	3	
7.5	0	
8.0	0	
8.5	0	
9.0	0	
9.5	0	
10.0	0	
10.5	0	
11.0	0	
11.5	0	
12.0	0	
12.5	0	
13.0	0	
13.5	0	
14.0	0	
14.5	0	
15.0	0	
15.5	0	
16.0	0	
16.5	0	
17.0	0	
17.5	0	
18.3	0	
19.0	0	
20.0	0	
21.0	0	
22.0	3	
24.5	3	
25.2	3	
26.8	3	
27.5	3	
28.6	3	

Table 3
Velocity Suitability Index

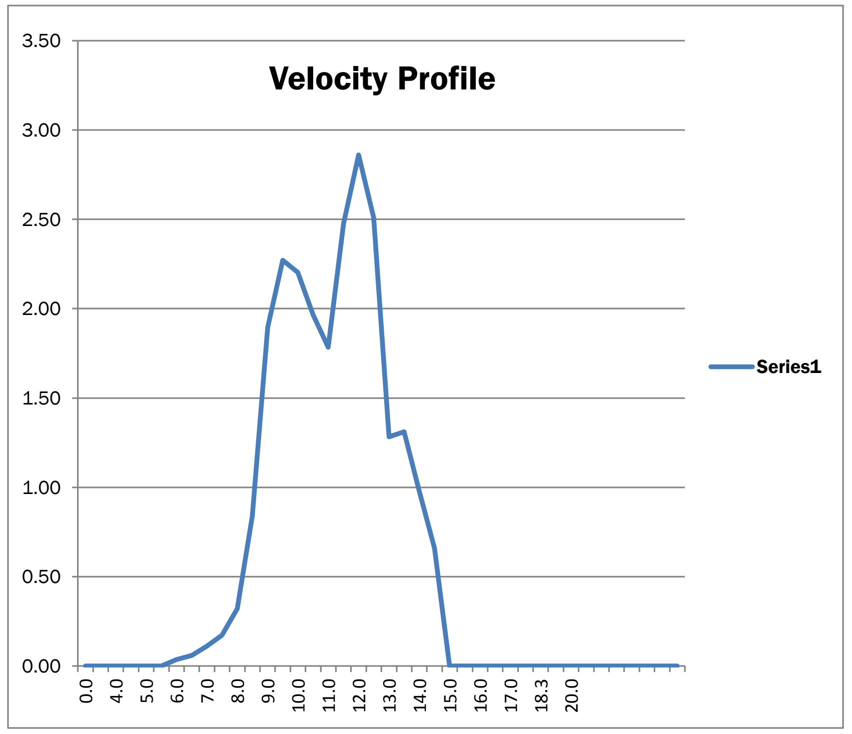
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
3.0	0.00	0.00
4.0	0.00	0.00
4.7	0.00	0.00
5.0	0.00	0.00
5.5	0.00	0.00
6.0	0.04	0.02
6.5	0.06	0.03
7.0	0.11	0.03
7.5	0.17	0.06
8.0	0.32	0.10
8.5	0.84	0.14
9.0	1.90	0.15
9.5	2.27	0.18
10.0	2.20	0.16
10.5	1.96	0.13
11.0	1.78	0.13
11.5	2.48	0.16
12.0	2.86	0.23
12.5	2.51	0.25
13.0	1.28	0.17
13.5	1.31	0.11
14.0	0.97	0.06
14.5	0.66	0.03
15.0	0.00	0.00
15.5	0.00	0.00
16.0	0.00	0.00
16.5	0.00	0.00
17.0	0.00	0.00
17.5	0.00	0.00
18.3	0.00	0.00
19.0	0.00	0.00
20.0	0.00	0.00
21.0	0.00	0.00
22.0	0.00	0.00
24.5	0.00	0.00
25.2	0.00	0.00
26.8	0.00	0.00
27.5	0.00	0.00
28.6	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
49.0	1.00	0.01	1.00	0.10	4.9
49.0	1.00	0.02	1.00	0.12	6.0
49.0	1.00	0.02	1.00	0.12	6.0
49.0	1.00	0.03	0.05	0.01	0.4
49.0	1.00	0.05	0.05	0.01	0.5
49.0	0.73	0.07	0.05	0.01	0.6
49.0	0.06	0.08	0.05	0.00	0.2
49.0	0.04	0.10	0.05	0.00	0.2
49.0	0.04	0.08	0.05	0.00	0.1
49.0	0.05	0.07	0.05	0.00	0.2
49.0	0.07	0.07	0.05	0.00	0.2
49.0	0.03	0.09	0.05	0.00	0.1
49.0	0.02	0.14	0.05	0.00	0.1
49.0	0.03	0.15	0.05	0.00	0.2
49.0	0.32	0.09	0.05	0.01	0.4
49.0	0.29	0.06	0.05	0.01	0.3
49.0	0.62	0.03	0.05	0.01	0.3
49.0	0.88	0.02	0.05	0.01	0.3
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 883				Total Weighted Usable Area:	21

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

Weighted Usable Area Analysis Transect 10 - Riffle Reach
APEX JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	9.0	9.9	0.1	0.4	9.4
2.0	9.9	10.8	0.3	0.6	10.3
3.0	10.8	11.7	0.3	0.1	11.2
4.0	11.7	12.6	0.2	0.1	12.1
5.0	12.6	13.5	0.1	0.1	13.0
6.0	13.5	14.4	0.1	0.2	13.9
7.0	14.4	15.3	0.1	0.2	14.8
8.0	15.3	16.2	0.2	0.5	15.7
9.0	16.2	17.1	0.3	0.3	16.6
10.0	17.1	18.0	0.4	0.1	17.5
11.0	18.0	18.9	0.4	0.8	18.4
12.0	18.9	19.8	0.4	0.6	19.3
13.0	19.8	20.7	0.4	0.1	20.2
14.0	20.7	21.5	0.5	0.3	21.1
15.0	21.5	22.4	0.4	0.4	22.0
16.0	22.4	23.3	0.3	0.6	22.9
17.0	23.3	24.2	0.2	0.5	23.8
18.0	24.2	25.1	0.2	0.7	24.7
19.0	25.1	26.0	0.2	0.4	25.6
20.0	26.0	26.9	0.2	0.2	26.5
21.0	26.9	27.8	0.2	0.2	27.4
22.0	27.8	28.7	0.2	0.3	28.3
23.0	28.7	29.6	0.1	0.5	29.2
24.0	29.6	30.5	0.0	0.1	30.1
25.0	30.5	31.4	0.1	0.3	31.0
26.0	31.4	32.3	0.1	0.4	31.9
27.0	32.3	33.2	0.2	0.6	32.8
28.0	33.2	34.1	0.1	0.6	33.7
29.0	34.1	35.0	0.0	0.2	34.6

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	98.09
1.0	9	
2.0	9	
3.0	9	
4.0	9	
4.3	9	
6.0	9	
7.5	9	
9.0	9	
10.5	3	
12.0	3	
13.5	3	
15.0	3	
16.5	3	
18.0	3	
19.5	3	
21.0	0	
22.5	0	
24.0	0	
25.5	0	
27.0	0	
28.5	0	
30.0	0	
31.5	0	
33.0	0	
34.5	0	
36.0	5	
37.0	5	
37.7	5	
38.6	5	

Table 3
Velocity Suitability Index

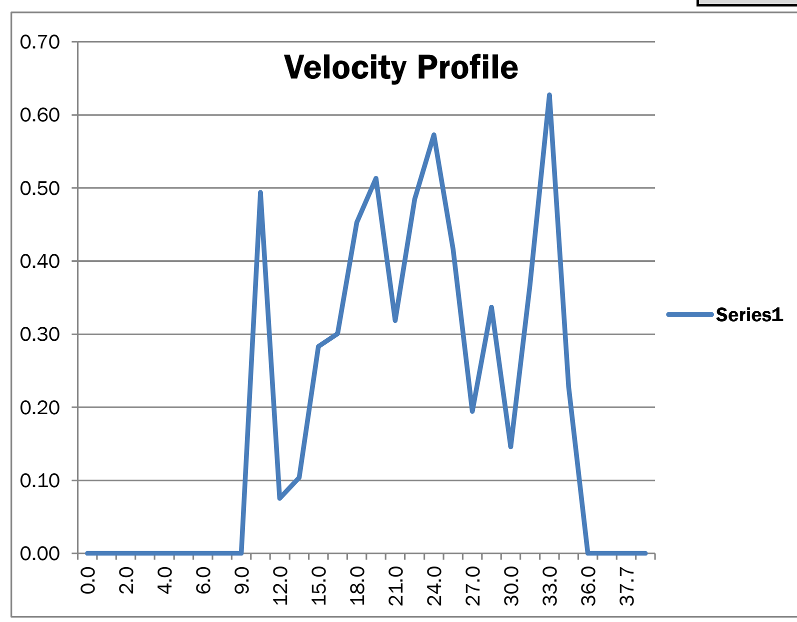
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
1.0	0.00	0.00
2.0	0.00	0.00
3.0	0.00	0.00
4.0	0.00	0.00
4.3	0.00	0.00
6.0	0.00	0.00
7.5	0.00	0.00
9.0	0.00	0.00
10.5	0.49	0.31
12.0	0.08	0.19
13.5	0.10	0.09
15.0	0.28	0.11
16.5	0.30	0.28
18.0	0.45	0.37
19.5	0.51	0.40
21.0	0.32	0.46
22.5	0.49	0.30
24.0	0.57	0.20
25.5	0.42	0.18
27.0	0.19	0.18
28.5	0.34	0.16
30.0	0.15	0.02
31.5	0.37	0.09
33.0	0.63	0.14
34.5	0.23	0.02
36.0	0.00	0.00
37.0	0.00	0.00
37.7	0.00	0.00
38.6	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
147.1	1.00	0.19	1.00	0.44	64.6
147.1	1.00	0.11	1.00	0.33	49.0
147.1	1.00	0.05	1.00	0.21	31.2
147.1	1.00	0.05	1.00	0.22	32.9
147.1	1.00	0.17	1.00	0.41	59.8
147.1	1.00	0.23	1.00	0.48	70.0
147.1	0.99	0.25	1.00	0.49	72.8
147.1	1.00	0.29	0.05	0.03	3.9
147.1	1.00	0.18	0.05	0.02	3.1
147.1	0.94	0.11	0.05	0.02	2.4
147.1	1.00	0.10	0.05	0.02	2.3
147.1	1.00	0.10	0.05	0.02	2.3
147.1	1.00	0.08	0.05	0.01	2.1
147.1	1.00	0.01	0.05	0.00	0.5
147.1	1.00	0.04	0.05	0.01	1.5
147.1	0.90	0.08	0.05	0.01	1.9
147.1	1.00	0.01	0.05	0.01	0.7
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 2,501				Total Weighted Usable Area:	401

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

APEX JAM
Proposed Mesohabitat Unit Proportions

EXISTING MESHOHABITAT PROPORTIONS				
Mesohabitat	Length (feet)	Proportion	1,000 ft Normalized Length	Count
Pool	225	15.6%	156.3	2
Glide	650	45.1%	451.4	3
Riffle	565	39.2%	392.4	4
Total	**875**	**61%**	**607.63889**	**5**

PROPOSED MESHOHABITAT PROPORTIONS (replace 35 ft of glide with pool)				
Mesohabitat	Length (feet)	Proportion	1,000 ft Normalized Length	Count
Pool	260	18.06%	180.6	4
Glide	615	42.71%	427.1	2
Riffle	565	39.24%	392.4	4
Total	**875**	**61%**	**607.63889**	**6**

PROPOSED REACH LENGTHS		
Transect	Description	Moderate Reach Length (feet)
1.00	Glide	213.54
2.00	Glide	213.54
3.00	Riffle	98.09
4.00	Pool	45.14
NEW TSECT	Pool	45.14
5.00	Hydraulic Control	
6.00	Pool	45.14
7.00	Pool	45.14
8.00	Riffle	98.09
9.00	Riffle	98.09
10.00	Riffle	98.09
	Total	**1,000.00**

Table 5 Mesohabitat unit proportions used to weight Rogue PHABSIM transects.

Habitat Type	Length (ft)	Percentage
Emigrant Creek-between Bear Creek and Emigrant Dam		
Pool	225	15.6
Glide	650	45.1
Riffle	565	39.2
Total	1440	100.0

APEX JAM
Flow Rate: 2 cfs
Winter Rearing Total Weighted Usable Area Calculations

Transect	River Station	River Station Difference	Total Area	Weighted Usable Area
1	0	0	4,228	756
2	16	16	3,246	182
3	47	32	3,335	238
Modified Transect 4	69	22	1,444	479
New Transect	77	8	1,354	813
5	95	18		
6	120	25	1,255	165
7	155	35	1,372	465
8	191	37	3,237	625
9	285	94	883	21
10	334	49	2,501	401
	Total	**334**	**22,856**	**4,145**

Existing WUA (Table D-1)	
Total Area	**Weighted Usable Area**
23,655	3,244

Percent Difference (Existing/Proposed)	
Total Area	**Weighted Usable Area**
-3.4%	27.8%

Step 4

GeoEngineers

C-3
Proposed Barb Jam

Weighted Usable Area Analysis Transect 1 - Glide Reach
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (f/s)	Mid Point (ft)
1.0	5.7	6.4	0.10	0.07	6.0
2.0	6.4	7.1	0.16	0.10	6.7
3.0	7.1	7.8	0.16	0.10	7.4
4.0	7.8	8.5	0.18	0.16	8.1
5.0	8.5	9.2	0.24	0.21	8.8
6.0	9.2	9.9	0.31	0.25	9.5
7.0	9.9	10.6	0.33	0.22	10.3
8.0	10.6	11.3	0.28	0.20	11.0
9.0	11.3	12.0	0.33	0.23	11.7
10.0	12.0	12.7	0.36	0.21	12.4
11.0	12.7	13.4	0.35	0.22	13.1
12.0	13.4	14.1	0.28	0.19	13.8
13.0	14.1	14.9	0.11	0.07	14.5
14.0	14.9	15.6	0.06	0.17	15.2
15.0	15.6	16.3	0.23	0.41	15.9
16.0	16.3	17.0	0.38	0.58	16.6
17.0	17.0	17.7	0.46	0.62	17.3
18.0	17.7	18.4	0.42	0.59	18.0
19.0	18.4	19.1	0.17	0.34	18.7
20.0	19.1	19.8	0.10	0.41	19.4
21.0	19.8	20.5	0.21	0.64	20.2
22.0	20.5	21.2	0.40	0.95	20.9
23.0	21.2	21.9	0.35	0.79	21.6
24.0	21.9	22.6	0.29	0.77	22.3
25.0	22.6	23.3	0.29	0.70	23.0
26.0	23.3	24.0	0.05	0.14	23.7
27.0	24.0	24.7	0.04	0.13	24.4
28.0	24.7	25.5	0.21	0.14	25.1
29.0	25.5	26.2	0.16	0.04	25.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (feet)
0.0	9.0	150.46
0.9	2.0	
2.8	9.0	
3.5	9.0	
4.5	9.0	
6.2	2.0	
7.0	2.0	
8.0	2.0	
9.0	2.0	
10.0	2.0	
11.0	2.0	
12.0	0.0	
13.0	0.0	
14.0	0.0	
15.0	0.0	
16.0	0.0	
17.0	0.0	
18.0	0.0	
19.0	0.0	
20.0	3.0	
21.0	3.0	
22.0	3.0	
23.0	3.0	
24.0	3.0	
25.0	3.0	
26.0	3.0	
27.0	3.0	
27.4	3.0	
27.5	3.0	
29.0	3.0	
30.4	3.0	

Table 3
Velocity Suitability Index

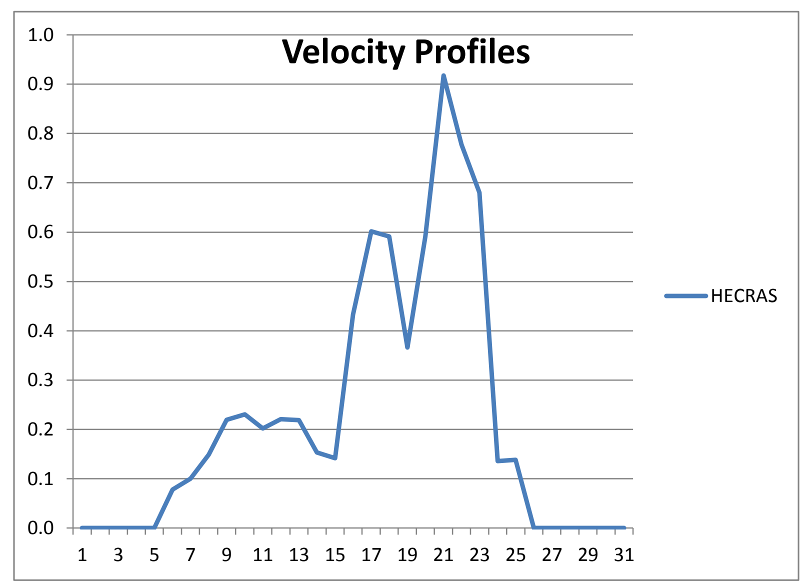
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Cover	Suitability Index
0.0	0.1
1.0	1.0
2.0	0.7
3.0	1.0
4.0	1.0
5.0	1.0
6.0	0.1
7.0	0.3
8.0	0.4
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.0	0.0
0.9	0.0	0.0
2.8	0.0	0.0
3.5	0.0	0.0
4.5	0.0	0.0
6.2	0.1	0.1
7.0	0.1	0.2
8.0	0.1	0.2
9.0	0.2	0.3
10.0	0.2	0.3
11.0	0.2	0.3
12.0	0.2	0.3
13.0	0.2	0.4
14.0	0.2	0.2
15.0	0.1	0.1
16.0	0.4	0.3
17.0	0.6	0.4
18.0	0.6	0.4
19.0	0.4	0.1
20.0	0.6	0.2
21.0	0.9	0.4
22.0	0.8	0.3
23.0	0.7	0.3
24.0	0.1	0.0
25.0	0.1	0.2
26.0	0.0	0.0
27.0	0.0	0.0
27.4	0.0	0.0
27.5	0.0	0.0
29.0	0.0	0.0
30.4	0.0	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitabilty	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
120.4	1.00	0.06	0.70	0.17	20.1
150.5	1.00	0.09	0.70	0.21	31.7
150.5	1.00	0.10	0.70	0.22	32.9
150.5	1.00	0.15	0.70	0.27	41.0
150.5	1.00	0.20	0.70	0.31	47.0
150.5	1.00	0.17	0.05	0.02	3.1
150.5	1.00	0.21	0.05	0.02	3.5
150.5	1.00	0.22	0.05	0.02	3.5
150.5	1.00	0.13	0.05	0.02	2.7
150.5	1.00	0.04	0.05	0.01	1.4
150.5	1.00	0.15	0.05	0.02	2.9
150.5	0.92	0.27	0.05	0.02	3.7
150.5	0.93	0.27	0.05	0.02	3.7
150.5	1.00	0.08	1.00	0.28	41.8
150.5	0.93	0.10	1.00	0.31	46.8
150.5	0.67	0.24	1.00	0.40	60.4
150.5	0.78	0.19	1.00	0.39	58.5
150.5	0.86	0.17	1.00	0.38	57.8
150.5	1.00	0.02	1.00	0.14	21.3
150.5	1.00	0.10	1.00	0.32	48.6
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 2979.2				Total Weighted Usable:	532.5

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 2 - Glide Reach
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	4.9	5.6	0.0	0.0	5.3
2.0	5.6	6.3			6.0
3.0	6.3	7.0			6.7
4.0	7.0	7.7			7.4
5.0	7.7	8.4			8.1
6.0	8.4	9.1			8.8
7.0	9.1	9.8			9.5
8.0	9.8	10.5			10.2
9.0	10.5	11.2			10.9
10.0	11.2	11.9			11.6
11.0	11.9	12.6	0.0	0.0	12.3
12.0	12.6	13.3	0.1	0.0	13.0
13.0	13.3	14.0	0.3	0.0	13.7
14.0	14.0	14.7	0.4	0.1	14.4
15.0	14.7	15.4	0.3	0.1	15.1
16.0	15.4	16.1	0.4	0.1	15.8
17.0	16.1	16.8	0.5	0.1	16.5
18.0	16.8	17.5	0.8	0.2	17.2
19.0	17.5	18.2	1.1	0.3	17.9
20.0	18.2	18.9	1.4	0.4	18.6
21.0	18.9	19.6	1.3	0.3	19.3
22.0	19.6	20.3	1.3	0.3	20.0
23.0	20.3	21.0	1.2	0.3	20.7
24.0	21.0	21.7	1.3	0.3	21.4
25.0	21.7	22.4	1.2	0.2	22.1
26.0	22.4	23.1	0.4	0.0	22.8
27.0	23.1	23.8	0.3	0.0	23.5
28.0	23.8	24.5	0.4	0.0	24.2
29.0	24.5	25.2	0.4	0.0	24.9
30.0	25.2	25.9	0.4	0.0	25.6
31.0	25.9	26.6	0.1	0.0	26.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	150.46
1.1	9	
1.4	9	
1.7	9	
2.0	9	
3.0	9	
4.0	2	
5.0	2	
6.0	2	
7.0	2	
8.0	2	
9.0	2	
10.0	2	
11.0	10	
11.6	10	
12.0	10	
12.5	10	
13.0	10	
13.5	10	
14.0	10	
14.5	10	
15.0	10	
15.5	10	
16.0	10	
16.5	10	
17.0	10	
17.5	10	
18.0	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.5	10	
21.0	10	
21.5	10	
22.0	10	
22.5	10	
23.0	10	
23.5	10	
24.0	10	
24.5	10	
25.0	10	
25.5	10	
26.0	10	
26.2	10	
26.8	10	
28.0	9	
28.5	9	
29.0	9	
30.1	9	

Table 3
Velocity Suitability Index

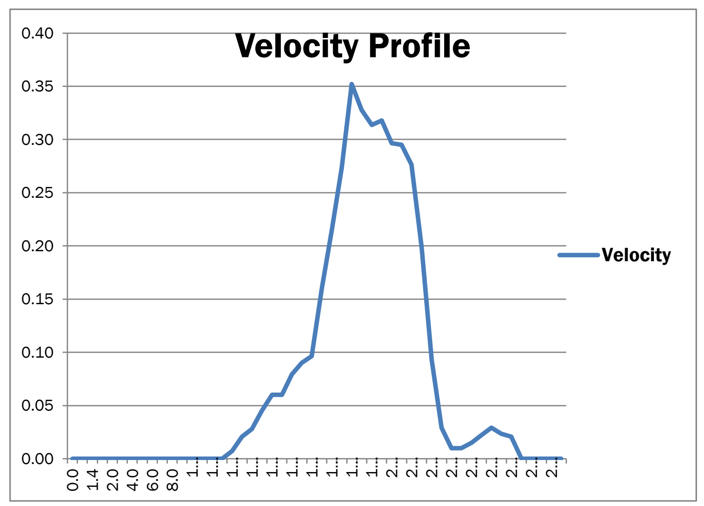
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.1
1.0	1.0
2.0	0.7
3.0	1.0
4.0	1.0
5.0	1.0
6.0	0.1
7.0	0.3
8.0	0.4
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.1	0.00	0.0
1.4	0.00	0.0
1.7	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.0	0.00	0.0
6.0	0.00	0.0
7.0	0.00	0.0
8.0	0.00	0.0
9.0	0.00	0.0
10.0	0.00	0.0
11.0	0.00	0.0
11.6	0.00	0.0
12.0	0.00	0.0
12.5	0.01	0.0
13.0	0.02	0.1
13.5	0.03	0.2
14.0	0.05	0.3
14.5	0.06	0.4
15.0	0.06	0.3
15.5	0.08	0.4
16.0	0.09	0.4
16.5	0.10	0.5
17.0	0.16	0.7
17.5	0.22	0.9
18.0	0.27	1.2
18.5	0.35	1.3
19.0	0.33	1.3
19.5	0.31	1.3
20.0	0.32	1.3
20.5	0.30	1.2
21.0	0.30	1.2
21.5	0.28	1.2
22.0	0.20	1.2
22.5	0.09	0.7
23.0	0.03	0.4
23.5	0.01	0.3
24.0	0.01	0.3
24.5	0.02	0.4
25.0	0.02	0.4
25.5	0.03	0.4
26.0	0.02	0.2
26.2	0.02	0.1
26.8	0.00	0.0
28.0	0.00	0.0
28.5	0.00	0.0
29.0	0.00	0.0
30.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
60.2	1.00	0.00	0.10	0.00	0.0
75.2	1.00	0.00	0.10	0.00	0.0
75.2	1.00	0.02	0.10	0.01	1.1
75.2	1.00	0.06	0.10	0.03	1.9
75.2	1.00	0.12	0.10	0.04	2.7
75.2	1.00	0.19	0.10	0.04	3.2
75.2	1.00	0.22	0.10	0.05	3.5
75.2	1.00	0.18	0.10	0.04	3.2
75.2	1.00	0.23	0.10	0.05	3.6
75.2	1.00	0.27	0.10	0.05	3.9
75.2	1.00	0.31	0.10	0.06	4.2
75.2	1.00	0.45	0.10	0.07	5.0
75.2	1.00	0.61	0.10	0.08	5.9
75.2	1.00	0.77	0.10	0.09	6.6
75.2	1.00	0.89	0.10	0.09	7.1
75.2	1.00	0.86	0.10	0.09	7.0
75.2	1.00	0.85	0.10	0.09	6.9
75.2	1.00	0.86	0.10	0.09	7.0
75.2	1.00	0.80	0.10	0.09	6.7
75.2	1.00	0.80	0.10	0.09	6.7
75.2	1.00	0.82	0.10	0.09	6.8
75.2	1.00	0.80	0.10	0.09	6.7
75.2	1.00	0.44	0.10	0.07	5.0
75.2	1.00	0.22	0.10	0.05	3.5
75.2	1.00	0.19	0.10	0.04	3.2
75.2	1.00	0.21	0.10	0.05	3.5
75.2	1.00	0.25	0.10	0.05	3.7
75.2	1.00	0.27	0.10	0.05	3.9
75.2	1.00	0.27	0.10	0.05	3.9
30.1	1.00	0.14	0.10	0.04	1.1
90.3	1.00	0.08	0.10	0.03	2.5
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 2287	Total Weighted Usable Area:				130

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 3 - Riffle Reach
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	4.3	5.3	0.0	0.1	4.8
2.0	5.3	6.4	0.1	0.1	5.8
3.0	6.4	7.4	0.1	0.1	6.9
4.0	7.4	8.5	0.0	0.1	8.0
5.0	8.5	9.6	0.3	0.4	9.0
6.0	9.6	10.6	0.2	0.3	10.1
7.0	10.6	11.7	0.4	0.4	11.2
8.0	11.7	12.8	0.4	0.4	12.2
9.0	12.8	13.8	0.3	0.3	13.3
10.0	13.8	14.9	0.4	0.4	14.4
11.0	14.9	15.9	0.4	0.4	15.4
12.0	15.9	17.0	0.4	0.4	16.5
13.0	17.0	18.1	0.4	0.3	17.5
14.0	18.1	19.1	0.2	0.3	18.6
15.0	19.1	20.2	0.1	0.3	19.7
16.0	20.2	21.3	0.1	0.3	20.7
17.0	21.3	22.3	0.1	0.4	21.8
18.0	22.3	23.4	0.2	0.4	22.9
19.0	23.4	24.4	0.2	0.5	23.9
20.0	24.4	25.5	0.2	0.4	25.0
21.0	25.5	26.6	0.2	0.5	26.0
22.0	26.6	27.6	0.2	0.3	27.1
23.0	27.6	28.7	0.1	0.2	28.2
24.0	28.7	29.8			29.2
25.0	29.8	30.8			30.3
26.0	30.8	31.9			31.4
27.0	31.9	33.0	0.1	0.2	32.4
28.0	33.0	34.0	0.1	0.1	33.5
29.0	34.0	35.1	0.1	0.1	34.5
30.0	35.1	36.1	0.1	0.1	35.6
31.0	36.1	37.2	0.1	0.1	36.7
32.0	37.2	38.3	0.1	0.1	37.7
33.0	38.3	39.3	0.1	0.1	38.8
34.0	39.3	40.4	0.1	0.1	39.9
35.0	40.4	41.5	0.1	0.1	40.9

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	5	98.09
1.0	5	
2.0	5	
2.6	5	
3.0	5	
4.0	5	
5.0	5	
6.0	2	
7.0	0	
8.0	0	
9.0	0	
9.5	0	
10.0	0	
10.5	0	
11.0	0	
11.5	0	
12.0	0	
12.5	0	
13.0	0	
13.5	0	
14.0	0	
14.5	0	
15.0	10	
15.5	10	
16.0	10	
16.5	10	
17.0	10	
17.5	10	
18.0	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.5	10	
21.0	10	
21.5	10	
22.0	10	
22.5	10	
23.0	10	
23.5	0	
24.0	0	
24.5	0	
25.0	0	
25.5	0	
26.0	0	
26.5	0	
27.0	0	
27.5	0	
28.0	0	
28.4	0	
29.0	0	
31.0	0	
33.0	0	
35.0	1	
37.0	1	
39.0	1	
41.0	9	
41.9	8	
42.1	8	
43.0	8	
45.7	2	

Table 3
Velocity Suitability Index

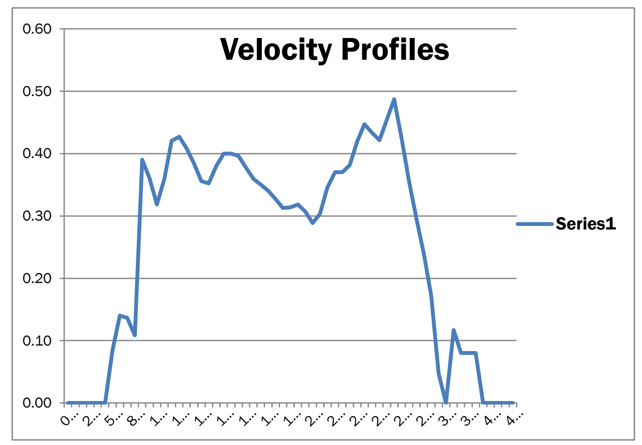
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.1
1.0	1.0
2.0	0.7
3.0	1.0
4.0	1.0
5.0	1.0
6.0	0.1
7.0	0.3
8.0	0.4
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.0	0.00	0.0
2.0	0.00	0.0
2.6	0.00	0.0
3.0	0.00	0.0
4.0	0.00	0.0
5.0	0.08	0.1
6.0	0.14	0.1
7.0	0.14	0.1
8.0	0.11	0.0
9.0	0.39	0.2
9.5	0.36	0.2
10.0	0.32	0.2
10.5	0.36	0.2
11.0	0.42	0.3
11.5	0.43	0.4
12.0	0.41	0.4
12.5	0.38	0.3
13.0	0.36	0.3
13.5	0.35	0.3
14.0	0.38	0.4
14.5	0.40	0.4
15.0	0.40	0.4
15.5	0.40	0.4
16.0	0.38	0.4
16.5	0.36	0.4
17.0	0.35	0.4
17.5	0.34	0.4
18.0	0.33	0.3
18.5	0.31	0.2
19.0	0.31	0.2
19.5	0.32	0.1
20.0	0.31	0.1
20.5	0.29	0.1
21.0	0.30	0.1
21.5	0.35	0.1
22.0	0.37	0.1
22.5	0.37	0.2
23.0	0.38	0.2
23.5	0.42	0.2
24.0	0.45	0.2
24.5	0.43	0.2
25.0	0.42	0.2
25.5	0.45	0.2
26.0	0.49	0.2
26.5	0.42	0.2
27.0	0.35	0.2
27.5	0.29	0.2
28.0	0.24	0.1
28.4	0.17	0.1
29.0	0.05	0.0
31.0	0.00	0.0
33.0	0.12	0.1
35.0	0.08	0.1
37.0	0.08	0.1
39.0	0.08	0.1
41.0	0.00	0.0
41.9	0.00	0.0
42.1	0.00	0.0
43.0	0.00	0.0
45.7	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
98.1	1.00	0.03	0.70	0.11	10.9
98.1	1.00	0.06	0.05	0.01	1.2
98.1	1.00	0.05	0.05	0.01	1.1
98.1	1.00	0.02	0.05	0.01	0.6
49.0	1.00	0.15	0.05	0.02	0.9
49.0	1.00	0.12	0.05	0.02	0.9
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.15	0.05	0.02	0.9
49.0	1.00	0.21	0.05	0.02	1.1
49.0	1.00	0.23	0.05	0.02	1.2
49.0	1.00	0.23	0.05	0.02	1.2
49.0	1.00	0.21	0.05	0.02	1.1
49.0	1.00	0.19	0.05	0.02	1.1
49.0	1.00	0.19	0.05	0.02	1.1
49.0	1.00	0.22	0.05	0.02	1.1
49.0	1.00	0.25	0.10	0.05	2.4
49.0	1.00	0.27	0.10	0.05	2.5
49.0	1.00	0.27	0.10	0.05	2.6
49.0	1.00	0.27	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.26	0.10	0.05	2.5
49.0	1.00	0.19	0.10	0.04	2.2
49.0	1.00	0.12	0.10	0.04	1.7
49.0	1.00	0.09	0.10	0.03	1.5
49.0	1.00	0.07	0.10	0.03	1.3
49.0	1.00	0.06	0.10	0.02	1.2
49.0	1.00	0.04	0.10	0.02	1.0
49.0	1.00	0.04	0.10	0.02	1.0
49.0	1.00	0.06	0.10	0.03	1.2
49.0	1.00	0.08	0.10	0.03	1.4
49.0	1.00	0.08	0.10	0.03	1.4
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.14	0.05	0.02	0.9
49.0	1.00	0.11	0.05	0.02	0.8
49.0	1.00	0.08	0.05	0.01	0.7
49.0	1.00	0.10	0.05	0.02	0.8
49.0	1.00	0.11	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.12	0.05	0.02	0.8
49.0	1.00	0.10	0.05	0.02	0.8
39.2	1.00	0.07	0.05	0.01	0.5
58.9	1.00	0.05	0.05	0.01	0.6
196.2	1.00	0.01	0.05	0.01	1.0
0.0	1.00	0.00	0.05	0.00	0.0
196.2	1.00	0.05	1.00	0.21	41.6
196.2	1.00	0.07	1.00	0.27	52.0
196.2	1.00	0.07	1.00	0.27	52.0
196.2	1.00	0.07	0.50	0.13	26.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 3335				Total Weighted Usable Area:	238

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 4 - Glide Reach
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	3.4	4.5	0.1	0.0	3.9
2.0	4.5	5.6	0.2	0.1	5.0
3.0	5.6	6.7	0.4	0.1	6.2
4.0	6.7	7.8	0.2	0.1	7.3
5.0	7.8	9.0	0.3	0.1	8.4
6.0	9.0	10.1	0.6	0.1	9.5
7.0	10.1	11.2	0.8	0.2	10.6
8.0	11.2	12.3	0.8	0.2	11.7
9.0	12.3	13.4	1.1	0.3	12.9
10.0	13.4	14.5	1.3	0.2	14.0
11.0	14.5	15.7	1.3	0.2	15.1
12.0	15.7	16.8	1.0	0.1	16.2
13.0	16.8	17.9	0.5	0.1	17.3
14.0	17.9	19.0	0.7	0.2	18.5
15.0	19.0	20.1	0.6	0.2	19.6
16.0	20.1	21.3	0.4	0.2	20.7
17.0	21.3	22.4	0.2	0.1	21.8
18.0	22.4	23.5	0.2	0.1	22.9
19.0	23.5	24.6	0.1	0.1	24.1
20.0	24.6	25.7			25.2
21.0	25.7	26.9			26.3
22.0	26.9	28.0			27.4
23.0	28.0	29.1	0.0	0.0	28.5
24.0	29.1	30.2	0.0	0.0	29.6
25.0	30.2	31.3			30.8
26.0	31.3	32.4	0.0	0.0	31.9

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	150.46
0.5	9	
0.9	9	
1.2	9	
2.0	9	
3.0	8	
4.0	8	
5.1	9	
5.5	9	
6.0	9	
6.5	9	
7.0	9	
7.5	0	
8.0	0	
8.5	0	
9.0	0	
9.5	0	
10.0	0	
10.5	0	
11.0	0	
11.5	0	
12.0	0	
12.5	0	
13.0	0	
13.5	0	
14.0	0	
14.5	0	
15.0	0	
15.5	0	
16.0	0	
16.5	10	
17.0	10	
17.5	10	
18.2	10	
18.5	10	
19.0	10	
19.5	10	
20.0	10	
20.6	10	
21.0	10	
21.5	0	
22.0	0	
22.5	0	
23.0	0	
24.0	0	
25.0	0	
26.0	0	
27.0	8	
28.0	8	
29.0	8	
30.0	8	
31.0	8	
32.0	8	
33.0	8	
34.0	8	
35.0	8	
36.0	8	
36.9	8	
43.0	8	
44.0	8	
46.6	8	
47.0	8	
48.1	8	

Table 3
Velocity Suitability Index

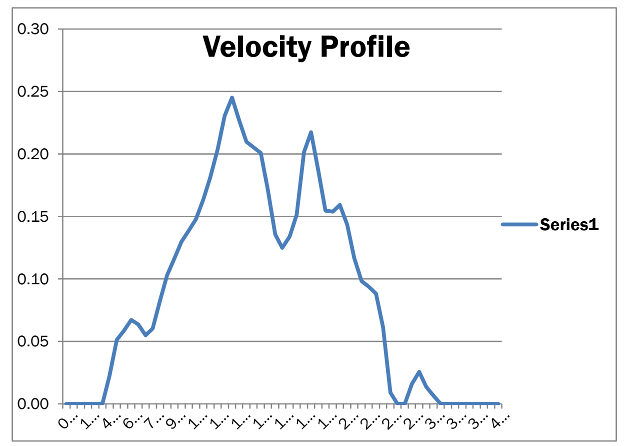
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.1
1.0	1.0
2.0	0.7
3.0	1.0
4.0	1.0
5.0	1.0
6.0	0.1
7.0	0.3
8.0	0.4
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.5	0.00	0.0
0.9	0.00	0.0
1.2	0.00	0.0
2.0	0.00	0.0
3.0	0.00	0.0
4.0	0.02	0.1
5.1	0.05	0.2
5.5	0.06	0.3
6.0	0.07	0.4
6.5	0.06	0.3
7.0	0.05	0.2
7.5	0.06	0.2
8.0	0.08	0.3
8.5	0.10	0.3
9.0	0.12	0.5
9.5	0.13	0.6
10.0	0.14	0.7
10.5	0.15	0.8
11.0	0.16	0.8
11.5	0.18	0.8
12.0	0.20	0.9
12.5	0.23	1.0
13.0	0.25	1.2
13.5	0.23	1.2
14.0	0.21	1.3
14.5	0.21	1.3
15.0	0.20	1.3
15.5	0.17	1.1
16.0	0.14	1.0
16.5	0.13	0.8
17.0	0.13	0.7
17.5	0.15	0.6
18.2	0.20	0.7
18.5	0.22	0.7
19.0	0.19	0.7
19.5	0.15	0.6
20.0	0.15	0.5
20.6	0.16	0.4
21.0	0.14	0.4
21.5	0.12	0.3
22.0	0.10	0.2
22.5	0.09	0.2
23.0	0.09	0.2
24.0	0.06	0.1
25.0	0.01	0.0
26.0	0.00	0.0
27.0	0.00	0.0
28.0	0.02	0.0
29.0	0.03	0.0
30.0	0.01	0.0
31.0	0.01	0.0
32.0	0.00	0.0
33.0	0.00	0.0
34.0	0.00	0.0
35.0	0.00	0.0
36.0	0.00	0.0
36.9	0.00	0.0
43.0	0.00	0.0
44.0	0.00	0.0
46.6	0.00	0.0
47.0	0.00	0.0
48.1	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
165.5	1.00	0.04	0.50	0.10	16.6
60.2	1.00	0.15	0.50	0.19	11.5
75.2	1.00	0.18	0.50	0.21	15.9
75.2	1.00	0.23	0.50	0.24	17.9
75.2	1.00	0.20	0.50	0.22	16.8
75.2	1.00	0.15	0.05	0.02	1.4
75.2	1.00	0.13	0.05	0.02	1.4
75.2	1.00	0.16	0.05	0.02	1.5
75.2	1.00	0.21	0.05	0.02	1.7
75.2	1.00	0.30	0.05	0.03	2.1
75.2	1.00	0.40	0.05	0.03	2.4
75.2	1.00	0.46	0.05	0.03	2.6
75.2	1.00	0.53	0.05	0.04	2.7
75.2	1.00	0.55	0.05	0.04	2.8
75.2	1.00	0.54	0.05	0.04	2.8
75.2	1.00	0.59	0.05	0.04	2.9
75.2	1.00	0.67	0.05	0.04	3.1
75.2	1.00	0.76	0.05	0.04	3.3
75.2	1.00	0.81	0.05	0.05	3.4
75.2	1.00	0.86	0.05	0.05	3.5
75.2	1.00	0.85	0.05	0.05	3.5
75.2	1.00	0.84	0.05	0.05	3.4
75.2	1.00	0.76	0.05	0.04	3.3
75.2	1.00	0.67	0.10	0.08	6.1
75.2	1.00	0.55	0.10	0.07	5.6
75.2	1.00	0.42	0.10	0.07	4.9
105.3	1.00	0.36	0.10	0.06	6.3
45.1	1.00	0.44	0.10	0.07	3.0
75.2	1.00	0.48	0.10	0.07	5.2
75.2	1.00	0.44	0.10	0.07	5.0
75.2	1.00	0.40	0.10	0.06	4.7
90.3	1.00	0.34	0.10	0.06	5.3
60.2	1.00	0.27	0.10	0.05	3.1
75.2	1.00	0.22	0.05	0.02	1.8
75.2	1.00	0.15	0.05	0.02	1.5
75.2	1.00	0.11	0.05	0.02	1.3
75.2	1.00	0.10	0.05	0.02	1.2
150.5	1.00	0.08	0.05	0.01	2.2
150.5	1.00	0.03	0.05	0.01	1.3
150.5	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
150.5	1.00	0.01	0.40	0.03	4.3
150.5	1.00	0.01	0.40	0.03	4.3
150.5	1.00	0.00	0.40	0.00	0.0
150.5	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.40	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 3912				Total Weighted Usable Area:	193

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 6 - Pool
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	1.8	2.7	0.2	0.0	2.2
2.0	2.7	3.6	0.6	0.0	3.1
3.0	3.6	4.5	0.7	0.0	4.0
4.0	4.5	5.4	0.7	0.0	4.9
5.0	5.4	6.3	0.9	0.0	5.8
6.0	6.3	7.2	1.1	0.0	6.7
7.0	7.2	8.1	1.1	0.0	7.6
8.0	8.1	9.0	1.1	0.1	8.5
9.0	9.0	9.9	1.1	0.1	9.4
10.0	9.9	10.8	1.1	0.1	10.3
11.0	10.8	11.7	1.1	0.1	11.2
12.0	11.7	12.6	1.1	0.1	12.1
13.0	12.6	13.5	1.0	0.1	13.0
14.0	13.5	14.4	1.0	0.1	13.9
15.0	14.4	15.3	1.0	0.1	14.8
16.0	15.3	16.2	1.0	0.1	15.7
17.0	16.2	17.1	1.0	0.1	16.6
18.0	17.1	18.0	1.3	0.1	17.5
19.0	18.0	18.9	1.5	0.1	18.4
20.0	18.9	19.8	1.7	0.1	19.3
21.0	19.8	20.7	1.9	0.1	20.2
22.0	20.7	21.5	2.1	0.1	21.1
23.0	21.5	22.4	2.1	0.1	22.0
24.0	22.4	23.3	2.0	0.1	22.9
25.0	23.3	24.2	1.9	0.1	23.8
26.0	24.2	25.1	1.5	0.1	24.7
27.0	25.1	26.0	1.1	0.1	25.6
28.0	26.0	26.9	0.8	0.1	26.5
29.0	26.9	27.8	0.6	0.0	27.4
30.0	27.8	28.7	0.4	0.0	28.3
31.0	28.7	29.6	0.3	0.0	29.2
32.0	29.6	30.5	0.2	0.0	30.1
33.0	30.5	31.4	0.1	0.0	31.0

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	39.06
0.6	9	
1.1	9	
1.2	9	
1.7	9	
2.0	9	
3.5	5	
5.0	5	
6.5	5	
8.0	10	
9.5	10	
11.0	10	
12.5	10	
14.0	10	
15.5	10	
17.0	10	
18.5	10	
20.0	0	
21.5	0	
23.0	0	
24.5	0	
26.0	0	
27.5	1	
29.0	1	
30.5	1	
31.3	1	
33.5	9	
35.2	9	
35.8	9	
36.0	9	
38.6	9	

Table 3
Velocity Suitability Index

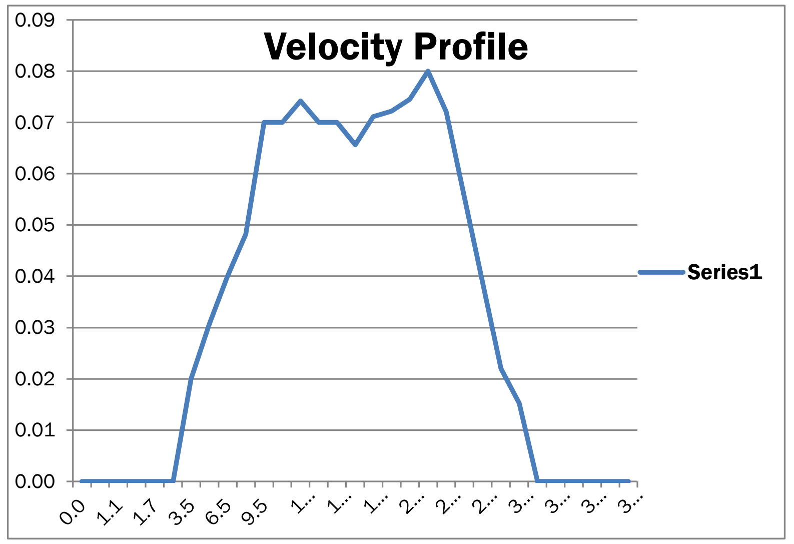
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.1
1.0	1.0
2.0	0.7
3.0	1.0
4.0	1.0
5.0	1.0
6.0	0.1
7.0	0.3
8.0	0.4
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
0.6	0.00	0.0
1.1	0.00	0.0
1.2	0.00	0.0
1.7	0.00	0.0
2.0	0.00	0.0
3.5	0.02	0.6
5.0	0.03	0.7
6.5	0.04	1.0
8.0	0.05	1.1
9.5	0.07	1.1
11.0	0.07	1.1
12.5	0.07	1.0
14.0	0.07	1.0
15.5	0.07	1.0
17.0	0.07	1.1
18.5	0.07	1.6
20.0	0.07	1.9
21.5	0.07	2.1
23.0	0.08	2.0
24.5	0.07	1.6
26.0	0.06	1.0
27.5	0.04	0.6
29.0	0.02	0.3
30.5	0.02	0.1
31.3	0.00	0.0
33.5	0.00	0.0
35.2	0.00	0.0
35.8	0.00	0.0
36.0	0.00	0.0
38.6	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
58.6	1.00	0.42	1.00	0.65	37.8
58.6	1.00	0.46	1.00	0.68	39.6
58.6	1.00	0.66	0.10	0.08	4.8
58.6	1.00	0.71	0.10	0.08	4.9
58.6	1.00	0.75	0.10	0.09	5.1
58.6	1.00	0.70	0.10	0.08	4.9
58.6	1.00	0.69	0.10	0.08	4.9
58.6	1.00	0.63	0.10	0.08	4.7
58.6	1.00	0.63	0.10	0.08	4.7
58.6	1.00	0.76	0.10	0.09	5.1
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	0.63	1.00	0.79	46.4
58.6	1.00	0.36	1.00	0.60	35.3
58.6	1.00	0.17	1.00	0.41	23.8
31.2	1.00	0.07	1.00	0.27	8.3
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 1086				Total Weighted Usable Area:	245

Step 3

Notes:

*Spreadsheet is for Winter Rearing WUA Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis New Transect - Lower Pool
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	1.7	2.6	0.2	0.0	2.2
2.0	2.6	3.5	0.6	0.0	3.0
3.0	3.5	4.4	0.8	0.0	3.9
4.0	4.4	5.2	1.1	0.0	4.8
5.0	5.2	6.1	1.4	0.0	5.7
6.0	6.1	7.0	1.4	0.0	6.5
7.0	7.0	7.8	1.5	0.0	7.4
8.0	7.8	8.7	1.6	0.0	8.3
9.0	8.7	9.6	1.5	0.0	9.1
10.0	9.6	10.4	1.5	0.0	10.0
11.0	10.4	11.3	1.5	0.0	10.9
12.0	11.3	12.2	1.4	0.1	11.7
13.0	12.2	13.1	1.5	0.1	12.6
14.0	13.1	13.9	1.5	0.1	13.5
15.0	13.9	14.8	1.6	0.1	14.4
16.0	14.8	15.7	1.9	0.1	15.2
17.0	15.7	16.5	2.1	0.1	16.1
18.0	16.5	17.4	2.4	0.1	17.0
19.0	17.4	18.3	2.7	0.1	17.8
20.0	18.3	19.1	2.8	0.1	18.7
21.0	19.1	20.0	3.0	0.1	19.6
22.0	20.0	20.9	3.0	0.1	20.4
23.0	20.9	21.7	3.0	0.1	21.3
24.0	21.7	22.6	3.1	0.1	22.2
25.0	22.6	23.5	3.1	0.1	23.0
26.0	23.5	24.4	3.1	0.1	23.9
27.0	24.4	25.2	2.9	0.0	24.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
1.2	9	39.06
2.0	3	
2.9	3	
3.7	3	
4.5	3	
5.3	3	
6.1	3	
6.9	3	
7.8	3	
8.6	3	
9.4	0	
10.2	0	
11.0	0	
11.8	0	
12.7	0	
13.5	10	
14.3	10	
15.1	10	
15.9	10	
16.7	10	
17.6	10	
18.4	10	
19.2	10	
20.0	10	
20.8	2	
21.6	2	
22.5	4	
23.3	4	
36.0	4	

Table 3
Velocity Suitability Index

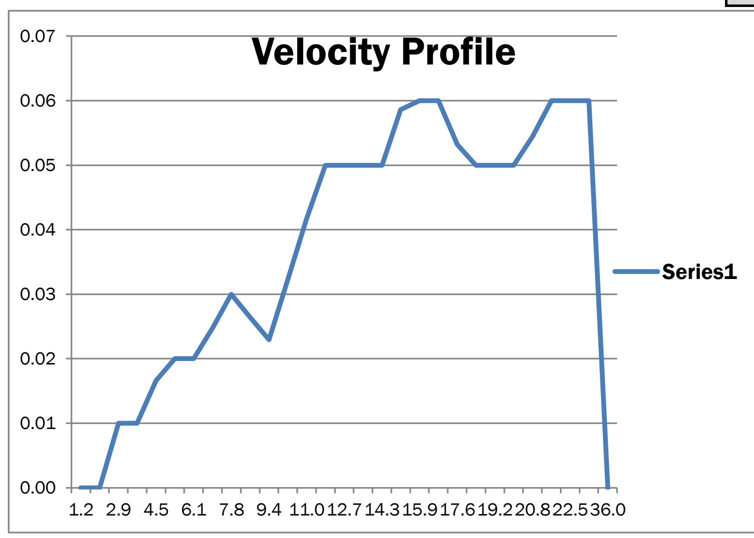
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.50
10.0	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
1.2	0.00	0.0
2.0	0.00	0.0
2.9	0.01	0.5
3.7	0.01	0.8
4.5	0.02	1.0
5.3	0.02	1.3
6.1	0.02	1.4
6.9	0.02	1.5
7.8	0.03	1.5
8.6	0.03	1.6
9.4	0.02	1.5
10.2	0.03	1.5
11.0	0.04	1.5
11.8	0.05	1.4
12.7	0.05	1.5
13.5	0.05	1.5
14.3	0.05	1.6
15.1	0.06	1.8
15.9	0.06	2.0
16.7	0.06	2.3
17.6	0.05	2.6
18.4	0.05	2.8
19.2	0.05	2.9
20.0	0.05	3.0
20.8	0.05	3.0
21.6	0.06	3.0
22.5	0.06	3.1
23.3	0.06	3.1
36.0	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
31.8	1.00	0.35	1.00	0.59	18.8
31.8	1.00	0.49	1.00	0.70	22.3
32.0	1.00	0.65	1.00	0.81	25.9
31.8	1.00	0.84	1.00	0.92	29.2
31.8	1.00	0.94	1.00	0.97	30.8
32.0	1.00	0.98	1.00	0.99	31.7
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	0.05	0.05	1.6
31.8	1.00	0.99	0.05	0.05	1.6
32.0	1.00	0.97	0.05	0.05	1.6
31.8	1.00	0.96	0.05	0.05	1.6
31.8	1.00	0.98	0.05	0.05	1.6
32.0	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
32.0	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
32.0	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
32.0	1.00	1.00	0.70	0.70	22.4
31.8	1.00	1.00	0.70	0.70	22.3
31.8	1.00	1.00	1.00	1.00	31.8
497.3	1.00	1.00	1.00	1.00	497.3
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 1295				Total Weighted Usable Area:	833

Step 3

Notes:

*Spreadsheet is for Winter Rearing Weighted Usable Area Calculations Only

user input

user criterion

Weighted Usable Area Analysis New Transect - Upper Pool
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	0.8	1.6	0.1	0.0	1.2
2.0	1.6	2.5	0.6	0.0	2.0
3.0	2.5	3.3	1.4	0.0	2.9
4.0	3.3	4.1	2.1	0.1	3.7
5.0	4.1	4.9	2.2	0.1	4.5
6.0	4.9	5.7	2.4	0.1	5.3
7.0	5.7	6.5	2.4	0.1	6.1
8.0	6.5	7.4	2.3	0.1	6.9
9.0	7.4	8.2	2.2	0.1	7.8
10.0	8.2	9.0	2.2	0.0	8.6
11.0	9.0	9.8	2.1	0.0	9.4
12.0	9.8	10.6	2.1	0.0	10.2
13.0	10.6	11.4	2.1	0.0	11.0
14.0	11.4	12.3	2.1	0.0	11.8
15.0	12.3	13.1	2.1	0.0	12.7
16.0	13.1	13.9	2.1	0.0	13.5
17.0	13.9	14.7	2.2	0.0	14.3
18.0	14.7	15.5	2.5	0.0	15.1
19.0	15.5	16.3	2.7	0.0	15.9
20.0	16.3	17.2	2.8	0.0	16.7
21.0	17.2	18.0	3.0	0.0	17.6
22.0	18.0	18.8	3.1	0.0	18.4
23.0	18.8	19.6	3.1	0.0	19.2
24.0	19.6	20.4	3.2	0.1	20.0
25.0	20.4	21.2	3.2	0.1	20.8
26.0	21.2	22.1	3.1	0.1	21.6
27.0	22.1	22.9	2.9	0.1	22.5
28.0	22.9	23.7	2.4	0.0	23.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
1.2	9	39.06
2.0	3	
2.9	3	
3.7	3	
4.5	3	
5.3	3	
6.1	3	
6.9	3	
7.8	3	
8.6	3	
9.4	3	
10.2	0	
11.0	0	
11.8	0	
12.7	0	
13.5	0	
14.3	10	
15.1	10	
15.9	10	
16.7	10	
17.6	10	
18.4	2	
19.2	2	
20.0	4	
20.8	4	
21.6	4	
22.5	4	
23.3	4	
36.0	4	

Table 3
Velocity Suitability Index

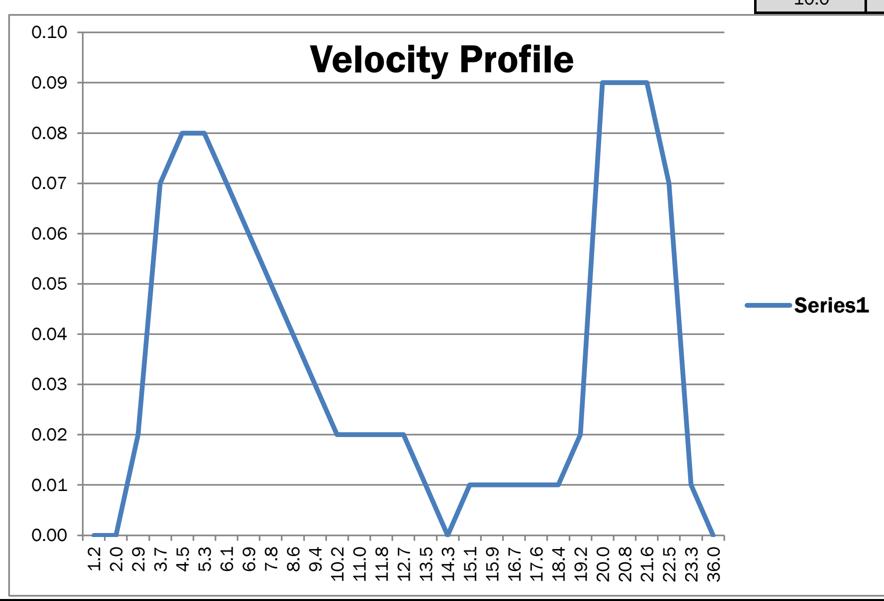
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.50
10.0	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
1.2	0.00	0.0
2.0	0.00	0.6
2.9	0.02	1.4
3.7	0.07	2.1
4.5	0.08	2.2
5.3	0.08	2.4
6.1	0.07	2.4
6.9	0.06	2.3
7.8	0.05	2.2
8.6	0.04	2.2
9.4	0.03	2.1
10.2	0.02	2.1
11.0	0.02	2.1
11.8	0.02	2.1
12.7	0.02	2.1
13.5	0.01	2.1
14.3	0.00	2.2
15.1	0.01	2.5
15.9	0.01	2.7
16.7	0.01	2.8
17.6	0.01	3.0
18.4	0.01	3.1
19.2	0.02	3.1
20.0	0.09	3.2
20.8	0.09	3.2
21.6	0.09	3.1
22.5	0.07	2.9
23.3	0.01	2.4
36.0	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
32.0	1.00	0.36	1.00	0.60	19.1
31.8	1.00	0.92	1.00	0.96	30.5
31.8	1.00	1.00	1.00	1.00	31.8
32.0	1.00	1.00	1.00	1.00	32.0
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	1.00	1.00	31.8
32.0	1.00	1.00	1.00	1.00	32.0
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	0.05	0.05	1.6
32.0	1.00	1.00	0.05	0.05	1.6
31.8	1.00	1.00	0.05	0.05	1.6
31.8	1.00	1.00	0.05	0.05	1.6
32.0	1.00	1.00	0.05	0.05	1.6
31.8	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
32.0	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
31.8	1.00	1.00	0.10	0.10	3.2
32.0	1.00	1.00	0.70	0.70	22.4
31.8	1.00	1.00	0.70	0.70	22.3
31.8	1.00	1.00	1.00	1.00	31.8
32.0	1.00	1.00	1.00	1.00	32.0
31.8	1.00	1.00	1.00	1.00	31.8
31.8	1.00	1.00	1.00	1.00	31.8
497.3	1.00	1.00	1.00	1.00	497.3
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 1327				Total Weighted Usable Area:	998

Step 3

Notes:

*Spreadsheet is for Winter Rearing Weighted Usable Area Calculations Only

user input

user criterion

Weighted Usable Area Analysis Transect 7 - Pool
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Pt. (ft)
1.0	0.8	1.6	0.2	0.0	1.2
2.0	1.6	2.4	0.8	0.0	2.0
3.0	2.4	3.2	1.9	0.0	2.8
4.0	3.2	4.0	2.3	0.0	3.6
5.0	4.0	4.8	2.5	0.0	4.4
6.0	4.8	5.6	2.5	0.0	5.2
7.0	5.6	6.4	2.4	0.0	6.0
8.0	6.4	7.2	2.3	0.1	6.8
9.0	7.2	8.1	2.3	0.1	7.6
10.0	8.1	8.9	2.3	0.1	8.5
11.0	8.9	9.7	2.3	0.1	9.3
12.0	9.7	10.5	2.3	0.1	10.1
13.0	10.5	11.3	2.3	0.1	10.9
14.0	11.3	12.1	2.3	0.1	11.7
15.0	12.1	12.9	2.2	0.1	12.5
16.0	12.9	13.7	2.2	0.1	13.3
17.0	13.7	14.5	2.1	0.0	14.1
18.0	14.5	15.3	2.1	0.0	14.9
19.0	15.3	16.1	2.1	0.0	15.7
20.0	16.1	16.9	2.0	0.0	16.5
21.0	16.9	17.7	1.9	0.0	17.3
22.0	17.7	18.5	1.8	0.0	18.1
23.0	18.5	19.3	1.6	0.0	18.9
24.0	19.3	20.1	1.6	0.0	19.7
25.0	20.1	20.9	1.5	0.0	20.5
26.0	20.9	21.7	1.5	0.1	21.3
27.0	21.7	22.5	1.5	0.1	22.1
28.0	22.5	23.3	1.4	0.1	22.9
29.0	23.3	24.1	1.2	0.1	23.7
30.0	24.1	24.9	1.2	0.1	24.5
31.0	24.9	25.8	1.3	0.0	25.3
32.0	25.8	26.6	1.4	0.0	26.2
33.0	26.6	27.4	1.4	0.0	27.0
34.0	27.4	28.2	1.3	0.0	27.8
35.0	28.2	29.0	1.1	0.0	28.6
36.0	29.0	29.8	0.8	0.0	29.4
37.0	29.8	30.6	0.5	0.0	30.2
38.0	30.6	31.4	0.2	0.0	31.0
39.0	31.4	32.2	0.0	0.0	31.8

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	39.06
1.0	3	
1.1	3	
1.5	3	
3.0	3	
4.5	3	
6.0	3	
7.5	3	
9.0	3	
10.5	0	
12.0	0	
13.5	0	
15.0	10	
16.5	10	
18.0	10	
19.5	10	
21.0	10	
22.5	10	
24.0	10	
25.5	10	
27.0	10	
28.5	2	
30.0	2	
31.9	2	
32.7	9	
33.4	9	
33.7	9	
34.0	9	
34.6	9	

Table 3
Velocity Suitability Index

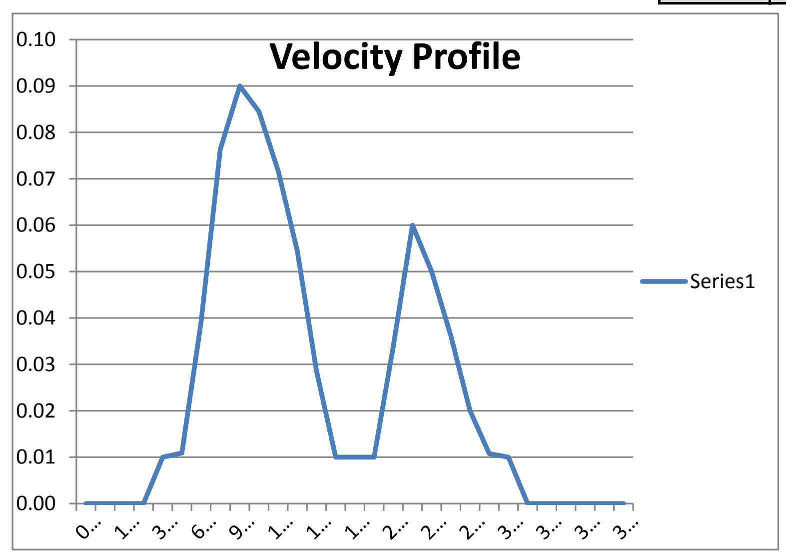
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.0
0.5	1.0
1.0	0.6
1.5	0.1
2.0	0.1
3.5	0.0
100.0	0.0

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.0
0.1	0.1
1.5	1.0
3.5	1.0
4.0	0.5
5.5	0.2
6.0	0.0
100.0	0.0

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.1
1.0	1.0
2.0	0.7
3.0	1.0
4.0	1.0
5.0	1.0
6.0	0.1
7.0	0.3
8.0	0.4
9.0	0.5
10.0	0.1



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.0
1.0	0.00	0.0
1.1	0.00	0.0
1.5	0.00	0.4
3.0	0.01	2.0
4.5	0.01	2.5
6.0	0.04	2.4
7.5	0.08	2.3
9.0	0.09	2.3
10.5	0.08	2.3
12.0	0.07	2.2
13.5	0.05	2.2
15.0	0.03	2.1
16.5	0.01	2.0
18.0	0.01	1.8
19.5	0.01	1.6
21.0	0.03	1.5
22.5	0.06	1.4
24.0	0.05	1.2
25.5	0.04	1.3
27.0	0.02	1.3
28.5	0.01	1.1
30.0	0.01	0.6
31.9	0.00	0.0
32.7	0.00	0.0
33.4	0.00	0.0
33.7	0.00	0.0
34.0	0.00	0.0
34.6	0.00	0.0

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability Index	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
58.6	1.00	0.25	1.00	0.50	29.5
58.6	1.00	1.00	1.00	1.00	58.6
58.6	1.00	1.00	1.00	1.00	58.6
58.6	1.00	1.00	1.00	1.00	58.6
58.6	1.00	1.00	1.00	1.00	58.6
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.05	0.05	2.9
58.6	1.00	1.00	0.10	0.10	5.9
58.6	1.00	1.00	0.10	0.10	5.9
58.6	1.00	1.00	0.10	0.10	5.9
58.6	1.00	1.00	0.10	0.10	5.9
58.6	1.00	1.00	0.10	0.10	5.9
58.6	1.00	0.98	0.10	0.10	5.8
58.6	1.00	0.94	0.10	0.10	5.7
58.6	1.00	0.81	0.10	0.09	5.3
58.6	1.00	0.88	0.10	0.09	5.5
58.6	1.00	0.89	0.70	0.66	38.7
58.6	1.00	0.74	0.70	0.60	35.3
74.2	1.00	0.36	0.70	0.42	31.3
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
Total Area: 1187				Total Weighted Usable Area:	430

Step 3

Notes:

*Spreadsheet is for Winter Rearing Weighted Usable Area Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 8 - Riffle
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	2.1	3.2	0.1	0.0	2.6
2.0	3.2	4.2	0.3	0.0	3.7
3.0	4.2	5.3	0.5	0.1	4.7
4.0	5.3	6.3	0.7	0.1	5.8
5.0	6.3	7.4	0.8	0.1	6.8
6.0	7.4	8.4	0.9	0.1	7.9
7.0	8.4	9.5	0.9	0.1	9.0
8.0	9.5	10.5	0.8	0.1	10.0
9.0	10.5	11.6	0.8	0.1	11.1
10.0	11.6	12.6	0.9	0.1	12.1
11.0	12.6	13.7	0.9	0.1	13.2
12.0	13.7	14.8	0.8	0.2	14.2
13.0	14.8	15.8	0.7	0.2	15.3
14.0	15.8	16.9	0.7	0.2	16.3
15.0	16.9	17.9	0.7	0.2	17.4
16.0	17.9	19.0	0.7	0.2	18.4
17.0	19.0	20.0	0.7	0.2	19.5
18.0	20.0	21.1	0.5	0.2	20.5
19.0	21.1	22.1	0.4	0.2	21.6
20.0	22.1	23.2	0.4	0.2	22.7
21.0	23.2	24.2	0.3	0.2	23.7
22.0	24.2	25.3	0.3	0.2	24.8
23.0	25.3	26.3	0.4	0.2	25.8
24.0	26.3	27.4	0.4	0.3	26.9
25.0	27.4	28.4	0.2	0.1	27.9
26.0	28.4	29.5			29.0
27.0	29.5	30.6	0.1	0.1	30.0
28.0	30.6	31.6	0.2	0.2	31.1
29.0	31.6	32.7	0.2	0.2	32.1
30.0	32.7	33.7	0.1	0.1	33.2
31.0	33.7	34.8	0.1	0.1	34.2
32.0	34.8	35.8	0.0	0.1	35.3

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	98.09
0.2	9	
0.6	9	
1.5	9	
2.2	2	
3.0	5	
4.5	5	
6.0	5	
7.5	5	
9.0	5	
10.5	5	
12.0	0	
13.5	0	
15.0	0	
16.5	0	
18.0	0	
19.5	10	
21.0	10	
22.5	10	
24.0	10	
25.5	10	
27.0	0	
28.5	0	
30.0	0	
31.5	0	
33.0	0	
34.5	0	
36.0	0	
37.5	0	
39.0	0	
41.0	2	
43.7	10	
43.8	10	
45.3	9	

Table 3
Velocity Suitability Index

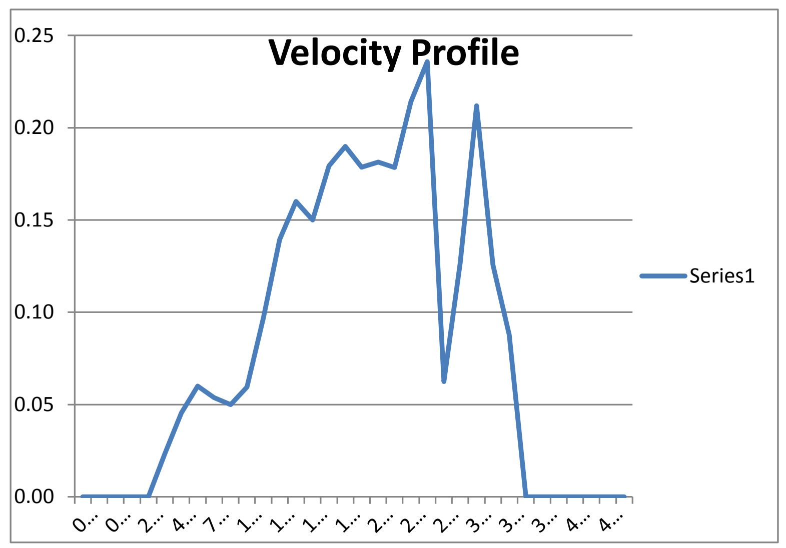
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.50
10.0	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
0.2	0.00	0.00
0.6	0.00	0.00
1.5	0.00	0.00
2.2	0.00	0.00
3.0	0.02	0.17
4.5	0.05	0.46
6.0	0.06	0.73
7.5	0.05	0.86
9.0	0.05	0.94
10.5	0.06	0.83
12.0	0.10	0.93
13.5	0.14	0.86
15.0	0.16	0.76
16.5	0.15	0.69
18.0	0.18	0.73
19.5	0.19	0.65
21.0	0.18	0.48
22.5	0.18	0.36
24.0	0.18	0.29
25.5	0.21	0.36
27.0	0.24	0.39
28.5	0.06	0.07
30.0	0.13	0.07
31.5	0.21	0.19
33.0	0.13	0.09
34.5	0.09	0.05
36.0	0.00	0.00
37.5	0.00	0.00
39.0	0.00	0.00
41.0	0.00	0.00
43.7	0.00	0.00
43.8	0.00	0.00
45.3	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
147.1	1.00	0.09	1.00	0.30	44.3
147.1	1.00	0.29	1.00	0.54	79.8
147.1	1.00	0.48	1.00	0.69	101.7
147.1	1.00	0.57	1.00	0.75	110.7
147.1	1.00	0.61	1.00	0.78	115.2
147.1	1.00	0.55	1.00	0.74	108.7
147.1	1.00	0.61	0.05	0.04	5.7
147.1	1.00	0.56	0.05	0.04	5.5
147.1	1.00	0.49	0.05	0.04	5.2
147.1	1.00	0.44	0.05	0.03	4.9
147.1	1.00	0.47	0.05	0.03	5.0
147.1	1.00	0.42	0.10	0.06	9.5
147.1	1.00	0.30	0.10	0.05	8.1
147.1	1.00	0.22	0.10	0.05	6.9
147.1	1.00	0.17	0.10	0.04	6.1
147.1	1.00	0.22	0.10	0.05	6.9
147.1	1.00	0.24	0.05	0.02	3.6
147.1	1.00	0.03	0.05	0.01	1.3
147.1	1.00	0.03	0.05	0.01	1.3
147.1	1.00	0.11	0.05	0.02	2.5
147.1	1.00	0.04	0.05	0.01	1.5
147.1	1.00	0.03	0.05	0.01	1.2
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.70	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.10	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
Total Area: 3237				Total Weighted Usable Area:	635

Step 3

Notes:

*Spreadsheet is for Winter Rearing Weighted Usable Area Calculations Only

user input

user criterion

Weighted Usable Area Analysis Transect 9 - Riffle
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	5.3	6.0	0.0	0.0	5.7
2.0	6.0	6.7	0.0	0.0	6.3
3.0	6.7	7.3	0.0	0.1	7.0
4.0	7.3	8.0	0.1	0.2	7.7
5.0	8.0	8.7	0.1	0.4	8.3
6.0	8.7	9.3	0.2	1.9	9.0
7.0	9.3	10.0	0.2	2.4	9.6
8.0	10.0	10.6	0.1	2.1	10.3
9.0	10.6	11.3	0.1	1.8	11.0
10.0	11.3	12.0	0.2	2.7	11.6
11.0	12.0	12.6	0.3	3.0	12.3
12.0	12.6	13.3	0.2	1.3	13.0
13.0	13.3	14.0	0.1	1.3	13.6
14.0	14.0	14.6	0.0	0.7	14.3
15.0	14.6	15.3	0.0	0.6	15.0

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	3.0	98.09
3.0	3.0	
4.0	3.0	
4.7	3.0	
5.0	3.0	
5.5	3.0	
6.0	3.0	
6.5	3.0	
7.0	3.0	
7.5	0.0	
8.0	0.0	
8.5	0.0	
9.0	0.0	
9.5	0.0	
10.0	0.0	
10.5	0.0	
11.0	0.0	
11.5	0.0	
12.0	0.0	
12.5	0.0	
13.0	0.0	
13.5	0.0	
14.0	0.0	
14.5	0.0	
15.0	0.0	
15.5	0.0	
16.0	0.0	
16.5	0.0	
17.0	0.0	
17.5	0.0	
18.3	0.0	
19.0	0.0	
20.0	0.0	
21.0	0.0	
22.0	3.0	
24.5	3.0	
25.2	3.0	
26.8	3.0	
27.5	3.0	
28.6	3.0	

Table 3
Velocity Suitability Index

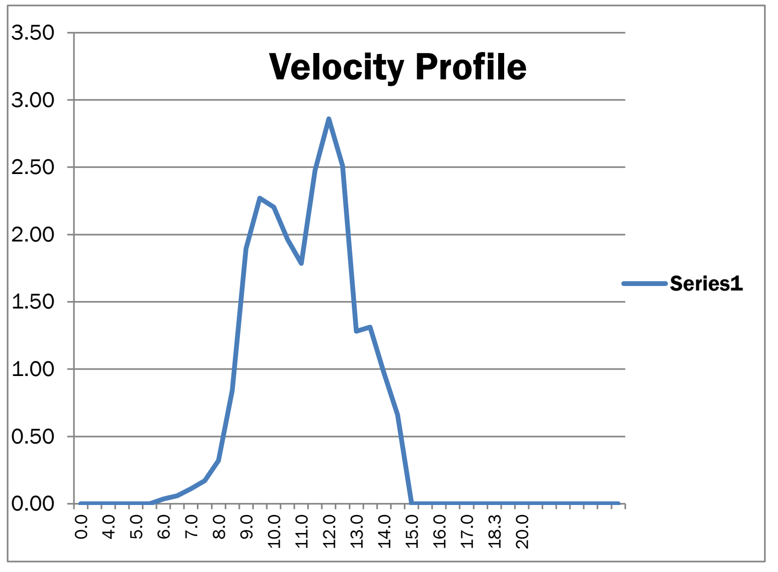
Velocity Suitability Points	
Velocity (ft/s)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.50
10.0	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
3.0	0.00	0.00
4.0	0.00	0.00
4.7	0.00	0.00
5.0	0.00	0.00
5.5	0.00	0.00
6.0	0.04	0.02
6.5	0.06	0.03
7.0	0.11	0.03
7.5	0.17	0.06
8.0	0.32	0.10
8.5	0.84	0.14
9.0	1.90	0.15
9.5	2.27	0.18
10.0	2.20	0.16
10.5	1.96	0.13
11.0	1.78	0.13
11.5	2.48	0.16
12.0	2.86	0.23
12.5	2.51	0.25
13.0	1.28	0.17
13.5	1.31	0.11
14.0	0.97	0.06
14.5	0.66	0.03
15.0	0.00	0.00
15.5	0.00	0.00
16.0	0.00	0.00
16.5	0.00	0.00
17.0	0.00	0.00
17.5	0.00	0.00
18.3	0.00	0.00
19.0	0.00	0.00
20.0	0.00	0.00
21.0	0.00	0.00
22.0	0.00	0.00
24.5	0.00	0.00
25.2	0.00	0.00
26.8	0.00	0.00
27.5	0.00	0.00
28.6	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitabilty Index	Cover Suitability	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
49.0	1.00	0.01	1.00	0.10	4.9
49.0	1.00	0.02	1.00	0.12	6.0
49.0	1.00	0.02	1.00	0.12	6.0
49.0	1.00	0.03	0.05	0.01	0.4
49.0	1.00	0.05	0.05	0.01	0.5
49.0	0.73	0.07	0.05	0.01	0.6
49.0	0.06	0.08	0.05	0.00	0.2
49.0	0.04	0.10	0.05	0.00	0.2
49.0	0.04	0.08	0.05	0.00	0.1
49.0	0.05	0.07	0.05	0.00	0.2
49.0	0.07	0.07	0.05	0.00	0.2
49.0	0.03	0.09	0.05	0.00	0.1
49.0	0.02	0.14	0.05	0.00	0.1
49.0	0.03	0.15	0.05	0.00	0.2
49.0	0.32	0.09	0.05	0.01	0.4
49.0	0.29	0.06	0.05	0.01	0.3
49.0	0.62	0.03	0.05	0.01	0.3
49.0	0.88	0.02	0.05	0.01	0.3
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	0.05	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 883				Total Weighted Usable Area:	21

Step 3

Notes:

*Spreadsheet is for Winter Rearing Weighted Usable Area Calculations Only

user input

user criterion

GeoEngineers

Weighted Usable Area Analysis Transect 10 - Riffle
BARB TYPE JAM Winter Rearing, 2 CFS

Table 1
HEC-RAS Import

Raw HEC-RAS					
Transect Number	Left Station (ft)	Right Station (ft)	Hydraulic Depth (ft)	Velocity (ft/s)	Mid Point (ft)
1.0	9.0	9.9	0.1	0.4	9.4
2.0	9.9	10.8	0.3	0.6	10.3
3.0	10.8	11.7	0.3	0.1	11.2
4.0	11.7	12.6	0.2	0.1	12.1
5.0	12.6	13.5	0.1	0.1	13.0
6.0	13.5	14.4	0.1	0.2	13.9
7.0	14.4	15.3	0.1	0.2	14.8
8.0	15.3	16.2	0.2	0.5	15.7
9.0	16.2	17.1	0.3	0.3	16.6
10.0	17.1	18.0	0.4	0.1	17.5
11.0	18.0	18.9	0.4	0.8	18.4
12.0	18.9	19.8	0.4	0.6	19.3
13.0	19.8	20.7	0.4	0.1	20.2
14.0	20.7	21.5	0.5	0.3	21.1
15.0	21.5	22.4	0.4	0.4	22.0
16.0	22.4	23.3	0.3	0.6	22.9
17.0	23.3	24.2	0.2	0.5	23.8
18.0	24.2	25.1	0.2	0.7	24.7
19.0	25.1	26.0	0.2	0.4	25.6
20.0	26.0	26.9	0.2	0.2	26.5
21.0	26.9	27.8	0.2	0.2	27.4
22.0	27.8	28.7	0.2	0.3	28.3
23.0	28.7	29.6	0.1	0.5	29.2
24.0	29.6	30.5	0.0	0.1	30.1
25.0	30.5	31.4	0.1	0.3	31.0
26.0	31.4	32.3	0.1	0.4	31.9
27.0	32.3	33.2	0.2	0.6	32.8
28.0	33.2	34.1	0.1	0.6	33.7
29.0	34.1	35.0	0.0	0.2	34.6

Step 1

Table 2
Cover Codes from Sutton

User Defined Station, Cover and Weighted Reach Length		
Station (ft)	Cover	Reach Length (ft)
0.0	9	98.09
1.0	9	
2.0	9	
3.0	9	
4.0	9	
4.3	9	
6.0	9	
7.5	9	
9.0	9	
10.5	3	
12.0	3	
13.5	3	
15.0	3	
16.5	3	
18.0	3	
19.5	3	
21.0	0	
22.5	0	
24.0	0	
25.5	0	
27.0	0	
28.5	0	
30.0	0	
31.5	0	
33.0	0	
34.5	0	
36.0	5	
37.0	5	
37.7	5	
38.6	5	

Table 3
Velocity Suitability Index

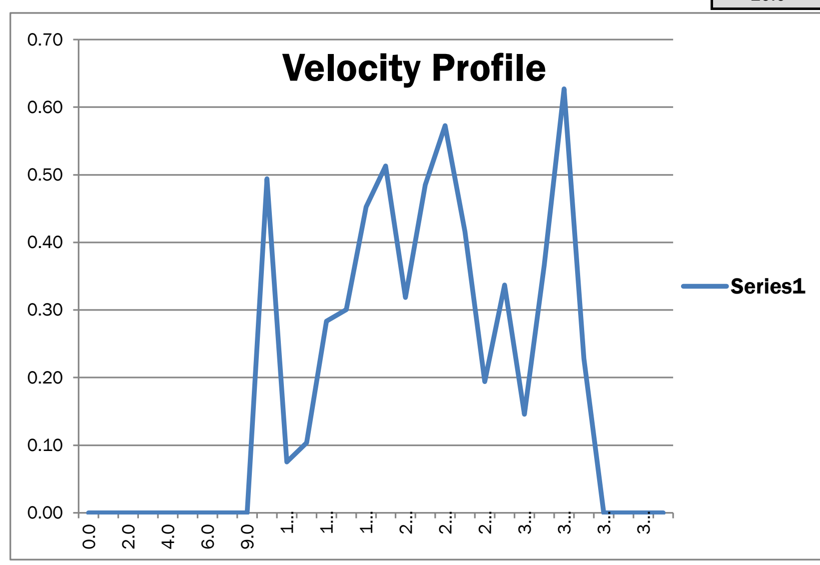
Velocity Suitability Points	
Depth (ft)	Suitability Index
0.0	1.00
0.5	1.00
1.0	0.60
1.5	0.10
2.0	0.05
3.5	0.00
100.0	0.00

Table 4
Depth Suitability Index

Depth Suitability Points	
Depth (ft)	Suitability Index
0.0	0.00
0.1	0.05
1.5	1.00
3.5	1.00
4.0	0.50
5.5	0.20
6.0	0.00
100.0	0.00

Table 5
Cover Suitability Index

Cover Suitability Points	
Code	Suitability Index
0.0	0.05
1.0	1.00
2.0	0.70
3.0	1.00
4.0	1.00
5.0	1.00
6.0	0.05
7.0	0.30
8.0	0.40
9.0	0.50
10.0	0.10



Data References

Table 6
HEC-RAS Interpolation to Match PHABISM Stations

Data Interpolation at Specified Stations		
Station (ft)	Velocity (ft/s)	Depth (ft)
0.0	0.00	0.00
1.0	0.00	0.00
2.0	0.00	0.00
3.0	0.00	0.00
4.0	0.00	0.00
4.3	0.00	0.00
6.0	0.00	0.00
7.5	0.00	0.00
9.0	0.00	0.00
10.5	0.49	0.31
12.0	0.08	0.19
13.5	0.10	0.09
15.0	0.28	0.11
16.5	0.30	0.28
18.0	0.45	0.37
19.5	0.51	0.40
21.0	0.32	0.46
22.5	0.49	0.30
24.0	0.57	0.20
25.5	0.42	0.18
27.0	0.19	0.18
28.5	0.34	0.16
30.0	0.15	0.02
31.5	0.37	0.09
33.0	0.63	0.14
34.5	0.23	0.02
36.0	0.00	0.00
37.0	0.00	0.00
37.7	0.00	0.00
38.6	0.00	0.00

Step 2

Table 7
Weighted Usable Area Calculations per Station and Totaled per Transect

Weighted Usable Area Calculations (Winter Rearing)					
Area (ft^2)	Velocity Suitability Index	Depth Suitability Index	Cover Suitability	Cover Factor	Weighted Usable Area
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
0.0	1.00	0.00	0.50	0.00	0.0
147.1	1.00	0.19	1.00	0.44	64.6
147.1	1.00	0.11	1.00	0.33	49.0
147.1	1.00	0.05	1.00	0.21	31.2
147.1	1.00	0.05	1.00	0.22	32.9
147.1	1.00	0.17	1.00	0.41	59.8
147.1	1.00	0.23	1.00	0.48	70.0
147.1	0.99	0.25	1.00	0.49	72.8
147.1	1.00	0.29	0.05	0.03	3.9
147.1	1.00	0.18	0.05	0.02	3.1
147.1	0.94	0.11	0.05	0.02	2.4
147.1	1.00	0.10	0.05	0.02	2.3
147.1	1.00	0.10	0.05	0.02	2.3
147.1	1.00	0.08	0.05	0.01	2.1
147.1	1.00	0.01	0.05	0.00	0.5
147.1	1.00	0.04	0.05	0.01	1.5
147.1	0.90	0.08	0.05	0.01	1.9
147.1	1.00	0.01	0.05	0.01	0.7
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
0.0	1.00	0.00	1.00	0.00	0.0
Total Area: 2501				Total Weighted Usable Area:	401

Step 3

Notes:

*Spreadsheet is for Winter Rearing Weighted Usable Area Calculations Only

user input

user criterion

GeoEngineers

BARB TYPE JAM
Proposed Mesohabitat Unit Proportions

EXISTING MESHOHABITAT PROPORTIONS				
Mesohabitat	Length (feet)	Proportion	1,000 ft Normalized Length	Count
Pool	225	15.6%	156.3	2
Glide	650	45.1%	451.4	3
Riffle	565	39.2%	392.4	4
Total	875	61%	607.6388889	5

PROPOSED MESHOHABITAT PROPORTIONS (no change to mesohabitat proportions)				
Mesohabitat	Length (feet)	Proportion	1,000 ft Normalized Length	Count
Pool	225	15.6%	156.3	4
Glide	650	45.1%	451.4	3
Riffle	565	39.2%	392.4	4
Total	875	61%	607.6388889	7

PROPOSED REACH LENGTHS		
Transect	Description	Moderate Reach Length (feet)
1.00	Glide	150.46
2.00	Glide	150.46
3.00	Riffle	98.09
4.00	Glide	150.46
5.00	Hydraulic Control	0.00
6.00	Pool	39.06
New Transect Lower	Pool	39.06
New Transect Upper	Pool	39.06
7.00	Pool	39.06
8.00	Riffle	98.09
9.00	Riffle	98.09
10.00	Riffle	98.09
	Total	1,000.00

Sutton (2007)

Table 5 Mesohabitat unit proportions used to weight Rogue PHABSIM transects.

Habitat Type	Length (ft)	Percentage
Emigrant Creek-between Bear Creek and Emigrant Dam		
Pool	225	15.6
Glide	650	45.1
Riffle	565	39.2
Total	1440	100.0

BARB TYPE JAM

Flow Rate: 2 cfs

Winter Rearing Total Weighted Usable Area Calculations

Transect	River Station	River Station Difference	Total Area	Weighted Usable Area
1.00	0	0.00	2,979.17	532.50
2.00	15.5	15.50	2,287.04	130.37
3.00	47	31.50	3,335.07	238.41
4.00	69	22.00	3,912.04	193.05
5.00	95	26.00		
6.00	119.5	24.50	1,085.94	244.79
New Transect Lower Pool	130	10.50	1,294.53	832.88
New Transect Upper Pool	150	20.00	1,326.56	998.11
7.00	154.5	4.50	1,187.50	429.55
8.00	191	36.50	3,236.98	635.38
9.00	285	94.00	882.81	21.05
10.00	334	49.00	2501.30	401.18
	Total	**334**	**24,029**	**4,657**

Existing Conditions Weighted Usable Area, from Sutton, Table D-1 (2007)	
Total Area	**Weighted Usable Area**
23,655	3,244

Percent Difference (Existing/Proposed)	
Total Area	**Weighted Usable Area**
+1.6%	+43.5%

Step 4

GeoEngineers

APPENDICES

GeoEngineers

Earth Science + Technology

Appendix D

GEOENGINEERS

TECHNICAL MEMORANDUM

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TO:	Jim Pendleton, Talent Irrigation District Manager; Carol Bradford, Medford Irrigation District Manager; Brian Hampson, Rogue River Valley Irrigation District Manager
FROM:	Barbara Burkholder, Jon Ambrose, Richard Piaskowski, and Ron Costello
DATE:	November 24, 2008
FILE:	4668-008-05
SUBJECT:	Rogue River Basin Project Storage Curve Development and Application

The Bureau of Reclamation (Reclamation) is currently going through formal Endangered Species Act (ESA) Section 7 consultation with the National Marine Fisheries Service (NMFS) concerning the effects of the Rogue Basin Project (Project) on Threatened Southern Oregon/Northern California (SONCC) coho salmon. In its draft proposed action sent to Project Irrigation Districts (July 25, 2008), Reclamation included minimum target flows to address coho salmon habitat needs in Emigrant Creek. The recommended target flows were developed using the PHABSIM system (Sutton, 2007) to determine different flow regimes for different water year types (dry and average/wet). To implement such flow regimes, a process must be established to determine water year type.

GeoEngineers has prepared this memorandum to provide a technical basis for recommendations to the Rogue Basin Water Users Council, Talent Irrigation District (TID), Medford Irrigation District, Rogue River Valley Irrigation District, and Reclamation in determining targeted water discharges from Emigrant Dam under different storage year types. We distinguish storage year type from water year type primarily to focus on storage trends rather than direct precipitation inputs. We recommend that this approach be considered for incorporation into the proposed action in Reclamation's Supplemental Biological Assessment, currently being prepared.

Storage Curve Development

Minimum target flows proposed by Reclamation for Emigrant Creek are met by normal water deliveries during the irrigation season (Piaskowski et al. 2008). Under current Project operations, water deliveries typically cease from October 15 through the following April to allow storage refill of Project reservoirs. It is during this "storage" season that water releases to Emigrant Creek are typically at their lowest; therefore, there is a need to consider water availability over the course of the storage season prior to determining any proposed minimum target flows below Emigrant Dam.

It is common for water storage projects to monitor precipitation patterns during the winter in order to gauge water availability for the following irrigation season. Precipitation in the Upper Rogue River sub-basin occurs almost entirely during the November through April period, and it is highly variable from month to month. Patterns of precipitation early in the storage season provide little indication of either total annual precipitation or the ultimate storage levels subsequently gained by the end of a storage season. Moreover, the Natural Resource Conservation Service (NRCS) water-year type determination for the April to July period does not provide timely information useful within a storage season that aids in establishing temporal minimum target flows. However, snow accumulation as a percent of normal may provide valuable information progressing through the storage season.

As an alternative to considering precipitation patterns as a sole indicator of temporal storage status, a process was developed to create storage functions (curves) upon which to gauge the status of total storage across the spectrum of Project reservoirs during the storage season (October 15 to May 15) of a given water year. The process is based on the ability of the Project to carry storage over from one year to the next, and it is predicated on the assumption that when storage is relatively high at the end of an irrigation season, it may be possible to release more water to meet proposed minimum target flows. Conversely, if reservoir storage is drawn down during either a low or drought water year and associated irrigation season, there is therefore less water in storage to meet the following year's Project water deliveries with no certainty that storage will be re-filled over the subsequent storage period.

The primary parameter used to develop the Rogue Project operation storage curves was daily total (i.e. pooled) storage (data obtained during August 2008 from http://www.usbr.gov/pn/hydromet/), which is the sum of daily active storage within Howard Prairie, Hyatt, and Emigrant reservoirs. This parameter, which is based on daily storage values consistently recorded from storage year 1992 (defined as period from October 15, 1991 to October 14, 1992) to the present, not only reflects operational carryover storage during the year, but also serves as an indirect measure of natural inputs such as precipitation and snowmelt. This is reflected in the initial seven months of the storage year (October 15 to May 15), where total storage levels are determined from carryover storage remaining from the previous summer and precipitation inputs during the winter months (Figure 1). It is evident that recognized dry years (1992, 1993, 1993, and 2002) start with a lower total storage than recognized wet years (1996, 1997, 1998, and 2000). Years 2002 and 2000 are highlighted in Figure 1, as these curves mimic the general shape of storage gain for both wet and dry years.

Snow water equivalent, indicative of the moisture content in the snow pack, can influence storage gains as early as February (Figure 2), but the majority of snowmelt occurs during late March to mid-April as warmer air temperatures increase runoff to the system, and therefore does not provide useful information until the end of the storage season (Figure 1).

Storage curves relating to total daily storage were generated using two different methodologies:

1) High and Low Storage Curves

This method establishes two curves (a 'high storage' curve and a 'low storage' curve) fixed around the average daily total storage, which calculated by taking the average of daily total storage values over 16 years (1992 to 2007) (Figure 3). Initially, the standard deviation of the average daily total storage is used to create the upper and lower curves, but the values calculated in the upper curve exceeded the maximum total storage amount observed in any year (Figure 4). A fixed deviation of 15,000 ac-ft is ultimately chosen since the resulting upper storage curve follows just below the maximum daily total storage values captured in wet years and resulting lower curve followed just above the maximum daily total storage values captured in dry years (Figure 3).

The primary advantage of this 2-curve scenario is that it delineates not only high (and therefore carryover) and low levels of storage, but also captures average storage conditions (Figure 5). Additional curves could be added to delineate further different levels of storage (high, above average, below average, low; etc.) (Figure 6). Daily total storage values associated with the middle (average), high and low storage curves are provided in Appendix A.

2) Sixty Percent Base Storage Curve

This method involves generating a single storage curve, where all values above the curve are considered 'high storage' years, and all values below the curve are considered 'low storage' years. This curve is determined by calculating 60% of the maximum storage (71,567 ac-ft) observed during the period of 1992-2007 (http://www.usbr.gov/pn/hydromet/). This value was chosen since 60% total storage represents approximately a year worth of irrigation water for the three Project Districts. To create the curve, the average daily total storage values are adjusted upward so that the curve started at 71,567 ac-ft on October 15, and then follows the same rate of storage gain as the average daily total storage values for each subsequent date until May 15 of the following year (Figure 7).

Storage Curve Application

We believe that the storage curves generated using the first method better represent the variation of storage conditions in the system and should be used to aid in determining water storage/release operations for Emigrant Dam during the storage season (October 15 to May 15). During the irrigation season (May 15 to October 15), minimum flows for Emigrant Creek as proposed by Reclamation are met by normal Project operational releases; and therefore, a process to determine minimum flows in this period of the year is not necessary.

Applying the storage curves would involve comparing the current total storage volume among Hyatt, Howard Prairie, and Emigrant reservoirs with the curves on a pre-determined schedule (e.g. weekly, bi-monthly, monthly) during the storage season (October 15 to May 15). On each pre-scheduled date, minimum flow values for Emigrant Creek would be determined according to where the current total storage volume falls within the zones created by the storage curves (low, average, high). The corresponding minimum flow value for the zone in which the current total value occurs is then released until the next scheduled date. Higher flows could be released at the discretion of the operations manager. Considering the current gate configuration, and variability observed in annual storage volumes, we recommend adjusting Emigrant Creek minimum flows using a monthly interval during the storage season.

Figure 8 demonstrates how the storage curves would apply to storage operations in "low", "average", and "high" storage years. The 1995 daily total storage data initially falls well within the low storage zone. As long as the 1995 total storage falls below that of the low storage curve, minimum flow releases would be governed by flow volumes designated for low storage years. When the 1995 total storage crosses the low storage curve line into the average zone, minimum flow releases would be governed by flow volumes designated for average storage years. These same rules apply to years 2004 and 2007. In 2007, as long as the total storage remains above the high storage curve, minimum flow releases are governed by flow volumes designated for high storage years.

References:

Piaskowski, R., J. Ambrose, B. Burkholder. 2008. Evaluation of Stream Flow Patterns and Coho Salmon (Oncorhynchus kisutch) Migration Behavior Patterns Relative to the Talent Division, Rogue River Basin Project. Prepared for Rogue Basin Water Users Council, Talent Irrigation District Medford Irrigation District and Rogue River Valley Irrigation by GeoEngineers, Inc. Portland, Oregon.

Sutton, R.J. 2007. Rogue River Basin Project Coho Salmon Instream Flow Assessment. Bureau of Reclamation Technical Memorandum No. 86-68290-02-07. November 2007.

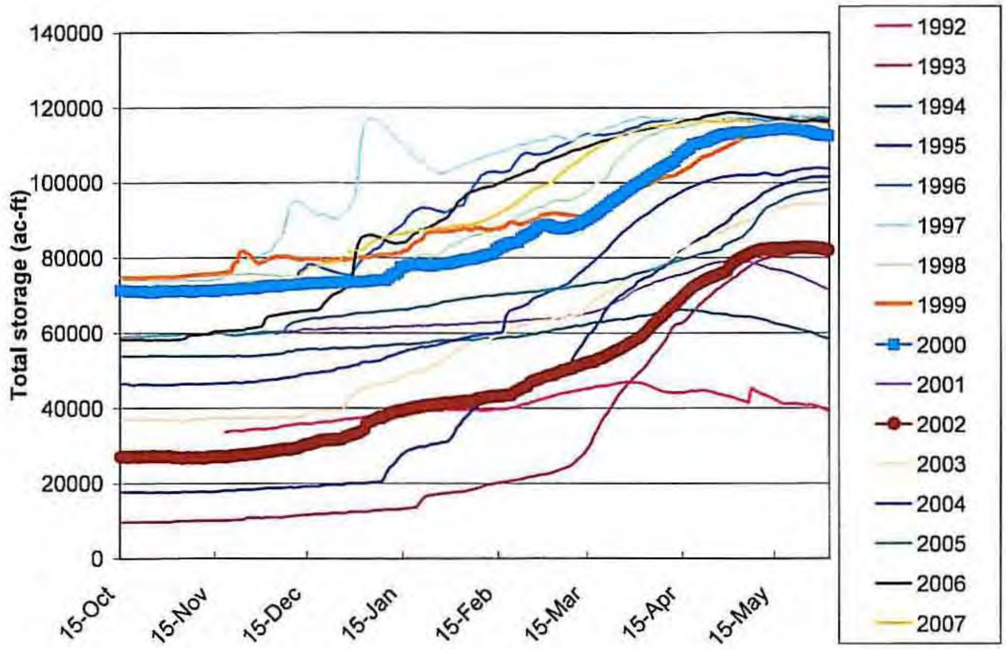

Figure 1: Daily total storage values for water years 1992-2007.

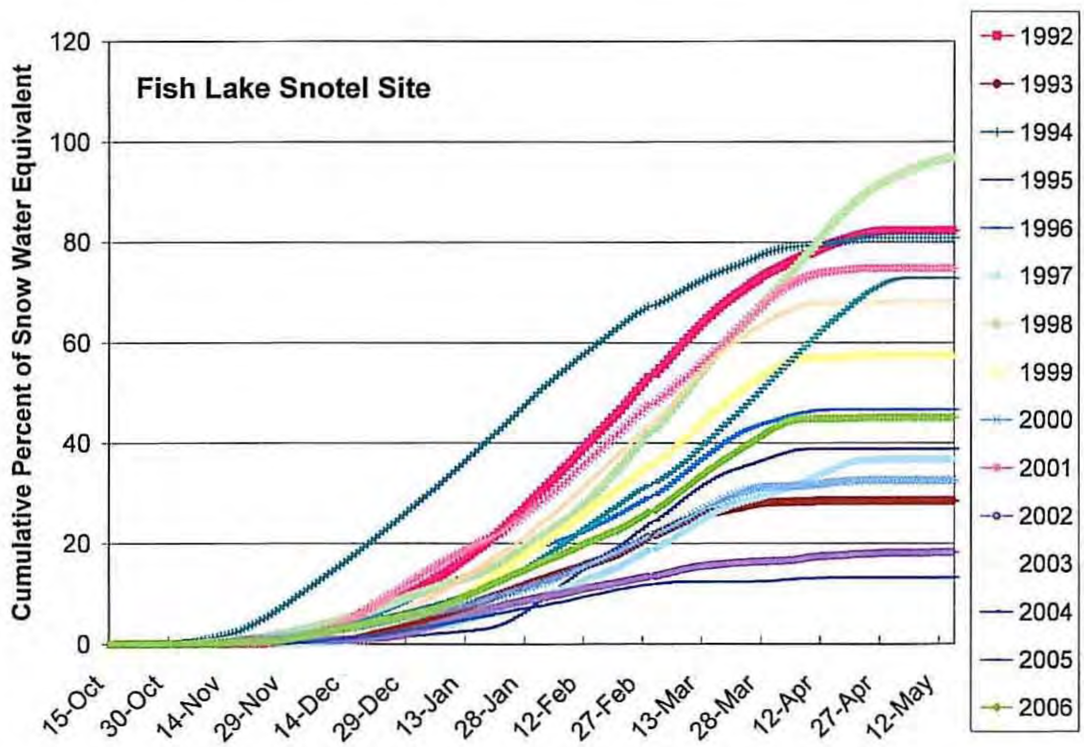

Figure 2: Cumulative percent of snow water equivalent observed for water years 1992-2007.

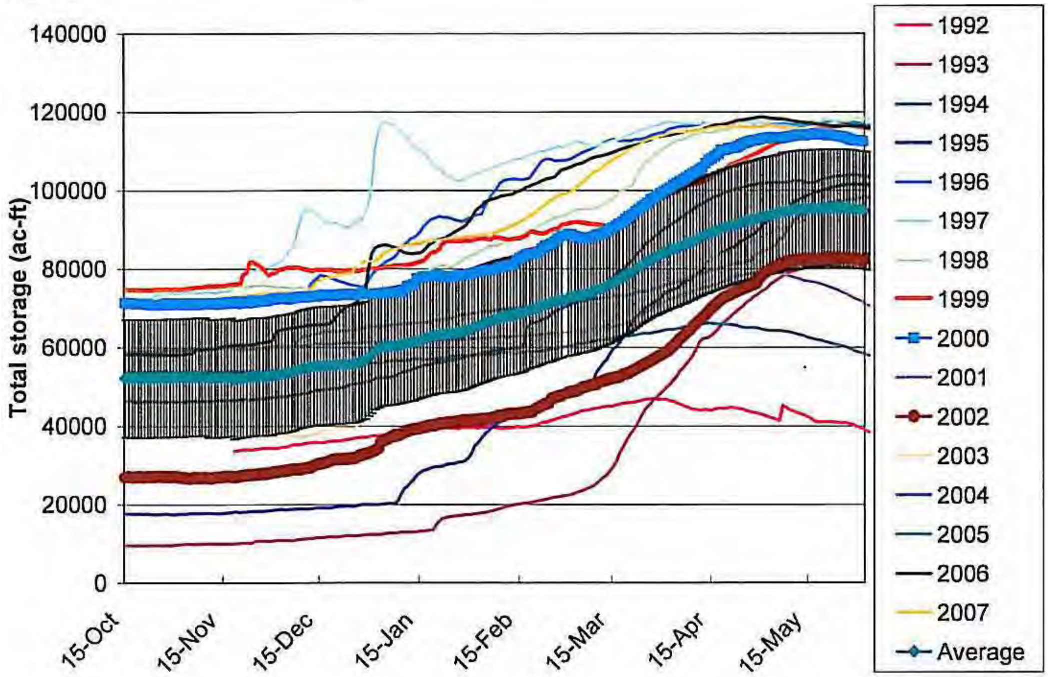

Figure 3: Average daily total storage values with a fixed deviation of ±15,000 ac-ft, plotted with daily total storage for individual water years between 1992 and 2007.

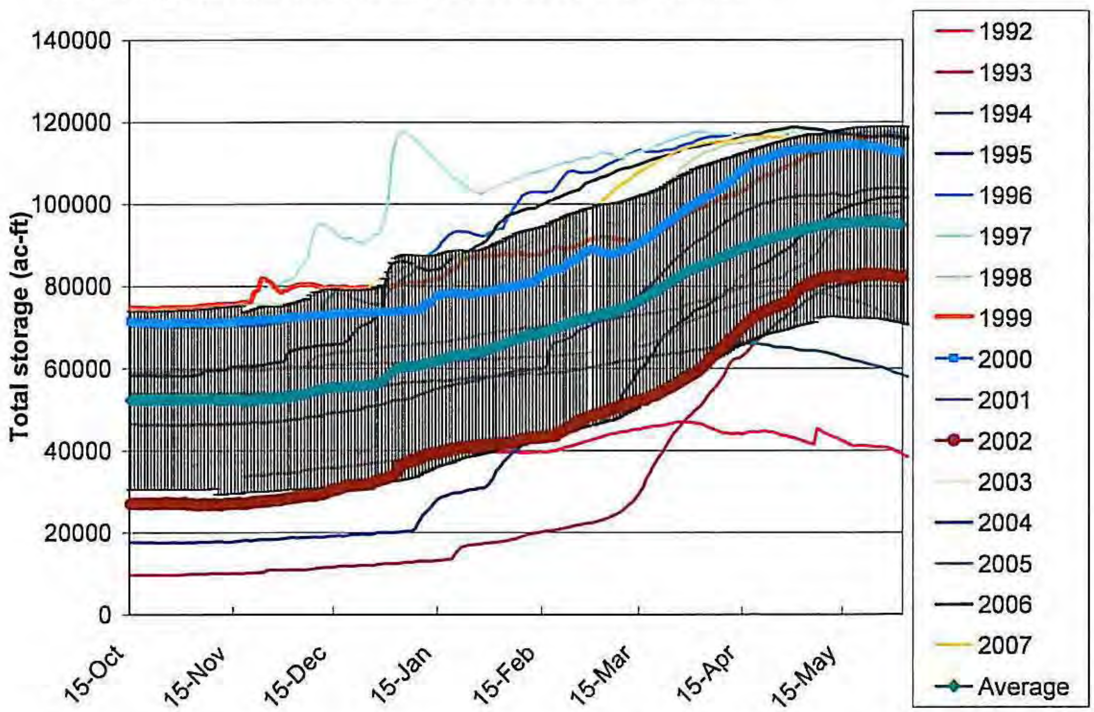

Figure 4: Average daily total storage values plotted with one standard deviation, plotted with daily total storage for individual water years between 1992 and 2007. Note how curve traced by upper standard deviation is greater than maximum observed storage.

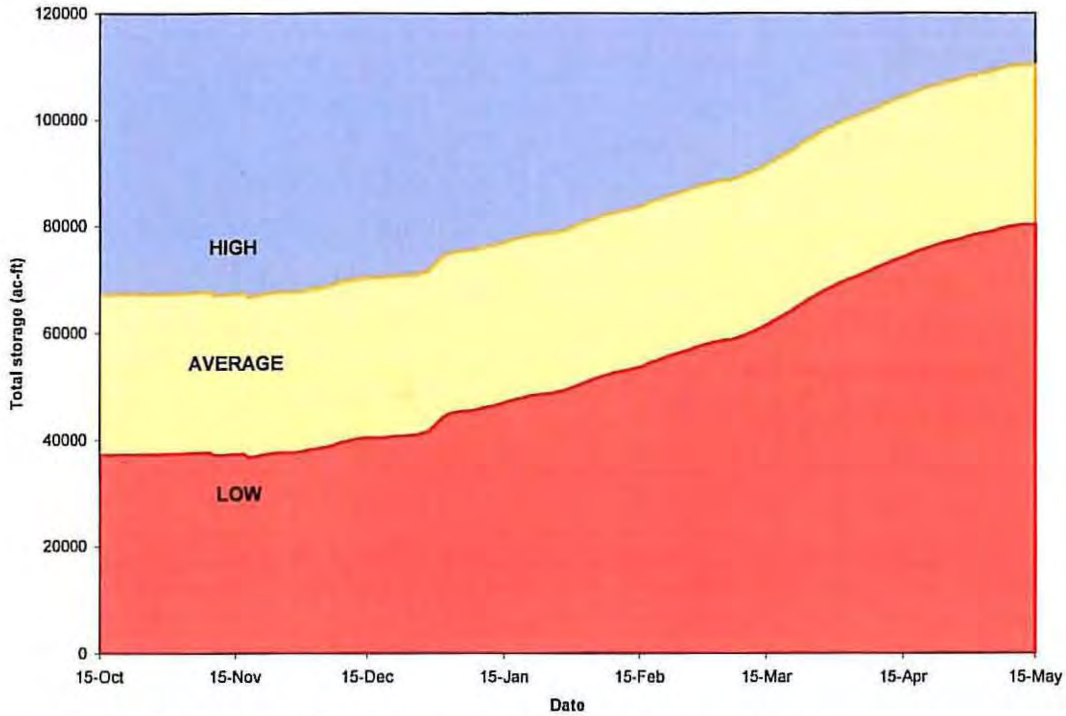

Figure 5: Plot of high/low storage curves and resulting storage zones.

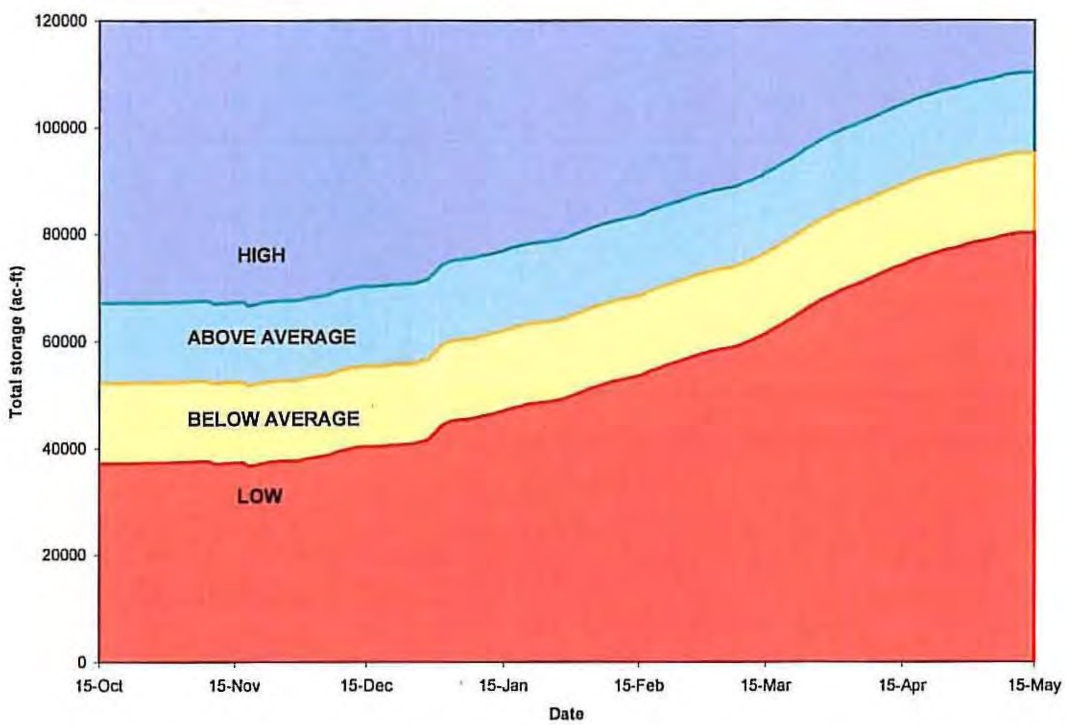

Figure 6: Plot of high/average/low storage curves delineating more zones within the average region.

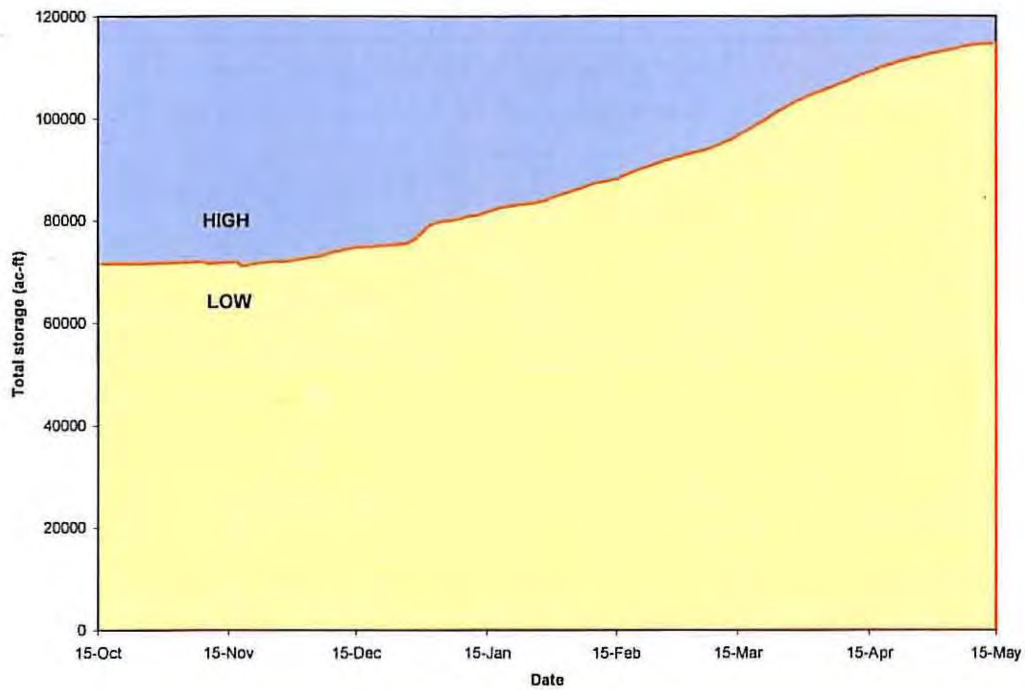

Figure 7: Plot of storage curve based on 60% maximum total storage.

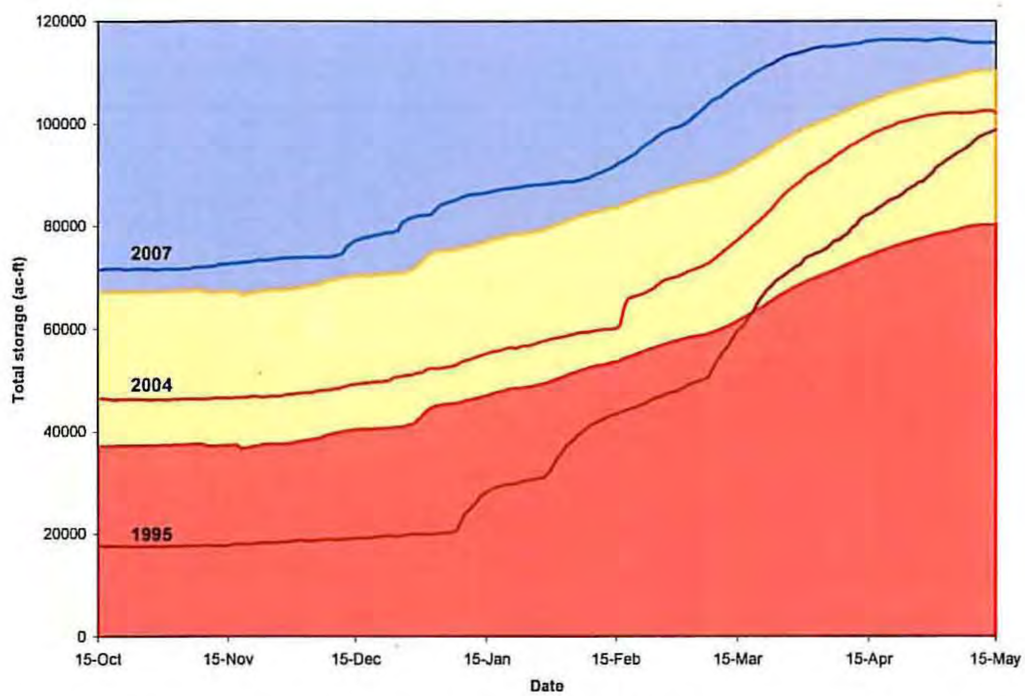

Figure 8: Total storage values for years 1995, 2004, and 2007 plotted against high/low storage curves.

Table A-1: Daily total storage values for the middle (i.e. average total storage), high and low storage curves as depicted in Figures 5 and 6:

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
15-Oct	52125.88357	67125.88357	37125.8836
16-Oct	52127.76857	67127.76857	37127.7686
17-Oct	52136.35714	67136.35714	37136.3571
18-Oct	52140.08286	67140.08286	37140.0829
19-Oct	52129.30143	67129.30143	37129.3014
20-Oct	52141.46143	67141.46143	37141.4614
21-Oct	52130.10143	67130.10143	37130.1014
22-Oct	52132.96643	67132.96643	37132.9664
23-Oct	52136.75286	67136.75286	37136.7529
24-Oct	52188.05929	67188.05929	37188.0593
25-Oct	52198.00857	67198.00857	37198.0086
26-Oct	52205.79571	67205.79571	37205.7957
27-Oct	52228.285	67228.285	37228.285
28-Oct	52260.34929	67260.34929	37260.3493
29-Oct	52264.08143	67264.08143	37264.0814
30-Oct	52289.90929	67289.90929	37289.9093
31-Oct	52322.56929	67322.56929	37322.5693
1-Nov	52306.08	67306.08	37306.08
2-Nov	52325.51357	67325.51357	37325.5136
3-Nov	52357.89857	67357.89857	37357.8986
4-Nov	52393.38429	67393.38429	37393.3843
5-Nov	52427.16214	67427.16214	37427.1621
6-Nov	52477.015	67477.015	37477.015
7-Nov	52525.25214	67525.25214	37525.2521
8-Nov	52565.63571	67565.63571	37565.6357
9-Nov	52577.29143	67577.29143	37577.2914
10-Nov	52090.28385	67090.28385	37090.2838
11-Nov	52077.99308	67077.99308	37077.9931
12-Nov	52113.43077	67113.43077	37113.4308
13-Nov	52160.82077	67160.82077	37160.8208
14-Nov	52219.62231	67219.62231	37219.6223
15-Nov	52262.75923	67262.75923	37262.7592
16-Nov	52305.87615	67305.87615	37305.8762
17-Nov	52360.17154	67360.17154	37360.1715
18-Nov	51681.03733	66681.03733	36681.0373

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
19-Nov	51829.25	66829.25	36829.25
20-Nov	51921.012	66921.012	36921.012
21-Nov	52150.36133	67150.36133	37150.3613
22-Nov	52222.18733	67222.18733	37222.1873
23-Nov	52406.59267	67406.59267	37406.5927
24-Nov	52471.624	67471.624	37471.624
25-Nov	52553.36933	67553.36933	37553.3693
26-Nov	52585.918	67585.918	37585.918
27-Nov	52579.76333	67579.76333	37579.7633
28-Nov	52576.73733	67576.73733	37576.7373
29-Nov	52645.246	67645.246	37645.246
30-Nov	52728.46933	67728.46933	37728.4693
1-Dec	52973.01267	67973.01267	37973.0127
2-Dec	53110.51667	68110.51667	38110.5167
3-Dec	53205.062	68205.062	38205.062
4-Dec	53335.80333	68335.80333	38335.8033
5-Dec	53490.05867	68490.05867	38490.0587
6-Dec	53618.46733	68618.46733	38618.4673
7-Dec	53813.158	68813.158	38813.158
8-Dec	54192.36933	69192.36933	39192.3693
9-Dec	54480.746	69480.746	39480.746
10-Dec	54632.88133	69632.88133	39632.8813
11-Dec	54746.73067	69746.73067	39746.7307
12-Dec	55008.16067	70008.16067	40008.1607
13-Dec	55120.16533	70120.16533	40120.1653
14-Dec	55226.86333	70226.86333	40226.8633
15-Dec	55284.358	70284.358	40284.358
16-Dec	55330.29	70330.29	40330.29
17-Dec	55325.70867	70325.70867	40325.7087
18-Dec	55351.08133	70351.08133	40351.0813
19-Dec	55405.05133	70405.05133	40405.0513
20-Dec	55507.394	70507.394	40507.394
21-Dec	55540.95	70540.95	40540.95
22-Dec	55590.06933	70590.06933	40590.0693
23-Dec	55656.90533	70656.90533	40656.9053
24-Dec	55720.67133	70720.67133	40720.6713
25-Dec	55741.70067	70741.70067	40741.7007
26-Dec	55841.63867	70841.63867	40841.6387

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
27-Dec	56122.62267	71122.62267	41122.6227
28-Dec	56386.36733	71386.36733	41386.3673
29-Dec	56650.42933	71650.42933	41650.4293
30-Dec	57475.10867	72475.10867	42475.1087
31-Dec	58221.44733	73221.44733	43221.4473
1-Jan	59100.56933	74100.56933	44100.5693
2-Jan	59565.74533	74565.74533	44565.7453
3-Jan	59918.29333	74918.29333	44918.2933
4-Jan	60112.35467	75112.35467	45112.3547
5-Jan	60228.988	75228.988	45228.988
6-Jan	60305.252	75305.252	45305.252
7-Jan	60386.166	75386.166	45386.166
8-Jan	60467.75	75467.75	45467.75
9-Jan	60686.07733	75686.07733	45686.0773
10-Jan	60908.25867	75908.25867	45908.2587
11-Jan	61074.15933	76074.15933	46074.1593
12-Jan	61222.36533	76222.36533	46222.3653
13-Jan	61378.16133	76378.16133	46378.1613
14-Jan	61683.76867	76683.76867	46683.7687
15-Jan	61891.674	76891.674	46891.674
16-Jan	62180.17267	77180.17267	47180.1727
17-Jan	62444.99267	77444.99267	47444.9927
18-Jan	62664.51867	77664.51867	47664.5187
19-Jan	62821.22733	77821.22733	47821.2273
20-Jan	63060.144	78060.144	48060.144
21-Jan	63223.62867	78223.62867	48223.6287
22-Jan	63337.496	78337.496	48337.496
23-Jan	63415	78415	48415
24-Jan	63496.87	78496.87	48496.87
25-Jan	63546.32267	78546.32267	48546.3227
26-Jan	63680.458	78680.458	48680.458
27-Jan	63836.44933	78836.44933	48836.4493
28-Jan	64034.04933	79034.04933	49034.0493
29-Jan	64232.088	79232.088	49232.088
30-Jan	64543.15067	79543.15067	49543.1507
31-Jan	64859.632	79859.632	49859.632
1-Feb	65230.87267	80230.87267	50230.8727
2-Feb	65507.686	80507.686	50507.686

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
3-Feb	65803.75267	80803.75267	50803.7527
4-Feb	66147.93867	81147.93867	51147.9387
5-Feb	66401.95467	81401.95467	51401.9547
6-Feb	66679.192	81679.192	51679.192
7-Feb	66992.926	81992.926	51992.926
8-Feb	67205.106	82205.106	52205.106
9-Feb	67438.96467	82438.96467	52438.9647
10-Feb	67626.718	82626.718	52626.718
11-Feb	67812.59267	82812.59267	52812.5927
12-Feb	67941.094	82941.094	52941.094
13-Feb	68109.74467	83109.74467	53109.7447
14-Feb	68341.86333	83341.86333	53341.8633
15-Feb	68498.714	83498.714	53498.714
16-Feb	68721.82667	83721.82667	53721.8267
17-Feb	69212.65533	84212.65533	54212.6553
18-Feb	69530.38933	84530.38933	54530.3893
19-Feb	69773.60867	84773.60867	54773.6087
20-Feb	70049.642	85049.642	55049.642
21-Feb	70367.37	85367.37	55367.37
22-Feb	70660.578	85660.578	55660.578
23-Feb	70933.43467	85933.43467	55933.4347
24-Feb	71183.92667	86183.92667	56183.9267
25-Feb	71479.59533	86479.59533	56479.5953
26-Feb	71693.43867	86693.43867	56693.4387
27-Feb	71990.77867	86990.77867	56990.7787
28-Feb	72282.32867	87282.32867	57282.3287
1-Mar	72632.934	87632.934	57632.934
2-Mar	72924.138	87924.138	57924.138
3-Mar	73166.09	88166.09	58166.09
4-Mar	73322.664	88322.664	58322.664
5-Mar	73501.832	88501.832	58501.832
6-Mar	73640.73933	88640.73933	58640.7393
7-Mar	73775.58867	88775.58867	58775.5887
8-Mar	73976.78467	88976.78467	58976.7847
9-Mar	74246.12	89246.12	59246.12
10-Mar	74579.368	89579.368	59579.368
11-Mar	74921.92267	89921.92267	59921.9227
12-Mar	75211.976	90211.976	60211.976

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
13-Mar	75550.944	90550.944	60550.944
14-Mar	75946.20533	90946.20533	60946.2053
15-Mar	76405.29133	91405.29133	61405.2913
16-Mar	76843.66933	91843.66933	61843.6693
17-Mar	77325.53	92325.53	62325.53
18-Mar	77824.57933	92824.57933	62824.5793
19-Mar	78291.72133	93291.72133	63291.7213
20-Mar	78768.94733	93768.94733	63768.9473
21-Mar	79229.55533	94229.55533	64229.5553
22-Mar	79796.46467	94796.46467	64796.4647
23-Mar	80398.54867	95398.54867	65398.5487
24-Mar	80937.148	95937.148	65937.148
25-Mar	81422.802	96422.802	66422.802
26-Mar	81862.60733	96862.60733	66862.6073
27-Mar	82375.16867	97375.16867	67375.1687
28-Mar	82813.92733	97813.92733	67813.9273
29-Mar	83214.11133	98214.11133	68214.1113
30-Mar	83619.434	98619.434	68619.434
31-Mar	84025.26467	99025.26467	69025.2647
1-Apr	84391.63133	99391.63133	69391.6313
2-Apr	84727.92067	99727.92067	69727.9207
3-Apr	85059.39267	100059.3927	70059.3927
4-Apr	85371.05067	100371.0507	70371.0507
5-Apr	85728.822	100728.822	70728.822
6-Apr	86050.46867	101050.4687	71050.4687
7-Apr	86418.598	101418.598	71418.598
8-Apr	86762.07	101762.07	71762.07
9-Apr	87121.334	102121.334	72121.334
10-Apr	87478.02733	102478.0273	72478.0273
11-Apr	87877.532	102877.532	72877.532
12-Apr	88227.774	103227.774	73227.774
13-Apr	88583.728	103583.728	73583.728
14-Apr	88887.04067	103887.0407	73887.0407
15-Apr	89165.742	104165.742	74165.742
16-Apr	89475.506	104475.506	74475.506
17-Apr	89822.734	104822.734	74822.734
18-Apr	90182.682	105182.682	75182.682
19-Apr	90442.27267	105442.2727	75442.2727

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
20-Apr	90742.51067	105742.5107	75742.5107
21-Apr	91030.14	106030.14	76030.14
22-Apr	91248.68933	106248.6893	76248.6893
23-Apr	91506.65067	106506.6507	76506.6507
24-Apr	91781.334	106781.334	76781.334
25-Apr	92008.03533	107008.0353	77008.0353
26-Apr	92190.494	107190.494	77190.494
27-Apr	92377.41467	107377.4147	77377.4147
28-Apr	92595.244	107595.244	77595.244
29-Apr	92822.33267	107822.3327	77822.3327
30-Apr	93077.428	108077.428	78077.428
1-May	93311.91533	108311.9153	78311.9153
2-May	93470.988	108470.988	78470.988
3-May	93640.23333	108640.2333	78640.2333
4-May	93815.69933	108815.6993	78815.6993
5-May	93979.86	108979.86	78979.86
6-May	94128.49733	109128.4973	79128.4973
7-May	94510.852	109510.852	79510.852
8-May	94661.36067	109661.3607	79661.3607
9-May	94811.58467	109811.5847	79811.5847
10-May	94955.57533	109955.5753	79955.5753
11-May	95080.18333	110080.1833	80080.1833
12-May	95145.492	110145.492	80145.492
13-May	95175.54467	110175.5447	80175.5447
14-May	95177.80267	110177.8027	80177.8027
15-May	95228.38067	110228.3807	80228.3807
16-May	95276.18533	110276.1853	80276.1853
17-May	95292.19133	110292.1913	80292.1913
18-May	95344.95667	110344.9567	80344.9567
19-May	95384.444	110384.444	80384.444
20-May	95489.172	110489.172	80489.172
21-May	95489.18133	110489.1813	80489.1813
22-May	95484.96267	110484.9627	80484.9627
23-May	95468.212	110468.212	80468.212
24-May	95456.42133	110456.4213	80456.4213
25-May	95423.228	110423.228	80423.228
26-May	95391.938	110391.938	80391.938
27-May	95344.45267	110344.4527	80344.4527

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
28-May	95281.10067	110281.1007	80281.1007
29-May	95193.04533	110193.0453	80193.0453
30-May	95119.55667	110119.5567	80119.5567
31-May	95059.87467	110059.8747	80059.8747
1-Jun	94940.85867	109940.8587	79940.8587
2-Jun	94769.168	109769.168	79769.168
3-Jun	94658.896	109658.896	79658.896
4-Jun	94560.33467	109560.3347	79560.3347
5-Jun	94476.348	109476.348	79476.348
6-Jun	94360.734	109360.734	79360.734
7-Jun	94243.25533	109243.2553	79243.2553
8-Jun	94122.35	109122.35	79122.35
9-Jun	93995.67133	108995.6713	78995.6713
10-Jun	93678.12333	108678.1233	78678.1233
11-Jun	93527.304	108527.304	78527.304
12-Jun	93364.70267	108364.7027	78364.7027
13-Jun	93166.73467	108166.7347	78166.7347
14-Jun	92999.902	107999.902	77999.902
15-Jun	92807.95867	107807.9587	77807.9587
16-Jun	92602.50067	107602.5007	77602.5007
17-Jun	92435.78067	107435.7807	77435.7807
18-Jun	92204.78	107204.78	77204.78
19-Jun	91974.3	106974.3	76974.3
20-Jun	91751.88867	106751.8887	76751.8887
21-Jun	91466.91067	106466.9107	76466.9107
22-Jun	91182.588	106182.588	76182.588
23-Jun	90902.21933	105902.2193	75902.2193
24-Jun	90620.72733	105620.7273	75620.7273
25-Jun	90294.57267	105294.5727	75294.5727
26-Jun	89985.37733	104985.3773	74985.3773
27-Jun	89640.94067	104640.9407	74640.9407
28-Jun	89350.958	104350.958	74350.958
29-Jun	88998.26533	103998.2653	73998.2653
30-Jun	88696.086	103696.086	73696.086
1-Jul	88343.36267	103343.3627	73343.3627
2-Jul	87996.85067	102996.8507	72996.8507
3-Jul	87632.91067	102632.9107	72632.9107
4-Jul	87238.20067	102238.2007	72238.2007

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
5-Jul	86875.27067	101875.2707	71875.2707
6-Jul	86513.92267	101513.9227	71513.9227
7-Jul	86157.932	101157.932	71157.932
8-Jul	85796.99133	100796.9913	70796.9913
9-Jul	85439.92333	100439.9233	70439.9233
10-Jul	85052.004	100052.004	70052.004
11-Jul	84660.02333	99660.02333	69660.0233
12-Jul	84297.99067	99297.99067	69297.9907
13-Jul	83898.41867	98898.41867	68898.4187
14-Jul	83500.48667	98500.48667	68500.4867
15-Jul	83060.66867	98060.66867	68060.6687
16-Jul	82625.64133	97625.64133	67625.6413
17-Jul	82182.922	97182.922	67182.922
18-Jul	81772.968	96772.968	66772.968
19-Jul	81346.62	96346.62	66346.62
20-Jul	80930.09133	95930.09133	65930.0913
21-Jul	80472.08467	95472.08467	65472.0847
22-Jul	80067.10533	95067.10533	65067.1053
23-Jul	79640.008	94640.008	64640.008
24-Jul	79191.70467	94191.70467	64191.7047
25-Jul	78748.92667	93748.92667	63748.9267
26-Jul	78319.556	93319.556	63319.556
27-Jul	77845.258	92845.258	62845.258
28-Jul	77398.10667	92398.10667	62398.1067
29-Jul	76929.56667	91929.56667	61929.5667
30-Jul	76452.41933	91452.41933	61452.4193
31-Jul	75973.382	90973.382	60973.382
1-Aug	75498.968	90498.968	60498.968
2-Aug	75017.402	90017.402	60017.402
3-Aug	74537.77667	89537.77667	59537.7767
4-Aug	74090.35933	89090.35933	59090.3593
5-Aug	73609.71733	88609.71733	58609.7173
6-Aug	73179.98	88179.98	58179.98
7-Aug	72713.474	87713.474	57713.474
8-Aug	72270.76333	87270.76333	57270.7633
9-Aug	71843.314	86843.314	56843.314
10-Aug	71371.11733	86371.11733	56371.1173
11-Aug	70936.98867	85936.98867	55936.9887

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
12-Aug	70481.58533	85481.58533	55481.5853
13-Aug	70056.14133	85056.14133	55056.1413
14-Aug	69597.97267	84597.97267	54597.9727
15-Aug	69150.964	84150.964	54150.964
16-Aug	68693.54267	83693.54267	53693.5427
17-Aug	68222.10267	83222.10267	53222.1027
18-Aug	67810.96133	82810.96133	52810.9613
19-Aug	67385.92933	82385.92933	52385.9293
20-Aug	66973.98467	81973.98467	51973.9847
21-Aug	66547.01933	81547.01933	51547.0193
22-Aug	66139.14	81139.14	51139.14
23-Aug	65747.62067	80747.62067	50747.6207
24-Aug	65342.446	80342.446	50342.446
25-Aug	64917.972	79917.972	49917.972
26-Aug	64538.90267	79538.90267	49538.9027
27-Aug	64126.81467	79126.81467	49126.8147
28-Aug	63743.91067	78743.91067	48743.9107
29-Aug	63361.01733	78361.01733	48361.0173
30-Aug	62979.288	77979.288	47979.288
31-Aug	62592.77867	77592.77867	47592.7787
1-Sep	62232.54133	77232.54133	47232.5413
2-Sep	61874.89533	76874.89533	46874.8953
3-Sep	61516.12133	76516.12133	46516.1213
4-Sep	61186.09733	76186.09733	46186.0973
5-Sep	60853.13667	75853.13667	45853.1367
6-Sep	60522.49133	75522.49133	45522.4913
7-Sep	60172.21	75172.21	45172.21
8-Sep	59858.06467	74858.06467	44858.0647
9-Sep	59555.47333	74555.47333	44555.4733
10-Sep	59257.28667	74257.28667	44257.2867
11-Sep	58960.35533	73960.35533	43960.3553
12-Sep	58655.688	73655.688	43655.688
13-Sep	58354.036	73354.036	43354.036
14-Sep	58071.86933	73071.86933	43071.8693
15-Sep	57815.36933	72815.36933	42815.3693
16-Sep	57554.874	72554.874	42554.874
17-Sep	57302.62	72302.62	42302.62
18-Sep	57044.136	72044.136	42044.136

Date	Middle Storage Curve (ac-ft)	High Storage Curve (ac-ft)	Low Storage Curve (ac-ft)
19-Sep	56788.372	71788.372	41788.372
20-Sep	56549.67333	71549.67333	41549.6733
21-Sep	56309.40133	71309.40133	41309.4013
22-Sep	56061.15667	71061.15667	41061.1567
23-Sep	55827.51733	70827.51733	40827.5173
24-Sep	55581.388	70581.388	40581.388
25-Sep	55353.554	70353.554	40353.554
26-Sep	55100.56667	70100.56667	40100.5667
27-Sep	54851.37933	69851.37933	39851.3793
28-Sep	54636.07533	69636.07533	39636.0753
29-Sep	54426.19333	69426.19333	39426.1933
30-Sep	54241.68067	69241.68067	39241.6807
1-Oct	54119.114	69119.114	39119.114
2-Oct	54021.28267	69021.28267	39021.2827
3-Oct	53938.68267	68938.68267	38938.6827
4-Oct	53850.94333	68850.94333	38850.9433
5-Oct	53795.006	68795.006	38795.006
6-Oct	53732.07667	68732.07667	38732.0767
7-Oct	53661.03867	68661.03867	38661.0387
8-Oct	53624.802	68624.802	38624.802
9-Oct	53587.87867	68587.87867	38587.8787
10-Oct	53538.25333	68538.25333	38538.2533
11-Oct	53515.02667	68515.02667	38515.0267
12-Oct	53461.68467	68461.68467	38461.6847
13-Oct	53446.978	68446.978	38446.978
14-Oct	53429.27467	68429.27467	38429.2747

Appendix E

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November 18, 2011

Rogue Basin Water Users Council
P.O. Box 467
Talent, Oregon 97450

Attention: Jim Pendleton, Talent Irrigation District Manager

Subject: Letter Report
Proposed Rogue River Basin Project Ramping Rate Protocol
Rogue River Project, Medford Oregon
File No. 11883-001-00

INTRODUCTION

This letter provides a ramping proposal for reservoir releases and irrigation diversions for infrastructure associated with the Rogue River Basin Project (Project). This proposal was developed in consultation with the Rogue Basin Water Users Council (RBWUC), which is comprised of the Talent, Medford, and Rogue River Valley Irrigation Districts.

For the purposes of this letter report, ramping refers to the rate at which water is regulated from Project infrastructure. Project infrastructure to be governed by ramping rate protocols include: Emigrant Reservoir, Oak Street Diversion Dam, and Phoenix Canal Diversion Dam. Project elements function differently during fall and winter (when the Project is storing water) than during spring and summer (when the Project is releasing and diverting water for irrigation). This letter report provides:

- A general description of the Project Effects on fish during each season (Storage and Irrigation).
- Summary of the minimum flows proposed by Reclamation.
- A proposal for ramping rate protocol that will be administered by Reclamation and the Rogue Basin Water Users Council (RBWUC) Irrigation Districts designed to minimize Project Effects on fish along with the other mitigation strategies proposed by Reclamation.

STORAGE SEASON (APPROXIMATELY OCTOBER 15 THROUGH APRIL 15)

Project Effects on Fish

- Storage and regulation of peak flows via reservoirs at Howard Prairie, Hyatt, and Emigrant.
- Rapid fluctuations in releases (ramping) from Emigrant mostly due to flood management governed by the U.S. Army Corps of Engineers (USACOE) flood rule curve.

Mitigation Proposal

Minimum Flow Releases

- The most recent Minimum In-stream Flow Proposals from Reclamation are presented in Table 1 below.

TABLE 1. CURRENT PROPOSED MINIMUM FLOW TARGETS FOR EMIGRANT CREEK (EMI) AND SOUTH FORK LITTLE BUTTE CREEK (GILO) IN CUBIC FEET PER SECOND (CFS)

Month	10% Exceedance		50% Exceedance		80% Exceedance	
	EMI	GILO	EMI	GILO	EMI	GILO
October	6	N/A	3	10	2	8
November	10	N/A	6	20	2	10
December	12	N/A	10	25	2	15
January	12	N/A	10	40	2	15
February	12	N/A	10	40	2	20
March	12	N/A	10	70	2	25
April	12	N/A	9	80	2	35
May	10	N/A	9	70	2	35
June	6	N/A	3	30	2	20
July	6	N/A	3	15	2	15
August	6	N/A	3	12	2	10
September	6	N/A	3	10	2	10

Ramping

EMIGRANT RESERVOIR

- When adjusting flow releases from Emigrant Reservoir during non-flood rule conditions, flows will not increase (up-ramp) more than 100% nor decrease (down-ramp) more than 50% from the previous 24-hour period.
- When Emigrant Reservoir is under a flood rule condition between October 1 and May 1, as established and required by the Flood Control Storage Schedule, releases will be determined by the details of that rule and schedule, per a mandate from the Secretary of the Army in 1969. The Flood Control Storage Schedule is designed to minimize flood potential in the communities downstream of Emigrant Reservoir by maintaining a required surcharge in Emigrant. To maintain the required

surcharge in Emigrant during periods of heavy runoff, the Districts may need to up-ramp or down-ramp releases from Emigrant that violate the provisions established for non-flood control periods. If at all feasible, and in recognition of the Project Effects on fish, efforts will be made to maintain the 50 percent down-ramping protocol even during periods of flood control.

DIVERSION CANALS

- No ramping protocol identified for Oak Street or Phoenix Diversion Canals since they do not function during the Storage Season.

IRRIGATION SEASON (APPROXIMATELY APRIL 16 THROUGH OCTOBER 14)

Project Effects on Fish

- Streamflow withdrawals for irrigation at Project diversions (Upper South Fork Little Butte Creek diversions, Oak Street Diversion, Phoenix Diversion)

Mitigation Proposal

Minimum Flow Releases

- The most recent Minimum In-stream Flow Proposals from Reclamation are presented in Table 1.

Ramping

Ramping protocol will be established at Project Infrastructure to minimize the potential for a gain or reduction in water surface elevation greater than 2 inches per hour in Emigrant or Bear Creeks ***as a result of direct Project action.***

Project impacts on up- and down-ramping in Emigrant Creek will be managed based on flow releases from Emigrant Reservoir and as measured at the EMI Hydromet station. Project impacts on down-ramping in Bear Creek downstream of the Oak Street Diversion will be managed based on diversion rates into the Talent Canal and measured at the BASO Hydromet station. Project impacts on down-ramping in Bear Creek downstream of the Phoenix Diversion will be managed based on diversion rates into the Phoenix Canal and measured at the BCTO Hydromet station. The 2-inch threshold in water surface elevation decrease was determined through an analysis of the rating curves at EMI, BASO, and BCTO, which are presented in Appendix A.

The proposed ramping protocol gives consideration to critical habitat flows in each affected stream reach. Critical flows were determined by Reclamation to define the low flow threshold condition at which down-ramping may have the greatest impact on WUA which may result in fish stranding. Table 2 presents Reclamation's proposed critical flow volumes for the gages of interest. Flows above the defined critical flow rates in each stream are large enough to withstand a more rapid ramping condition.

TABLE 2. CRITICAL FLOWS PROPOSED BY RECLAMATION

Hydromet Station	Critical Flow (cfs)
EMI	10
BASO	20
BCTO	20
GILO	40

EMIGRANT RESERVOIR

- When Emigrant Reservoir is under a flood rule condition between October 1 and May 1, as established and required by the Flood Control Storage Schedule, releases will be determined by the details of that rule and schedule, per a mandate from the Secretary of the Army in 1969. The Flood Control Storage Schedule is designed to minimize flood potential in the communities downstream of Emigrant Reservoir by maintaining a required surcharge in Emigrant. To maintain the required surcharge storage in Emigrant reservoir during periods of heavy runoff, the Districts may need to up-ramp or down-ramp releases from Emigrant that violate the provisions established for non-flood control periods. If at all feasible, and in recognition of the Project Effects on fish, efforts will be made to maintain the 50 percent down-ramping protocol even during periods of flood control.

Up-Ramping

It is generally recognized that up-ramping impacts on fish resources is much less than down-ramping. Nonetheless, when not under a flood rule conditions, up-ramping from Emigrant Reservoir during the irrigation season will be managed to minimize potential increases of water surface elevation of more than 2 inches per hour at EMI, according to the following schedule:

- When flows at EMI are between 2 and 6 cfs, flow increases from Emigrant will not exceed 8 cfs per hour.
- When flows at EMI are between 6 and 20 cfs, flow increases from Emigrant will not exceed 10 cfs per hour
- When flows at EMI are between 20 and 40 cfs, flow increases from Emigrant will not exceed 15 cfs per hour.
- When flows at EMI are between 40 and 100 cfs, flow increases from Emigrant will not exceed 20 cfs per hour.
- When flows are greater than 100 cfs at EMI, flow increases from Emigrant will not exceed 30 cfs per hour.

  The ramping schedule described above is based on an up-ramping analysis of the rating curve at EMI and on average, for the flow ranges identified, maintains a water surface increase of less than 2 inches per hour.

Down-Ramping

- Down-ramping rates from Emigrant Reservoir will be managed to not exceed 50 percent of the previous 24-hour average.
- When flows at EMI drop at or below the critical flow of 10 cfs, down-ramping will be limited to a maximum change of 5 cfs per hour to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at EMI and the corresponding reach.

OAK STREET CANAL

- Prior to increasing diversion flow rates at Oak Street, the District Manager will first consult the Hydromet gage at BASO to determine the current in-stream flow volume.

- When streamflow at BASO falls at or below the critical flow of 20 cfs, increases of diversion flow rates at the Oak Street Diversion will be limited to a maximum change of 5 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BASO and the corresponding reach.
- When streamflow at BASO is between 20 and 70 cfs, increases in diversion flow rates at Oak Street Diversion will be limited to a maximum change of 10 cfs per hour form the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BASO and the corresponding reach.
- When streamflow at BASO exceeds 70 cfs, increases in diversion flow rates at Oak Street Diversion will be limited to a maximum change of 20 cfs per hour form the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BASO and the corresponding reach

PHOENIX CANAL

- Prior to increasing diversion flow rates at Phoenix, the District Manager will first consult the Hydromet gage at BCTO to determine the current in-stream flow volume.
- When streamflow at BCTO falls at or below the critical flow of 20 cfs, increases in diversion flow rates at the Phoenix Diversion will be limited to a maximum change of 5 cfs per hour from the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BCTO and the corresponding reach.
- When streamflow at BCTO is between 20 and 80 cfs, increases in diversion flow rates at Phoenix Diversion will be limited to a maximum change of 10 cfs per hour form the prior condition to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BCTO and the corresponding reach.
- When streamflow at BCTO exceeds 80 cfs, increases in diversion flow rates at Phoenix Diversion will be limited to a maximum change of 20 cfs per hour form the prior to minimize the potential for a decrease of more than 2 inches per hour in the water surface elevation at BCTO and the corresponding reach.

Sincerely,
GeoEngineers, Inc.

Jonathan M. Ambrose
Project Manager, Hydrologist

Wayne S. Wright, PWS
Principal

JMA:lc

Three copies submitted

cc:	Douglas McDougal (1)	Chris Eder (2)	Chuck Wheeler (3)
	Marten Law	Bureau of Reclamation	National Marine Fisheries Service

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Appendix F

ROGUE RIVER VALLEY IRRIGATION DISTRICT				
WATER CONSERVATION & STREAM ENHANCEMENT				
Project Name		Project		
Date	Cost	Definition	Benefits	Results of Project
Eagle Gulch	$6,667 RRVID		Decrease seepage	Tributary to Little Butte Creek
1425-01-FC-10-7790	$15,333 M ID		lower O&M costs	Water Conservation and
9/4/01-5/2/02	$22,000 BOR	Pipeline	imp. public safety	sediment control.
GPS Unit	$5,000 RRVID	GPS Unit	Able to GPS Dist.	Clarifying District Boundaries
1425-00-FC-10-6160	$7,500.00		boundaries	and water rights.
2/8/00-12/31/02				
Blue Moon Diversion	$15,000 RRVID	fish screen		
1425-00-FC-10-6310	$60,000 BOR			
6/7/00-12/31/03				
GIS Accounting/Software	$15,000 RRVID	GIS/ Accounting Software		Purchase computer for purpose of mapping District water rights.
1425-02-FC-10-8350	$15,000 BOR			To process the accounting of perfected water rights
3/13/02-3/31/04				
Reclaimed Water Proj.	$25,000 BOR	Pipeline		
1428-03-FC-10-9610	$25,000 RRVID			
7/18/03-Present	expenses.			
Bear Creek Telemetry	$9,500 BOR	Telemetry	Monitor flows in	Flow monitoring in Bear
1425-00-FC-10-6350	$2,500 MID	station	Bear Creek	Creek
6/7/00-12/31/01	$2,500 RRVID			
Agate Dam Security	100% paid by	Security		To keep vandals out of the
1425-00-fc-10-6740	Bureau	System		Agate Dam Control Bldg.

ROGUE RIVER VALLEY IRRIGATION DISTRICT				
WATER CONSERVATION & STREAM ENHANCEMENT				
Project Name		Project		
Date	Cost	Definition	Benefits	Results of Project
8/2/00-12/31/01	$15,000 Total			
GIS Coordinator Pos.	$5,340 RRVID			
1425-01-fc-10-7310	$7,310 MID			
6/5/01-10/16/02	$9,855 TID			
	$22,500 BOR			
Fencing Antelope Div	100% BOR Pd.	Fencing/ Security		
1425-01-fc-10-07710	$ 2,000			
7/27/01-12/31/01				
Jackson St. Hydromet	$7,000 RRVID	Hydro met	Monitor Diversions	Monitor water level in
1425-01-fc-10-7290	$7,000 BOR			Jackson Creek
4/11/01-2/3/03				
Flow metering Equip	100% pd. BOR	Aqua Calc	water measurement	measuring water in various creeks
1425-02-fc-10-8690	$5,000			
5/10/02-12/31/02				
GIS Software/Computer Purchase	$10,000 BOR	Computer/GIS Software Purchase	Y2K compatibility, More accurately track District Service Area and water use within the District	BOR required District to be Y2K compatible.
1425-99-fc-10-05690	$10,000 RRVID			
8/3/99-9/30/00				
Coker Butte Telemetry	$5,000 BOR			
1425-99-fc-10-5100	$5,000 RRVID			
9/22/99-6/30/02				
Canal Demossing	$35,000 RRVID	Remove Canal		

ROGUE RIVER VALLEY IRRIGATION DISTRICT				
WATER CONSERVATION & STREAM ENHANCEMENT				
Project Name		Project		
Date	Cost	Definition	Benefits	Results of Project
1425-99-fc-10-6040	$35,000 BOR	Vegetation		
9/20/99-12/31/02				
Drivers Pipeline	$208,000 RRVID	Gravity Pipeline		Gravity pipeline demonstration system. Decrease the sporadic losses in high erosion areas.
	$208,000 BOR			Maintenance free irrigation
9/17/97-12/31/00				canal management
Telemetry NF/SF	$5,000 RRVID	telemetry	water	measuring water flow in
	$10,000 MID		measurement	the creek
3/13/02-12/31/03	$15,000 BOR			
Project Name		Project		Results of Project
Date	Cost	Definition		
Hopkins Canal 2000-2001	Developer Expense	720 feet of pipeline	Water Conservation	Safety and Water Savings
Hopkins Canal 2002-2003	Developer Exp and City of Medford	1300 feet of Box Culvert	Water conservation	Safety and Water savings
Hopkins Canal 2001-2002	Developer Exp and City of Medford	1350 feet of Box Culvert	Water Conservation	Safety and Water savings
Hopkins Canal 2002	RRVID	112 feet of Concrete lining	Water Conservation	Safety and Water savings
Berrydale System	RRVID	352 feet of 18” ADS Pipe	Water Conservation	Safety and Water savings
401 Lateral 2003-2004	RRVID	2800 feet of 12” ADS Pipe	Water Conservation	Safety and Water Savings

ROGUE RIVER VALLEY IRRIGATION DISTRICT				
WATER CONSERVATION & STREAM ENHANCEMENT				
Project Name		Project		
Date	Cost	Definition	Benefits	Results of Project
Cocker Butte Lateral 2002-2003	Developer and Jackson County	2700 feet of 36” PVC Pipe	Water Conservation	Safety and Water Savings
Cocker Butte Lateral 2002-2003	Developer/RR VID	175’ of 24” ADS Pipe	Water Conservation	Safety and Water Savings
Cocker Butte Lateral 2002-2003	Developer/RR VID	1130’ 18” ADS Pipe	Water Conservation	Safety and Water Savings
Upton Lateral 2001-2002	Developer/RR VID	636’ 18” ADS Pipe	Water Conservation	Safety and Water Savings
Upton Lateral 2000	Developer/RR VID	1200’ of 18” ADS Pipe	Water Conservation	Safety and Water Savings
Upton Lateral 1999-2000	Developer/RR VID	1900’ of 18” ADS Pipe	Water Conservation	Safety and Water Savings
Ranch Lateral 2003	Homeowner/ RRIVD	735’ of 18” ADS Pipe	Water Conservation	Safety and Water Savings
Project Name		Project		Results of Project
Date	Cost	Definition		
Pech Lateral 2000	Developer/ RRVID	1600’ of 12” PVC Pipe	Water Conservation	Safety and Water Savings
Upton Lateral 2001 (Jerry May)	Developer/RR VID	1680’ of 12” PVC Pipe	Water Conservation	Safety and Water Savings
Blue Moon 2003	Developer	3500’ of 24” PVC Pipe	Water Conservation	Safety and Water Savings
Jackson St. Diversion	RRVID/MUR A City of Medford and USBR	Fish Friendly state of the Art Diversion. Fish Screens	ESA Compliant Fish Screens and Fish Ladder	I.T.S for Diversion

Medford Irrigation District
Instream Leases

Order #	ACRES	CREEKS INVOLVED WITH LEASE
IL-889	328	NORH FORK LITTLE BUTTE TRIBUTARY TO LITTLE BUTTE CREEK
IL-907	129.36	BEAR CREEK SOURCE TRIBUTARY TO ROGUE RIVER/FOURMILE
IL-956	83.4	NORTH & SOUTH FORKS LITTLE BUTTE CREEK
IL-864	24.29	NORTH & SOUTH FORKS LITTLE BUTTE CREEK
IL-854	56.7	NORTH & SOUTH FORKS LITTLE BUTTE CREEK
IL-850	91.6	LITTLE BUTTE CREEK TRIBUTARY TO ROGUE RIVER
IL-861	9.72	NORTH & SOUTH FORKS LITTLE BUTTE CREEK
IL-770	27.8	NORH FORK LITTLE BUTTE TRIBUTARY TO LITTLE BUTTE CREEK
IL-783	28.5	NORH FORK LITTLE BUTTE TRIBUTARY TO LITTLE BUTTE CREEK
IL-757	7.6	BEAR CREEK SOURCE TRIBUTARY TO ROGUE RIVER
IL-771	28.5	NORH FORK LITTLE BUTTE TRIBUTARY TO LITTLE BUTTE CREEK
IL-756	20.06	BEAR CREEK SOURCE TRIBUTARY TO ROGUE RIVER/

Revised 9/2009

MEDFORD IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
East Main Canal Project 2008-2009 #1425-08-FG-1L-1348	BOR & MID $49,104.00	to line segments of open canal	Improve reliability, efficiency and effectiveness of water delivery to patrons, prevents seepage losses and soil erosion	Reduction aquatice growth in the canal system with impoved water quality. Aquatic growth in minimized.
West Main Canal Project 2008-2009 #1425-08-FG-1L-1348	BOR & MID $51,046.00	to install segments of pipe and line segments of open canal	Improve reliability, efficiency and effectiveness of water delivery to patrons,prevents seepage lossesand soil erosion	Allows more efficient water deliveries and reduction aquatice growth in the canal system with impoved water quality. Aquatic growth in minimized.
Pipelines/Westside 2008-2009 #1425-08-FG-1L-1348	BOR & MID $12,400.00	convert earthen ditches to pipe	Improve reliability, efficiency and effectiveness of water delivery to patrons	Conserved water and increased efficiency of water deliveries. Seepage controlled and operations and maintenance improved.
Water Measurement Devices hydromet, weirs, telemetry stations 2008-2009	BOR & MID $40,900.00	*Updated Equipment *Improved Weirs *Built a new weir	Development of geographic information system/tools to better conserve and manage water	Results have proven to save water on a daily basis and to be one of the best tools for water conservation.

MEDFORD IRRIGATION DISTRICT
WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Exposed Canal Liner - Demonstration Project #1425-7-FC-10-03550 1997	$25,000 MID $25,000 BOR	Demonstration project on 1200 feet of exposed canal liner.	Aquatic vegetative and seepage control	Saved water, improved water quality, controlled seepage and aquatic vegetation growth.
EMC Bear Creek Siphon 1425-7-FC-10-03550 1998	$4,088.94 MID $4,088.94 BOR	Water delivery measurement station, Flume	Water conservation & District delivery system management tool	Technical information, water rights, data, operations and maintenance costs, water management tool..
Fish Lake Repair 1425-8-FG-10-04880 1998	$4,764 MID $4,764 BOR	Emergency Level 1 Repair to floor of reservoir	Water conservation & District delivery system management	Repaired the clay blanket to the floor of the reservoir, public safety, water saved
Fish Lake Dam Upgrades Doc. Id. BD80510-00036 1998, 1999	$162,416 MID $81,208 RRVID $1,629,285 BOR	Upgrades to Fish Lake Dam	Public safety, water conservation, BOR Safety of Dams	Improved water measurements, mechanized gates, saved water, public safety
East and West Main Canal, 5 Siphons at Daisy, Jackson, Horn's, Walker, and Neidermeyer Creeks #1425-8-FC-10-04610 1998 - 2006	$100,000 MID $100,000 BOR	Constructed 5 siphons, piped 1800 feet of EMC and piped 1200 feet of WMC 48" pipe.	Separation of canal systems from natural streams, fish passages, soil erosion, public safety	Water savings by controlling seepage and vegetative growth, improved soil erosion, fish passage, public safety
WP Telemetry #1425-9-FC-10- 05090 1999	$5,000.00 MID 45,000.00 BOR	Water delivery measurement station	Water conservation & District Delivery system management tool	Technical information, water rights, data, operations and maintenance costs, water management tool..

MEDFORD IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Water 2025 Challenge Program- Northwest Water 2025 GIS and Aerial Imagery Consortium Project MID is a full partner started in 2005 - continued to present and into the future.	50/50 Cost Share $365,218.00 over all program	Consortium members will pool resources to acquire aerial imagery, implement GIS Technology, identity & implement water conservation measures.	Monitor consumptive use, improve the District's ability to identify conservation opportunities, expedite water transfers & instream leases, implement water conservation programs, quantify benefits gained, develop to water supply issues & interface directly with conservation organizations to prevent water supply crises.	
Planned Griffin Creek Fish Passage & Screening Water Shed Enhancement Project within MID'S Boundaries - 2007 start plans engineering, partnerships.	Cost is unknown at this time	Griffin Creek is a major tributary to Bear Creek. Bear Creek produces habitat such as Steelhead, Chinook, Coho & other species. Fish passage screening problems exist throughout Griffin Creek. MID has begun meeting with water users within it's District to form a partnership. 6 barriers have been identified in this reach	Fish passage & screening improvements within this stream reach include private diversions along with District diversions. This project will open app.. 4 miles for habitat. When the existing barriers downstream are all fixed, this stretch will already be open for Fish passage as occurred in Jackson Creek.	
2005 Concrete Lined Earthen Canals	$10,000.00	Piped open ditches and replaced old deteriorated concrete pipe with PVC pipe	Old concrete pipe leaks, allow tree roots to grow inside, wasting water and costly to maintain, public safety, water quality improvements	All of the benefits listed were the results and allowed for much more efficient water deliveries and water savings.
2005-2007 Water Measurement Devices hydromet, weirs, telemetry stations	$6,000.00	*Updated equipment * Improved weirs *Built new weirs	Improve management of water resources	Results have proven to save water on a daily basis while serving the water users with their needs. M.I.D. has experienced several drought years in a row & enhanced measurements throughout the delivery system has proven one of the best tools for water conservation
Pipe/Box Culvert Main Canals & Laterals - Partnerships with Developers & Cities	$1,000,000.00	Several sections of the District's main canal systems have been enclosed. M.I.D. works with Developers and cities to install pipe/box culvert whenever possible when developing parcels.	These type of projects (Partnerships) will continue to benefit the urbanized areas of the valley. Seepage, water quality, public safety, evaporation, aquatic growth, saves operation & maintenance of these areas so M.I.D. can put efforts elsewhere into improvements	The cumulative effect of these partnerships over the past several years has definitely shown improvements to all of the expected benefits.

MEDFORD IRRIGATION DISTRICT
WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Barnett Pipeline 2006	MID & BOR $400,000	8,000 feet plus of 15" PVC pipe. Reroute the irrigation delivery system to separate it from Larson Creek. Install pipeline from TID to MID's East Main Canal.	Steelhead ,Coho and Chinook are able to use Larson Creek where it was blocked with stop-logs TID runoff will be directly picked up in the MID system by pipeline. Irrigation water will not be delivered through Larson Creek. The District's check structure across Larson Creek has been removed (2006). Now that the barrier is gone and the irrigation water is out of the creek by way of the new pipeline, water quality should be enhanced & 3 miles of fish habitat has be opened along with water conservation measures.	In the City limits of Medford an improved habitat for fish and wildlife is formed by opening app. 3 miles of Larson Creek to Steelhead & Coho. Water quality is improved in Larson Creek and water conservation to District delivery facilities. There is also a decrease of aquatic growth in the canal system.
2005 Concrete Lined Earthen Canals	$30,000.00	Water conservation method to control seepage, evaporation, moss control	These areas of the main canal were targeted as high water loss areas as noted in the results	These projects during 2005 benefited the water resources by drastically stopping seepage in high loss sections, stopped aquatic weed growth which attributes highly to evaporation loses & water quality issues. Results where recognized immediately.
Planned Instream Leases 2006 - 2007	2006 Partnership with M.I.D, T.I.D., R.R.V.I.D. and O.W.T. helped with patron water fees and transfer fees	Districts worked with the Oregon Water Trust to release District stored water into Bear Creek during the 2006 Irrig. season to enhance stream flows. Plans by the District, to continue Instream Leasing during 2007 season which will include Bear Crk. & Little Butte Creek	During 2007, the Instream Leases will flow from Fish Lake (head waters of the North Fork Little Butte & the entire stretch of Bear Creek) to the Rogue River. Benefits include lowering water temp. imbetterment of the fish habit conditions etc..	<u>Bear Creek Instream Leasing Pilot Project</u> 2006 increased stream flow during irrigation June-Oct in Bear Creek by 4.7 cfs /Emigrant Dam to The Rogue River Partners have been able to establish a leasing procedure & have learned important lessons for the future while adding water to the creeks & rivers.
2005 Concrete Lined Earthen Canals	$10,000.00	Piped open ditches & replaced old deteriated concrete pipe with PVC pipe	Old concrete pipe leaks, allows tree roots to grow inside. Wasts water and is costly to maintain, public safety, water quality improvements	All of the benefits listed were the results and allowed for much more efficient water deliveries, water savings and O7M expenses.
Water Measurement Devices hydromet, weirs, telemetry stations 2005-2007	$6,000.00	*Updated equipment * Improved weirs * Built new weirs	*Improve management of water resources * Real time data	Results have proven to save water on a daily basis while serving the water users with their needs. M.I.D. has experienced several drought years in a row & enhanced measurements throughout the delivery system has proven one of the best tools for water conservation.
Pipe/Box Culvert Main Canals & Laterals - Partnerships with Developers & Cities	$1,000,000.00	Several sections of the District's main canal systems and laterals have been enclosed. M.I.D. works with Developers and citys to install pipe/box culvert whenever possible when developing parcels.	These type of projects (Partnerships) will continue to benefit the urbanized areas of the valley. Seepage, water quality, public safety, evaporation, aquatic growth, saves operation & maintenance of these areas so M.I.D. can put efforts elsewhere into improvements.	The cumulative effect of these partnerships over the past several years has definitely shown improvements to all of the expected benefits.

Regvised 2/2007

MEDFORD IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
East Main Canal Project 2004	BOR & MID $42,000	Concrete lining with 14 yards of gunite, 6' wide on the canal bottom a distance of 150'	Lining the bottom of the canal with gunite helps to conserve water, prevents seepage losses, soil erosion.	Reduces maintenance costs to on farm delivery, prevents water seepage losses and improves water quality. Aquatic growth is minimized.
W-N Lateral 2004-2005	MID & BOR $8,000	Replaced deteriorated concrete pipe with 800 feet of 10" PVC pipe	The PVC pipe is water tight and will conserve water, help with more efficient deliveries, be vegetation free.	Water conserved through less seepage and loss gets to the patrons more efficiently.
W-C Lateral 2004-2005	MID & BOR $5,600	700' OF 12" ADS pipe currently open ditch.	The open dirt ditch absorbed water and caused losses.	The pipe is water tight and water is delivered in conservative manner, the vegetation and moss is almost eliminated.
W-D Lateral 2005	MID & BOR $2,400	400' of 10" ADS pipe installed.	Replacing an open dirt channel conserves water loss, controls aquatic growth.	Water deliveries are more efficient to the farm, water is conserved, aquatic vegetation is not a problem.
West Main Canal Pipe Project 2005 - 2006	MID & BOR $60,000	Pipe 320' with 36" ADS pipe.	Conservation of water losses, aquatic vegetation control.	Conserved water and increased efficiency of water deliveries. Seepage controlled and operations and maintenance improved.
Scott's Lateral 2006	MID & BOR $3,200	400 feet of 12 inch ADS pipe.	Replaced open earth ditch with water tight pipe, controlling seepage, moss, rodent damage.	Conserved water and increased efficiency of water deliveries. Damage done by rodents to system alleviated.
Exposed Canal Liner - Demonstration Project #1425-7-FC-10-03550 2006		Install 400 feet concrete lining at the Bradshaw Drop Diversion.	Control moss, aquatic vegetation, seepage, help maintain accurate telemetry readings.	Seepage controlled, water conserved and moss build up at measurement station reduced.

MEDFORD IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Stoneridge Project #1425-02-FC-10-8230 2002	$30,000 MID $30,000 BOR	400 feet of Concrete Canal Lining	Reduce Seepage, Prevent soil erosion, water conservation, prevent soil erosion, moss control	Saved water, seepage and vegetative control, soil erosion, improved water quality, moss control, cut evaporation losses
Huener Lane to Daisy Creek #1425-02-FC-10-8260 2002, 2003	$20,000 MID $20,000 BOR	420 feet of 60" pipeline	Vegetation control, decrease seepage, lower O&M costs, improve public safety	Saved water, improved soil erosion, public safety, seepage and vegetative control, improved water quality.
Phonenix Canal Lining #1425-00FC-10-6510 2002-2004	$43,000 MID $43,000 BOR	Improve water measurement accuracy by controllin aquatic vegetation.	Reduce aquatic vegetation growth, sediment and debris problems, improved water quality, improved water measurement accuracy.	Reduced vegetation, sediment and debris problems, improved water quality, improved water measurement reading devises accuracy.
Main Canal Linings 2004	MID $65,603 BOR $65,473	Replace existing fish screen passage that had 30% loss to juveniles.	Benefits summer & winter steelhead, coho salmon & cutthroat trout.	The new screens will protect 98% of the juveniles, with a consequent increase in adult salmon& steelhead.
Lateral Pipings 2004	MID $14,743, BOR $14,743	Install pipelines to laterals in areas of open earthen ditch delivery systems	Water conservation and deliver efficiency, eliminate moss growth and water losses.	Water conservation, lower operations & maintenance costs, seepage controlled.
North Fork of Little Butte Creek: Fish Screens & Ladder 2004, 2005	MID, RRVID, ODF&W, FRIMA $633,352	Replace existing fish screen passage that had 30% loss to juveniles.	Benefits summer & winter steelhead, coho salmon & cutthroat trout.	The new screens will protect 98% of the juveniles, with a consequent increase in adult salmon & steel head.
Water 2025 Challenge Grant: Larson Creek Siphon & Pipeline 2004 & 2005	MID, BOR, OWEB, ODF&W $600,000	2200 feet of 60" HDPE pipe and a siphon under Larson Creek. Removal of Diversion structures.	Water conservation, separate District facilities from natural fish habitat, open up 3 miles of historic tostream habitat. Lower O&M costs in Larson Creek.	2200' feet of new 60" HDPE pipeline has replaced open earthen canal improving water quality instream, water conservation to District facilities, native fish species are able to travel upstream now in natural habitat & fish barriers have all been removed.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
E-7 Pipeline 1995-1996	$65,375 TID	Install 12,650' of gravity pressure line	Provide pressurized water so water users could convert from flood to sprinkler irrigation	Water conservation, soil erosion, public safety
"Bring Back the Natives" NFWF #96-092-001 RRNF #96-CCS-52 NFF #96-CCS-091-0605 1996 -2000	$57,203 TID $16,349 NFWF $14,000 RRNF $10,300 NFF	Replace 140' of the McDonald Ditch flume at Greeley Creek. Replace 120' of two flumes upstream of Sheep Creek. Replace several existing flumes with 2,880' of pipe. Repair road access upstream from Greeley Creek. Form concrete waste way at Sheep Creek. Install four waste ways on public land. Install fish screen for the diversion at McDonald Creek.	Reduced the probability of failure of the canal caused by slides, downed trees and over flows. Also reduced maintenance/repair costs to the canal. Increased water transportation efficiency.	Improvements have benefited the fisheries resource within the Little Applegate River by reducing soil erosion. Increased canal efficiency.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Conveyance Systems Technology #1425-4-FC-10-00910 1996	$11,439 TID $10,000 BOR	CST Software, setup and training	Develops databases of physical parameters for definable studies and for use in watershed hydrologic modeling and other computer models for water conservation and improved efficiencies in the Bear Creek drainage area. Developed into the Efficiency Block, which we are currently using.	Water conservation
Ashland Canal Flow Measurement #1425-7-FG-10-03080 1997	$12,000 BOR	Acquisition and installation of measurement devices.	Assess seepage losses from the Ashland Canal.	Water conservation
Meters and Automated Gates #1425-7-FG-10-02940 1997-1998	$12,795 TID $11,000 BOR	Measure flows on piped laterals. Gate automation on Talent Canal at Oak Street and Ashland Canal at Greensprings.	Better control of water by monitoring use on piped laterals. Allows users to be conscious of their own use. Off site monitor and control of head gates on two canals by direct dial up.	Water conservation, flood control, public awareness

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Oak Street Fish Screen #6-07-10-W1127 #8-07-10-W1197 1997-1998	$15,426 TID $236,672 BOR	Install a self-cleaning fish screen at the Talent Canal Diversion at Bear Creek	Prevents fish from entering canal and keeps screen clear of debris with a mechanical brush system	Fish protection
T18 Pipeline 1997	$26,122 TID	Install 2,300' of 12" pipe	To provide gravity pressure to irrigators.	Water conservation, soil erosion.
T14 Pipeline 1997-1999	$25,107 TID	Pipe 6,098' of open lateral	To provide gravity pressure to irrigators, so that they can convert from flood irrigation to sprinkler irrigation.	Water conservation, soil erosion
Integrated Pest Management Study #1425-7-FC-10-02960 1997-2001	$215,339 TID $215,000 BOR	Evaluate aquatic vegetation canal management techniques, including mechanical/manual, chemical, cultural, operational, structural and biological control measures and provide a management and implementation guide for other	Identified and monitored noxious weeds. Demonstrated various aquatic vegetation management methods including the use of grass carp. Constructed modifications to system to prevent grass carp from entering natural water ways. Constructed and modified equipment for the use of flails.	Identified poor methods of aquatic vegetation control. Developed protocol for aquatic management. Identified problem areas in the system and corrected. Increased public awareness. Fish passage enhancement. Shared information with other districts.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
		irrigation districts.		
Lower Wagner Creek Fish Ladder 1998	$22,335 TID	Install a fish ladder at the lower Wagner Creek Diversion	Provides fish passage beyond the District's lower diversion in Wagner Creek	Fish passage enhancement
Oak Street Fish Ladder 1425-98-SI-10-07540 1998	$320,000 BOR	Install a fish ladder at the Talent Canal diversion at Bear Creek.	Allows fish passage around diversion in Bear Creek.	Fish passage enhancement
Neil Creek Pump 1999	$550 TID	Remove the pump station in Neil Creek	Removed the pump station structure from Neil Creek.	Fish passage enhancement, water quality

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Lower Wagner Creek Fish Screen 1999-2000	$14,270 TID	Install fish screen at the District's lower diversion on Wagner Creek	Prevents fish passage into the District's system.	Fish passage enhancement
Upper Wagner Creek Fish Screen 1999-2000	$13,441	Install fish screen at the District's upper diversion on Wagner Creek	Prevents fish passage into the District's system.	Fish passage enhancement
Water Conservation Coordinator and Computer Upgrade #1425-9-FC-10-05260 1999-2000	$42,976 TID $37,621 BOR	Fill WCC/GIS position and upgrade computers	Develop a GIS program for the district to support planning, water conservation, operation and maintenance, and other program needs.	Water management and conservation planning.
E-14 Pipeline 1999-2000	$40,840 TID	Install 4,975' of gravity pipeline	To provide gravity pressure to irrigators, so that they can convert from flood irrigation to sprinkler irrigation.	Water conservation, soil erosion
Neil Creek Fish Screen 2000	$6,115 TID	Install fish screen at the District's diversion on Neil Creek	To prevent fish from entering the District's diversion.	Fish passage enhancement

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Water Measurement #1425-7-FC-10-03270 2000	$7,537 TID $6,000 OWRD	Purchase of 3 shaft encoders, an AquaCalc 5000-G portable measuring device and a transit-time flow meter.	Replace outdated recorders with shaft encoders. Data is electronically collected and transferred directly to the OWRD computer. A portable transit-time measuring device measures the flow to individual irrigators without major intrusion into existing structures.	More accurate and timely data collection for water conservation. Increased water deliveries thorughout the TID system.
E-1 Maywood Pipeline 2000	$13,938 TID	Replace 2,720' of concrete culvert with plastic pipe.	To reduce leaks and provide gravity pressure to those on the system.	Water conservation, soil erosion, public safety
Seepage Enhancement #1425-01-MA-10-3150 2001	$13,400 BOR	Instrumentation Enhancement at Hyatt and Keene Creek Dams	Measure sediment and seepage from the toe drain system on both dams.	Dam safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Measuring Devices 2000	$3,678 TID $3,678 OWRD	Purchase of 2 flow meters, one sensor and 14 water level recorders	Measures water use on gravity pressure lines. Water level recorders are used in a series along a canal to identify volume and time of day that unauthorized diversions are made and measures use where meters are not available.	Water conservation, water theft
Telemetry #1425-7-FC-10-03270 2001	$4,539 TID $4,000 OWRD	Purchase and install telemetry equipment on the East Canal near Valley View Road and on the West Canal at Billings Syphon	Remote monitoring of the volume of water in the East Canal at Valley View and the start of the West Canal at the Billings Syphon	Water conservation
Canal Lining #1425-00-FC-10-7040 2000-2002	$41,146 TID $40,000 BOR	Demonstration of various types of canal lining	Install several types of canal lining material throughout the system to determine which product is best.	Water conservation, soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
GIS Coordinator #1425-01-FC-107310 2000-2002	$22,807 TID $39,003 BOR	Technical assistance under BOR's Water Conservation Field Services Program	Develop accurate maps of the distribution system and associated easements, inventory and map water rights and existing system structures, improve organizational planning with emphasis on management efficiency.	Water conservation, sharing of information
Re-regulation Ponds #1425-00-FC-10-6280 2000-2003	$35,828 TID $35,828 BOR	Install a re-regulation pond and piping on the Talent Canal	The installation of the re-regulation pond reduced releases from the reservoir. The excess water in the canal at night is stored and used during high use, generally in the afternoons. It is estimated that 500 acre feet of water is saved during each season.	Water conservation. Increased water delivery efficiency.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Greenmeadows #1425-01-FC-10-7590 2001-2002	$41,332 TID $40,000 BOR	Demonstration of the feasibility of low-head plastic pipeline materials in lined canals that are still leaking.	Install 1880' of 30" ADS Pipe in canal prism to reduce seepage.	Water conservation, soil erosion, water quality, public safety
Moss Cutter #1425-01-FC-10-7660 2001-2004	$99,330 TID $15,000 Headwaters/TID joint account $62,800 BOR	Construct a prototype machine to remove aquatic vegetation from irrigation district canals	The moss cutter uses high pressure water to break up moss that grows in the canals during the irrigation season.	Water conservation, soil erosion, water quality, public safety, decrease dependence on chemical control of aquatic weed growth.
Flow Meters #1425-01-FC-10-7240 2001-2005	$17,330 TID $17,330 BOR	Test several sizes of magnetic flow meters to measure water flow in several gravity pressure lines.	Magnetic meters did not function well in the District's system. Propeller meters were found to be the most effective. The District installed 7 meters on pressurized laterals.	Water conservation, water theft

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Ramp Flumes, Telemetry, Guaging Stations #1425-01-FC-10-7200 2001-2005	$23,285 TID $6,000 OWRD $20,000 BOR	Construct ramp flumes and install telemetry and guaging station equipment at various locations throughout the District's system	Five telemetry stations, six ramp flumes and four guaging stations were installed.	Water conservation. Create system efficiency block to better evaluate high use/high loss areas within the canal system.
Automated Trash Racks #1425-02-FC-10-8200 2002-2004	$20,000 TID $20,000 BOR	Installation of automated Trash Racks at headgates of major laterals	Self cleaning screens were installed to aid in removing the excess debris caused from mechanical cleaning. The debris would accumulate too quickly for crews to keep the canals open.	Soil erosion, water quality, public safety
Fern Valley Pipeline Phase I, II & III #1425-02-FC-10-8120 2002-2006	$79,899 TID $76,670 BOR $2,424 LANDOWNER	Gravity pressurize the Fern Valley Pipeline, a pipeline of approximately 5 miles.	The District has installed 9,880' of various sized pipe, allowing for waterusers to convert approximately 200 acres from flood irrigation to sprinkler. This lateral will eventually tie into the Hughes Lateral.	Water conservation, soil erosion, water quality, fish passage enhancement, public safety, water right management.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Pipe Study #1425-02-FC-10-8130 2002-2005	$5,000 TID $5,000 BOR	Study options for putting the District's entire system into pipe and/or canal lining.	This study became part of a larger project called the WISE Project. Several stakeholders have come together to improve the Bear Creek and Little Butte Creek watersheds. The WISE Project is ongoing. The feasibility study is being completed at this time.	Water conservation, water quality, improve fish habitat
Canal Lining #1425-03-FC-10-9480 2003-2005	$36,675 TID $30,000 BOR	Line problem areas of canals	Conserve water through reducing seepage from unlined canals.	Water conservation, soil erosion, water quality, public safety
E1A Pipeline 2003	$64,460 TID	Install 3,885' of pipe	Provide gravity pressure to area that had frequent dry periods	Increased water delivery efficiency.
Talent Canal Pipelines #1425-03-FC-10-9460 2003-2004	$50,925 TID $17,250 BOR	Pipe laterals T7, T14 and T16. District installed 8,270' of pipe.	Control and prevent soil erosion by replacing open canals with buried pipelines and allowing waterusers to convert from flood irrigation to sprinkler.	Water conservation, soil erosion

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Fish Passage & Coalition Building 2003-2005	$3,285 TID $6,060 NFWF thru Headwaters	Install fish passage on Upper Wagner Creek and Neil Creek Diversions. Facilitate outreach and coordination with agricultural community to build support for restoration of fish and wildlife habitat.	The temporary fish ladders are installed at the same time the diversions are installed and are removed with the diversions at the end of the season. Joint effort between TID, Headwaters and the agricultural community on fish passage and wildlife habitat restoration.	Fish passage, restoration of wildlife habitat
Larson Creek Project #1425-03-FC-1L-9800 2003-2008	$26,744 TID $62,244 BOR	The District installed 4,408' of various sizes of pipe as part of an overall project to separate the irrigation delivery system from Larson Creek.	Project removes three stop-log diversions, provides a new stream channel and restores Larson Creek to a natural flow regime.	Water conservation, fish passage enhancement, water quality, increase water delivery efficiency
Delivery Canal Flume Replacement 2004	$13,792 TID $10,344 BOR $3,066 MID $1,531 RRVID	Install 180' of 60" ADS pipe in the Joint Works Delivery Canal	Replace existing wooden flume that was showing signs of failure	Water conservation, prevent soil erosion

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
West Canal Griffin Creek Spillway 2004	$12,150 TID	Install 440' 18" ADS pipe	Soil is mostly granite in this area. Piping will reduce seepage and decrease the risk of canal failure through this section.	Water conservation, prevent soil erosion, moss control, right of way recovery
West Canal Near Mel Lowe Lane 2004	$7,400 TID	Install 240' 24" ADS pipe	Piping will reduce seepage and decrease the risk of canal failure through this section.	Water conservation, prevent soil erosion, moss control, right of way recovery
Computers 1425-04-FC-1L-1050 2004	$5,300 TID $5,300 BOR	Upgrade computer systems for GIS	Provide hardware to aid efforts in managing the District's irrigation system by using GIS software, automation and telemetry equipment.	Water conservation, increase water delivery efficiency
Talent Canal Near Buena Vista 1425-04-FC-1L-1050 2004-2008	$40,043 TID $40,000 BOR	Install 1820' of 24" ADS pipe in the canal near the Buena Vista subdivision.	Piping reduced seepage and decrease the risk of canal failure through this section.	Water conservation, prevent soil erosion, water quality, public safety
Talent Canal Lining 1425-04-FG-1L-1065 2004-2006	$10,932 TID $8,425 BOR	Line section of canal on Carpenter Hill and Frink Orchard	Prevent excessive saturation of canal bank which could cause canal failure.	Water conservation, prevent soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
West Canal piping on Argraves East Canal piping on Quinowski 1425-04-FG-1L-1057 2004-2005	$57,209 TID $57,209 BOR	Repair and pipe areas where slides have damaged the canal integrity. 260' of pipe was installed on the Argraves' property and 320' of pipe was installed on the Quinowski property along with 400' of slotted pipe.	Prevents further canal damage in areas where slides have occurred.	Water conservation, prevent soil erosion, water quality, public safety
Talent Canal Near 7th Day Adventist 2005	$3,660 TID	Install 100' 18" ADS pipe	Piping will reduce seepage and decrease the risk of canal failure through this section.	Water conservation, prevent soil erosion, moss control, water quality
T7 & T18 Self Cleaning Screens 2005	$17,390 TID	Install 2 self cleaning screens on the T7 and T18 laterals,	The installation of self cleaning screens at the intake of the District's pressure laterals prevents the canals from topping the banks, promotes more efficient methods of irrigation and provides a more continuous supply of irrigation water during the season.	Water conservation, prevent soil erosion, increase water delivery efficiency

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
West Canal Near Morey Road 2005	$22,900 TID	Install 400' 36" ADS pipe	Piping will reduce seepage and decrease the risk of canal failure through this section.	Water conservation, prevent soil erosion, moss control, water quality
Ashland Canal Fish Screen @ Buckhorn 2005	$5,225 TID	Replace screen on the Ashland Canal Diversion on Emigrant Creek	Update the fish screen at the Ashland Canal diversion to NOAA criteria.	Fish screening
T14 Camp Baker 2005	$5,506 TID	Install 960' of 4" PVC pipe	Install gravity pressure line which will encourage irrigators to convert to more efficient methods of irrigation.	Water conservation, water quality, improve water distribution
Coleman Creek Siphon Automated Traveling Screen 2005	$48,390 TID $28,710 Headwaters/TID joint account	Install automated traveling screen in the Talent Canal at the Coleman Creek Siphon.	The automated screen uses a conveyor type system to remove debris from the canal. The debris is piled on the canal bank and is periodically hauled off. The installation of the screen stopped the uncontrolled wasteway operation into the natural stream.	Soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Study of native fishes in the Bear Creek Watershed 2005	$14,085 Headwaters/TID joint account	Master's level study of the status of native fishes in the Bear Creek Watershed.	Long term goal of project is to improve aquatic habitat in the Bear Creek Watershed.	Power Point presentation on results of study to gather information on native fish
Joint Works Delivery Canal Ramp Flume 2005	$4,410 TID $3,310 BOR $980 MID $490 RRVID	Install ramp flume at the discharge gate at Howard Prairie Dam	To more accurately measure releases and give more precise measurements with better operational controls at Howard Prairie Lake.	Water conservation
Canal Lining 2005	$36,341 TID	Line sections of canals using shotcrete with Nikon Fiber	Lining canals prevents seepage and saturation of canal bank.	Water conservation, prevent soil erosion, water quality, public safety
Talent Canal Build up road by Crooked Creek 2005	$5,029 TID	Build up the canal road on the Talent Canal near Crooked Creek	This area was a low spot on the canal road. Building up the road in this area would prevent the canal from overflowing into Crooked Creek and provided freeboard for screen and measuring device installation.	Prevent soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Delivery Canal Repair Wall @ Keene Creek Reservoir 2005	$3,412 TID $2,559 BOR $758 MID $379 RRVID	Repair the wall of the Delivery Canal at the Keene Creek Reservoir.	The repair prevented further damage to the Delivery Canal wall, which if left alone, could have failed and caused a failure to Keene Creek Dam.	Prevent soil erosion, water quality, public safety
Billings Siphon raise outfall 2005	$7,377 TID	Raise the Billings Siphon outfall canal prism.	Accomodates the installation of the ramp weir measuring device for more accurate measurement.	Prevent soil erosion, water quality, public safety, water measurement efficiency
Cover Myers Creek Siphon on the East Canal 2006	$10,373 TID	Cover the East Canal Siphon on Myers Creek. The flooding uncovered the siphon.	This work will help prevent erosion of the siphon, thereby helping to prevent a failure of the siphon and removes the hydraulic jump in the creek.	Prevent soil erosion, water quality, public safety, fish passage
Clean the Ashland Canal Diversion in Emigrant Creek 2006	$11,983 TID	Clean the Ashland Canal Diversion in Emigrant Creek due to flooding.	Cleaning the diversion out prevents additional flooding of Emigrant Creek and provided a clean transition at the headworks of the Ashland Canal.	Prevent soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Pipe Ashland Canal through Dietz property 2006	$8,268 TID	Pipe 100' of the Ashland Canal through the Dietz Property.	Installing pipe through this area prevented further leaks from the Ashland Canal.	Water conservation, prevent soil erosion, water quality, public safety
Canal Lining 2006	$17,271 TID	Line the Talent Canal through this problem area.	Conserve water through reducing seepage.	Water conservation, prevent soil erosion, water quality, public safety
T6 Pipeline 2006	$13,056 TID	Install 1,000' of pipe.	Control and prevent soil erosion by replacing the open ditch with buried pipeline and allowed for the waterusers to convert from flood irrigation to sprinkler.	Water conservation, prevent soil erosion, water quality, public safety
Water Measurement #1425-06-FG-1L-1223 2006-2008	$9,482 TID $9,482 BOR	Install measuring devices on the Talent Canal @ Crooked Creek, on the East Canal near Billings Siphon and on the West Canal @ Coleman Creek.	The purchase and installation of water measurement devices to accurately measure flows in the canals at the different locations and to create efficiency blocks within the delivery system.	Water conservation, prevent soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Pipe Fletcher Line on the East Canal 2006	$6,338 TID	Install 900' of pipe in a lateral on the East Canal.	Control and prevent soil erosion by replacing the open ditch with buried pipeline.	Water conservation, prevent soil erosion, water quality, public safety
Pipe sections of the Talent Canal #1425-05-FG-1L-1125 2006-Current	$42,088 TID $42,088 BOR	Install pipe in the canal near the Sundown Vineyard.	Control and prevent soil erosion by replacing the open canal with buried pipe.	Water conservation, prevent soil erosion, water quality, public safety
T16 Pipeline 2007	$27,257 TID	Install 3,940' of pipe in the open lateral on the Talent Canal.	Control and prevent soil erosion and to conserve water by replacing open ditch with a buried pipeline.	Water conservation, prevent soil erosion, water quality, public safety
T13 Pipeline 2007	$7,402 TID	Install 200' of pipe in the open lateral on the Talent Canal.	Control and prevent soil erosion and to conserve water by replacing the open ditch with a buried pipeline.	Water conservation, prevent soil erosion, water quality, public safety
Pipe the West Canal near the Jackson Hot Springs 2007	$7,224 TID	Install 60' of pipe in the open canal.	Control and prevent soil erosion by replacing the open canal with buried pipe.	Water conservation, prevent soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Automated Traveling Screens #1425-06-FG-1L-1203 2007	$79,831 TID $79,831 BOR	Install two automated traveling screens on the Talent Canal: one at Wagner Creek and one at Crooked Creek	Self cleaning screens were installed to aid in removing the excess debris caused from mechanical cleaning. The debris would accumulate too quickly for crews to keep the canals open.	Soil erosion, water quality, public safety
Hughes Lateral #1425-06-FG-1L-1213 2007-Current	$61,126 TID $61,126 BOR	Replace approximately 6200' of concrete tile with pressure pipe, and to tie into the Fern Valley Pipeline.	Prevent loss of water through leaks in old pipe, also provides for adequate pressure to encourage waterusers to convert to more efficient methods of irrigation.	Water conservation, prevent soil erosion, water quality, public safety
Canal Lining 2007	$3,863 TID	Line sections of canals using shotcrete with Nikon Fiber	Lining canals prevents seepage and saturation of canal bank.	Water conservation, prevent soil erosion, water quality, public safety
Pipe the West Canal @ 2918 Griffin Creek Road 2008	$12,798.79 TID $6,750 LANDOWNER	Install 680' of 18" ADS pipe in the open canal.	Control and prevent soil erosion by replacing the open canal with buried pipe.	Water conservation, prevent soil erosion, water quality, public safety

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Pipe the Fredericks Lateral @ 9391 Wagner Creek Road 2008	$1,478.65 TID $2,140.50 LANDOWNER	Install 100' of 24" Corregated Metal Pipe	Control and prevent soil erosion by replacing the open canal with buried pipe.	Water conservation, prevent soil erosion, water quality, public safety
Water Conservation Improvements 1425-08-FG-1L-1353 2008-Current	$1,277 TID $1,277 BOR	Purchase of computer and installation of water resource management software; re-line 850' of canal and new lining on 450' of canal; pipe 1,460' of the West Canal near Burrell Road with 18" HDPE water tight pipe; convert 2,060' of the T13 Lateral from concrete tile to 6" pressure pipe.	More efficient water resource management and water right tracking with GIS and water management software; prevent loss of water through seepage from canals and leaks in old pipes, control and prevent soil erosion by lining or piping open sections of canal, provides pressure to encourage waterusers to convert to more efficient methods of irrigation.	Efficient water resource management, better control of water right, water conservation, prevent soil erosion, improve water quality & public safety.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
System Optimitation Review (SOR) 1425-08-FG-1L-1377 2008-Current	$0 TID $0 MID $0 RRVID 0$ BOR	Joint project to 1)quantify water losses; 2)determine feasibility of adding re-regulating basins; 3)evaluate modifications to storage & operations; 4)evaluate modifications to water deliveries; 5)deploy data gathered by incorporating results in regional water & land use planning.	Identify opportunities to conserve & manage water more efficiently: identify specific areas of water loss and evaluate the following: installation of re-regulating basins; operational and storage changes; and changes to water deliveries.	Promote rapid inclusion of results into regional water & land use planning, Water Management & Conservation Plans, ESA consultations, TMDL determinations, and related efforts, and ultimately a more rapid adjustment to the overall system.

TALENT IRRIGATION DISTRICT

WATER CONSERVATION & STREAM ENHANCEMENT

Project Name Date	Cost	Project Definition	Benefits	Results of Project
Canal Lining & Piping Projects Proposed		Re-line 400' of canal; new lining on 400' of canal; install 3,500' of 18" ADS pipe in the Talent Canal near Jasmine Street & installation of an underdrain to redirect upslope water to its natural course.	Reduce leaks and seepage; provide adequate & uninterrupted water deliveries; increase storage by water savings; reduce the potential for personal & property damage; reduce erosion; increase operational efficiency; enhance aquatic/riparian habitat by redirecting flow from an upslope source to its natural drainage way.	Water conservation, prevent soil erosion, water quality, public safety
Pipe E12 Lateral Proposed		Install 7,280' of various pipe sizes to enclose the open ditches and replace the old concrete tile.	Prevents loss of water through leaks and seepage from open ditches and old concrete tile, provides pressure to encourage waterusers to convert to more efficient methods of irrigation	Water conservation, prevent soil erosion, water quality, public safety

With ever increasing demands on water, the Talent Irrigation District is constantly looking for ways to improve the District's water efficiency. The above list is by no means inclusive but serves as a snapshot of the District's primary projects in the last few years.

Appendix G

Analysis of Water Temperature Data as Part of Continued Operation and Maintenance of the Rogue River Basin Project, Oregon.

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Resource and Technical Service, Ecosystems Analysis

DATE: December 16, 2008

Summary

This technical memorandum summarizes the pertinent data and provides an analysis of water temperature in the Rogue River Basin Project as it applies to current Project operations. The analysis focuses on the Bear Creek and Little Butte Creek watersheds, with special emphasis on Emigrant Creek above and below Emigrant Reservoir, Bear Creek, Little Butte Creek, and South Fork Little Butte Creek. Data from several tributaries to Bear Creek are also evaluated to determine whether each tributary has a general cooling or warming effect on Bear Creek. The intent of the analysis is to provide further insight into the net effect of Project operations on water temperature and to provide a comparison of current water temperatures to the applicable temperature thresholds for SONCC coho life stages.

The data for Bear Creek show that from slightly above Ashland to the confluence with the Rogue River water temperature increases in the downstream direction during the hot summer months. Temperatures are relatively similar throughout the stream during the remainder of the year (Figure 1). Reclamation believes the baseline temperature data for Emigrant Creek and Bear Creek show that during the summer months when temperatures are at their highest (July-September), Project operations have actually resulted in a partial net cooling of water temperature.

As compared to the applicable temperature thresholds for SONCC coho life stages, Bear Creek frequently exceeds established thresholds, particularly in the lower portions of the stream where the cumulative effects of all thermal sources are realized. The expectation is that the fish are seeking cool water refugia during these periods of high temperature.

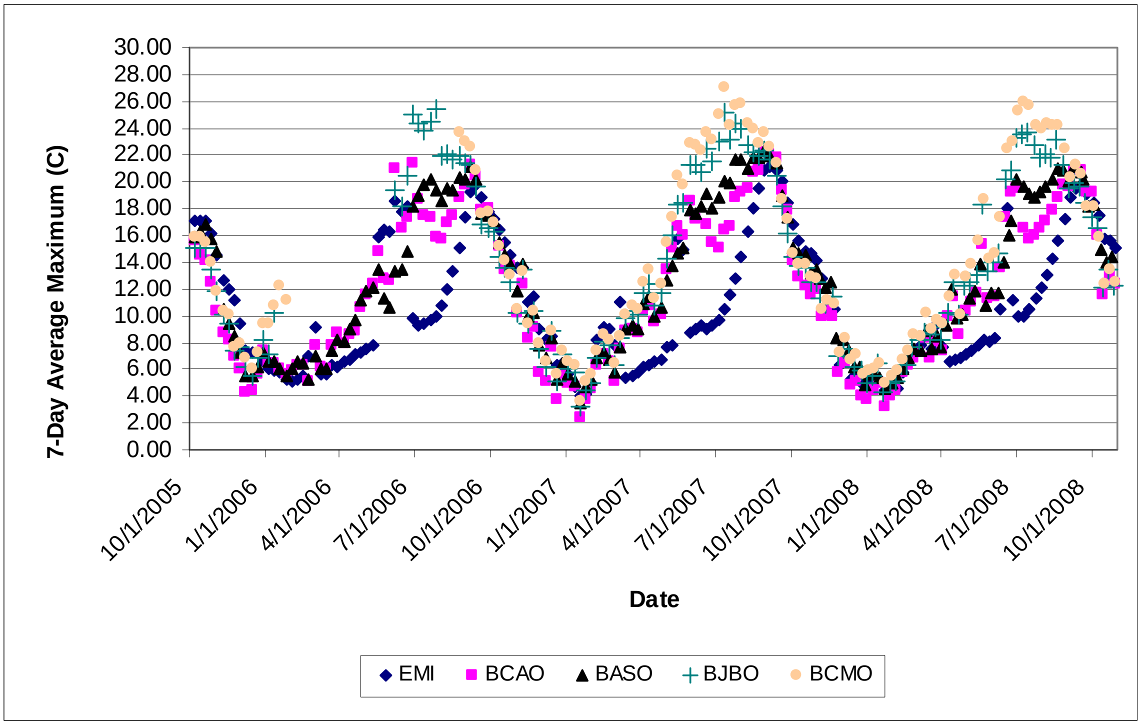

Figure 1. October 2005 – October 2008, 7-day average maximum water temperatures in Bear Creek and Emigrant Creek (see Table 1 for site locations) (gaps indicate missing data).

The temperature data for Little Butte Creek and South Fork Little Butte Creek are less robust than for Bear Creek, but are sufficient enough to draw conclusions. Temperatures in Little Butte Creek increase slightly between Lake Creek and Eagle Point during the summer months and are relatively similar during the remainder of the year. The temperature thresholds are frequently exceeded during the summer. The temperature thresholds are also exceeded in South Fork Little Butte Creek near Gilkey during the summer, but snorkeling in August 2006 identified the presence of juvenile SONCC coho upstream from Gilkey, indicating the fish are persisting during their most sensitive life stage.

Bear Creek and Emigrant Creek Analysis and Interpretation

Data from five Hydromet stations below Emigrant Reservoir and two stations above the reservoir provide a good data set to analyze water temperature in Bear Creek and Emigrant Creek. Table 1 shows the site location information for each station. It should be noted that these data are provisional; they have not been reviewed for quality assurance.

Table 1. Site location information for Emigrant Creek and Bear Creek hydromet stations.

STATION NAME	LOCATION	LAT/LONG
EGSO	Emigrant Creek above Green Springs Power Plant	LAT: 42-07-20 LONG: 122-32-47
GSPO	Green Springs Power Plant Discharge	LAT: 42-07-20 LONG: 122-32-47
EMI	Emigrant Creek below Emigrant Reservoir	LAT: 42-09-50 LONG: 122-36-15
BCAO	Bear Creek directly above Ashland	LAT: 42-11-42 LONG: 122-40-07
BASO	Bear Creek directly below Ashland	LAT: 42-12-58 LONG: 122-43-16
BJBO	Bear Creek at Jackson Street Bridge (in Medford)	LAT: 42-19-54 LONG: 122-52-10
BCMO	Bear Creek near Rogue River confluence	LAT: 42-25-35 LONG: 122-57-25

Water temperatures in Emigrant Creek above Emigrant Reservoir are largely dictated by unimpounded natural flows above Green Springs power plant and Green Springs power plant discharges. During the critical summer months (July-September) the 7-day average maximum temperatures above the power plant are normally between 20 and 26^{o}C. The Green Springs power plant discharge has a cooling effect on Emigrant Creek, with a normal peak July-September 7-day average maximum of between 15-20^{o}C. It should be noted that the Green Springs power plant is supplied water via the Howard Prairie delivery canal. An analysis of 2001-2006 temperature data from the delivery canal shows that summer-time 7-day average maximum waters temperatures typically exceed 18^{o}C around 100 days per year (GeoEngineers 2007).

Emigrant Reservoir essentially acts as a temperature re-regulator within the system. Due to thermal stratification in the reservoir, July-August water temperatures in Emigrant Creek below the reservoir are notably cooler than temperatures above the reservoir. Figure 2 compares the July-September, 2008 7-day average maximum water temperatures at EGSO and EMI. This comparison shows that reservoir releases provide a substantial amount of cooling to Emigrant Creek, and subsequently to Bear Creek, for most of the hot summer months. Without the reservoir in place early summer water temperatures at the EMI location would be considerably warmer. The cooling effect is most pronounced in July and August as the lower layers of cool water in the reservoir are released. During these months the cooling is dramatic. As releases continue throughout the summer the cool water layers are depleted and release temperatures become incrementally warmer. By September the release temperatures at EMI are very similar to EGSO. The comparison suggests that without Project operation the initial (natural) water temperatures in Emigrant and Bear Creeks would be substantially warmer than they are under Project operations, and as a result, the downriver temperatures would be proportionally higher.

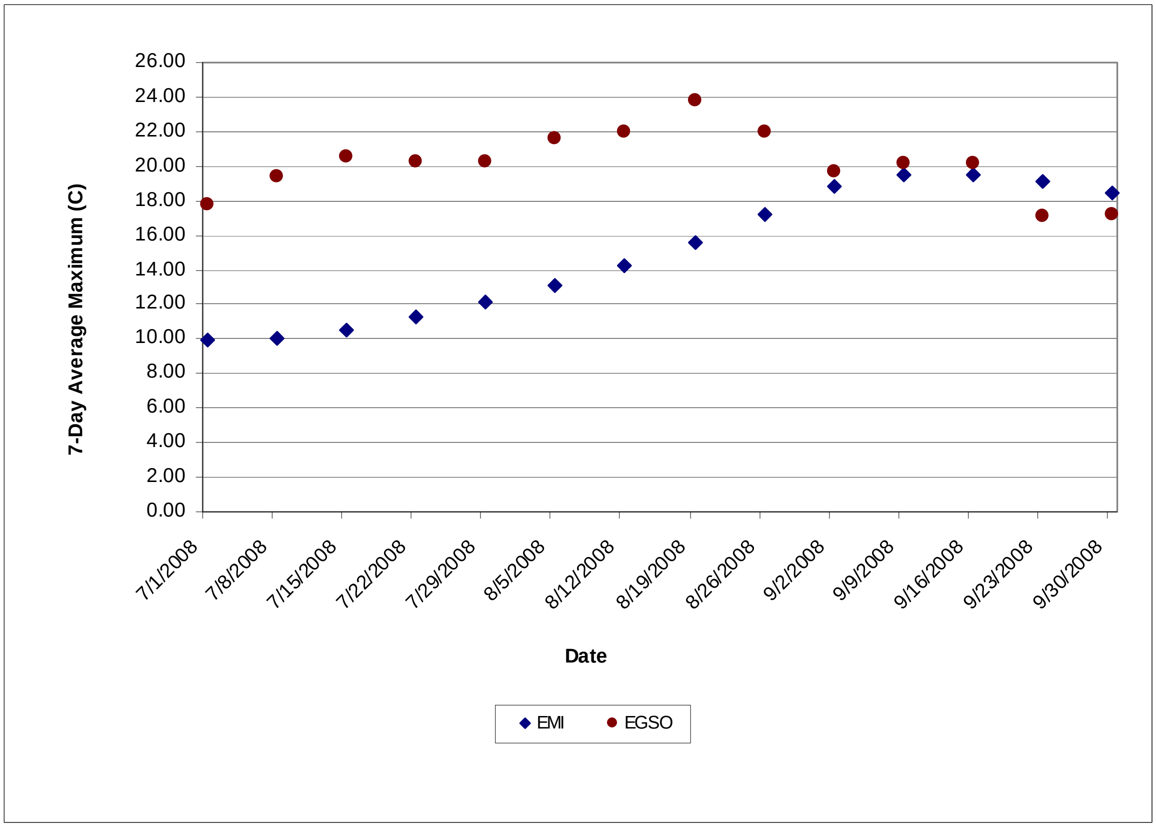

Figure 2. July – September 2008, 7-day average maximum water temperatures at EGSO and EMI (gaps indicate missing data).

Water temperatures in Bear Creek during the hot summer months are heavily influenced by Emigrant Reservoir releases, particularly the upper portions of Bear Creek. The system is very sensitive to boundary condition temperatures (ODEQ 2007). The releases provide a cooling effect that would not occur without the reservoir in place. As such, Reclamation believes this aspect of Project operation has resulted in a net positive effect on stream temperature in Bear Creek (i.e., reduced water temperatures), particularly in the reach above Medford.

While cool water releases from Emigrant Reservoir provide substantial cooling to Emigrant Creek, and subsequently to Bear Creek, the effect of the rapid increase and drop in temperature in June on juvenile coho is unclear. Figure 3 illustrates the timing and magnitude of the change. Further evaluation is necessary on this topic.

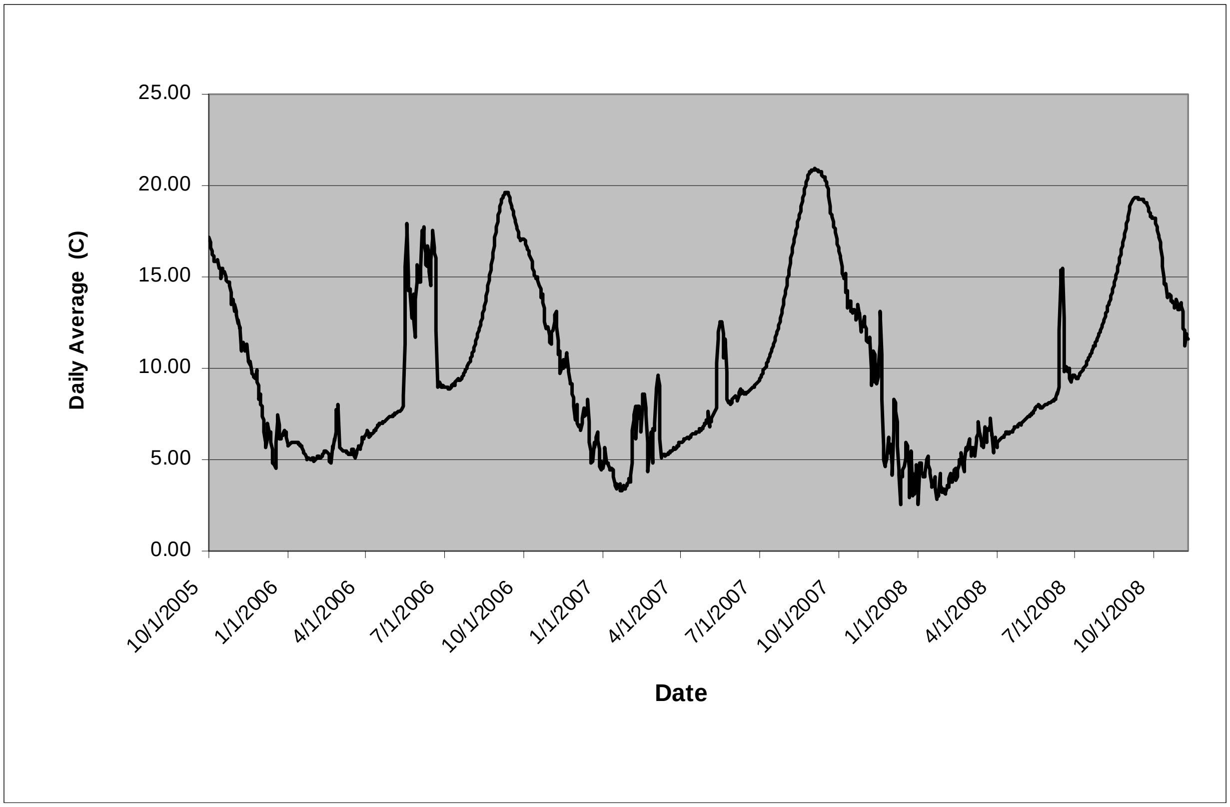

Figure 3. Daily average maximum water temperature data at EMI.

Summer data from the remaining Hydromet stations below Emigrant Reservoir are illustrated in Figure 4. The data show that Bear Creek does indeed warm as it flows toward the Rogue River and searches for thermal equilibrium. The longitudinal accretion is due to a combination of varying channel characteristics, increased solar loading, point and non-point sources contributions, and some warmer tributary inputs, although natural solar loading is by far the largest contributing factor. Below Larson Creek (River Mile 12), there is essentially no topographic shading of Bear Creek (ODEQ 2007). Project withdrawals which decrease the volume of water in Bear Creek likely contribute to the susceptibility of thermal loading, but they are not the sole source. Again, the extent of this warming would be even greater if it were not for the beneficial cooling effect of Emigrant Reservoir releases.

Water temperatures in Bear Creek are not correlated with flow during the hot summer months. To determine this, the daily average flows at BASO, BJBO, and BCMO were regressed against the daily average water temperatures (Figures 5-7). In all instances there is a poor correlation between flow and water temperature. This suggests that during the hot summer months, factor(s) other than Project related flows affect water temperature to a greater extent.

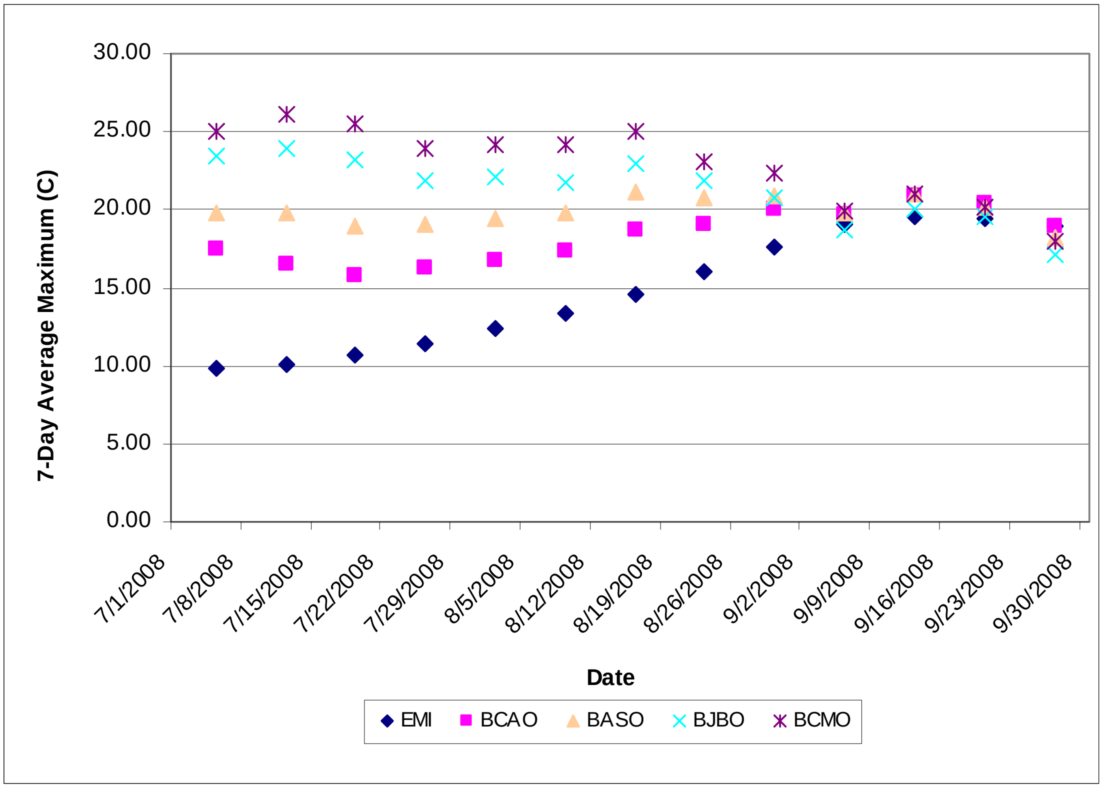

Figure 4. July – September 2008, 7-day average maximum water temperatures in Emigrant and Bear Creek **(gaps indicate missing data).**

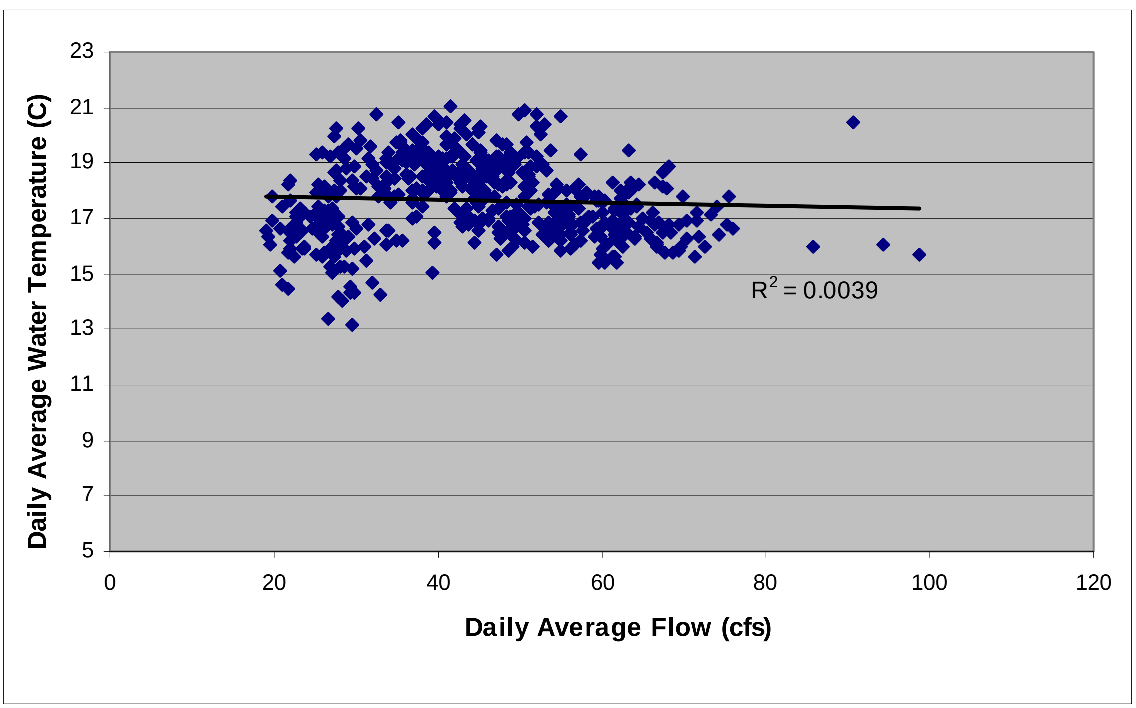

Figure 5. Flow vs. water temperatue at BASO, July – September, 2003-2008.

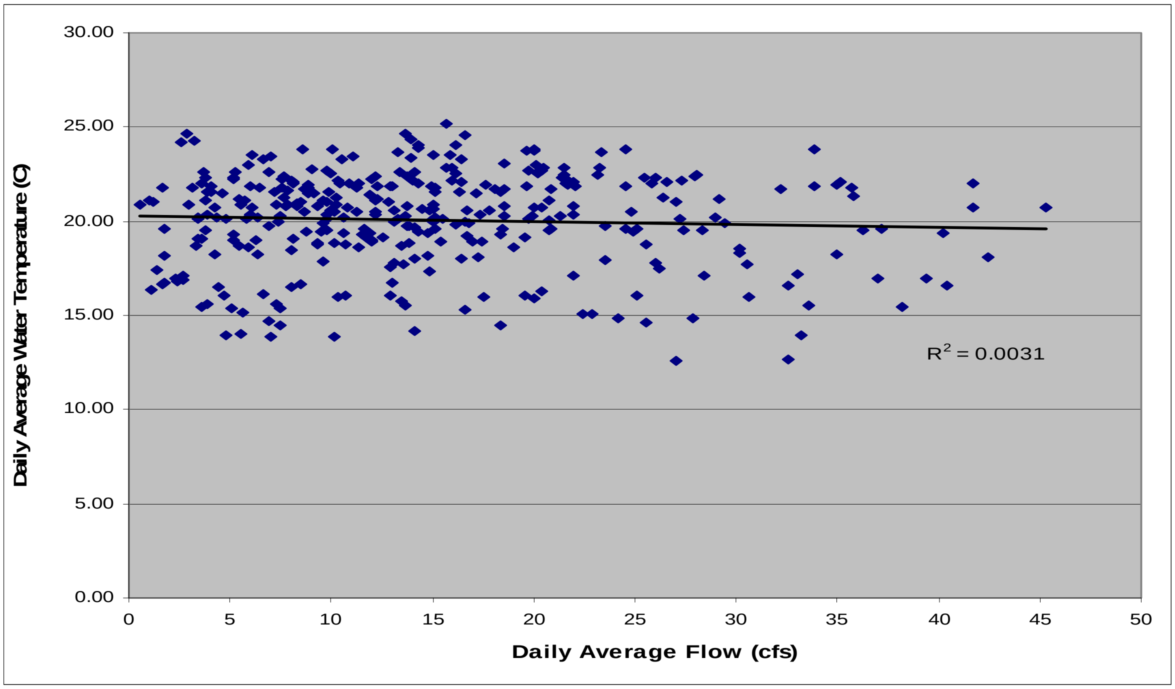

Figure 6. Flow vs. water temperatures at BJBO, July – September *(partial months)*, 2005-2008.

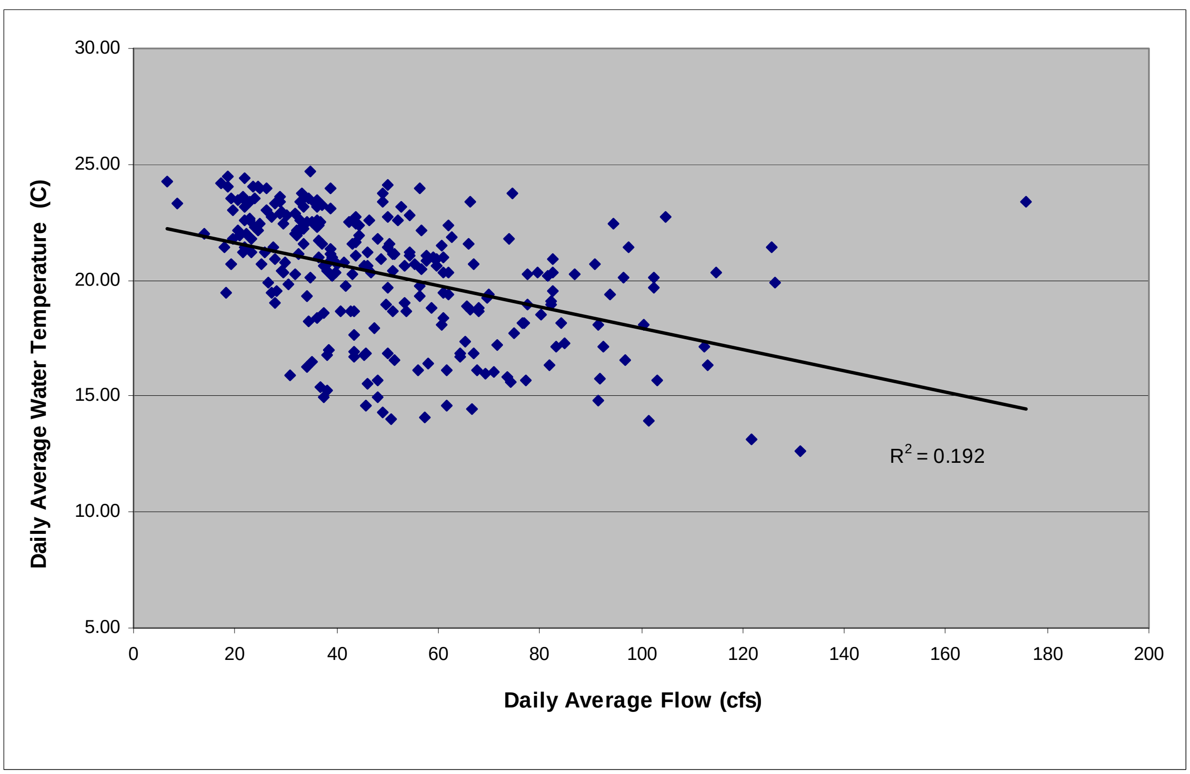

Figure 7. Flow vs. water temperature at BCMO, July – September *(partial months)*, 2005, 2007-2008.

The Oregon Department of Environmental Quality (ODEQ) completed a temperature Total Maximum Daily Load (TMDL) for Bear Creek in 2007(ODEQ 2007). The TMDL was approved by the U.S. Environmental Protection Agency on October 2, 2007. The TMDL identifies limited riparian shade as the primary factor affecting solar loading in Bear Creek, and in turn prescribes a 39% increase in shade for Bear Creek as well as varying shade increases for several tributaries. As TMDL implementation measures are put into place ODEQ expects water temperatures in Bear Creek to decrease.

Table 2 shows SONCC coho life stages sorted by month and their associated critical temperature thresholds specific to Bear Creek. The thresholds (13^{o}C and 18^{o}C) are derived from the ODEQ water quality standards, which are an adoption of EPA Region 10 temperature standards guidance for Pacific Northwest states and tribes. These values represent the preferred upper limit for each life stage. In months where different criteria apply due to life stage overlap, the most stringent criterion is used. Other literature suggests that temperatures above these levels are tolerable, but these ranges are not used in the analysis. For example, Bell (1991) suggests an upper temperature limit of 25.6^{o}C for coho fry/juvenile rearing. Figures 8-12 show the temperature thresholds overlaying the 7-day average maximum water temperature for various periods of record at EMI, BCAO, BASO, BJBO, and BCMO.

Table 2. SONCC coho life stages and critical temperature thresholds for Bear Creek.

LIFE STAGE	J	F	M	A	M	J	J	A	S	O	N	D
Spawning	13C	--	--	--	--	--	--	--	--	--	13C	13C
Incubation	13C	13C	13C	13C	13C	--	--	--	--	--	13C	13C
Smolt Emigration/ Juvenile Rearing[1]	--	15th-28th 18C	18C	18C	18C	18C	--	--	--	--	--	--
Juvenile Rearing	--	--	--	--	--	--	18C	18C	18C	--	--	--
Adult Passage[2]	18C	--	--	--	--	--	--	--	--	18C	18C	18C

-- These months fall outside the *critical period* for this life stage
[1] Smolt trap data from ODFW and temperature data from Reclamation's Hydromet Stations
[2] Gold Ray fish counts and periodicity charts (Jay Doino, ODFW, personal communication, November 16, 2006)

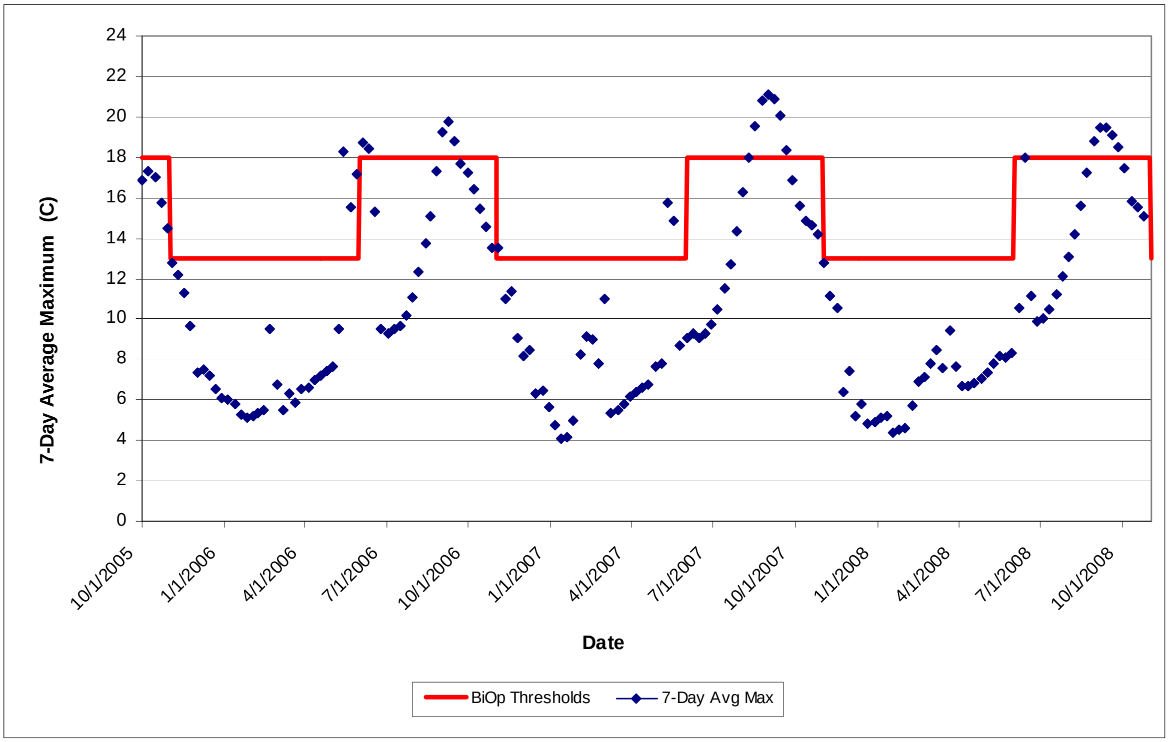

Figure 8. Seven-day average maximum water temperature data at EMI (gaps indicate missing data).

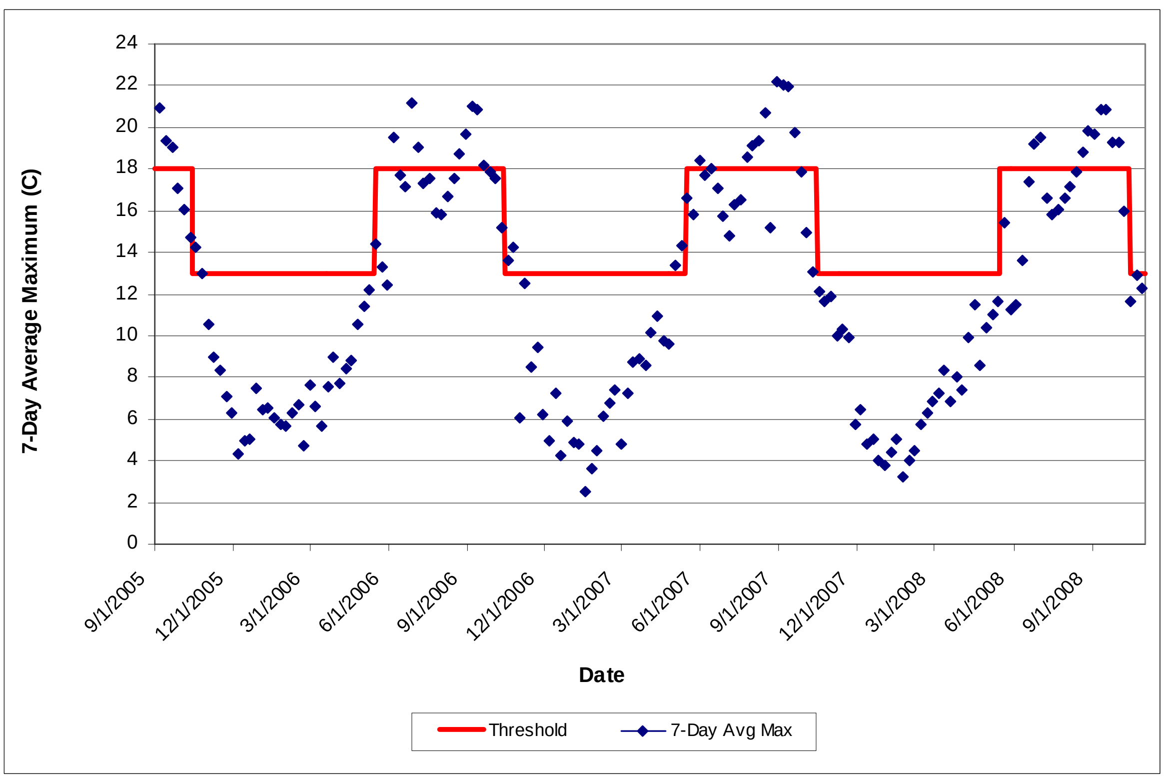

Figure 9. Seven-day average maximum water temperature data at BCAO (gaps indicate missing data).

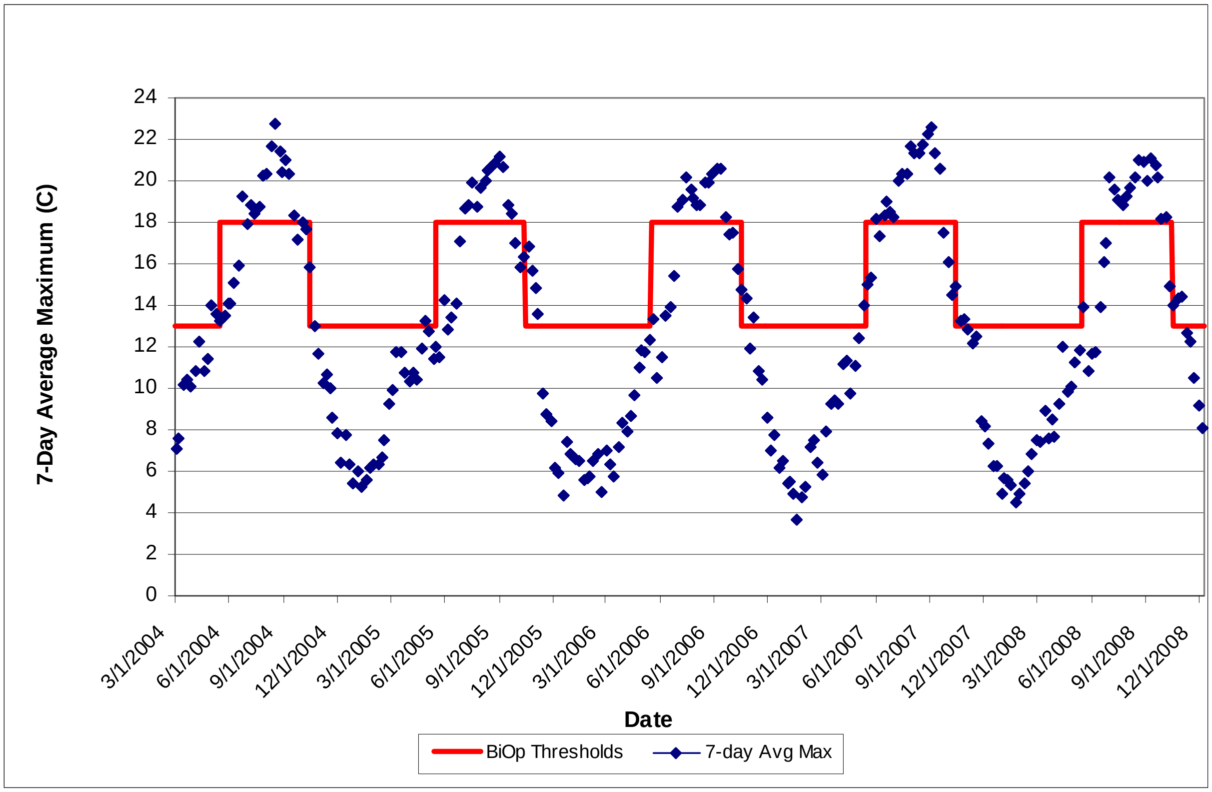

Figure 10. Seven-day average maximum water temperature data at BASO (gaps indicate missing data).

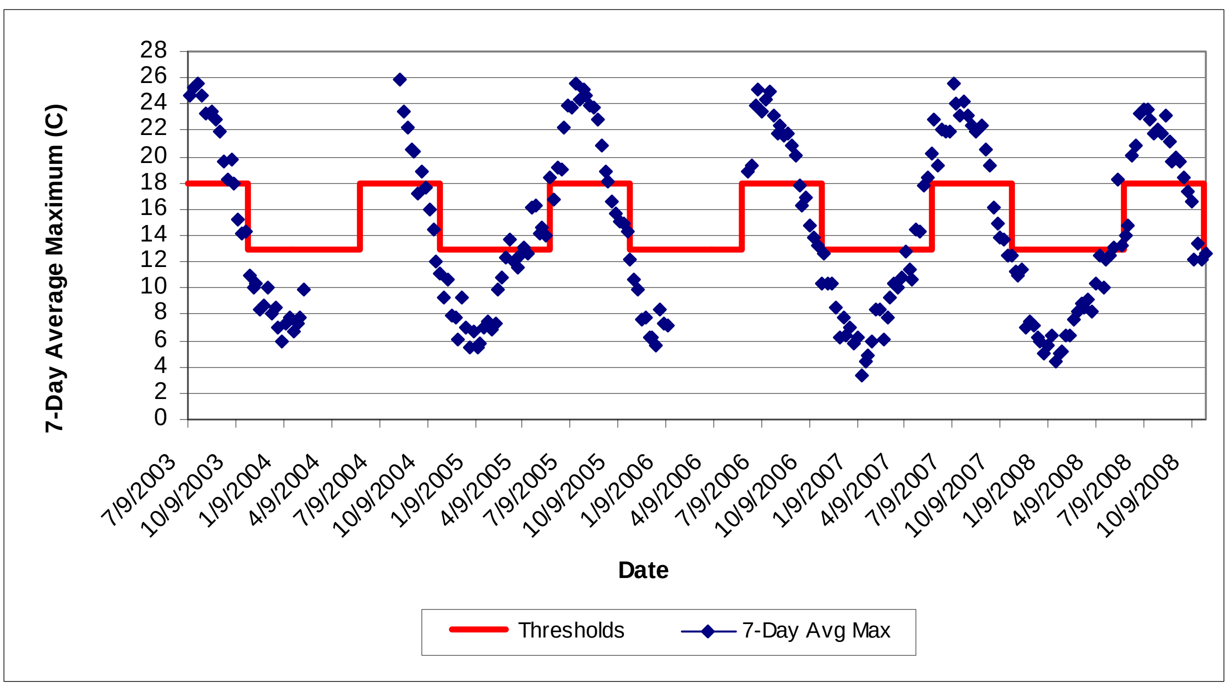

Figure 11. Seven-day average maximum water temperature data at BJCO (gaps indicate missing data).

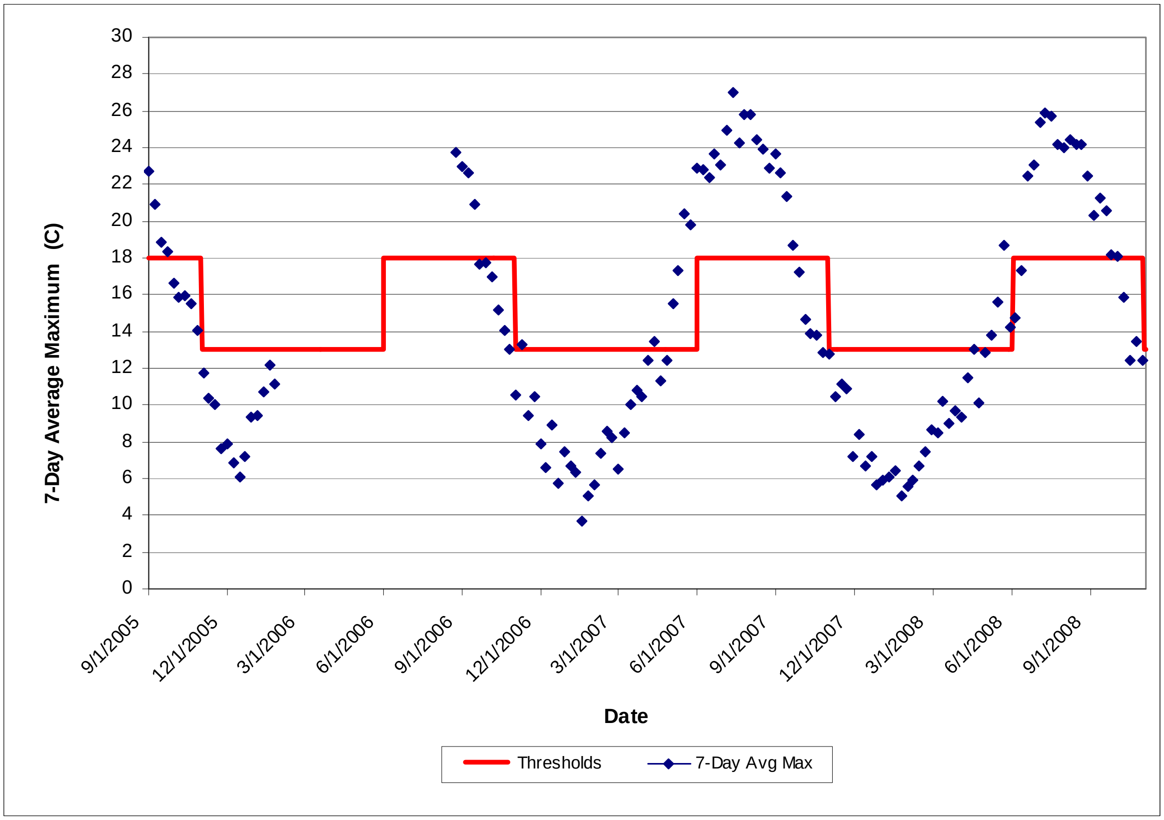

Figure 12. Seven-day average maximum water temperature data at BCMO **(gaps indicate missing data).**

Figures 8-12 show that the temperature thresholds are commonly exceeded throughout Bear Creek in the summer months. This is even the case below Emigrant Dam (EMI) and above Ashland (BASO) where the cooling effects of Emigrant Dam releases are readily apparent. Based on the magnitude of the exceedences, which expectedly increase in the downstream direction, it is likely that there is some temperature derived impact to the SONCC Coho.

To supplement the Hydromet temperature data discussed above, Reclamation installed a series of temperature loggers in Emigrant Creek, Bear Creek, and several major tributaries to Bear Creek, (Reclamation 2007). The loggers were installed in mid-August 2007 and removed in mid-October 2007 to prevent the over-winter loss of equipment. The loggers were reinstalled in March 2008 and again removed in October 2008. Table 3 shows the name and geographic location of each tributary logger.

To estimate the effect of each tributary on water temperatures in Bear Creek, the daily maximum water temperature from the nearest upstream Bear Creek site was compared to the daily maximum water temperature for the tributary. This is a gross comparison because there is likely some amount of heating or cooling in Bear Creek between the two locations. However, the comparison does provide a general sense for whether the tributary is providing localized cooling or warming in Bear Creek. A flow-proportioned mixed temperature is not possible at this time because daily flow data are not available for the tributaries.

Table 3. 2007 Bear Creek tributary temperature monitoring sites.

STREAM NAME	LOCATION	LAT/LONG
Jeffery Creek	Above confluence with Bear Creek	42°14.812' / 122°46.331'
Gaerky Creek	Above confluence with Bear Creek	42°12.188' / 122°41.062'
Butler Creek	Above confluence with Bear Creek	42°13.438' / 122°44.211'
Anderson Creek	Above confluence with Bear Creek	42°16.105' / 122°48.316'
Coleman Creek	Above confluence with Bear Creek	42°17.113' / 122°49.276'
Willow Creek	Above confluence with Bear Creek	42°24.018' / 122°57.169'

Figures 13-22 display a comparison of water temperature for each tributary to that of Bear Creek The comparison is compared for the years 2007 and 2008, except for Jeffery and Willow Creeks. These two tributaries did not have 2008 data available.

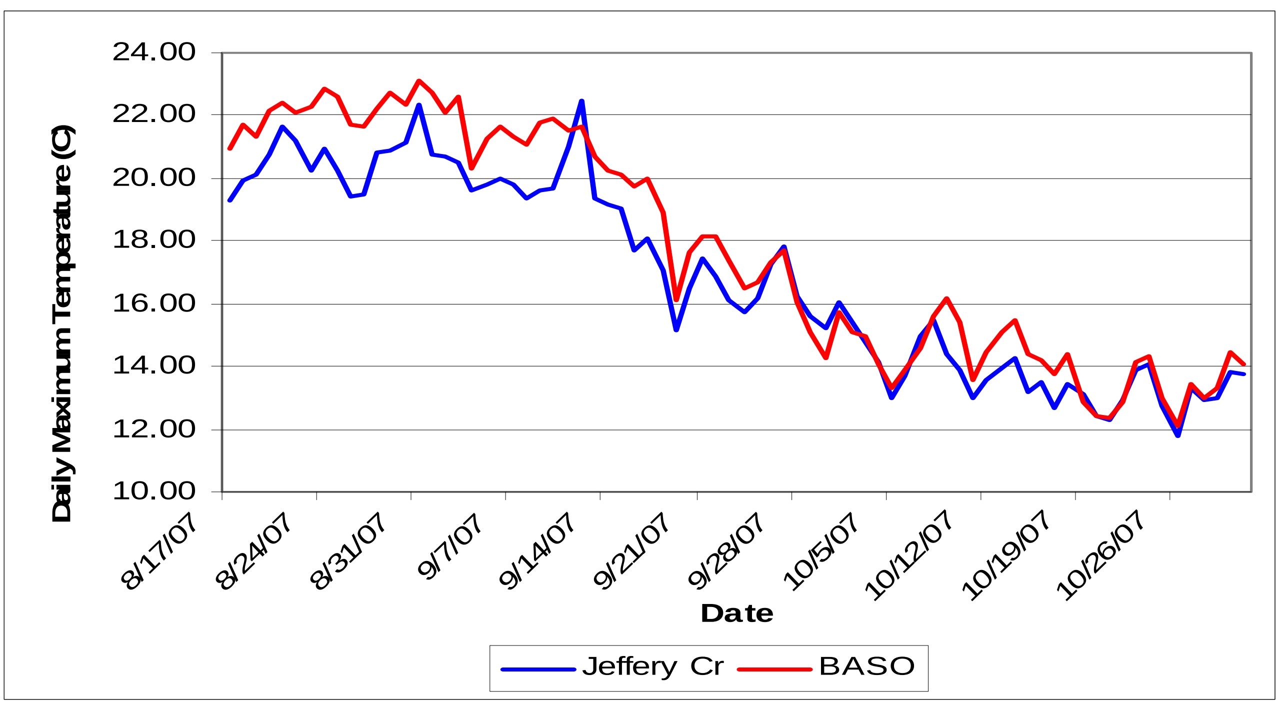

Figure 13. August – October 2007, maximum daily water temperature in Jeffery and Bear Creeks.

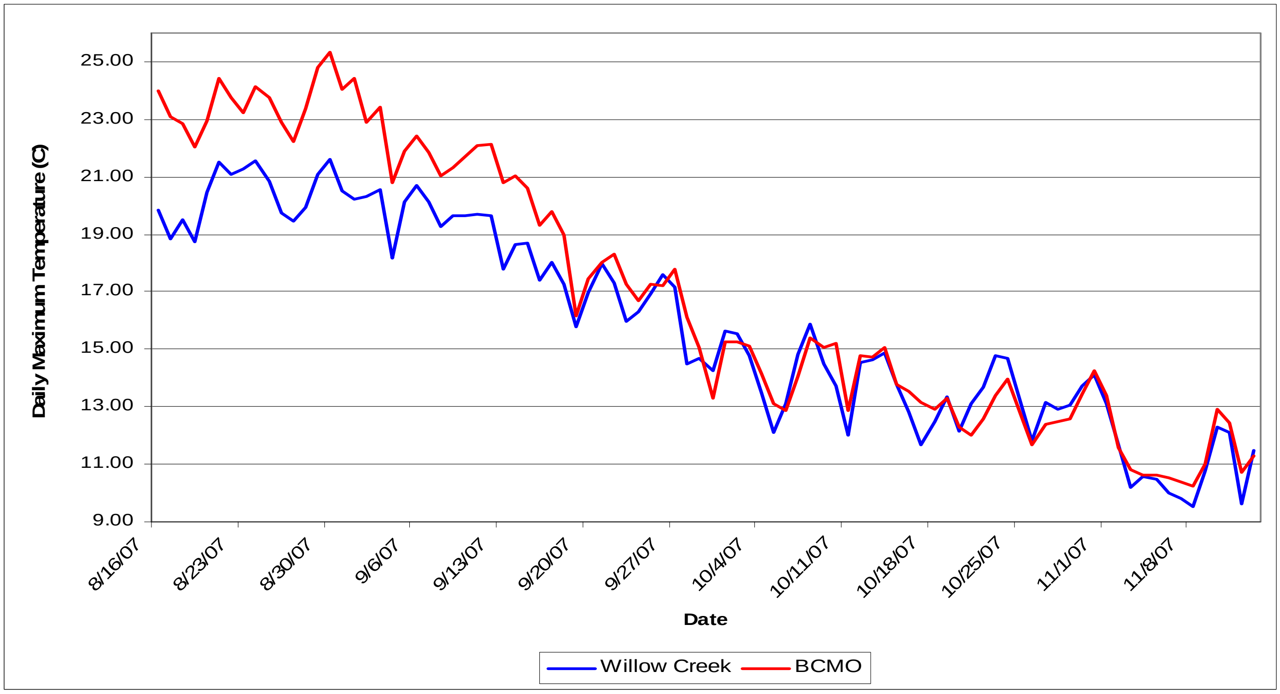

Figure 14. August – November 2007, maximum daily water temperature in Willow and Bear Creeks.

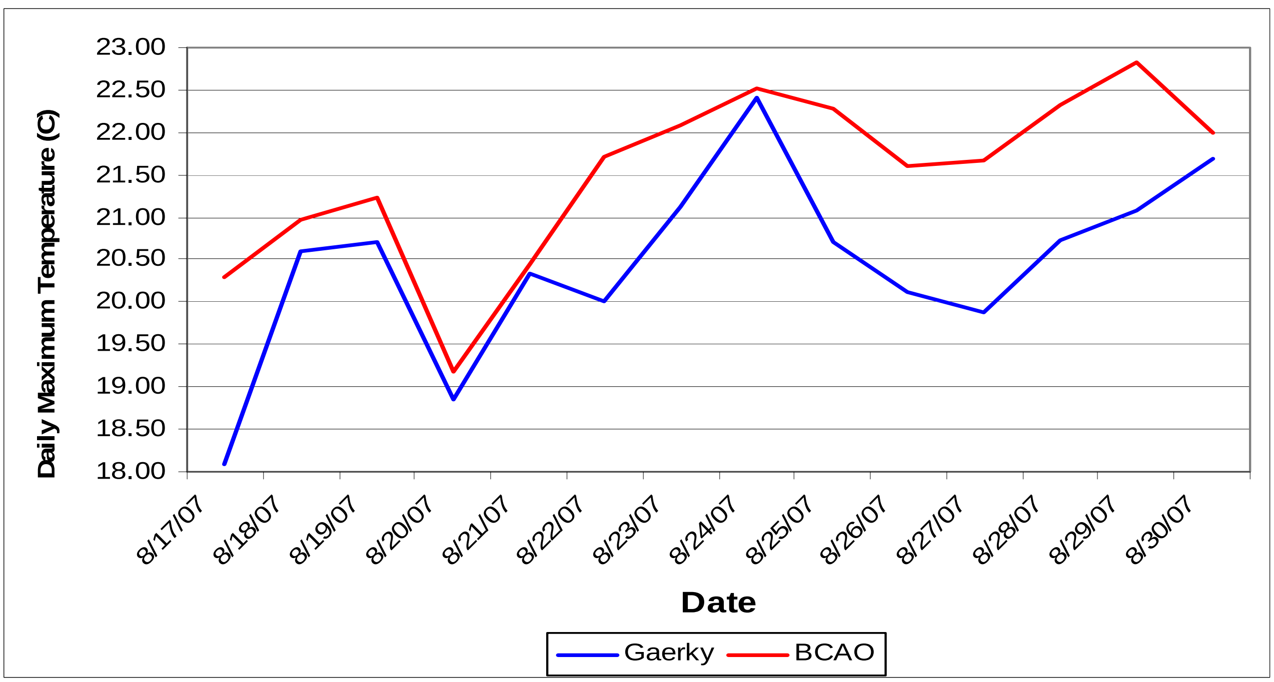

Figure 15. August 2007, maximum daily water temperatures in Gaerky and Bear Creeks.

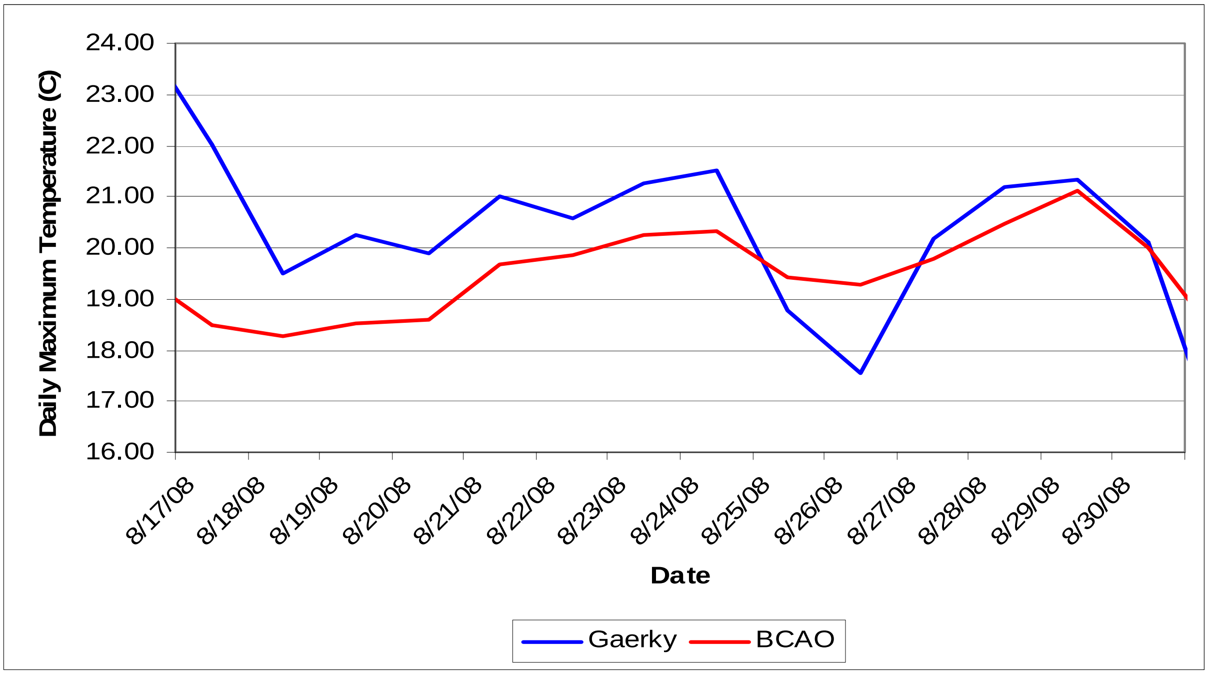

Figure 16. August 2008, maximum daily water temperatures in Gaerky and Bear Creeks

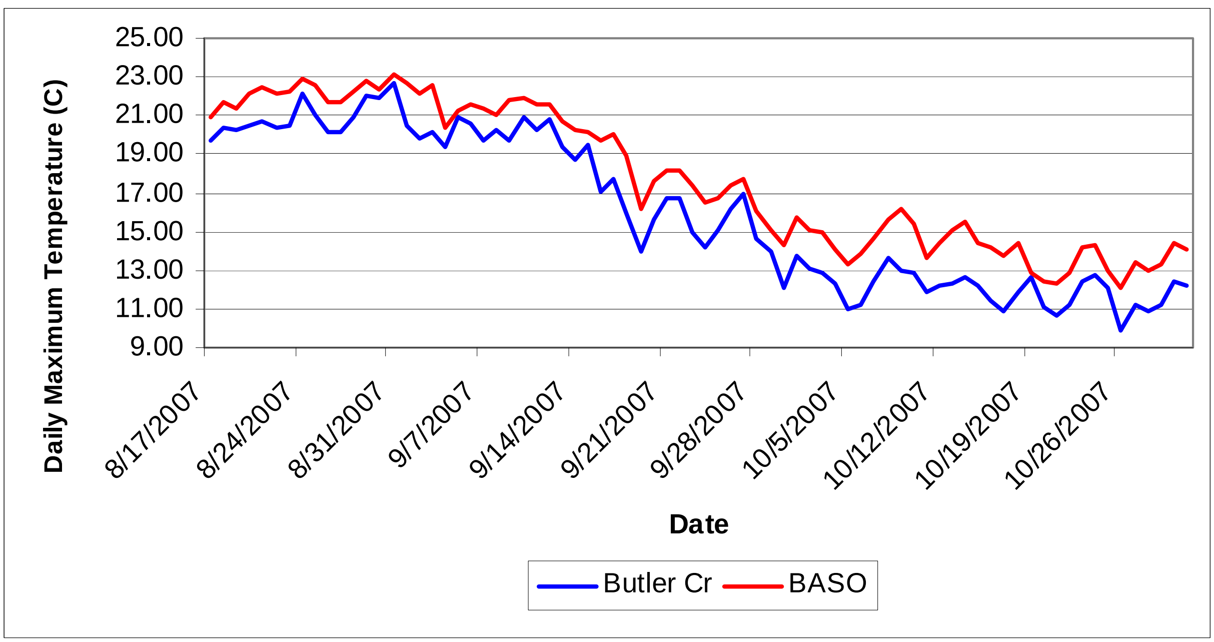

Figure 17. August – October 2007, maximum daily water temperatures in Butler and Bear Creeks.

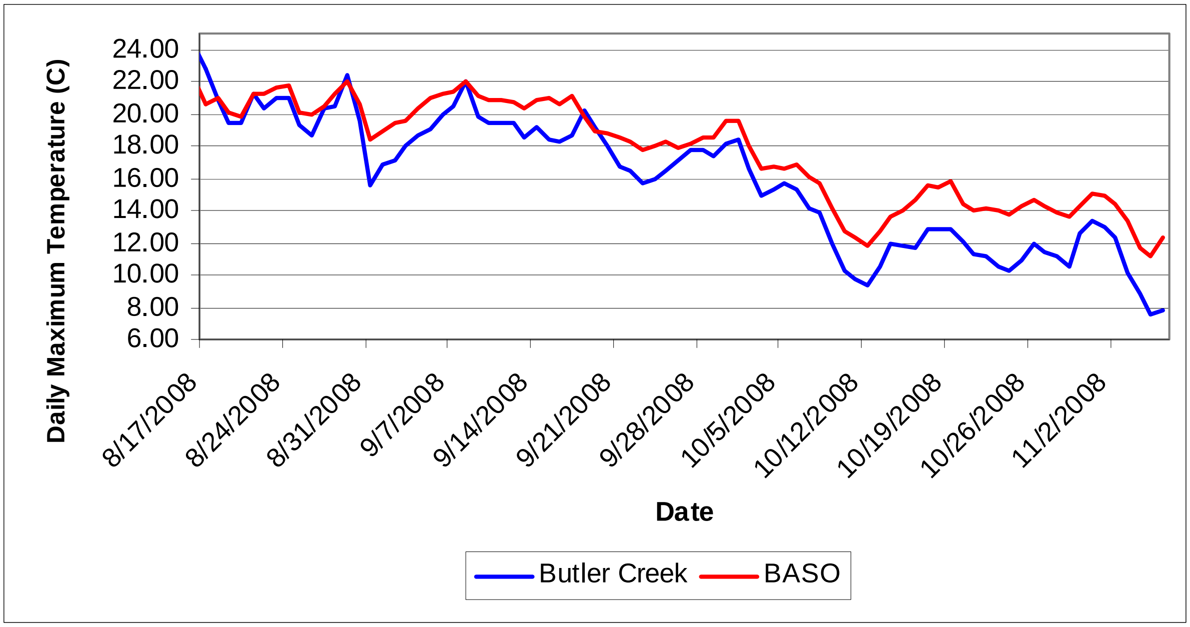

Figure 18. August – October 2008, maximum daily water temperatures in Butler and Bear Creeks.

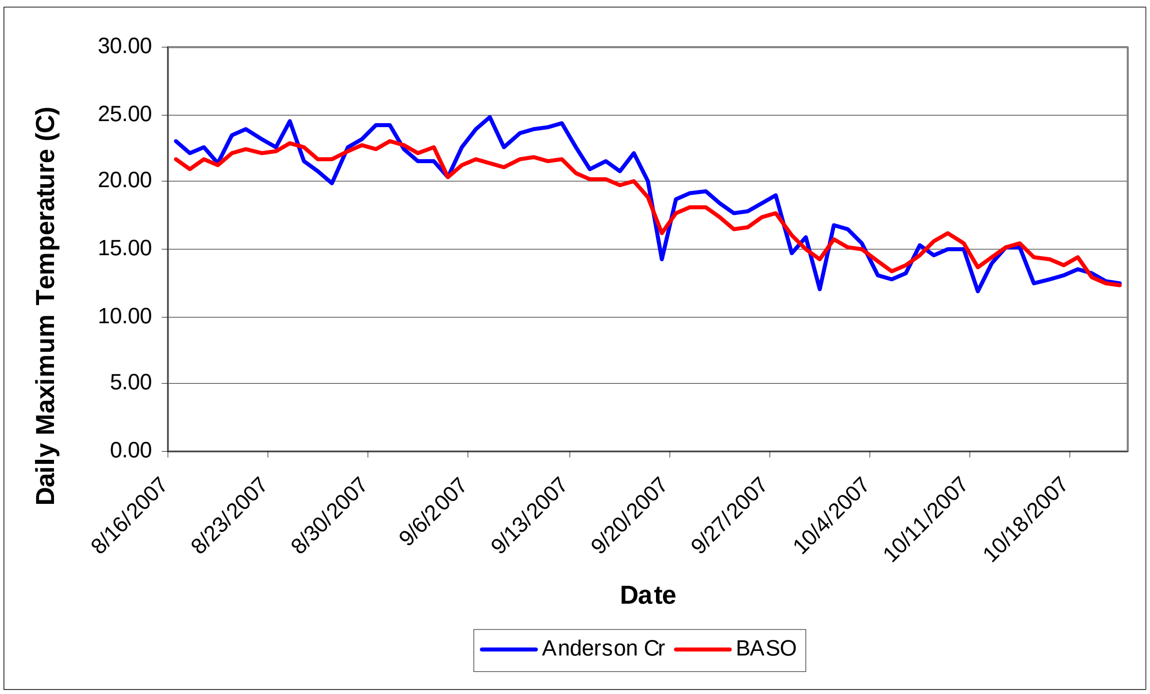

Figure 19. August – October 2007, maximum daily water temperatures in Anderson and Bear Creeks.

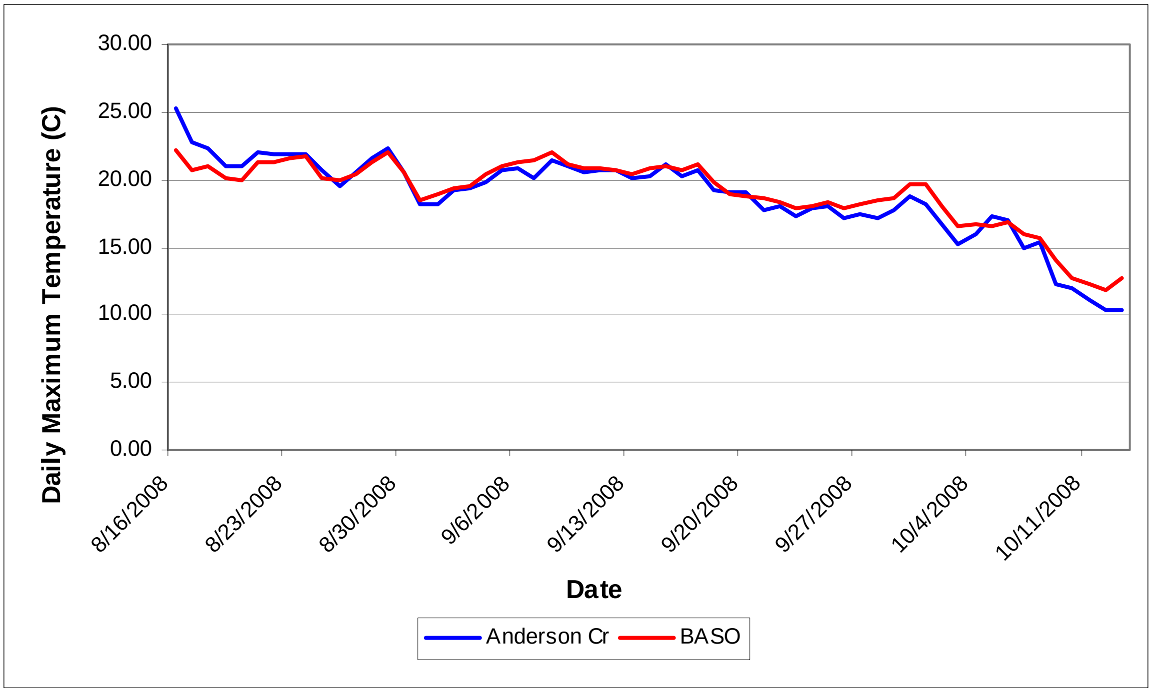

Figure 20. August – October 2008, maximum daily water temperatures in Anderson and Bear Creeks.

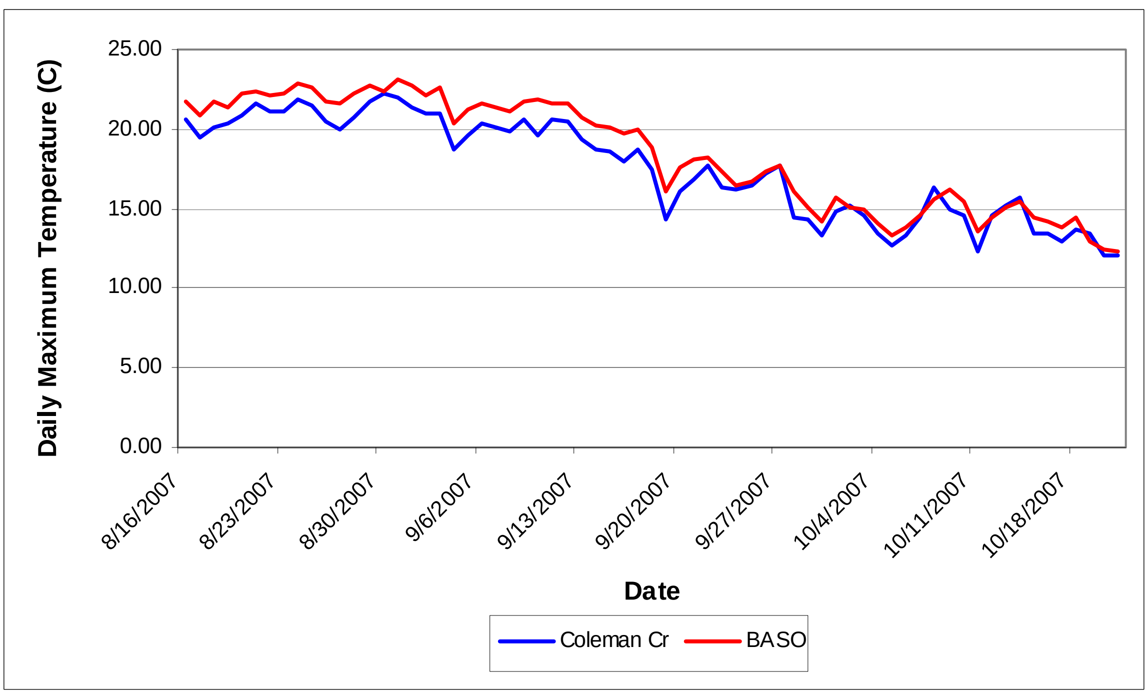

Figure 21. August – October 2007, maximum daily water temperatures in Coleman and Bear Creeks.

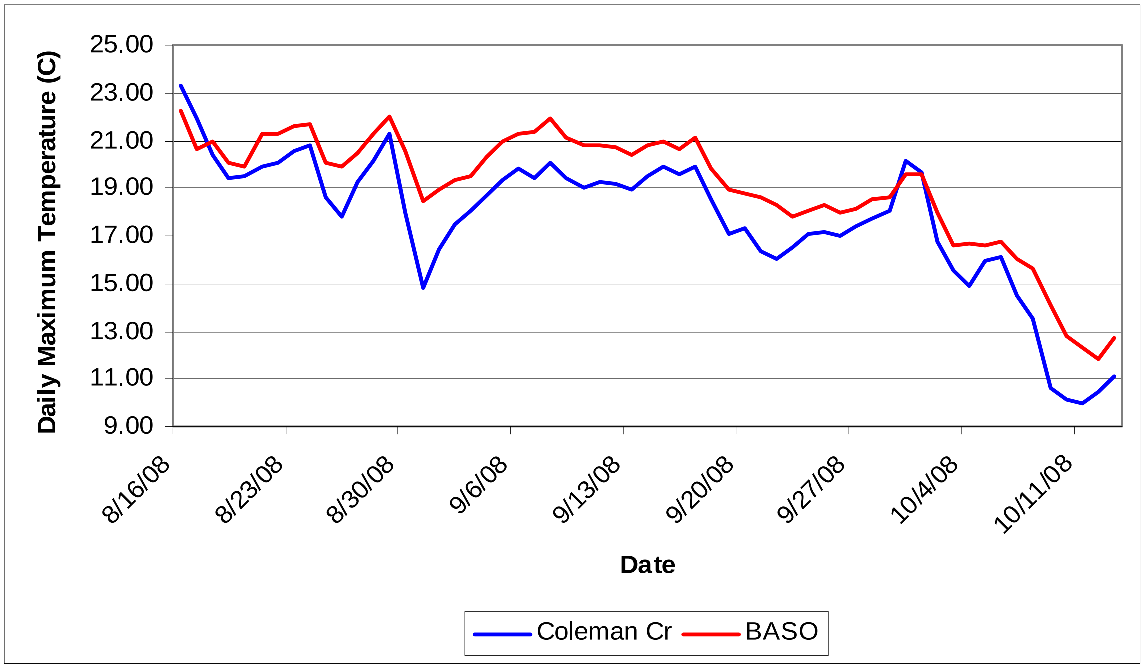

Figure 22. August – October 2008, maximum daily water temperatures in Coleman and Bear Creeks.

Based on the limited late-summer data illustrated in Figures 13-22, Project operations do not appear to result in tributary water temperature, that after mixing, result in increased localized temperatures in Bear Creek. The figures show the tributaries water temperatures to be at or below that of Bear Creek, except in a few incidences described below. In most cases when the temperatures in the tributaries are greater than those in Bear Creek, they are greater by a degree Celsius or less. Anderson Creek in 2007 and Gaerky Creek in 2008 were the only tributaries that had temperatures routinely above those of Bear Creek. It is evident from the graphs, that even though the two creeks had higher temperatures, they did not affect Bear Creek's temperature because there was no corresponding increase after the confluence.

Little Butte Creek Analysis and Interpretation

Water temperature data from two Hydromet stations on Little Butte Creek and two stations on South Fork Little Butte Creek are used to evaluate water temperatures in the Little Butte Creek watershed (Table 4). Again, all of the data are provisional; it has not been reviewed for quality assurance.

Table 5 shows SONCC coho life stages sorted by month(s) and their associated critical temperature thresholds specific to South Fork Little Butte Creek. Similar to the Bear Creek thresholds, they are derived from the ODEQ water quality standards and are specific to the Rogue Basin. In months where different criteria apply due to life stage overlap, the most stringent criterion is used.

Table 4. Site location information for South Fork Little Butte Creek Hydromet station.

STATION NAME	LOCATION	LAT/LONG
GILO	South Fork Little Butte Creek near Gilkey	LAT: 42-21-31 LONG: 122-30-31
LBCO	Little Butte Creek at Lake Creek	LAT: 42-25-20 LONG: 122-37-20
LBEO	Little Butte Creek below Eagle Point	LAT: 42-27-46 LONG: 122-45-55

Table 5. SONCC coho life stages and critical temperatures thresholds for Little Butte Creek and South Fork Little Butte Creek.

LIFE STAGE	J	F	M	A	M	J	J	A	S	O	N	D
Spawning	13C	--	--	--	--	--	--	--	--	--	13C	13C
Incubation	13C	13C	13C	13C	13C	--	--	--	--	--	13C	13C
Smolt Emigration/ Juvenile Rearing[1]	--	15^{th}-28^{th} 16C	16C	16C	16C	16C	--	--	--	--	--	--
Juvenile Rearing	--	--	--	--	--	--	16C	16C	16C	--	--	--
Adult Passage[2]	16C	--	--	--	--	--	--	--	--	16C	16C	16C

-- These months fall outside the *critical period* for this life stage

[1] Smolt trap data from ODFW and temperature data from Reclamation's Hydromet Stations

[2] Gold Ray fish counts and periodicity charts (Jay Doino, ODFW, personal communication, November 16, 2006)

Figure 23 shows the temperature thresholds overlaying the 7-day average maximum water temperatures at GILO. The data show that temperatures typically reach a maximum of 23-24^{o}C during the critical summer months, which is well above the temperature thresholds for those months. However, snorkeling by Reclamation biologists on August 17, 2006 identified the presence of juvenile SONCC coho near Gilkey, indicating the fish are persisting during their most sensitive life stage. The observed fish did not appear to be limited by elevated water temperatures (i.e., they appeared healthy). The most likely explanation for the presence of the juveniles, despite generally elevated water temperatures, is the presence of colder water refugia. Juvenile coho have been observed using thermal refugia in the warm mainstem Klamath River during the summer (Sutton et al. 2007). Generally, most juveniles move into refugia when mainstem temperatures exceed about 22 ^{o}C (Sutton et. Al 2007).

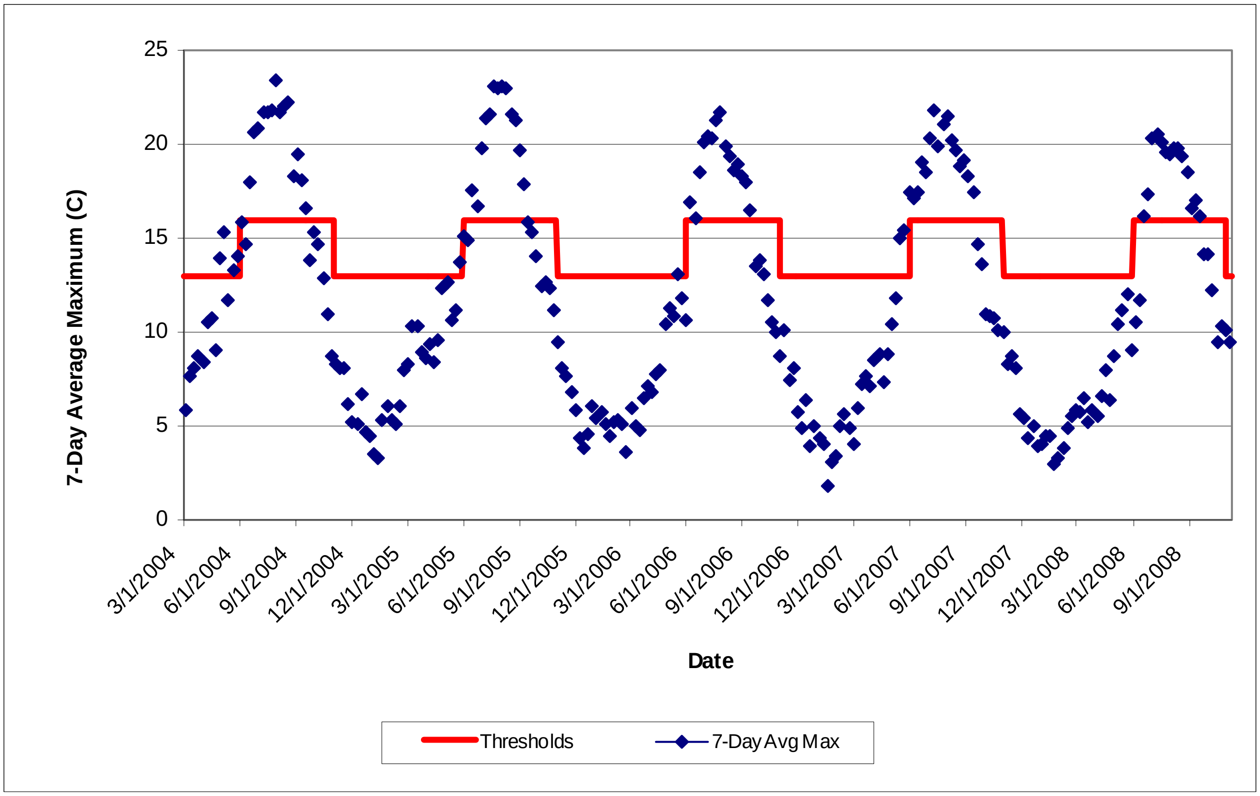

Figure 23. Seven day average maximum water temperature data at GILO (gaps indicate missing data).

Figure 24 shows the temperature thresholds overlaying the 7-day average maximum water temperatures at LBCO (Lake Creek) and LBEO (Eagle Point). The data show that temperatures typically reach a maximum of 22°C at LBCO during the summer months, which is well above the temperature thresholds for those months. Temperatures typically reach a maximum of 26-27°C at LBEO, indicating there is thermal loading between the two sites. However, this loading is not attributed to Project operation since there are no Project related inputs or withdrawals between the two locations. During the remainder of the year the temperatures at the two sites are similar.

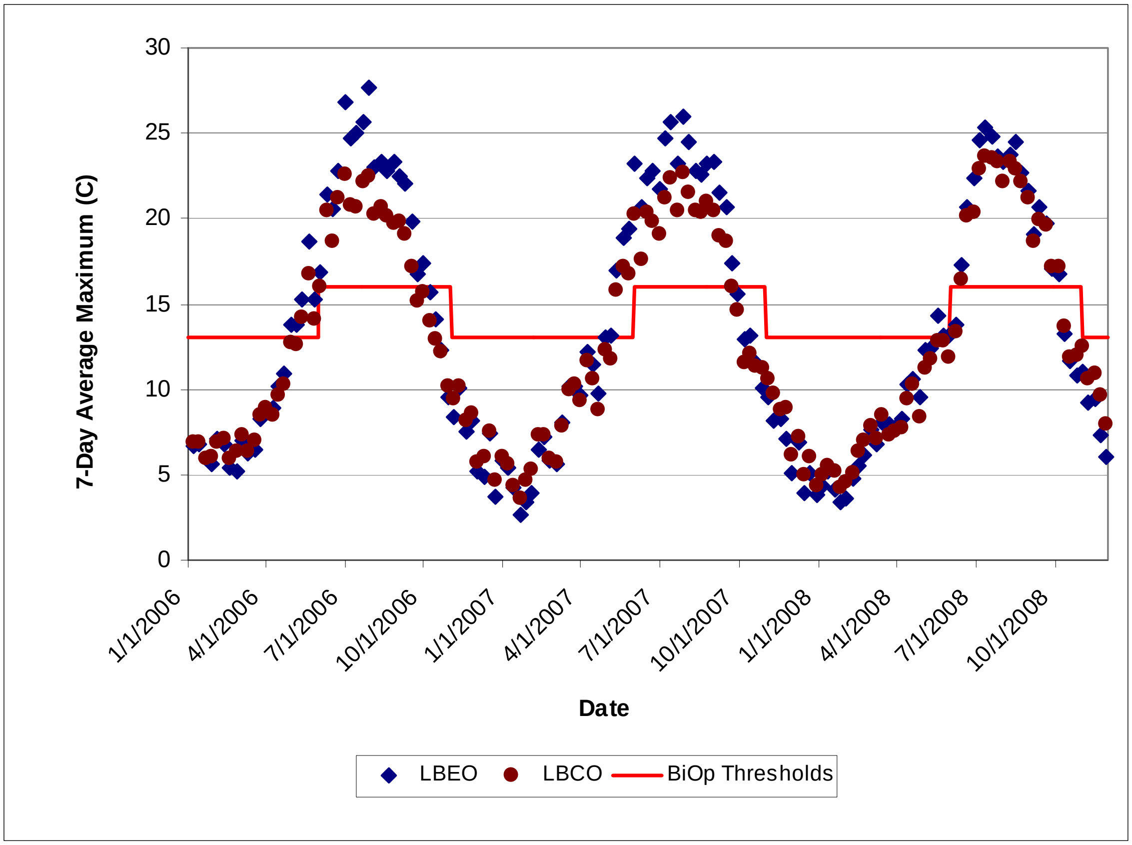

Figure 24. 2006-2008 7-day average maximum water temperature data LBCO and LBEO (gaps indicate missing data).

To supplement the Hydromet temperature data in the Little Butte Creek watershed, Reclamation installed temperature loggers below the confluence of Antelope Creek (Reclamation 2007). The loggers were installed in mid-August 2007 and removed in mid-October 2007 to prevent the over-winter loss of equipment. Figure 25 compares the daily maximum temperature below Antelope Creek to the daily maximum temperature at LBEO. The data show that Antelope Creek is not having a significant effect on water temperature in Little Butte Creek, which is to be expected since the Little Butte Creek portion of the project is not in operation late in the summer.

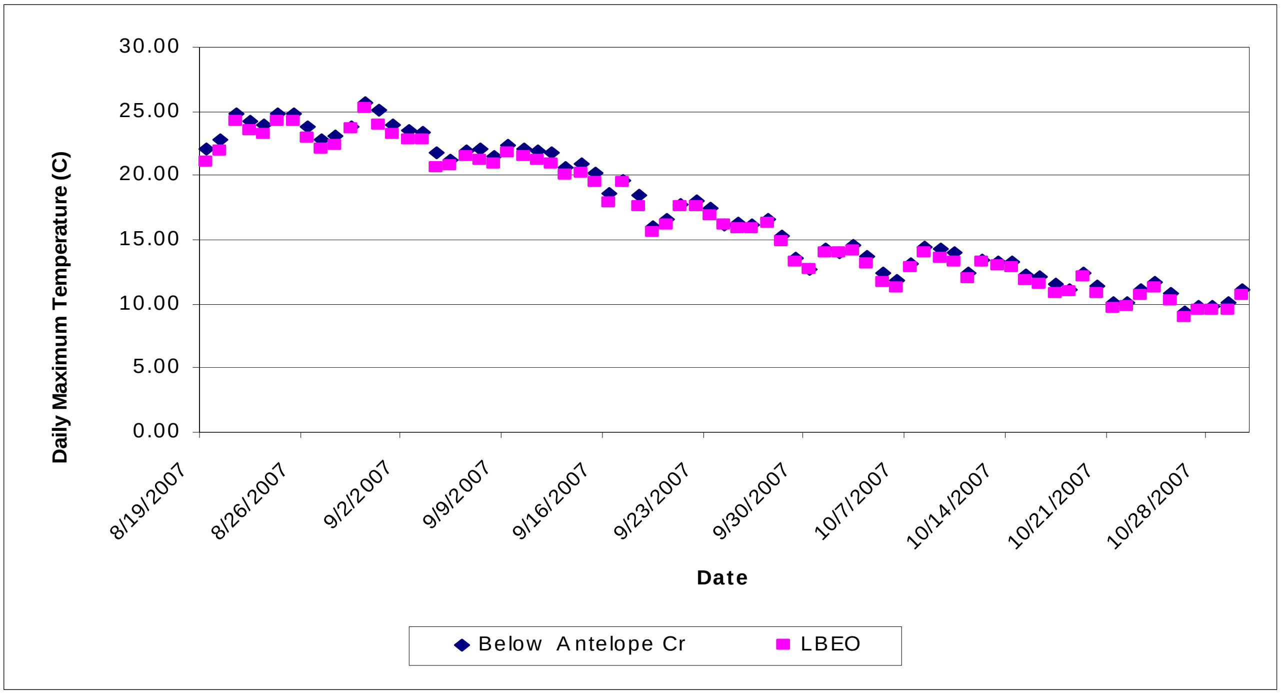

Figure 25. Daily maximum water temperatues at LBEO and below Antelope Creek (gaps indicate missing data).

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