United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer To:
8-10-08-F-070070

APR 0 2 2008

Memorandum

To: Area Manager, U. S. Bureau of Reclamation
Klamath Falls, Oregon

From: Klamath Basin Issues Coordinator
Yreka, California

Subject: Formal Consultation on the Bureau of Reclamation's Proposed Klamath Project Operations from 2008 to 2018

This memorandum transmits our Biological Opinion (BO), attached, on the effects of Bureau of Reclamation's (Reclamation) proposed Klamath Project Operations from 2008 to 2018 (Project). We received your request for formal consultation on this Project on October 23, 2007. Your request included a Final Biological Assessment describing the Project and its effects on listed species, the endangered Lost River sucker (*Delistes luxatus*) and endangered shortnose sucker (*Chasmistes brevirostris*).

Regulations governing interagency cooperation provide 90 calendar days to conduct formal consultation with your agency (unless we mutually agree to an extension or a different timeline) and an additional 45 calendar days to prepare our biological opinion [50 CFR 402.14(e)]. Given the complicated aspects of the analysis for this BO, both agencies agreed to extend the due date past the date that it would normally be due (i.e., March 6, 2008).

We would like to acknowledge the partnership of Reclamation in pursuing recovery actions that benefit endangered suckers in the Upper Klamath Basin. Adverse effects to endangered suckers in the Upper Klamath Basin have been reduced and future prospects for their recovery have been improved largely due to these extensive recovery actions. Since the early 1990s, the Service, Reclamation, State of Oregon, Klamath Tribes, Klamath Water Users Association (KWUA), other partners, and private landowners have been working to improve water quality and aquatic habitat conditions in the Upper Klamath Basin. The Service and our partners have supported approximately 400 habitat restoration projects in the Upper Klamath Basin, including 50 wetland and 150 riparian projects. Accomplishments of the projects include: (1) restoration of over 25,000 acres of wetlands adjacent to UKL and in the watershed above the lake; (2) upcoming removal of Chiloquin Dam; (3) screening of the outlet of Clear Lake Dam; (4) construction of a new fish ladder at Link River Dam; (5) screening of the main irrigation diversion of the Klamath Project (A-Canal); (6) 13 fish passage improvement projects, including screening and fish ladders; and many other actions. The cost of these projects has been shared by many entities, including State and Federal programs such as Partners for Fish and Wildlife, Hatfield Restoration, Jobs in the Woods, and Oregon Resources Conservation Act programs, as well as private grant programs and significant contributions from landowners and the KWUA.

In the attached biological opinion, due to the accomplishments of recovery actions taken on behalf of endangered suckers in the Upper Klamath Basin, including significant investments by Reclamation, we find that Reclamation's proposed action is not likely to jeopardize the continued existence of the endangered suckers or to adversely modify their critical habitat. However, we have continuing concerns regarding the effects of entrainment on endangered suckers at Link River Dam and other effects of the Project likely causing incidental take. Therefore, we have included reasonable and prudent measures in an incidental take statement with the BO that we intend to assist you in implementing over the next several years.

We look forward to this continued cooperation, and if you have any questions or concerns regarding this consultation, please contact Laurie Sada, Deputy Field Supervisor at the Klamath Falls Fish and Wildlife Office, at 541-885-8481.

Attachment

cc:
Chairman, Klamath Tribes, Chiloquin, Oregon
Irma Lagomarsino, National Marine Fisheries Service, Arcata, California

Biological/Conference Opinion Regarding the Effects of the U.S. Bureau of Reclamation's Proposed 10-Year Operation Plan (April 1, 2008 – March 31, 2018) for the Klamath Project and its Effects on the Endangered Lost River and Shortnose Suckers

April 2, 2008

Prepared by the U.S. Fish and Wildlife Service

Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon
and
Yreka Fish and Wildlife Office, Yreka, California

USGS fishery biologist Brian Hayes with a large female Lost River sucker from Upper Klamath Lake. U.S. Geological Survey Photo

12 mm-long larval sucker. **40 mm-long juvenile Lost River Sucker.**

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ABBREVIATIONS AND ACRONYMS

ac	acres
AFA	*Aphanizomenon flos-aquae*
ALR	Agency Lake Ranch
BA	biological assessment
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	best management practices
BO	biological opinion
BOD	biological oxygen demand
C	Celsius
CDFG	California Department of Fish and Game
cfs	cubic feet per second
CIP	Conservation Implementation Plan
cm	centimeter
DO	dissolved oxygen
ESA	Endangered Species Act
ET	evapotranspiration
FERC	Federal Energy Regulatory Commission
FES	Fish Evaluation Station
FL	fork length
IM	Interactive Management
KFPTC	Klamath Fish Passage Technical Committee
kg	kilograms
KHP	Klamath Hydroelectric Project
KID	Klamath Irrigation District
KLS	Klamath largescale sucker (*Catostomus snyderi*)
KSD	Klamath Straights Drain
KSS	Klamath smallscale sucker (*Catostomus rimiculus*)
KWUA	Klamath Water Users Association
LDOE	low dissolved oxygen event
LKL	Lower Klamath Lake
LRDC	Lost River Diversion Channel
LRS	Lost River sucker (*Deltistes luxatus*)
LVID	Langell Valley Irrigation District
m	meter
mbf	million board feet
mg/l	milligrams/liter
mm	millimeter
MPID	Modoc Point Irrigation District
MSL	mean sea level
NAS	National Academy of Science
NEPA	National Environmental Policy Act
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	National Marine Fisheries Service

NAS	National Academy of Science
NRC	Natural Research Council
NRCS	Natural Resource Conservation Service
NWR	National Wildlife Refuge
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University (Department of Fisheries and Wildlife)
PCE	primary constituent elements
PCHU	Proposed Critical Habitat Unit
PIT	passive integrated transponder
pH	hydrogen ion concentration
pers. comm.	personal communication
POR	period of record
Project	Klamath Project
Reclamation	U.S. Bureau of Reclamation
rkm	river kilometer
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measure
Service	U.S. Fish and Wildlife Service
SNS	shortnose sucker (*Chasmistes brevirostris*)
SOD	sediment oxygen demand
SWE	snow-water equivalent
TAF	thousand acre-feet
TID	Tulelake Irrigation District
TL	total length
TMDL	total maximum daily load
TNC	The Nature Conservancy
UKL	Upper Klamath Lake
USACE	U.S. Army Corps of Engineers
USBLM	U.S. Bureau of Land Management
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRIMS	Water Resources Integrated Modeling System
WUMP	Water User Mitigation Plan

1.0 INTRODUCTION

This document transmits the U.S. Fish and Wildlife Service's (Service or USFWS) biological opinion (BO) and conference opinion on the Bureau of Reclamation's (Reclamation) proposed operation of the Klamath Project (Project) in Klamath County, Oregon and Modoc and Siskiyou Counties, California from April 1, 2008, to March 31, 2018, in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). At issue are the effects of the proposed action on the endangered Lost River sucker (*Deltistes luxatus*) (LRS), endangered shortnose sucker (*Chasmistes brevirostris*) (SNS), and proposed critical habitat for the LRS and the SNS (collectively referred to as suckers). Reclamation's request for formal consultation was received on October 23, 2007.

During the consultation, regular meetings and conference calls were made to ensure coordination was maintained between Reclamation, National Marine Fisheries Service (NMFS), and the Service. Additionally, technical staff of all three agencies exchanged considerable amounts of information via email through the consultation in order to develop and share information necessary for the consultation. A draft BO was provided to Reclamation for their review and comment.

This BO is based on: (1) information provided in Reclamation's final Biological Assessment (BA) dated October 23, 2007; (2) information presented in previous BAs and BOs addressing operation of the Project; (3) information obtained from Reclamation in meetings regarding operation of the Project, and from the results of ongoing Reclamation field research activities; (4) information, including new information, provided in published and unpublished reports on the biology, distribution, systematics, and status of the affected listed species and the ecosystems upon which they depend; (5) communications with field researchers who have conducted, or are now conducting, research on the biology of affected listed species or the ecosystems upon which they depend; and (6) other available commercial and scientific information, including comments and reports received in response to reviews of our April 2001 BO on the Project and the National Academy of Science (NAS) final report from the Committee on Endangered and Threatened Fishes in the Klamath River Basin entitled *Endangered and Threatened Fishes in the Klamath River Basin* (NRC 2004). A complete administrative record of this consultation is on file at the Service's Klamath Falls Fish and Wildlife Office in Klamath Falls, Oregon.

1.1 Consultation History

Reclamation has consulted with the Service since 1989 on the effects of operating the Project on Federally-listed threatened and endangered species. Table 1-1 summarizes previous completed ESA section 7 consultations on the Project.

Table 1-1. History of the completed consultations for the Klamath Project.

Date	Subject of Consultation	Affected Listed Species
June 14, 1989 (superseded by 1995 BO)	Formal consultation on the use of acrolein in canals and drains within the Klamath Project service area.	Shortnose Sucker Lost River Sucker
August 14, 1991 (superseded by 2008 BO)	Formal consultation on the effects of the 1991 operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon
January 6, 1992 (superseded by 2008 BO)	Formal consultation on the effects of the 1992 operation of the Klamath Project (interim biological opinion).	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon
March 27, 1992 (superseded by 2008 BO)	Reinitiation of formal consultation on the effects of the 1992 operation of the Klamath Project.	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon
May 1, 1992 (superseded by 2008 BO)	Reinitiation of formal consultation on the effects of the 1992 operation of the Klamath Project at Clear Lake Reservoir.	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon
July 22, 1992 (superseded by 2008 BO)	Formal consultation on the effects of long-term operation of the Klamath Project.	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon
February 22, 1993 (superseded by 2008 BO)	Reinitiation of formal consultation on long-term operation of the Klamath Project at Upper Klamath Lake.	Shortnose Sucker Lost River Sucker
August 11, 1994 (superseded by 2008 BO)	Reinitiation of formal consultation on long-term operation of the Klamath Project, with special reference to operations at Clear Lake Reservoir.	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon
February 9, 1995 (not superseded by 2008 BO)	Formal consultation on the use of pesticides and fertilizers on Federal lease lands, and acrolein and herbicide use on Klamath Project rights-of-way; reinitiation of formal consultation on the use of acrolein for aquatic weed control in Reclamation canals and drains.	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon Applegate's Milk-vetch
February 2, 1996 (not superseded by 2008 BO)	Reinitiation of consultation on the use of pesticides and fertilizers on federal lease lands, and acrolein and herbicide use on Klamath Project rights-of-way.	Shortnose Sucker Lost River Sucker Bald Eagle American Peregrine Falcon
July 15, 1996 (superseded by 2008 BO)	Reinitiation of consultation on PacifiCorp and The New Earth Company operations, as permitted by the Bureau of Reclamation under the Klamath Project.	Shortnose Sucker Lost River Sucker
April 2, 1998 (superseded by 2008 BO)	Amendment to July 22, 1992, BO to extend date for completion of A-Canal screen until 2002.	Shortnose Sucker Lost River Sucker
April 20, 1998 (superseded by 2008 BO)	Amendment to the 1992 BO to cover operation of Agency Lake Ranch impoundment.	Shortnose Sucker Lost River Sucker
April 21, 1998 (superseded by 2008 BO)	Amendment to July 15, 1996, consultation on PacifiCorp and The New Earth Company operations, as permitted by the Bureau of Reclamation under the Klamath Project	Shortnose Sucker Lost River Sucker

Date	Subject of Consultation	Affected Listed Species
July 13, 1998 (superseded by 2008 BO)	Amendment to the 1992 BO dealing with Anderson-Rose releases.	Shortnose Sucker Lost River Sucker
April 15, 1999 (superseded by 2008 BO)	Amendment to the 1996 BO addressing lowered water levels in Upper Klamath Lake to reduce risk of flooding in spring 1999.	Lost River Sucker Shortnose Sucker
August 18, 1999 (not superseded by 2008 BO)	Amendment to the 1995 BO on use of pesticides and fertilizers on leased lands and use of acrolein in canals operated by the Langell Valley Irrigation District.	Lost River Sucker Shortnose Sucker
September 10, 1999 (superseded by 2008 BO)	Revised amendment to the 1992 BO to cover operations and maintenance of Agency Lake Ranch impoundment.	Lost River Sucker Shortnose Sucker
April 5, 2001 (superseded by 2008 BO)	Reinitiation of formal consultation on long-term operations of the Klamath Project; a one year consultation at the request of Reclamation.	Lost River Sucker Shortnose Sucker Bald Eagle
April 13, 2001 (superseded by 2008 BO)	Reinitiation of formal consultation on releases at Anderson Rose Dam.	Lost River Sucker Shortnose Sucker
August 22, 2001 (superseded by 2008 BO)	Amendment to the April 5, 2001 BO on Klamath Project operations to cover Safety of Dams modification of Clear Lake Dam.	Lost River Sucker Shortnose Sucker Bald Eagle
September 12, 2001 (superseded by 2008 BO)	Amendment to the April 5, 2001 BO to cover the Link River Topographic Survey Fish Passage Assessment.	Lost River Sucker Shortnose Sucker
September 21, 2001 (superseded by 2008 BO)	Formal consultation for revision of the 2001 Klamath Project Sucker Salvage Plan to cover the Klamath Falls Airport Runway Safety Area Extension Project and Station 48 Maintenance Project.	Lost River Sucker Shortnose Sucker
March 28, 2002 (superseded by 2008 BO)	Formal consultation for continued operation of the Klamath Project from April 1, 2002 to May 31, 2002.	Lost River Sucker Shortnose Sucker Bald Eagle
May 31, 2002 (superseded by 2008 BO)	Formal consultation for continued operation of the Klamath Project from June 1, 2002 to March 31, 2012.	Lost River Sucker Shortnose Sucker Bald Eagle
July 24, 2002 (Not superseded by 2008 BO)	Formal consultation on the effects of A Canal Fish Screen and Link River Dam Fishway Facilities Construction and Operation	Lost River Sucker Shortnose Sucker Bald Eagle
March 4, 2003 (superseded by 2008 BO)	Amendment to the 2002 Biological Opinion on the Effects of the 10-Year Operations Plan for the Klamath Project as it Relates to Operation of Clear Lake and Gerber Reservoir	Lost River Sucker Shortnose Sucker
May 31, 2007 (Not superseded by 2008 BO)	Formal consultation for the implementation of the pesticide use program on the Federal lease lands	Lost River Sucker Shortnose Sucker Bald Eagle

1.1.1 Summary of Consultation History Since 2002

Since the May 31, 2002 BO was completed, Reclamation and the Service have worked in concert to ensure that the Reasonable and Prudent Alternatives and the Reasonable and Prudent Measures were implemented and the Project was operated in a way that was compatible with the conservation needs of the LRS and SNS. Some of the major achievements include the following:

Development of the Klamath Fish Passage Technical Committee

Reclamation formed the Klamath Fish Passage Technical Committee (KFPTC) in 2002 to help guide efforts to install Federal and State approved fish screens and/or fish ladders on the Project and in the Upper Klamath Basin. The KFPTC, composed of biologists, engineers, and water users, meets approximately bi-monthly in an open forum to discuss, review, plan, and design fish screen/passage issues and concepts. KFPTC members include the Service, the Oregon Department of Fish and Wildlife (ODFW), California Department of Fish and Game (CDFG), Klamath Irrigation District (KID), Langell Valley Irrigation District (LVID), Tulelake Irrigation District (TID), The Klamath Tribes, Klamath Watershed Partnership, and Klamath Water User Association. Depending on which facility in the Upper Klamath Basin is being reviewed for screening or passage, Reclamation invited other interested and/or affected entities to participate in the KFPTC's planning, design, and technical discussion process.

Construction of A-Canal Fish Screen and Fish Bypass Facility

Reclamation completed construction of a state-of-the-art fish screen at the entrance to the A-Canal near the outlet of Upper Klamath Lake (UKL) in March 2003, to reduce the high rates of fish entrainment known to occur at this diversion site. The LRS and SNS were particularly vulnerable to entrainment at A-Canal before the screen was installed. The A-Canal fish screen was designed to satisfy State of Oregon and Federal fish screen criteria, agreed upon in a June 29, 2000, meeting between Reclamation, ODFW, the Service, and KID. The A-Canal screen and bypass criteria are the same standards specified by NMFS to protect salmonids. The screen was designed for juvenile suckers (greater than 30 millimeter (mm) total length) and anadromous fish to prevent them from being entrained into irrigation diversions. In addition, the screen is believed to provide an additional benefit to larval suckers (10 to 20 mm), which in theory are able to pass through mesh openings, due to the hydraulic conditions which create positive sweeping flows across the screen surface.

Construction of the Link River Dam Fishway

Reclamation constructed a new vertical slot fishway at Link River Dam from July-December 2004 between the stilling basin and Keno Canal with the fish exit in the eastern-most canal gate bay. The new fishway is specifically designed to allow suckers, which are not strong jumpers like salmonids, and therefore do not normally pass through typical fishway, to easily swim through the slots and migrate above Link River Dam.

Chiloquin Dam Removal and Construction of a New Fish Screen for Modoc Point Irrigation District (MPID)

Reclamation has worked in partnership with the Bureau of Indian Affairs (BIA) to complete the studies and planning process leading to the removal of Chiloquin Dam located at river mile 0.9 on the Sprague River, a short distance upstream from its confluence with the Williamson River. The dam was built by the United States Indian Service in 1914 as an irrigation diversion dam. Chiloquin Dam was been identified by the Service as a partial barrier for endangered suckers trying to reach upstream spawning habitat in the Sprague River and one of the anthropogenic factors leading to their endangered species listing in 1988. Reclamation was assigned the task to complete the first phase of the Chiloquin Dam Fish Passage Appraisal Study in 2003 (USBR 2003).

BIA and Reclamation worked cooperatively in the second phase to complete the necessary National Environmental Policy Act (NEPA) process leading to a Federal decision to remove Chiloquin Dam and BIA has subsequently provided the funds to allow the dam removal Project to be implemented starting in 2007. Reclamation has supported BIA throughout the 5 year study process by providing Project coordination and engineering design assistance. Reclamation is presently assigned the role to provide construction management and contract administrative services needed to ensure the Project is successfully completed on-the-ground. Reclamation and BIA awarded a contract to allow the Chiloquin Dam removal to be implemented in two phases:

1. Construct a new MPID Pumping Plant and 2 small pump stations for a private landowner on the Williamson River from June to December 2007; and

2. Construct a new pump station for a private landowner and remove Chiloquin Dam on the Sprague River from June to December 2008.

Upper Klamath Lake Fish Screening

Reclamation recently proposed focusing its fish screen activities by working to install State and Federally-approved fish screens on privately owned diversions in Upper Klamath Lake. Reclamation and Service biologists believe this action is warranted because screening non-Federal diversions in UKL will provide the greatest potential benefits to endangered sucker populations where they are most abundant, populations are relatively robust, and the larger number of juvenile suckers in UKL is particularly vulnerable to entrainment if private diversions on UKL remain unscreened. Reclamation initiated a process for the Upper Klamath Lake Fish Screen Program by issuing a grant to ODFW and leveraging Federal and State funds to provide 90 percent of the cost of constructing fish screens for willing landowners.

Lost River Sub-basin Fish Improvements

Reclamation has collected data showing that entrainment of suckers is occurring in the Lost River Diversion Channel and the Miller Hill Pumping Plant located within the Lost River Diversion Channel. For this reason, Reclamation is currently in the process of developing a design to install vertical traveling screens at the Miller Hill Pumping Plant. Reclamation is currently in informal section 7 consultation process for screen installation at Miller Hill Pumping Plant.

Conservation Implementation Program (CIP) and ESA Recovery Implementation

Through the CIP, Reclamation has annually funded projects since 2004 throughout the Klamath River drainage system that included enhancement and restoration of habitat conditions, improved water quality, improved fish passage, reduced entrainment through the installation of fish screens, monitoring, research, and increased water conservation efficiencies. Over $10 million has been expended on major items funded by the CIP and for ESA recovery implementation for LRS, SNS, and coho salmon. In fiscal years 2007 and 2008, Reclamation budgeted $4.8 million for CIP and endangered species recovery activities to be expended within the CIP. Reclamation has dedicated $2.0 million in FY 2008 funds for the Klamath Watershed Restoration grant program.

In addition to the above-mentioned actions to aid in recovery of the LRS and SNS, Reclamation has made considerable progress on implementing Reasonable and Prudent Alternatives (RPAs), Reasonable and Prudent Measures (RPMs), and conservation recommendations from the May 31, 2002 BO. Table 1-2 describes compliance with the RPAs and RPMs.

Table 1-2. Reclamation actions taken to comply with the May 31, 2002 BO RPAs and RPMs requirements.

RPA or RPM	Requirement	Action	Completion Date
RPA 1	Reduce effects of adverse water quality & habitat loss	Incorporated a 50% exceedance factor and Natural Resource Conservation Service's (NRCS's) April 1 forecast to refine the water year type.	Occurs annually
RPA 2	Reduce Entrainment of suckers at Link River Dam & associated Hydropower intake bays	PacifiCorp operated intakes during the daytime & minimized night flows from mid-July to mid-October annually. Since 2003, Reclamation has been working to evaluate different entrainment reduction methods and to improve fish passage at Link River Dam. Link Dam fish ladder was completed in 2004. Spill study will occur in 2008.	Bulkhead construction occurred in 2003; monitoring is ongoing
RPA 3	Study factors affecting water quality; implement actions to reduce die-off frequency and increase access to Refuge habitat; assess ongoing sucker population monitoring, implement improvements, develop annual assessment report. Development and implementation of plans required under this RPA element shall be undertaken through a collaborative process; the following development and implementation dates are suggested.		
RPA 3a	Develop a dissolved oxygen risk assessment model for UKL and incorporate results into project management.	Developed and received approval of plan. Field data collected during the summer of 2002. Reclamation completed the Risk assessment model and prepared a final report in Fall 2005	July 16, 2002 plan approved Model completed 2005
RPA 3b	Assess and manage UKL sucker water quality refuge areas	Reclamation funded a number of research studies with U.S. Geological Survey (USGS) between 2002 and 2007	Reports submitted to USFWS in 2005, 2006, & 2007
RPA 3c	Assess ongoing sucker population monitoring and implement needed improvements; develop Annual assessment report	Reclamation funded research studies with USGS & Oregon State University (OSU) to conduct on-going larval, juvenile and adult monitoring activities. Reclamation funded & assisted USFWS for monitoring suckers in Gerber & Clear Lake in 2004. Reclamation continued to fund USGS to complete the Gerber and Clear Lake studies since 2005. Reclamation hosts an annual workshop/meeting, in addition to other meetings, to discuss sucker population monitoring, data collection, study design, and data analysis.	Begun in 2003, continues annually
RPA 3d	Sucker die-off monitoring and assessment	Reclamation completed a sucker die-off and assessment plan in June 2002. Reclamation continued to work with stakeholders to assure the plan is properly and effectively implemented if a fish kill should occur.	2002 and implemented annually as needed
RPM 1	Minimize entrainment throughout the Project. Development and implementation of plans required under this RPM element shall be undertaken through a collaborative process; the following development and implementation dates are suggested.		
RPM 1a	Assess and implement methods to reduce entrainment of larval suckers		
RPM 1b	Assess and implement methods to reduce entrainment of juvenile, subadult, and adult suckers at project diversions	Completed construction of A-Canal Fish Screen. Testing showed the screen reduced entrainment of larval suckers by 46%. Installed and operate fish bypass pump at A Canal; several years of monitoring of all screened diversions to ensure proper operation and effectiveness. Installed fish screens at Clear Lake in 2002. Perform annual maintenance of screens and automated cleaning brushes to ensure proper operation; Conduct annual salvage activities throughout the Project each fall at end of irrigation	April 2003 On-going, annually

RPA or RPM	Requirement	Action	Completion Date
		season and submit reports to the Service; Chair of Klamath Fish Passage Technical Committee to ID screening needs; provided a grant to ODFW to install screens on private diversions on UKL; continual monitoring of Agency Lake Ranch (ALR) screens; purchased INTRALOX screens for ALR, but will now install at Miller Hill as ALR dikes to be breeched in 2008	On-going, annually Implement Miller Hill screens in near future
RPM 1c	Implement methods to reduce entrainment of juvenile, sub-adult, and adult suckers at A-Canal prior to completion of proposed fish screen	Completed A-Canal Fish Screen	April 2003
RPM 2	Monitor, implement, and report on water quality in project delivery area	Conducted water quality monitoring throughout the Project since 2002 in UKL, Lost River, and Lake Ewauna in coordination with USFWS	On-going since 2002
RPM 3	Minimize habitat alteration in Project lakes and reservoirs as a result of project operations		
RPM 3a	Provide adequate Link River habitat and assess sucker habitat needs in the Link River and downstream in Lake Ewauna and the Keno Reservoir	Provide releases of at least 250 cubic feet per second (cfs) June – Oct annually; Initiated Link River-Lake Ewauna-keno habitat & water quality studies from 2003 to present. Continue to monitor and research sucker habitat use/distribution and water quality improvement w/ constructed wetlands	On-going annually since 2003
RPM 3b	Provide adequate habitat below Clear Lake and Gerber Reservoir Dams	Monitor flows and water quality in the upper Lost River & Miller Creek; conducted fisheries assessment of Miller Creek; monitor fisheries and water quality data on Clear Lake and Gerber	On-going, annually since 2003
RPM 3c	Assess habitat conditions and endangered sucker needs in the Lost River	Began collecting information in 2003.	Expected completion of report in 2008
RPM 3d	Determine habitat needs for larval suckers and implement actions to provide additional habitat	Funded research projects with OSU, USGS, USFWS, and others since 2003; Acquired and managed ALR and Barnes properties to improve wetland habitats; continue to work with The Nature Conservancy (TNC) & USFWS on Williamson River Delta restoration project	On-going, annually since 2003
RPM 3e	Determine juvenile habitat distribution in UKL relative to bathymetry and lake elevations	Completed shoreline substrate and bathymetry study, submitted report to USFWS	2003
RPM 3f	Analyze risk to sucker populations from multiple dry and critically dry years and develop management plan to reduce that risk	Research projects model correlations of population levels in responses to lake surface elevations	Final report due December 2007

Additionally, Reclamation has voluntarily made considerable progress on implementation of the conservation recommendations as shown in the Table 1-3.

Table 1-3. Reclamation's actions taken in response to the May 31, 2002 BO conservation measures.

Number	Conservation Measure	Status
1	Coordinate with Bureau of Land Management (BLM), USGS, ODFW, CDFG, Klamath Tribes, and the Service to establish a population of Lost River suckers in Gerber Reservoir with brood stock from Clear Lake	Reclamation has funded USGS to conduct monitoring surveys in Gerber and Clear Lake. Information from these studies could be used to identify brood stock for reintroduction purposes. The fish present in Gerber appear to be a hybrid of Klamath largescale and shortnose suckers. Reclamation has implemented this recommendation to the limit of our authority
2	Serve as a clearing house for water quality data from the Upper Klamath Basin	Parties and stakeholders cannot agree upon parameters to measure, locations to collect data, or who should be the clearing house
3	Fish passage at Chiloquin Dam-secure funding to improve passage	Along with BIA, received funding for construction of new pumping plant and dam removal. Pumping plant construction currently underway, scheduled for completion in late 2007/early 2008, Chiloquin Dam scheduled for removal in 2008. Reclamation continues to monitor effects to suckers pre and post removal
4	Work with Tule Lake National Wildlife Refuge (NWR), CDFG, & irrigation districts to protect suckers in Tule Lake sump	Reclamation coordinates with USFWS and TID to manage lake surface elevations of the sumps to protect suckers
5	Coordinate with Environmental Protection Agency (EPA) and States of CA and OR on the Lost River Total Maximum Daily Loads (TMDLs)	Reclamation provided data in support of this effort and is coordinating as appropriate
6	Implement a pilot project to enhance sucker spawning at known spawning sites along the eastern shoreline of UKL	Reclamation has funded USGS to monitor spawning activities at these sites
7	Develop an operations plan for ALR	ALR will become part of the Refuge system; therefore, it is more cost effective for the long term property owner to develop the operations plan.
8	Develop a plan to maximize the efficient delivery and use of water within the Project delivery area using local expertise from water users.	Through the Water Conservation Program, Reclamation has provided 18 miles of pipe to Irrigation Districts to replace open canals between 2002 and 2007. An additional 2 miles is scheduled to be installed in 2008.
9	Assess the potential relationship between flood-induced, sediment loading inflows into UKL and catastrophic fish die-offs. Include a model to determine how operation of Project facilities could effect the storage of storm-mobilized organics and nutrients	Reclamation and USGS continue to study nutrient loading into UKL and fish die-off to further understand whether or not there is a correlation. Currently, insufficient data is available to develop a model at this time.

Further, Reclamation, the Klamath Water Users Association (KWUA), and Project irrigation districts have implemented a number of additional conservation and restoration actions. Table 1-4 describes these actions, which Reclamation believes have contributed to reduced agricultural demand for water in the Upper Klamath Basin.

Table 1-4. Conservation and restoration actions completed or supported by the KWUA and other irrigation districts in the Upper Klamath Basin.

Topic	Goal	Action
KWUA Ecosystem Enhancement and Sucker Recovery Efforts	On-the-ground, effective and scientifically sound ecosystem enhancement projects in the basin	• Sprague River riparian improvements: 14 miles of riparian fencing and other improvements at a cost of $250,000 • Assessments of grazing allotments in Modoc National Forest
Fish Passage Improvement Projects	Entrainment of listed suckers and lack of connectivity between sucker populations has identified effects of Klamath Project Operations. Project irrigators have played an active role in improving fish passage.	• Screening the A Canal ($15M) • Chiloquin Dam: participating in collaborative process • ODFW Fish Passage Improvements:13 projects for $250,000; 40 more planned at estimated cost of $1.3M (Jan 2003 estimate) • Participation in technical committee to develop fish screen implementation plan for diversions throughout the Project • Construction of the Link Dam Fish Ladder in 2003
Local efforts to improve water quality	Reduce agricultural non-point pollution loads and achieve load allocation under the TMDLs	• Landowner advisory councils working with OR Dept of Ag (ODA) to address water quality management on the Lost and Klamath Rivers • UKL Pilot Oxygenation Study • Strategic water treatment ponds located through the project based on objectives, location and cost criteria • Implementation of 'Walking Wetlands' • Improved working relationships and management activities with Tule Lake National wildlife Refuge for wetlands, water quality, and listed sucker management • Reduced numbers of cattle in Klamath County from 1997 to 2007 by 33% (NASS website 10-4-07) • Acreage removed from agricultural production and converted to wetlands between 1996 and 2007 totals approximately 25,000

NASS website: http://www.nass.usda.gov/QuickStats/PullData_US_CNTY.jsp 10/4/2007

*Includes Wood River Ranch 2,900 acres (ac), ALR 7159 ac, Barnes Ranch 2,671 ac, Lower Klamath National Wildlife Refuge acquisition of 2,200 ac, Williamson River Delta 5,600 ac.

1.1.2 Summary of Recent Consultation History

Reclamation and the Service have been working on this consultation for over a year. We have met together numerous times and have also met on multiple occasions with NMFS to ensure the consultations were coordinated. Additionally we had regular conference calls with Reclamation and NMFS. Details of meetings and other pertinent information are in the administrative record.

The key dates for development and completion of this consultation are presented in Table 1-5.

Table 1-5. Key dates for development and completion of this consultation.

Date	Action
September 12, 2007	Reclamation provided the Service with a draft BA for review.
October 6, 2007	The Service provided Reclamation with written comments on the draft BA.
October 23, 2007	Reclamation provided the Service with a request for reinitiation of formal consultation on the Klamath Project and provided a final BA.
November 21, 2007	The Service provided Reclamation with a memo acknowledging receipt of their request for reinitiation of formal consultation.
February 26, 2008	The Service met with the Klamath Tribes to discuss the BO.
March 6, 2008	The Service provided Reclamation with a draft BO.
March 14, 2008	Reclamation provided the Service with written comments on the draft BO.

1.1.3 Relevant New Scientific Information Developed Since the 2002 Biological Opinion

The Departments of the Interior and of Commerce contracted with the National Research Council (NRC) to assess the scientific basis for the 2001 biological assessments and opinions issued by Reclamation, the Service and the NMFS. Under this contract, NRC conducted a two-part assessment of endangered and threatened fish in the Klamath Basin. The first part of the assessment examined the scientific evidence behind the 2001 biological assessment prepared by Reclamation and the 2001 biological opinions issued by the Service and NMFS. The first phase of the assessment resulted in what NRC describes as an "interim report" that was issued in February 2002. The second phase of the assessment would "take a broader approach to evaluation of evidence related to the welfare of the endangered or threatened species." This report titled "*Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery*" was published in 2004.

The Service incorporated the interim recommendations of the NRC committee into its 2002 BO to the degree possible. The NRC Committee included some assessment of the 2002 consultations and made the following statements about the 2002 BA and BO:

> "These documents reflect a closer interaction between the agencies than in previous years. U.S. Bureau of Reclamation (USBR) moved toward more restrictive operational practices than it had previously proposed and towards the development of reserve water

supplies; USFWS and NMFS were more cautious in requiring actions whose basis would be contradicted by site-specific studies, and they acknowledged the need to consult with other parties in addition to USBR."

The principal findings of the 2004 final report included the following statements:

- Although suckers of all age classes are present in UKL, population densities of suckers are low, and there are no signs that populations are returning to their previously high abundance.
- Expansion of spawning on the Sprague River could increase the abundance of fry descending to UKL and would beneficially extend the interval over which they arrive at the lake.
- The tributaries do, however, show loss of riparian vegetation and wetland (largely due to agricultural practices), which could adversely influence the survival of fry. The physical condition of channels in general and spawning areas in particular is degraded, but the nature and extent of degradation is poorly documented for the tributaries.
- Larval suckers are readily dispersed from their points of origin by currents and ultimately are found in shallow water in or near emergent vegetation at the margins of the lake. Loss of such vegetation, especially near the tributary mouths could be disadvantageous to the fry.
- Standardized sampling of young suckers and studies of year-class strength for large suckers do not, however, indicate associations between water level and abundance of larvae.
- There is substantial juvenile sucker mortality, but current information is insufficient to show whether it is extraordinary in comparison with mortality in other lakes that have more favorable living conditions.
- Sub-adult and adult suckers seek deeper water than younger ones and congregate in specific areas of UKL. In contrast to the tributaries, poor water quality in the lake itself appears to be their greatest vulnerability. Direct evidence of harm to large suckers by poor water quality includes physical indications of stress and mass mortality ("fish die-offs") at times of exceptionally poor water quality.
- Mass mortality of large suckers in UKL has occurred for many decades, but anthropogenic factors, especially those leading to a strong dominance of *Aphanizomenon flos-aquae* (AFA), probably have increased in severity and frequency.
- There is no evidence of a causal connection between water level and water quality or fish mortality over the broad operating range in the 1990s. Neither mass mortality of suckers nor extremes of poor water quality shows any detectable relationship to water level.
- Planning must anticipate that poor water quality will continue to affect the sucker populations of Upper Klamath Lake.
- Suckers in UKL also are affected by entrainment from Link River near the outflow of the lake. Screens installed at the main irrigation-water withdrawal point probably will be beneficial, but loss of small suckers still can be expected. The Link River Dam intakes are not screened.
- Nonnative fishes, which are diverse and abundant in UKL, may be suppressing the populations of endangered suckers there, but no practical mechanisms for reducing their abundance are known.

For the most part, we concur with the findings of the NRC Committee. For example, in this BO we have concluded there is a lack of evidence that UKL levels have a discernable effect on water quality. This is supported by new information developed by USGS (Morace 2007) that concluded there was no demonstrable direct effect of lake level on water quality; however, several variables including water temperature and wind speed appear to interact with lake levels in affecting water quality in UKL, but inadequate data limited the strength of the analysis.

Regarding a possible relationship between lake levels and sucker production and survival, the NRC Committee concluded there was no empirical evidence of such a relationship. We do not dispute this finding; however, we believe there is ample evidence that lake levels could affect the amount and extent of habitat and this could affect suckers. In the discussions of the environmental baseline and effects of the proposed action we will present evidence of how lake levels affect habitat.

1.2 Other Relevant Activities Associated with this Consultation

In December of 2007 (FWS# 81333-2007-F-80), the Service completed a biological opinion addressing the effects of the Federal Energy Regulatory Commission's (FERC) proposed action to relicense the Klamath Hydroelectric Project. This project, consisting of four hydroelectric facilities on the Klamath River, is located immediately downstream of and has utilized joint facilities with Reclamation's Klamath Irrigation Project. These two projects are not considered interrelated or interdependent because they could operate independently, and thus do not meet the "but for" test for interdependence. For information on the effects of the hydroelectric project, see the Environmental Baseline section, below.

2.0 PROPOSED ACTION

2.1 The Klamath Project

Reclamation proposes to operate the authorized features and facilities of Klamath Project, from April 1, 2008 to March 31, 2018, to store, divert, and manage flows of the Klamath and Lost Rivers. Water is stored behind several dams in reservoirs or lakes within the Upper Klamath River Basin.

The Klamath Project is located in south-central Oregon and northern California. It covers lands in Klamath County, Oregon, and Siskiyou and Modoc Counties in northern California. Clear Lake Dam and Reservoir, Tule Lake, and Lower Klamath Lake lie south of the Oregon-California border. Gerber Dam and Reservoir; Upper Klamath Lake; Link River Dam; and the Lost River, Miller, Malone, and Anderson-Rose Diversion Dams are located in Oregon. Clear Lake Dam and Reservoir are Project facilities located in California (Figure 2-1).

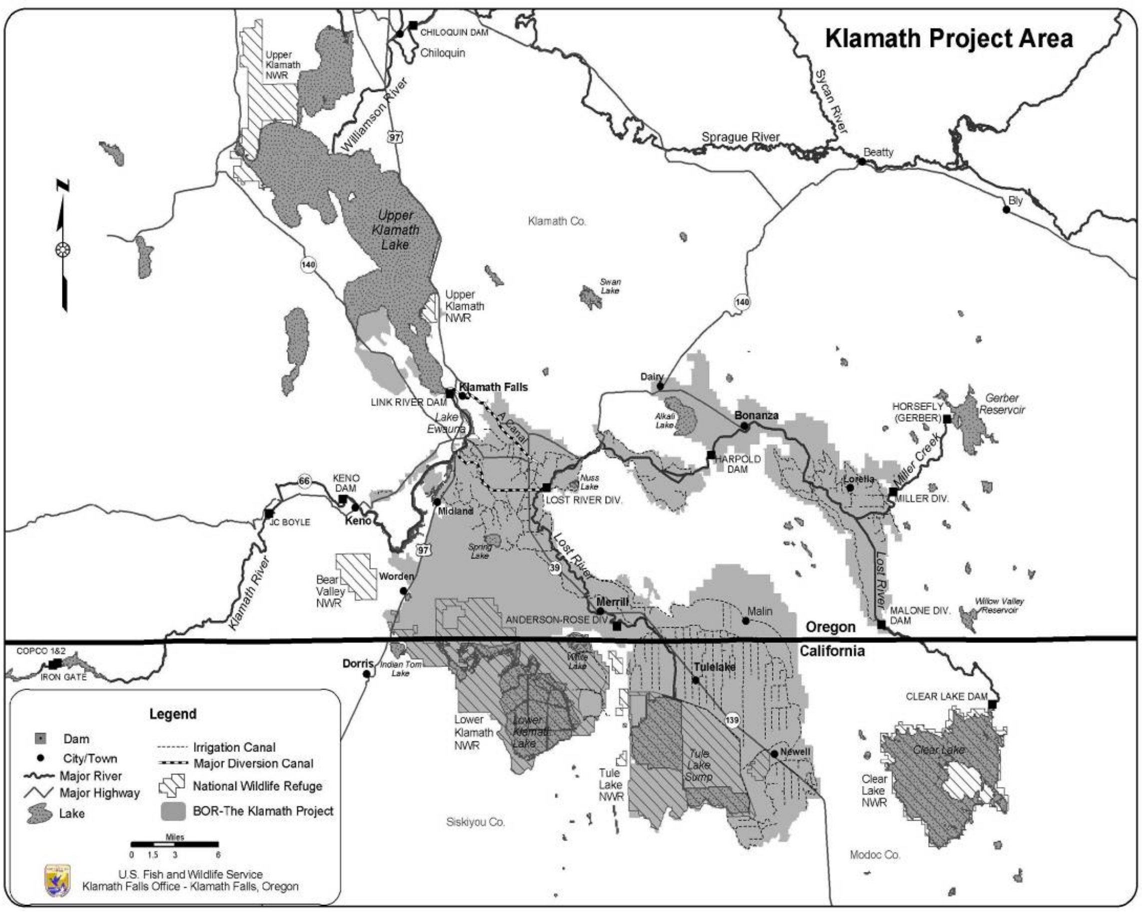


Figure 2-1. Map showing the land served by the Klamath Project (shaded area).

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.), authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of water for the reclamation of arid and semi-arid lands in the Western States. Congress facilitated development of the Klamath Project by authorizing the Secretary to raise or lower the level of Lower Klamath and Tule Lakes and to dispose of the land uncovered by such operation for use under the Reclamation Act of 1902. The Oregon and California legislatures passed legislation for certain aspects of the Klamath Project, and the Secretary of the Interior authorized construction May 15, 1905, in accordance with the Reclamation Act of 1902 (Act of February 9, 1905, Ch. 567, 33 Stat. 714). The Project was authorized to drain and reclaim lake bed lands in Lower Klamath and Tule Lakes, to store water of the upper Klamath and Lost Rivers, including storage of water in the Lower Klamath and Tule Lakes, to divert and deliver supplies for Project purposes, and to control flooding of the reclaimed lands.

The East Side of the Project consists of Langell Valley and Horsefly Irrigation Districts. Langell Valley Irrigation District operates Clear Lake and Gerber Reservoirs to provide irrigation water to their customers as well as maintaining reservoir levels for listed suckers under the 2002 BO. Releases from Clear Lake and Gerber Reservoirs are made directly for Langell Valley customers, and Horsefly customers receive water from return flows, accretions and additions from Bonanza Big Spring. Irrigation on the East Side is managed to minimize any return flows passing Harpold Dam, a Horsefly Irrigation District facility. Except under conditions of critical water shortage within the Main Project, no releases are made from East Side dams to provide water for the Main Project and water used for irrigation in the Main Project from UKL is not used in the East Side of the Project due to facility limitations.

The earth-filled Clear Lake Dam was completed in 1910 and operated under a Safety of Dams restriction of 350 thousand acre-feet (TAF) from 1999 until it was replaced by a roller-compacted concrete dam in 2003. Since 2003, the reservoir can be operated at its full capacity of 513 TAF. The dam and reservoir also serve to prevent flooding in and around Tulelake, California. Excess water from the Lost River sub-basin is diverted to the Klamath River via Lost River Diversion Channel (LRDC) to reduce flooding in the Tule Lake area. These releases enhance Klamath River flows in winter months when UKL is being filled.

The west side of the Project (i.e., "Main Project") consists of three large irrigation districts, one large drainage district, several small irrigation districts, and other water delivery entities, and two National Wildlife Refuges (Tule Lake and Lower Klamath Lake National Wildlife Refuges) that are served by water diverted from UKL. The three larger districts are the Klamath Irrigation District, the Tulelake Irrigation District and the Klamath Drainage District. The Klamath Drainage District also receives water through two privately owned and operated canals, the Ady Canal and the North Canal. A more detailed description of the Project can be found in Appendix 1-C of the 2007 BA (USBR 2007), and Appendix B of the 2002 BO (USFWS 2002). According to Reclamation's 2007 BA, some minor changes have been made to Project features since 2000 (e.g., pump replacements, replacement of Clear Lake Dam), but none of these changes significantly alter the 2000 description of the Project structure and function (USBR 2000a).

Current Operations

The Project uses water stored in UKL (Klamath River system) and in Gerber and Clear Lake Reservoirs (Lost River system). The distribution system delivers water via a system of canals to lands in the Langell Valley, Poe Valley, Klamath Irrigation District, Tule Lake area, and Lower Klamath Lake area (see Figure 2-2). The primary diversion points include the Malone and Miller Creek Diversion Dams in the Langell Valley, diverting Lost River (Clear Lake releases) and Miller Creek (Gerber Reservoir releases) respectively; the Lost River Diversion Dam and Channel control diversions into and out of the Klamath River; the A-Canal diverts water from UKL to the Project, controlling water to the Klamath Irrigation District as well as the Poe Valley and the Tule Lake areas; the Anderson-Rose Diversion Dam on the Lost River, which also diverts water to the Tule Lake area; and the Ady Canal, which diverts water from the Klamath

River into the Lower Klamath Lake area. In addition, Project irrigators divert directly from both the river systems and UKL (USBR 2000a).

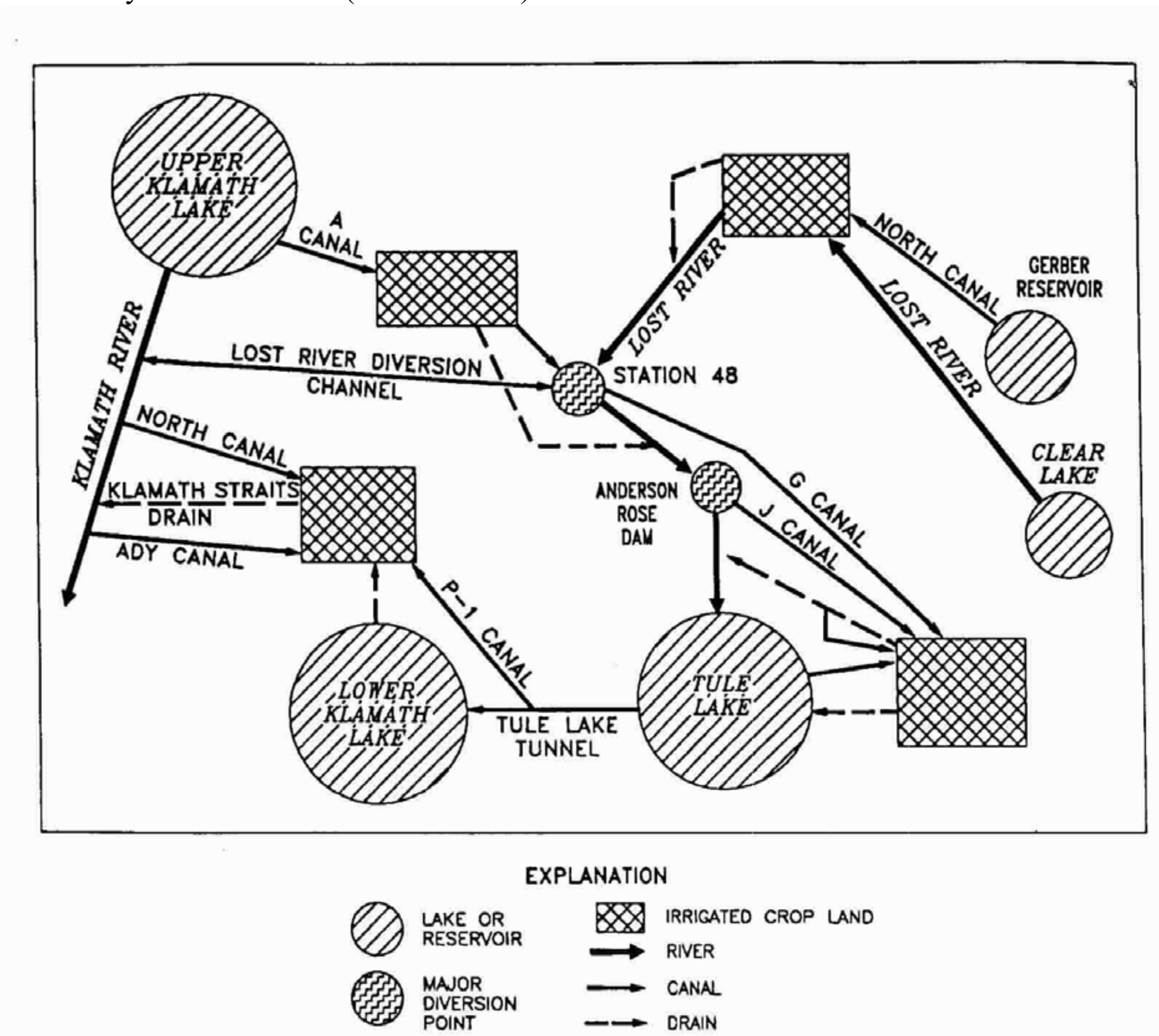


Figure 2-2. Schematic diagram showing the primary Project facilities and movement of water through the Project. Note that water in the Lost River Diversion Channel can move in both directions.

For each water year, typical deliveries by the Project begin in late fall, when the Ady and North Canals are used to deliver water from the Klamath River to lands throughout the Lower Klamath Lake area. This water is used to flood-irrigate private lands, Federal lease lands, and Lower Klamath NWR lands. The drain water is returned to the Klamath River via the Klamath Straits Drain (KSD). Winter flooding is the primary pattern of irrigation in this area of the Project. However, irrigation and Refuge water deliveries continue throughout the year. Diversions in the Ady and North Canals range from a low during the summer months of 100 cubic feet per second (cfs) to a high of 500 cfs during the late fall and winter.

In late March or early April, the A-Canal diversions from UKL begin. Flows generally begin at about 500 cfs to charge the canal system, with a gradual increase to a peak of near 1,000 cfs in May or June (USBR 1992). The other main diversion for use within the Project is from the Lost River Diversion Channel via the Klamath River below Link River Dam. Water deliveries typically continue into October. Drainage water from lands irrigated from the A-Canal and other return flow from facility operations can return in one of two directions. Some of this water returns to the Klamath River, however, the majority is returned to the Lost River for reuse by other districts and the Tule Lake NWR (USBR 1992). Return flows from the LRDC diversions return to Tule Lake. The bulk of these return flows, approximately 400 cfs on average from June to August each year, enter the Klamath River through the KSD upstream of Keno Dam either directly or after being diverted into and released from the Lower Klamath NWR. In the fall and winter, flood water from the Lost River Basin is added to the total flow of the Klamath River upstream of Keno via the Lost River Diversion Channel. Such inflow may be as high as 3,000 cfs, but is usually from 200 to 1,500 cfs (PacifiCorp 2000).

Diversions at Miller Creek and Malone Diversion Dams generally begin in April with flows of about 200 cfs. Flows reach a peak of about 400 cfs and are stopped by about October. These diversions serve about 30,000 acres in the Langell Valley. Drainage water from this system returns to the Lost River.

Diversions at Anderson-Rose Dam generally begin in mid-March with flows of 200 cfs. Flows reach a peak of about 450 cfs and end during November. Anderson-Rose Dam diversions serve the Tule Lake area. All the drainage flows enter the Tule Lake Sumps.

The Tule Lake NWR receives water from the Klamath and Lost Rivers. Since the Lost River Basin was a naturally closed basin, Reclamation constructed a pump and tunnel system ("D-Plant") from Tule Lake to Lower Klamath NWR. Return agricultural flows accrue to Tule Lake and are reused for irrigation before the water is ultimately passed through the pump system to the Lower Klamath Lake area where it is used for irrigation and Refuge operations. Finally, the water is returned to the Klamath River via the KSD.

In an average year, Gerber Dam, the source of water for the Miller Creek Diversion Dam, releases about 40 TAF of irrigation water. Clear Lake releases in an average year about 36 TAF annually. UKL is normally operated to stay within a set of operational guidelines that provide for storage, flood protection, ESA requirements, and Tribal trust responsibilities. All water that is not needed to regulate within these guidelines is released to the Project via the A-Canal or to the Klamath River. Seasonal diversions from UKL and the Klamath River average from 350 to 450 TAF through A-Canal, LRDC, and other canals.

The Project also modifies flows in the Lost River, Link River, and the Klamath River. Lost River flows are significantly reduced below the Lost River Diversion Dam and Anderson-Rose Diversion Dam (USBR 1992). PacifiCorp, under the direction of Reclamation, has operated its Klamath River Hydropower Facilities to meet UKL levels and downstream flows in the Klamath River below Iron Gate Dam (PacifiCorp 2000). Natural stream flows in the Project area follow the typical western pattern of very high flows in the spring followed by very low flows in the late summer and fall. The Project now tends, in most years, to temper the magnitude of these extremes and to change the natural timing of these flow patterns (USBR 2000a; Figure 3-7).

Repayment Contracts

The Project water users obtain their irrigation water from Project reservoirs pursuant to various contracts with Reclamation. Reclamation obtained water rights for the Project in accordance with California and Oregon State law, pursuant to the Reclamation Act of 1902. The priority date for Project water rights is generally 1905, but some rights date back to 1878.

Reclamation entered into numerous contracts pursuant to the Reclamation Act of 1902 with various water users and entities to provide for the repayment of Project costs and the delivery of Project water. The contracts specify the acreage to be irrigated and in most cases do not specify an amount of water relying on beneficial use for the amount of water used. The contracts are all written in perpetuity.

In all, over 250 contracts for water supply are administered either directly or through irrigation districts on the Project. Contracts also cover the operation of the system that has been transferred to the water users for operational responsibility. Irrigation districts that fall into this category are Klamath Irrigation District, Tule Lake Irrigation District, and the Langell Valley Irrigation District.

While the primary water delivery facilities for the Project are owned by the United States, certain districts and individual water users own their own distribution and/or diversion facilities. In the latter case, the United States delivers water to the water user's diversion or delivery system. Some of these entities are listed below with the date of their contract and the number of acres identified in the contract to be irrigated (note: only the most recent contract is listed):

District Name	Contract Date	Acreage
Van Brimmer Ditch Company	November 6, 1909	3,315
Klamath Basin Improvement District	April 25, 1932	10,403
Enterprise Irrigation District	March 18, 1935	2,981
Malin Irrigation District	May 5, 1936	3,507
Pine Grove Irrigation District	June 19, 1936	927
Sunnyside Irrigation District	June 25, 1936	595
Westside Improvement District	October 20, 1936	1,190
Shasta View Irrigation District	August 20, 1938	4,141
Klamath Drainage District	April 28, 1943	19,229
Emmitt District Improvement Company	December 1, 1947	424
Midland District Improvement Company	February 2, 1952	581
Poe Valley Improvement District	July 20, 1953	2,636
Ady District Improvement Company	August 5, 1954	435
Plevna District Improvement Company	February 7, 1958	523
Horsefly Irrigation District	August 24, 1976	9,843
UKL Contractors	Various contract dates	7,918
Individual Contracts	Various contract dates	9,960

Nearly all contracts written during the past 85 years on the Klamath Project obligate the United States to the delivery of irrigation water. Clauses in most contracts include language similar to the following example:

> *"The United States shall deliver in the Klamath River at the outlet of Upper Klamath Lake in all a total of 522.7 irrigable acres, a sufficient quantity of water as may be beneficially used upon said lands...the quantity of water sufficient for the irrigation of said 522.7 acres shall be as determined by the Secretary of the Interior...."*

The contracts additionally provide that the United States shall be held harmless in the event of a water shortage.

Temporary Water Contracts

Each year Reclamation makes a determination if surplus water is available for sale to Project water users without existing long term contracts (see forecasting). In many cases irrigators have been receiving surplus irrigation water from Reclamation for over 50 years. For numerous reasons these irrigators were never given a contract for a long term supply of Project water with the United States. Concurrently, in accordance with their contract with the United States, certain districts also make a determination whether or not to sell surplus water.

The acreage represented by these temporary contracts represents less than 2 percent of the total acreage irrigated on the Project. Water is delivered to these lands through the existing irrigation systems. In many cases the water is delivered and controlled by the irrigation districts.

2.2 Description of the Proposed Action

The purpose of the proposed action is to fulfill Reclamation's legal responsibilities and obligations within the Klamath River basin during varying hydrological conditions. These legal responsibilities and obligations include: the Tribal trust resources; ESA; senior water rights; project water users' contractual rights; National Wildlife Refuges; and other requirements mandated by law and within the authority of the Secretary of the Interior.

Under this consultation, Reclamation proposes to operate the Project from April 1, 2008 through March 31, 2018 (USBR 2007). The proposed action consists of four major elements:

1. To store and divert waters of the Klamath and Lost Rivers, to manage return flows for authorized Klamath Project purposes, and to meet water delivery contractual agreements between Reclamation and Project water users in furtherance of other legal responsibilities.

2. To operate the Project to maintain UKL elevations and Klamath River flows that meet or exceed the proposed minimum levels as specified in the BA. Gerber Reservoir and Clear Lake will continue to be operated as defined in the 2002 BO and 2003 amendment (USFWS 2002, 2003), with minimum lake levels being 4798.1 feet and 4520.6 feet, respectively.

3. To implement an IM process by which Tribal and State governments and other Federal agencies will work collaboratively with Reclamation to manage and distribute available water supplies after meeting proposed minimum Iron Gate Dam flows, UKL elevations, and Project water delivery obligations and storage.

4. To work with KWUA to establish a Water User Mitigation Plan (WUMP) to lessen the impact of a water shortage. The WUMP will be managed by Reclamation for 4 years, after which it will be the responsibility of the KWUA under a Joint Powers Agreement.

Reclamation proposes to store water in UKL, Gerber Reservoir, and Clear Lake, with most of the storage occurring from October to April. In UKL, storage will also occur at other times if net inflows exceed Project and river flow requirements. In UKL, lake elevation will normally peak between March and May and usually reach a minimum between late September and mid-October.

As a result of flood control operations in the Lost River, water will be diverted to the Klamath River via the LRDC. On average, 143 TAF are diverted annually from the Lost River to the Klamath River (USBR 2007, Table 1-2). Additionally, return flows from the Project and water released from the Tule Lake and Lower Klamath NWRs are returned to the Klamath River through the KSD. On average KSD contributes 112 TAF to the Klamath River (USBR 2007, Table 1-2). LRDC and KSD return water to the Klamath River upstream of Keno Dam.

Diversions to the Project will normally occur from early April though mid-October. However, some water is used by the Project in winter to enable pre-irrigation of some lands and to provide water to the Refuges for waterfowl and bald eagle management. Deliveries to the Refuges and Project lands will be similar to those occurring during the 43-year period of record of 1961 to 2004. This reference period represents the time when the Project was more-or-less fully built-out and no significant changes were made that altered the operation of the Project.

This proposed action differs in a number of ways from the existing operation of the Project as covered by the 2002 BO. In 2002, Reclamation proposed to operate the Project in a manner consistent with the historical operations from water year 1990 through 1999. The resulting monthly minimum UKL elevations were based on the ranges of inflow values, or water-year types for each year as determined by the total annual net inflow to the lake. Four water year types were identified for UKL: above average, below average, dry, and critically dry. Minimum monthly UKL elevations were progressively lower with each drier year type.

Beginning in 2002 and extending through 2007, Reclamation had difficulties implementing their proposed action as described in the 2002 BA. One reason for these difficulties was that the net seasonal and annual inflows to the UKL that occurred between 2002 and 2007 were much different from those that occurred in the 1990s. The 1990s had two years of record low inflows (1992 and 1994) and several years of high inflows (e.g., 1993), and as a result the frequency of water year types and UKL elevations was unlike that of the 1990s. From 2002 to 2006, the climate was drier than average, so that period was also unlike the period of record. In order to produce an annual UKL elevation curve that more closely fitted the period of record, the Service worked with Reclamation to adjust the proposed monthly elevations to fit a more normally distributed curve. This did help minimize some of the difficulties associated with using the 1990s as a basis for Project operations; however, there was another problem and that was that in the use of water year types.

Water year types were developed as a short-hand basis to relate forecasted net inflows to UKL with projected lake elevations and Klamath River flows, on a monthly basis. However, for a given forecast of net annual inflow to UKL there was a wide range of actual monthly inflows that could result in the same forecasted annual inflow. For example, April to October monthly inflows varied as much as three times the variance for the entire season (USBR 2007, Table 1-1). As a result, there were times that actual monthly inflows were less than what was needed to meet UKL elevations despite the projection that UKL elevations would be met based on the forecast net annual inflow. Additionally, the forecasted net annual inflow did not always accurately represent the actual net inflow due to variations in snowfall across the basin that makes forecasts inaccurate. Reclamation's calculations included different releases to the river than those required by NMFS, which impacted storage and thus affected Reclamation's ability to meet end-of-month UKL levels. Addressing these inherent uncertainties in the forecasting and reliance on water year types and the difficulties in operating UKL to specific elevations based on those projections is one objective of Reclamation's proposed action.

Lake Level Management at UKL

Through the consultation process, NMFS requested a change be made to the modeled operational rules for the default distribution of Interactive Management (IM; described below in section 2.1.1) water in order to provide greater certainty that Klamath River flows would meet the needs of coho salmon. This change was described in a March 28, 2008 memo from Area Manager, Pablo Arroyave to Service's Field Supervisor, Curt Mullis. The flows and lake levels were in the modeled run called "WRIMS 36B+." The Service analyzed the effects this change would have on UKL elevations and determined that they were relatively minor and therefore concurred with the change, as did Reclamation. Klamath River flows and UKL elevations resulting from the WRIMS 36B+ are shown below in Tables 2-8 and 2-9, respectively. These exceedance tables replace those in the proposed action section of BA.

Table 2-1 shows minimum monthly UKL elevations that will result from the proposed action, as well as the 70 percent exceedance elevations from the BA (WRIMS 36B+), and operational refill target elevations that Reclamation will try to meet to ensure the lake is full each year in March (i.e., reaches 4143.3 feet). A 70 percent exceedance value means that 70 percent of the historic observations were equal to or greater than a set value and 30 percent were less. Thus, under a 70 percent exceedance for UKL, the value under consideration would be met in 70 percent of the years. In a 10 year period, 7 years should fall within the 70 percent exceedance value, if climate is similar to the period of record. The BA states that in most years, UKL elevations will exceed the minimum elevation. The probability of refilling UKL varies depending on a variety of factors (e.g., winter precipitation, groundwater levels, net inflows, and end-of-season UKL elevation), but based on the period of record, the probability of filling the lake is about 85 percent when the starting elevation is 4138 feet at the beginning of the water year in October (USBR 2007).

Operation of Clear Lake and Gerber Reservoir

End-of-month minimum elevations resulting from Reclamations proposed action at Clear Lake and Gerber Reservoir have not changed from what was proposed in the 2002 BA and are shown below in Tables 2-2 and 2-3.

Table 2-1. UKL end-of-month, minimum elevations (feet above mean sea level (MSL), USBR datum) resulting from Reclamation's proposed action, 70 percent exceedance elevations, and operational refill targets. Based on WRIMS 36B+ and Table 1-4 in the BA (USBR 2007).

Month	Minimum UKL Elevation (Feet, MSL)	70 Percent Exceedance Elevations (Feet, MSL)	Operational Refill Targets (Feet, MSL)
October		4139.0	4139.1
November		4139.8	4139.9
December		4141.0	4140.8
January		4141.8	4141.7
February	4141.5	4142.6	4142.5
March	4142.2	4143.2	4143.0
April	4142.2	4143.2	
May	4141.6	4142.6	
June	4140.5	4141.5	
July	4139.3	4140.2	
August	4138.1	4139.3	
September	4137.5	4138.9	

Table 2-2. Clear Lake end-of-month, minimum elevations (feet above mean sea level MSL, USBR datum) by inflow year types resulting from Reclamation's proposed action (from Table 5.7 of USBR 2002).

	Inflow Year Types			
Month	Above Average (Feet, MSL)	Below Average (Feet, MSL)	Dry (Feet, MSL)	Critically Dry (Feet, MSL)
October	4531.2	4526.8	4522.5	4520.4
November	4531.0	4526.8	4522.5	4520.5
December	4531.5	4526.7	4522.8	4520.7
January	4532.4	4527.0	4522.9	4522.6
February	4531.9	4531.1	4527.0	4524.6
March	4534.6	4531.5	4527.1	4524.6
April	4535.3	4531.2	4526.9	4524.6
May	4535.3	4530.6	4526.4	4523.6
June	4534.7	4529.9	4525.7	4522.8
July	4533.8	4528.8	4524.5	4521.8
August	4532.8	4527.7	4523.5	4520.6
September	4532.1	4527.1	4522.8	4520.6

Table 2-3. Gerber Reservoir end-of-month, minimum elevations (feet above mean sea level MSL, USBR datum) by inflow year types resulting from Reclamation's proposed action (from Table 5.6 of USBR 2002).

	Inflow Year Types			
Month	**Above Average (Feet, MSL)**	**Below Average (Feet, MSL)**	**Dry (Feet, MSL)**	**Critically Dry (Feet, MSL)**
October	4822.6	4804.4	4798.0	4801.6
November	4822.7	4804.3	4798.0	4801.7
December	4824.8	4804.4	4798.0	4802.1
January	4826.7	4804.5	4798.2	4807.7
February	4825.4	4817.5	4804.8	4811.8
March	4833.6	4821.3	4804.2	4812.3
April	4835.0	4821.2	4808.3	4811.8
May	4834.2	4818.9	4808.1	4809.8
June	4832.8	4816.1	4803.6	4808.1
July	4830.1	4812.3	4799.2	4805.9
August	4827.6	4808.7	4798.6	4803.6
September	4825.3	4804.6	4798.1	4801.7

Operation of Klamath Basin National Wildlife Refuge Complex

The Refuge Complex consists of Tule Lake and Clear Lake NWRs in the Lost River drainage and the Lower Klamath, Upper Klamath, Bear Valley, and Klamath Marsh NWRs in the Klamath River drainage. Of these, the Tule Lake and Lower Klamath Lake NWRs overlay the Project. The Upper Klamath and Clear Lake NWRs encompass part or the entire lake surface, respectively. The Refuges are managed by the Service.

The Federal lease land program on the Tule Lake and the Lower Klamath NWRs is administered by Reclamation pursuant to a 1977 cooperative agreement with the Service. Water is diverted from Project storage facilities to provide for crop production on private lands and Refuge leased lands located within the Project service area (USBR 2001a). Effects of pesticide use on the lease lands were addressed through ESA section 7 consultation with the Refuge and Reclamation in 2007 (FWS# 1-10-07-0056).

The Refuges also receive water through Project facilities for wetland management. Reclamation's 2007 BA states that deliveries to Project lands and Refuges will be similar to those occurring during the 43-year period of record of 1961 to 2004. We assume this means that under similar hydrologic conditions to what occurred in the period of record, the Refuges will get similar amounts of water, but that actual water availability will ultimately determine the amount of water going to these lands.

The Tule Lake sumps, located on Tule Lake NWR, are located at the terminus of the Lost River drainage. Because Reclamation stated in the BA that Refuge deliveries to Tule Lake NWR will be similar to those occurring during the 43-year period of record 1961 to 2004, we assume that an approximate surface elevation of 4034.6 feet will be maintained from April 1 through September 30 of each year. An approximate elevation of 4034.0 feet will be maintained at Tule Lake sumps from October 1 to March 31 of each year (USBR 2001a).

Operation of Agency Lake Ranch (ALR) and Barnes Ranch

In 1998, Reclamation acquired the 7,200-acre ALR on the west side of Agency Lake at the north end of UKL. The ranch property, comprised of former agricultural croplands and pasture, is used to store water for Project use that would otherwise be spilled to the Klamath River during periods of high runoff. In 2006, Reclamation, in partnership with the Service and The Nature Conservancy, purchased the Barnes Ranch. The Barnes Ranch is adjacent to ALR and will be used for water storage. Based on discussions with Reclamation, they will continue to operate ALR-Barnes as they have over the recent past as a pumped storage facility; however, under a memorandum of understanding, both properties will be turned over to the Upper Klamath NWR. Reclamation is raising the elevation of dikes at the northern end of the Barnes property to increase storage and to avoid damage to adjacent property. There are plans to breach dikes along the ALR in the near future. Once both are completed, the gross storage capacity of UKL should be increased by approximately 64 TAF.

Pesticide Use on Reclamation-managed Lands

Pesticides and herbicides are used on Reclamation-managed lands, primarily canal right-of-ways, to control noxious weeds. The effect of herbicide treatment on LRS and SNS has been addressed in previous section 7 consultations. The Service's February 9, 1995, BO (FWS log # 1-7-95-F-26; USFWS 1995) provided incidental take coverage for use of the aquatic herbicide acrolein in Project irrigation canals operated by the Klamath Irrigation District and the Tulelake Irrigation District. The 1995 BO was amended on August 18, 1999 (FWS log # 1-10-99-F-103), to include canals operated by Langell Valley Irrigation District. Mosquito control in Project canals by the Klamath County Vector Control was also covered in the February 9, 1995, BO. The effects of pesticide and fertilizer use on the Federal lease lands near the Tule Lake NWR, was also covered by the February 9, 1995, BO and amendments.

Pesticide use on the Federal lease lands in Tule Lake and Lower Klamath NWRs underwent section 7 consultation in May 2007 (FWS #1-10-07-F-0056). Since the pesticide use program on the refuges is jointly managed by Reclamation and the Service, the consultation provided incidental take coverage to both agencies. Reclamation does not plan to change the proposed action covered by those consultations.

2.2.1 Interactive Management (IM) Process

Reclamation plans to use an IM approach to more effectively utilize the available IM water for the benefit of listed and Tribal trust species. An IM approach refers to a process that allows involved parties to make recommendations to benefit listed fish and Tribal trust species on a timely basis based on current data. Federal, State, and Tribal staff will be invited to represent their interests on an IM Technical Team. The IM Technical Team may develop recommendations on the available IM water, distributing the water between UKL and the Klamath River at Iron Gate Dam.

Operational Rules

An arrangement of operational rules and an IM process will be used by Reclamation to manage the distribution of stored water and the flows of the Klamath and Lost Rivers. The Project's operational rules, in order of priority, include: (1) meet or exceed the minimum Iron Gate Dam flows[1]; (2) meet or exceed the minimum UKL elevations; (3) sustain water diversions to meet

[1] Although all Project storage and diversion facilities are located upstream of Keno Dam, the water released from the Project Area is measured at Iron Gate Dam. Iron Gate Dam is located approximately 41 miles downstream of Keno Dam

contractual agreements between Reclamation and water users, including the National Wildlife Refuges; and (4) meet the UKL Refill Targets. Remaining water is identified as surplus water, also referred to as potential IM Water.

Determining Available IM Water
Reclamation will determine the amount of IM water by applying the operational rules identified above and making adjustments based on other relevant information. The information Reclamation will be use to determine available IM Water during the April through September period includes, but is not limited to: minimum Klamath River flows at Iron Gate Dam; current UKL inflows; Natural Resources Conservation Service (NRCS) UKL inflow forecast; current UKL elevation; UKL Refill Target elevations; minimum UKL elevations; Project water diversion obligations; soil moisture content; non-Project diversions and, other basin-wide hydrological and climatological information, including short-term weather forecasts.

Utilizing the above information, Reclamation will perform the following tasks in determining the amount of available IM Water. Tasks will be performed on a semi-monthly bases (twice a month) during the April through September time period.

1) Forecast the UKL inflow for the subsequent semi-monthly period using the NRCS forecast and the inflow trend;

2) In coordination with the Klamath Water Users Association and the managers of the National Wildlife Refuges, estimate Project demand for the subsequent semi-monthly period;

3) Forecast the Keno Dam to Iron Gate Dam Klamath River accretions for the subsequent semi-monthly period; and,

4) Analyze potential augmentation of the minimum Iron Gate Dam flows and its corresponding effect on UKL elevations and water storage.

October through March, Reclamation will observe the targets for the refilling of UKL in determining the available IM Water. After factoring in the trends of inflow into the UKL during this period, any water above that needed to meet the targets for the refilling of UKL would be potentially available to augment the minimum Iron Gate Dam flows.

IM Technical Team
Reclamation and the Services propose to invite key technical representatives within the Klamath River Basin to form an IM Technical Team. The list of Technical Team participants will include staff from the three consulting Federal agencies (NMFS, USFWS, and Reclamation) and may include other organizations such as: U.S. Geological Survey; Hoopa Valley Tribe; Karuk Tribe; Klamath Tribes of Oregon; Yurok Tribe; California Department of Fish and Game; and, Oregon Department of Fish and Wildlife. These representatives from key Federal and State resource agencies, the Tribes and stakeholders with expertise in the water and fish resources will formulate the IM Technical Team's recommendations.

The IM Technical Team will recommend how IM Water is distributed between augmentation of UKL elevations and the augmentation of flows below Iron Gate Dam. Reclamation will manage the IM Water as recommended by an IM Technical Team, unless following the recommendation would result in a real threat to human health and safety, although it is unlikely the IM Technical Team would make such a recommendation.

Some examples of a recommendation that would result in a real threat to human health and safety include: the recommendation exceeds safe operation of facilities; there is an unacceptable risk of flooding; or the recommendation places the integrity of structures within the system at risk of damage or failure, or a similar emergency. For example, if a substantial increase in Iron Gate Dam releases were recommended, required notification of the public below the dam to insure safety could result in a delay of the release.

As the IM Technical Team formulate their semi-monthly distribution of IM water, they would consider factors including, but not limited to, the following: current and forecasted UKL inflows; current UKL elevations; major Klamath River tributary flows below Iron Gate Dam (e.g., Shasta, Scott, Salmon and Trinity Rivers) based upon, in part, the previous two weeks trend; review of the most current biological data (e.g., out-migrant trap information, fish radio-tracking data, year-class strength and disease conditions); water quality data, including air and water temperatures; assessment of the effects of potential beneficial and adverse impacts on species of concern of the recommended UKL elevations and recommended flows below Iron Gate Dam; and opportunity for experimental flows and effects to on-going studies. Reclamation's intent of using an IM Technical Team to determine distribution of IM Water is to better manage water to the benefit of the fish by including other resource managers in the decision making process and to make that process more transparent.

Should the IM Technical Team be unable to reach an agreement on a recommendation, Reclamation would operate the Project facilities based on the operational rules and the default distribution rules, as discussed below, unless NMFS and the USFWS formulate and forward a joint recommendation to Reclamation.

Modeling of the IM Process

In an attempt to simulate Iron Gate Dam flows and UKL elevations that should be realized from the Project, operating under the operational rules and the proposed default distribution rules, Reclamation utilized its WRIMS Model. The following assumptions, or distribution rules, were used by Reclamation in modeling the IM process:

1) Based on a precipitation index, the model estimated the water diversions necessary to meet contractual agreements between Reclamation and water users as outlined in Table 2-4.

Table 2-4. Modeled Project Demands based on the Precipitation Index, in thousand-acre feet (TAF).

Feb-Mar Precipitation Index	A1 Demand [1] Apr-Mar (TAF)	Refuge Demand Apr-Mar (TAF)	Oct-Jan Precipitation Index	A2 Demand [2] Apr-Mar (TAF)
0.00 - 1.999	340	30	0.00 - 3.99	105
2.00 - 2.749	310	25	4.00 - 6.99	95
2.75 - 3.299	300	20	7.00 - 9.99	90
> or = 3.30	275	15	> or = 10.00	80

[1] A1 demand represents the Main Project and includes all deliveries through the A-Canal and Lost River Diversion Channel.

[2] A2 demand includes deliveries to areas served by the North and Ady Canals in the southwest portion of the Project. Ady and North Canals are privately owned and operated facilities with a water right separate from the Project water right.

2) An allocation of water to augment flows at Iron Gate Dam above minimum levels was based on the computed surplus water supply that was likely to occur by the end of September. The surplus water supply is calculated in April as:

Surplus Water Supply = A + B – C – D + E - F

A = The end-of-March storage in UKL.
B = Upper Klamath Lake inflow, April through September (perfect foresight).
C = September target carryover storage.
D = Iron Gate minimum flow requirement, April through September.
E = Link River to Iron Gate Dam gain, April through September (perfect foresight).
F = Agriculture and National Wildlife Refuge demand, April through September.

3) In modeling, a portion of surplus water was allocated to increasing Iron Gate Dam flows above the minimum levels. This portion was based on a seasonal water supply factor which is calculated in each time period as:

Seasonal Water Supply Factor = G + H - I

G = The end-of-previous time period storage in Upper Klamath Lake.
H = The UKL inflow, “now” through September, (perfect foresight).
I = September target carryover storage.

This approach allows some adaptation to changing water supply conditions. The percentage of the April through September surplus water supply allocated to flow augmentation was interpolated relative to this continually updated seasonal water supply are depicted in Table 2-5.

Table 2-5. The modeled percentage of the Surplus Water Supply allocated to augment minimum Iron Gate Dam discharge, by semi-monthly or monthly period, by thousand-acre feet (TAF), May through September.

Semi-monthly or Monthly Period [1]	If Seasonal Supply Factor TAF was:	If Seasonal Supply Factor TAF was:	If Seasonal Supply Factor TAF was:	If Seasonal Supply Factor TAF was:
May 1 - 15	0 to 790	790 to 920	920 to 1181	above 1181
May 16 - 31	0 to 728	728 to 850	850 to 1069	above 1069
June 1 - 15	0 to 661	661 to 775	775 to 949	above 949
June 15 - 30	0 to 579	579 to 687	687 to 853	above 853
July 1 - 15	0 to 501	501 to 604	604 to 756	above 756
July 16 - 31	0 to 434	434 to 530	530 to 685	above 685
August	0 to 363	363 to 458	458 to 609	above 609
September	0 to 256	256 to 349	349 to 498	above 498
Surplus Water Supply to Augment the Iron Gate Discharge is:	**20%**	**20% to 36%**	**36% to 35%**	**35%**

[1] In modeling, there was no flow augmentation above Iron Gate Dam minimum flows in April. However, flows in excess of minimums did occur during spill events. Spills have historically occurred in April.

4) In Reclamation's modeling, the distribution of the annual flow augmentation (amount of Surplus Water Supply to augment the minimum Iron Gate Dam discharge) was as indicated in Table 2-6.

Table 2-6. Distribution of Surplus Water Supply to augment the Iron Gate Dam discharge, by thousand-acre feet (TAF), May through September.

Semi-monthly or Monthly Period [1]	Seasonal Supply Factor (TAF)	Distribution of Surplus Water Supply to Augment the Iron Gate Dam Discharge	Seasonal Supply Factor (TAF)	Distribution of Surplus Water Supply to Augment the Iron Gate Dam Discharge	Seasonal Supply Factor (TAF)	Distribution of Surplus Water Supply to Augment the Iron Gate Dam Discharge	Seasonal Supply Factor (TAF)	Distribution of Surplus Water Supply to Augment the Iron Gate Dam Discharge
May 1 - 15	0 to 790	33%	790 to 920	26%	920 to 1181	15%	above 1181	15%
May 16 - 31	0 to 728	33%	728 to 850	25%	850 to 1069	15%	above 1069	15%
June 1 - 15	0 to 661	10%	661 to 775	14%	775 to 949	22%	above 949	20%
June 15 - 30	0 to 579	10%	579 to 687	14%	687 to 853	22%	above 853	20%
July 1 - 15	0 to 501	3%	501 to 604	6%	604 to 756	7%	above 756	7.5%
July 16 - 31	0 to 434	3%	434 to 530	6%	530 to 685	7%	above 685	7.5%
August	0 to 363	3%	363 to 458	4%	458 to 609	4%	above 609	5%
September	0 to 256	5%	256 to 349	8%	349 to 498	9%	above 498	10%

[1] In modeling, there was no flow augmentation above Iron Gate Dam minimum flows in April. However, flows in excess of minimums did occur during spill events. Spills have historically occurred in April.

5) In modeling, there was no augmentation above Iron Gate Dam minimum flows in the months of October through April. However, flows in excess of minimums did occur during spill events. Spills have historically occurred as late as June. As noted earlier, the management of these spills may be possible through the IM process.

6) The UKL elevation level augmentation was considered that portion of the water surplus that was not explicitly used to augment river flows

An Example

Table 2-7 shows the modeling results based upon the above operational assumptions (distribution rules) for the first year of Reclamation's simulation, 1961. This simulation was repeated for each year from 1961 through 2004. In this example, for 1961, the surplus water supply was calculated on April 1 as 267.71 TAF. Modeling assumed full implementation of the expanded UKL water storage, which includes the expanded water storage provided by incorporating the Williamson River Delta property and the Agency Lake/Barnes Ranches.

Table 2-7. Flow augmentation calculations using modeled assumptions (distribution rules) for the first year of Reclamation's simulation, 1961.

447.27	Iron Gate Dam Minium Flow Requirements April-Sept
304.81	Agriculture and Refuge Demands Apr-Sep
123.45	Upper Klamath Lake Storage at Elevation 4138.0 ft
267.71	April 1 Surplus Calculation (560.14 + 436.6 + 146.5 - 447.27 - 304.81 - 123.45)

		A	B	C	D	E	F	G	H
	Semimonthly or Monthly Time Period	Upper Klamath Lake Storage (TAF)	Upper Klamath Lake Inflow (TAF)	Keno to Iron Gate Dam Gain (TAF)	Seasonal Water Supply Factor (TAF)	Default Percentage of Surplus Water to Augment Iron Gate Dam Flows	Annual Surplus to Augment Iron Gate Dam Flows (TAF)	Default Distribution	Augmentation of Iron Gate Dam Flows (TAF)
1	Mar 16-31	560.14							
2	Apr 1-15	574.13	54.7	16.5					
3	Apr 16-30	574.13	54.7	16.5					
4	May 1-15	565.09	47.1	17.3	778.00	20.0%	53.54	33%	17.7
5	May 16-31	555.71	50.2	18.5	708.21	20.0%	53.54	33%	17.6
6	Jun 1-15	525.58	41.0	11.7	634.96	20.0%	53.54	10%	5.4
7	Jun 16-30	494.64	41.0	11.7	563.84	20.0%	53.54	10%	5.4
8	Jul 1-15	443.30	19.5	2.8	492.74	20.0%	53.54	3%	1.6
9	Jul 16-31	388.81	20.8	3.0	422.83	20.0%	53.54	3%	1.6
10	Aug	326.95	48.1	21.7	348.39	20.0%	53.54	3%	1.6
11	Sep	300.07	59.4	26.8	238.37	20.0%	53.54	5%	2.7
12	Apr-Sep		436.6	146.5					

Column A – Upper Klamath Lake storage TAF.
Column B – Upper Klamath Lake inflow.
Column C – Total gains (accretions) between Link River and Iron Gate Dam.
Column D – the model calculates the Seasonal Water Supply Factor.
Column E – using the value in column D and the distribution rules in Table 2-5, the model calculates the percentage of the surplus that will become the annual Iron Gate Dam flow augmentation.
Column F – multiply the value in column E by 267.71, the surplus water supply calculated on April 1.
Column G – Modeled distribution rules based on Table 2-6.
Column H – multiply the value in Column F by the value in Column G to get the flow augmentation for each time period (TAF).

Default Distribution Rules

The above approach was used in Reclamation's modeling to simulate implementation of the proposed IM process. The modeling approach demonstrated above was used in water years 1961 through 2004 to generate results that are displayed in the exceedance tables. These exceedance tables (Tables 2-8 and 2-9) are designed to illustrate the estimated frequency that Iron Gate Dam flows and UKL elevations under the Proposed Action. Exceedance tables may be defined as the probability that flow (in cfs) will exceed a specified reference level during a given exposure time. The exceedance tables are an artifact of applying the operational rules and the distribution rules (assumptions) used in the model. However, if the IM process alters the distribution rules used in the above modeling, the attached exceedance tables would also change.

Reclamation proposes that the above distribution rules used in the modeling of the Project be utilized as the starting point for the IM Technical Team to formulate their recommendations. The IM Technical Team recommendations could then convey how to modify this distribution of the IM Water.

Table 2-8. Modeled Proposed Action Iron Gate Dam Flow Exceedances (cfs, WRIMS 36B+).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1300	1300	1300	1300	1300	1450	1500	1500	1400	1000	1000	1000
90%	1300	1300	1300	1300	1300	1450	1500	1500	1400	1000	1000	1000
85%	1300	1300	1300	1300	1300	1450	1500	1524	1408	1001	1001	1000
80%	1300	1300	1300	1300	1300	1687	1500	1603	1434	1008	1005	1006
75%	1300	1300	1300	1300	1300	2224	1500	1668	1455	1016	1008	1013
70%	1300	1300	1300	1300	1300	2360	1500	1803	1498	1029	1014	1024
65%	1300	1300	1300	1300	1323	2475	1592	1876	1520	1035	1017	1030
60%	1300	1300	1300	1309	1880	2537	1892	2028	1569	1050	1024	1041
55%	1300	1300	1345	1656	2473	2772	2270	2114	1594	1056	1028	1048
50%	1300	1300	1410	1751	2577	2812	2669	2289	1639	1070	1035	1060
45%	1300	1300	1733	2018	2728	2888	2880	2381	1670	1077	1038	1066
40%	1300	1300	1837	2242	3105	2949	2982	2455	1683	1082	1041	1071
35%	1300	1300	2079	2549	3505	3199	3212	2612	1699	1100	1050	1085
30%	1300	1434	2471	2578	3632	3784	3713	2802	1743	1118	1053	1089
25%	1300	1590	2908	2627	3822	4316	4136	2976	1782	1137	1058	1097
20%	1300	1831	2997	2908	3960	4813	4521	3352	1856	1152	1066	1135
15%	1300	2040	3078	3498	4762	5315	5239	3692	2194	1222	1093	1162
10%	1300	2875	3296	3948	5663	5950	5544	3885	2526	1369	1126	1246
5%	1300	3385	4923	6307	7172	6625	5939	4247	2667	1430	1147	1281

Table 2-9. Modeled Proposed Action Upper Klamath Lake Elevation Exceedance (Feet, MSL, USBR datum, WRIMS 36B+).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	4137.76	4138.05	4138.50	4139.44	4140.46	4141.27	4141.83	4141.47	4140.42	4139.38	4138.42	4138.00
90%	4137.87	4138.46	4139.14	4139.95	4140.98	4142.04	4142.53	4141.96	4140.64	4139.51	4138.47	4138.00
85%	4138.08	4138.89	4139.57	4140.63	4141.49	4142.64	4142.67	4142.23	4141.02	4139.65	4138.53	4138.00
80%	4138.31	4139.14	4140.15	4141.19	4141.93	4142.89	4142.91	4142.37	4141.17	4139.78	4138.62	4138.15
75%	4138.86	4139.45	4140.69	4141.48	4142.41	4143.15	4143.06	4142.52	4141.35	4139.98	4138.79	4138.32
70%	4139.00	4139.77	4140.97	4141.83	4142.56	4143.15	4143.22	4142.62	4141.53	4140.15	4139.30	4138.94
65%	4139.04	4139.87	4141.24	4142.02	4142.68	4143.15	4143.30	4142.64	4141.55	4140.30	4139.42	4139.08
60%	4139.62	4140.51	4141.31	4142.17	4142.70	4143.15	4143.30	4142.69	4141.72	4140.44	4139.47	4139.13
55%	4139.85	4140.60	4141.66	4142.30	4142.70	4143.15	4143.30	4142.92	4141.95	4140.72	4139.76	4139.68
50%	4140.09	4140.70	4141.70	4142.30	4142.70	4143.15	4143.30	4142.94	4142.05	4140.96	4140.05	4139.74
45%	4140.14	4140.75	4141.70	4142.30	4142.70	4143.15	4143.30	4142.97	4142.15	4141.02	4140.13	4139.91
40%	4140.26	4140.96	4141.70	4142.30	4142.70	4143.15	4143.30	4143.04	4142.18	4141.08	4140.25	4140.06
35%	4140.44	4141.18	4141.70	4142.30	4142.70	4143.15	4143.30	4143.12	4142.22	4141.32	4140.38	4140.17
30%	4140.66	4141.38	4141.70	4142.30	4142.70	4143.15	4143.30	4143.20	4142.29	4141.38	4140.67	4140.30
25%	4140.74	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.55	4141.53	4140.73	4140.38
20%	4140.84	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.59	4141.58	4140.75	4140.53
15%	4141.05	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.65	4141.61	4140.92	4140.65
10%	4141.14	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.76	4141.79	4141.04	4140.81
5%	4141.65	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.91	4141.89	4141.20	4141.07

2.3 Action Area

The "action area" is defined in 50 CFR §402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action."

Based on information contained in the description of the proposed action in Reclamation's October 22, 2007, Final Biological Assessment (USBR 2007), the Service has determined that the action area for this consultation extends from Iron Gate Dam upstream in the Klamath River to Link River Dam, including Link River Dam, Link River and Lake Ewauna; UKL to its high water line, and tributaries as far upstream as are affected by Klamath Project operations; Clear Lake and Gerber Reservoir to their high water lines, and tributaries as far upstream as are affected by Project operations; the entire Lost River from Clear Lake Dam to and including the Tule Lake sumps, including all of Miller Creek, and any tributaries of the Lost River as far upstream as they are affected by Project operations, as well as Lower Klamath NWR.

Also included in the action area are operations of dams, canals, drains, and facilities owned or operated, or related to Reclamation's Project. An interdependent or interrelated action is farming of approximately 200,000 acres of irrigated land serviced by the Project.

The Service considers that pesticides use on private lands within the Project is interrelated or interdependent to the proposed action if the activities are dependent on Project water or if Project drains are used. Therefore effects of pesticides use on private lands to the LRS and SNS will be analyzed in the effects section of this BO.

In May 2007, formal section 7 consultation for the implementation of the Pesticide Use Program on Federal Leased Lands, Tule Lake and Lower Klamath NWRs was completed (FWS # 1-10-07-F0056). The Federal Lease Lands are public lands within the two Refuges administered by the Secretary of Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent with the Kuchel Act (P.L. 88-567). While the Lease Lands are under the administrative jurisdiction of the Refuges, Reclamation administers the agricultural leasing program via a cooperative agreement between Reclamation and the Refuge, including pesticide use, for the Refuges consistent with the Kuchel Act.

3.0 STATUS OF THE SPECIES/ENVIRONMENTAL BASELINE

Because the ranges of the LRS and SNS overlap that of the action area, the *Status of the Species* and *Environmental Baseline* sections are combined in the following discussion. In the status section, information on the species' status, information on life history, population dynamics (e.g., population size, variability, stability, age-class distribution, sex ratio, and etc.), distribution, and other factors essential for survival are described. Relevant biological and ecological information presented in the status section is essential to formulation of the BO.

The environmental baseline presents an analysis of the effects of past and present human and natural factors that have led or that will continue to affect the status of the LRS and SNS within the action area, including habitat/ecosystem conditions. In simplest terms, it is the status of the species within the action area given the response to past, present, and future factors. Although it focuses on the impacts past and present actions have had on the listed species, it includes an analysis of any future impacts from Federal actions that have undergone section 7 consultation and any contemporaneous State and private actions.

3.1 Status of the Species in the Action Area

This section reviews the current condition of the LRS and the SNS in the action area and the factors responsible for that condition. Many of the factors impacting sucker status represent Project effects and will be discussed in greater detail in the *Effects of the Action* section below. Much of the information presented here was developed as a result of a recent 5-year review of the listing status of the LRS and SNS (USFWS 2007b, 2007c). As a result of these reviews, the Service recommended downlisting the LRS to threatened and continued endangered status for the SNS. To date, no formal proposal downlisting the LRS has been made.

3.1.1 Physical Description and Life History

Lost River suckers are large fish (up to 1 meter (m) long and 4.5 kilograms (kg) in weight that are distinguished by their elongate body and sub-terminal mouth with a deeply notched lower lip. They have dark brown to black backs and brassy sides that fade to yellow or white on the belly. They are native to the Lost River and upper Klamath River systems where they have adapted to lake living (Moyle 2002).

Shortnose suckers are distinguished by their large heads with oblique, terminal mouths with thin but fleshy lips. The lower lips are deeply notched. They are dark on their back and sides and silvery or white on the belly. They can grow to about 60 centimeters (cm), but growth is variable among individuals (Moyle 2002).

The endangered LRS and SNS are part of a group of suckers that are large, long-lived, late-maturing, and live in lakes and reservoirs but spawn primarily in streams; collectively, they are commonly referred to as lake suckers (NRC 2004). The lake suckers differ from most other suckers in having terminal or sub-terminal mouths that open more forward than down, an apparent adaptation for feeding on zooplankton rather than sucking food from the substrate (Scoppettone and Vinyard 1991). Zooplanktivory can also be linked to the affinity of these suckers for lakes, which typically have greater abundance of zooplankton than do flowing waters.

LRS and SNS grow rapidly in their first five to six years, reaching sexual maturity sometime between years four and six for SNS and four and nine for LRS (Perkins et al. 2000a). LRS and

SNS have been aged to 55 and 33 years, respectively. Females produce a large number of eggs, 44,000 to 236,000 for LRS and 18,000 to 72,000 for SNS per year when they spawn. Some females spawn every year, while others spawn every 2 or 3 years. Larger, older females produce substantially more eggs and, therefore, can contribute relatively more to recruitment than a recently matured female. However, only a small percentage of the eggs survive to become larvae.

LRS and SNS spawn from February through May. River spawning habitat is riffles or runs with gravel and cobble substrate, moderate flows, and depths of less than 4 feet (Buettner and Scoppettone 1990). Females broadcast their eggs and they are buried within the top few inches of the substrate. Some LRS have been noted to spawn in UKL, particularly at springs occurring along the shorelines. Spawning site fidelity has been documented suggesting two discrete spawning stocks of LRS (i.e., those using UKL springs and Williamson/Sprague Rivers). LRS and SNS do not die after spawning and can spawn many times during their lifetime. Individual males and females of both species commonly spawn in consecutive years.

Soon after hatching, sucker larvae move out of the gravel; they are about 7 to 10 mm TL and mostly transparent with a small yolk sac (Buettner and Scoppettone 1990). Larvae generally spend relatively little time upriver before drifting downstream to the lakes. However, in 2006, the Service documented a large number of larvae residing in the Sprague River until June when they were 25 to 35 mm TL, probably related to better flow and stream habitat conditions (J. Hodge, USFWS, pers. comm. 2007). In the Williamson River, larval sucker out-migration from spawning sites begins in April and is generally completed by July. Downstream movement takes place mostly at night and near the water surface (Klamath Tribes 1996; Tyler et al. 2004). Once in the lake, larval suckers disperse to near-shore areas (Cooperman 2004; Cooperman and Markle 2004).

In UKL, larval suckers are first captured in early April during most years, with peak catches occurring in June, and densities dropping to very low levels by mid-July (Cooperman and Markle 2000). Larval habitat is generally along the shoreline, in water 10 to 50 cm deep and associated with emergent aquatic vegetation, such as bulrush (Buettner and Scoppettone 1990; Cooperman and Markle 2004). Emergent vegetation provides cover from predators, protection from currents and turbulence, and abundant prey (including zooplankton, macroinvertebrates, and periphyton). Larvae transform into juveniles at about 25 mm TL. This generally occurs by mid-July.

Juvenile suckers (age 0) utilize a wide variety of near-shore habitat including emergent wetlands and non-vegetated areas and off-shore habitat (Terwilliger 2006; VanderKooi et al. 2006; Hendrixson 2007a, 2007b). As they grow during the summer many move offshore.

Adult suckers generally use water depths 3 feet or deeper (Peck 2000; Banish et al. 2007). Sub-adults are assumed to be similar to non-spawning adults in their requirements and habitats (NRC 2004). LRS and SNS are generally limited to lake habitats when not spawning, although small river-resident populations have been documented.

3.1.2 Upper Klamath Lake and Tributary Populations

LRS and SNS are endemic to the lake and tributary habitats of the Upper Klamath Basin including the Lost River sub-basin (see Figure 3-1). Their primary rearing habitat is in UKL (see Figure 3-2). Adult LRS and SNS are widely distributed throughout the lake in the fall, winter

(USFWS 2002; NRC 2004). In the spring months, LRS and SNS stage in the north end of the lake near Goose Bay and Modoc Point prior to spawning in tributaries or shoreline spawning areas (Hendrixson et al. 2004). Adult LRS and SNS are primarily found in the northern portion of the lake above Bare Island during summer months (Peck 2000; Banish et al. 2007). Reasons for this summer distribution are not clear but may be related to better water quality near spring-fed Pelican Bay and the Williamson River (Reiser et al. 2001; USFWS 2002; Banish et al. 2007). During the summer and early fall, UKL water quality conditions periodically deteriorate to stressful and even lethal levels for suckers as a result of decomposition of massive algae blooms and resultant low levels of dissolved oxygen (Loftus 2001). A multiple-year radio telemetry study has documented LRS and SNS concentrating in or near Pelican Bay during periods of deteriorating water quality, presumably to seek refuge at areas of better water quality (Banish et al. 2007).

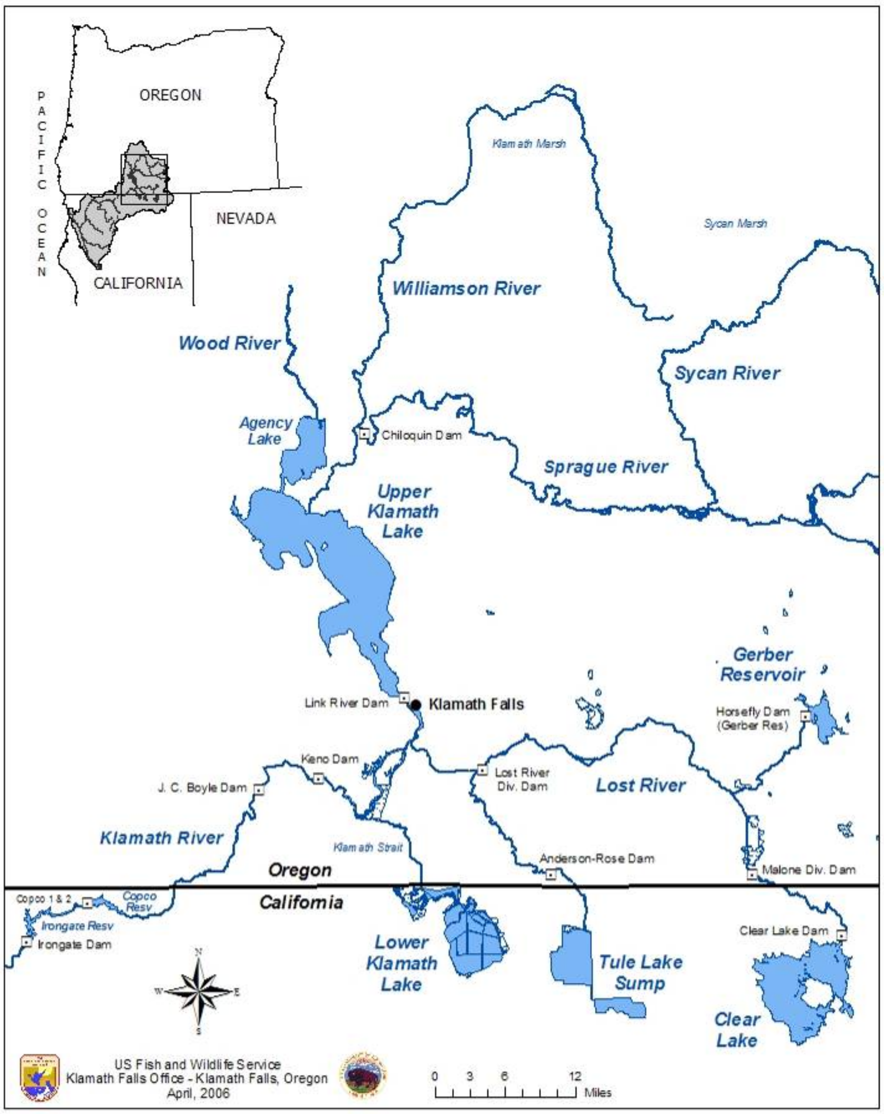


Figure 3-1. Map of the Upper Klamath River Basin showing primary water bodies.

The LRS population in UKL appears to consist of two distinct stocks: fish that spawn along the eastern shoreline of UKL; and fish that spawn in the Williamson and Sprague Rivers (Perkins et al. 2000a). Mark-recapture data show that the two stocks maintain a high degree of fidelity to spawning areas and seldom interbreed (Hayes et al. 2002, Barry et al. 2007a, 2007b). The river spawning stock migrates up the lower Williamson and lower Sprague Rivers in the spring to spawn. Chiloquin Dam has been identified as a partial barrier to upstream passage that may prevent a portion of the sucker spawning run from migrating further upstream into the Sprague River or may delay the timing of the migration to upstream areas (Scoppettone and Vinyard 1991; NRC 2004), particularly during periods of low discharge. With removal of Chiloquin Dam by Reclamation and BIA during the summer of 2008, adult sucker migrations in the Sprague River will be unimpeded by 2009.

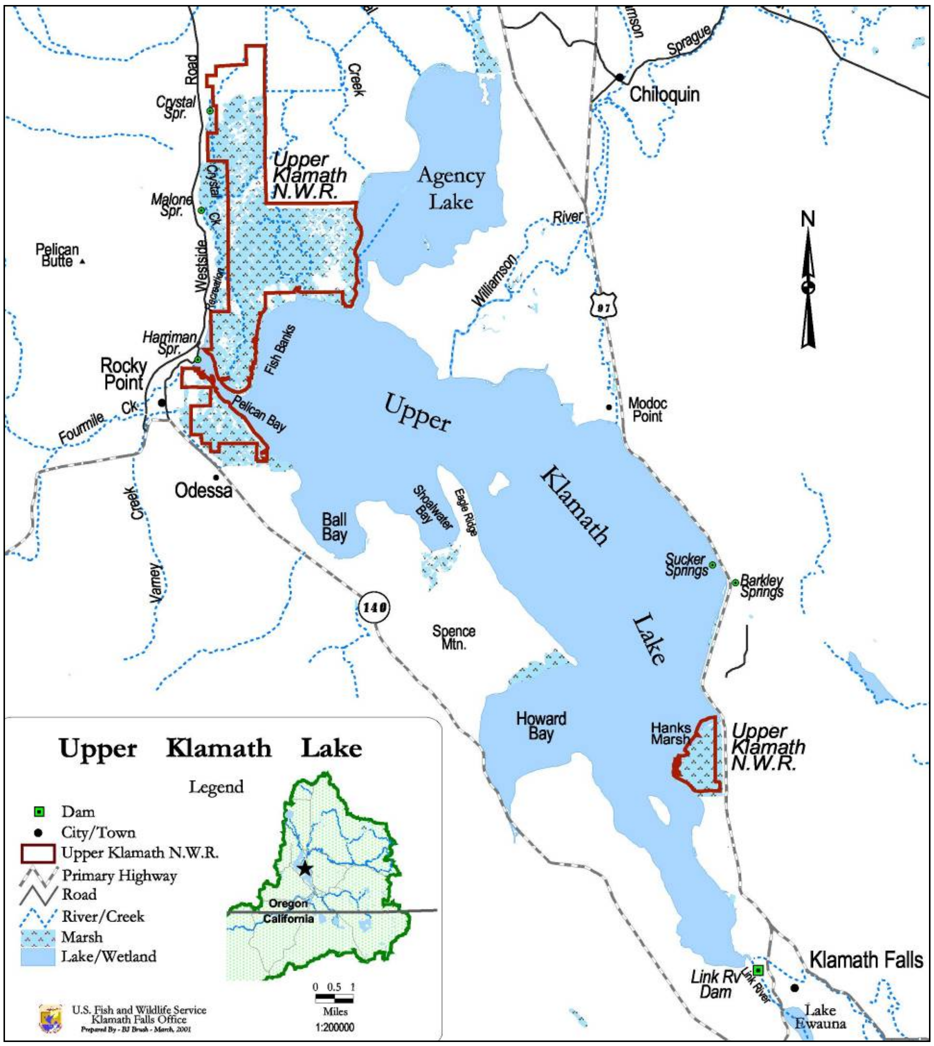


Figure 3-2. Map of Upper Klamath Lake and vicinity.

Known areas of concentrated LRS spawning in the Williamson and Sprague Rivers include the lower Williamson River from river mile 6 to the confluence of the Sprague River (rm 11), lower Sprague River below Chiloquin Dam, and in the Beatty Gap area of the upper Sprague River (rm 75) (Buettner and Scoppettone 1990; Tyler et al. 2007; Ellsworth et al. 2007). Other areas in the Sprague River watershed where LRS may spawn include the lower Sycan River and in the Sprague River near the Nine Mile area (Ellsworth et al. 2007).

SNS from UKL currently spawn in the lower Williamson and Sprague Rivers (Tyler et al. 2007; Ellsworth et al. 2007). The few adult SNS captured at shoreline spawning areas in UKL indicate that some SNS spawning is likely to still occur at these locations (Hayes et al. 2002; Barry et al. 2007a, 2007b). Although species identification is not clear, a small number of suckers presumed to be SNS may spawn in the Wood River (USBR 2001a). It is possible that sucker spawning may occur in other tributaries to UKL; however, investigations have not located suckers in tributaries other than the Williamson, Sprague, and Wood Rivers.

Since the early 1980s, information on the relative abundance of adult sucker populations has been obtained from the number of captured suckers migrating up the Williamson River each spring (USFWS 2002). The Williamson River spawning abundance index, based on actual and interpolated catch per unit effort data, shows a decline in abundance for both species during the three die-off years in the mid-1990s and a hiatus in recruitment of new individuals in 1998 and 1999 before the population began to increase in 2000 (Cunningham et al. 2002; Tyler et al. 2004). The increase in the spawning abundance index that began in 2000 could represent the recruitment of a single dominant year class over a period of two years or the recruitment of two distinct year classes. If a single year class recruited in over two years during 2000 and 2001, it would likely be the 1991 year class for LRS and the 1993 year class for SNS (USFWS 2002).

Recent analysis of sucker population data corroborates the assessment in Scoppettone and Vinyard (1991) at the time of listing that the population of LRS in UKL was dominated by older individuals and showed no evidence of substantial recruitment during the 1980s and early 1990s (Janney and Shively 2007; Janney et al. in review). Although limited age data on SNS existed at the time of listing, length frequency data from the 1980s suggests that this population was also comprised of older individuals with little evidence of recruitment (Janney and Shively 2007; Janney et al. in review).

Length frequency data indicated a size shift to smaller male LRS starting in 1992 and smaller female LRS in 1995 among LRS captured in UKL tributaries (Janney and Shively 2007). The frequency of large male LRS began decreasing in 1994 for both tributary and shoreline spawning groups, with very few large male LRS present in survey efforts between 1996 and 1999 (Janney and Shively 2007). Large females began decreasing in numbers in 1995 and by 2000 they were rarely collected at shoreline areas and in the tributaries.

Length frequency data on SNS from monitoring efforts on UKL tributaries indicates a shift to smaller male and female adults occurred in 1995 (Janney and Shively 2007). This shift to smaller individuals indicates a recruitment event of smaller individuals presumably from the 1991 year class. The SNS population in UKL shows an increasing trend in length frequency beginning in 1996 with the possibility of some recruitment occurring in 1999 (Janney and Shively 2007). Larger and presumably older SNS began decreasing during mid 1990s and by 2001 and 2002 there were few larger fish (Janney and Shively 2007).

Between 1995 and 2007, USGS captured, tagged, and released 4,500 female and nearly 5,700 male LRS at lakeshore spawning areas in UKL (Janney et al. in review). Of these, 2,500 females and 4,000 males were recaptured or remotely detected on at least one occasion. Survival estimates were calculated based on the Cormack-Jolly-Seber model (Janney et al. in review). Mean annual survival probability for lakeshore spawning LRS from 1995 to 2006 was estimated to be 0.9. Based on this estimate, average life expectancy of LRS upon reaching maturity was approximately 8 years. Since LRS can live 50+ years and do not reach sexual maturity until they are 5 to 10 years of age, we would expect a viable population to have an annual survival rate of at least 90 percent.

From 1995 to 2005, USGS used trammel nets to monitor adult sucker migrations in the lower Williamson River to obtain annual population indices and to capture, mark, and release suckers

(Janney et al. in review). In 2000, USGS began systematic capture, mark and release of suckers in the Sprague River fish ladder. A resistance board fish weir was installed in 2005 on the Williamson River (rm 6) to enhance capture-recapture efficiency (Janney et al. in review). These capture-recapture data were included with data from other sampling efforts and used to estimate vital population parameters.

Between 2000 and 2007, over 5,000 female and 1,900 male LRS were captured, tagged, and released in the Sprague River (Janney et al. in review). Of the tagged suckers, USGS subsequently recaptured or remotely detected over 1,200 females and 700 males on at least one occasion. Comparison of survival estimates between shoreline and river spawning sub-populations suggest that survival of the Sprague River spawning segment was substantially lower than the lakeshore segment in 2000, 2002, and 2004 (Janney et al. in review).

Between 1995 and 2004, USGS captured, tagged, and released over 8,000 female and 5,000 male SNS in the Sprague River (Janney et al. in review). Of the tagged suckers, 55 percent of the females and 70 percent of the males were subsequently recaptured or remotely detected on at least one occasion. Based on the recapture data, the model averaged survival estimates varied considerably by year. Estimate of precision was relatively poor in several years due to sparse recapture data, but it improved substantially in later years as sampling effort and consistency increased and underwater passive integrated transponder (PIT) tag antennas were incorporated into the study design. SNS survival was generally lower than LRS survival and was especially low in 1996, 1997, 2001, and 2004. SNS mean annual survival probability over the study period was estimated to be 80 percent. Based on this estimate, average life expectancy of SNS upon reaching maturity was only 4 years. Therefore, the combination of reduced and variable survival and low and intermittent recruitment could present negative consequences for the viability of SNS populations in UKL. Since SNS can live over 30 years, and do not reach sexual maturity until 4 to 6 years of age, we would expect natural survival of adults to ideally be greater than 90 percent (0.9) and show little variation over time.

Both LRS and SNS transformed from populations dominated by old fish with little size diversity and consistently poor recruitment in the late 1980s and early 1990s, to populations dominated by smaller recruitment-sized fish and very few remaining large individuals by the late 1990s (Janney et al. in review). This marked shift in size structure to smaller individuals suggests that substantial recruitment in the sucker spawning populations occurred sometime during the mid-1990s. A combination of mortality concurrent with this influx of smaller individuals during the mid-1990s likely explains the rapid decline in relative frequency of large and presumably old individuals. Because large female suckers are disproportionately more fecund than young recruitment-sized females (Perkins et al. 2000a), the absence of large females in spawning populations could substantially reduce reproductive output of spawning populations (NRC 2004). In recent years, populations of both species exhibited a slowly increasing trend in size (i.e., 10 to 15 mm increase in median fork length per year) and have exhibited little size diversity (Janney and Shively 2007; Janney et al. in review). This homogenous size structure suggests populations are comprised mostly of similarly-aged individuals with little evidence of recent substantial recruitment.

A small group of LRS appears to reside in the Sprague River near Beatty. A few adult LRS were first encountered during the summer of 2001 during fish survey work in the Sprague River (L. Dunsmoor, Klamath Tribes, pers. comm. 2007). In 2007, the Service located small groups of adult LRS above the confluence of the Sycan River and below Beatty Gap and near the town of Sprague River (J. Murphy, USFWS, pers. comm. 2007). Although there was a substantial fish survey effort conducted on the Sprague River in 2007 by OSU and the Service, no adult SNS were collected. The additional sub-population of LRS in the Sprague River may help provide species resiliency, genetic diversity, and improve its ability to adapt to changing environmental conditions.

3.1.2 Clear Lake Reservoir Populations

Both LRS and SNS reside in Clear Lake Reservoir (see Figure 3-3 below). Monitoring of fish populations has occurred sporadically over the last 35 years. Data collected by Andreasen (1975) and Koch et al. (1973) suggested these sucker populations were in decline; however, more recent and intensive monitoring from 1989-2000 indicated that populations of LRS and SNS were abundant and had diverse age structures (Buettner and Scoppettone 1991; USBR 1994; Scoppettone et al. 1995; USFWS 2002). Intensive adult population monitoring resumed from 2004 through 2007. Data from 2004 to 2006 indicate that LRS and SNS were relatively abundant in Clear Lake, although there was a lower frequency of larger individuals present compared to data from the 1990s (Leeseberg et al. 2007; Barry et al. 2007c). Such a change in length frequency suggests relatively good recruitment but low adult survivorship (USFWS 2002).

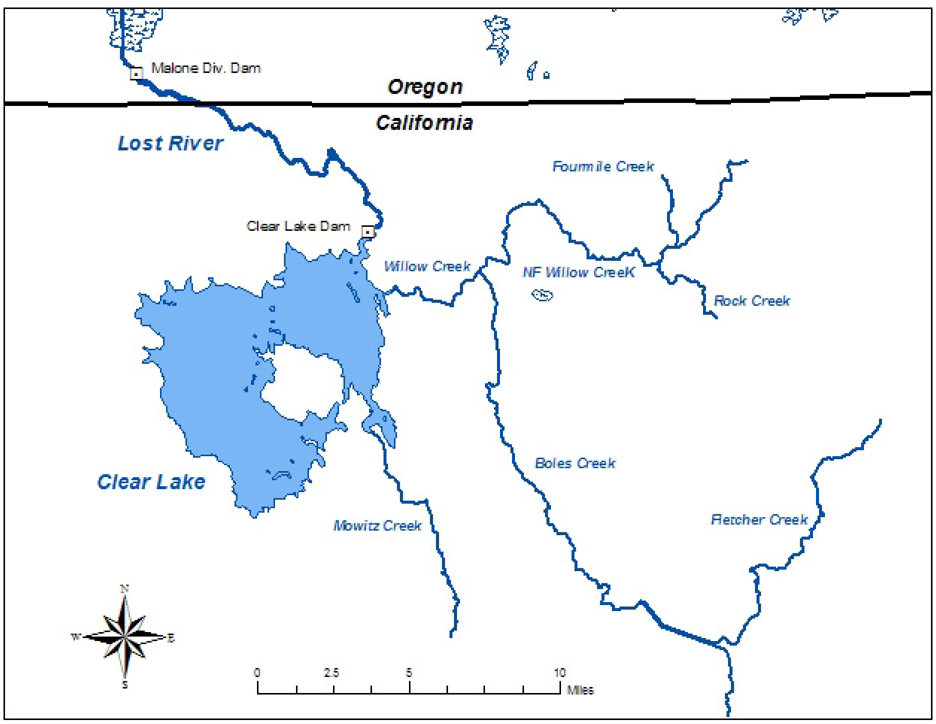


Figure 3-3. Vicinity map for the Clear Lake area.

In 2006, USGS installed a PIT tag detection station in lower Willow Creek, the primary spawning tributary to Clear Lake. Surprisingly, 46 percent of the suckers tagged in the fall of 2005 were detected upstream at lake levels of 4527 to 4529 feet and relatively high flows (Barry et al. 2007c). It is likely that the percentage of suckers in the spawning migration was actually higher because high flows caused the width of Willow Creek to surpass that of the antenna array, creating gaps in coverage that migrating suckers could pass through. In 2007, with similar late winter and spring water levels and low spring flows only 13 percent of suckers tagged in Clear Lake in 2005 to 2006 migrated upstream (P. Barry, USGS, pers. comm. 2007), suggesting that spawning run size is positively correlated with stream flow. This relationship has also been demonstrated in the Sprague and Williamson Rivers (Barry et al. 2007c).

3.1.3 Gerber Reservoir

In Gerber Reservoir, monitoring has documented a substantial SNS population (or SNS x Klamath largescale suckers (*Catostomus snyderi*; KLS), as mentioned below, exhibiting multiple size classes and presumably multiple age classes. Data from 2004 to 2006 indicate a lower frequency of larger adults compared to those from 2000 (Piaskowski and Buettner 2003; Leeseberg et al. 2007; Barry et al. 2007c). Such a change in length frequency suggests relatively good recruitment but low adult survivorship (USFWS 2002). LRS have not been reported in Gerber Reservoir (Piaskowski and Buettner 2003; USBR 2001a, 2002; Leeseberg et al. 2007; Barry et al. 2007c).

Sucker spawning at Gerber Reservoir occurs primarily in Barnes Valley and Ben Hall Creeks (USBLM 2000; Piaskowski and Buettner 2003; USFWS 2002; see Figure 3-4).

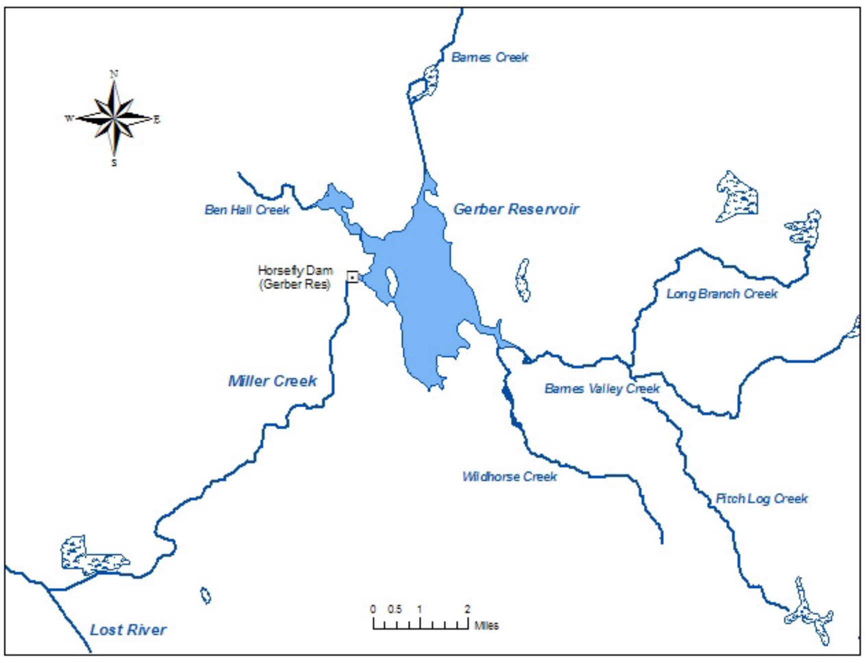


Figure 3-4. Vicinity map for the Gerber Reservoir area.

In 2006, USGS installed PIT tag detection stations on lower Ben Hall and Barnes Valley Creeks. Of the 2,300 suckers tagged in the fall of 2005, 75 percent were detected at the remote station on Ben Hall or Barnes Valley Creeks during spring 2006, a high flow year. While the population of SNS in Gerber Reservoir appears to have more frequent recruitment than some other populations, the problems of restricted distribution and lack of genetic connectivity with other populations still exist (USFWS 2002). A high degree of hybridization between SNS and KLS is thought to occur in Gerber Reservoir (Markle et al. 2005). However, until the status of these fish has been resolved, the Service considers the Gerber sucker population to be SNS.

3.1.4 Lost River Populations

Historically, large runs of LRS and SNS from Tule Lake migrated up the Lost River to spawn near Olene and at Big Springs near Bonanza (Howe 1969; USFWS 2002; see Figure 3-5). However, there may have been river resident populations similar to those in the Sprague River (J. Murphy, USFWS, pers. comm. 2007) and Clear Lake tributaries (Buettner and Scoppettone 1991). As a result of the development of the Klamath Project and other actions to develop water resources, several diversion dams were constructed creating lacustrine (lake) habitat in the Lost River more suitable to these fish (USBR 2000a).

SNS have been reported throughout the Lost River in past investigations (Koch and Contreras 1973; USBR 2001a; Shively et al. 2000b). Although monitoring has not been conducted for several years, we presume the Lost River currently supports a small population of SNS and very few LRS (USFWS 2002). The majority of both adults and juveniles are caught above Harpold Dam and to a lesser extent from Wilson Reservoir (Shively et al. 2000b; USBR 2001a). Based on length frequency distributions, it appears that several year classes were represented within the Lost River during the last fish surveys in 1999 and 2000 (Shively et al. 2000b).

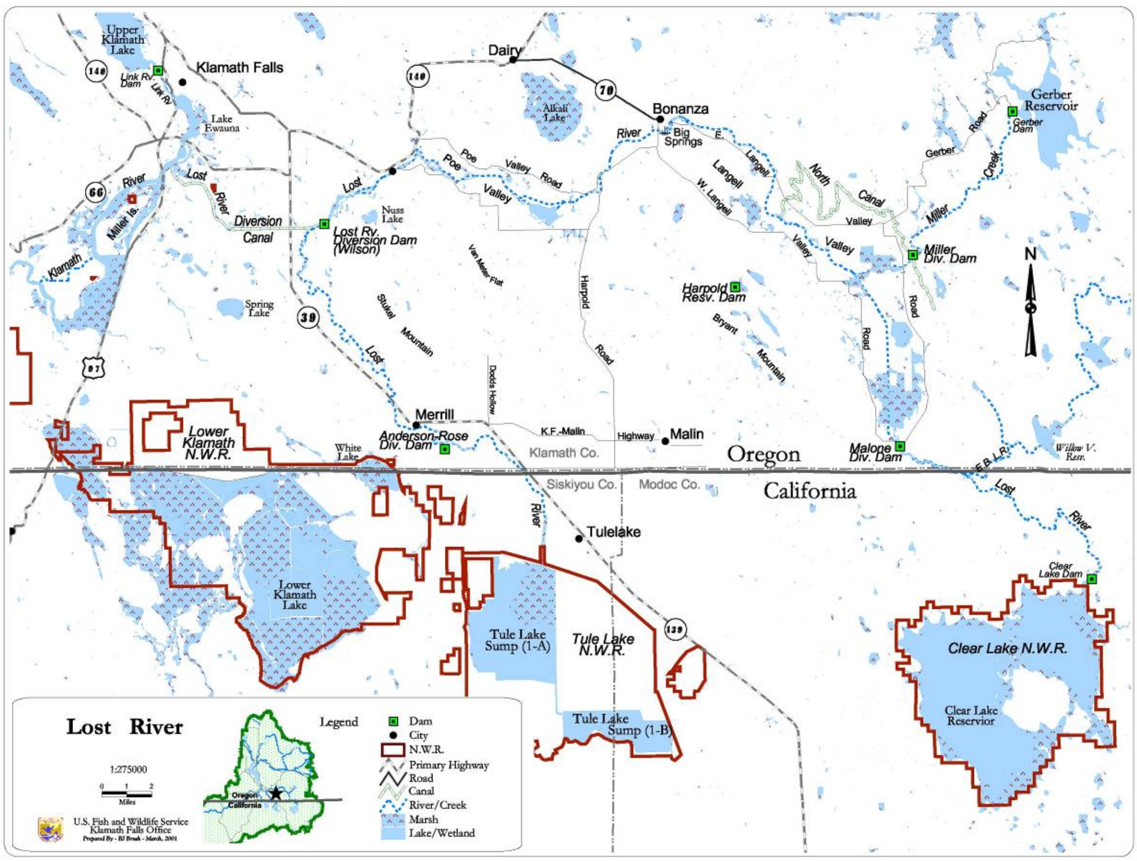


Figure 3-5. Vicinity map for the Lost River and Lower Klamath Lake areas.

Sucker spawning habitat in the Lost River is very limited. Sucker spawning has been documented below Anderson-Rose Dam (USBR 2001a; Hodge 2007, 2008), in Big Springs near Bonanza (USBR 2001a), and at the terminal end of the West Canal as it spills into the Lost River (USBR 2001a). Suspected areas that have suitable spawning habitat (i.e., riffle areas with rocky substrate) include the spillway area below Malone Dam, immediately upstream of Keller Bridge, immediately below Big Springs in the Lost River, immediately below Harpold Dam, and adjacent to Station 48. Sucker spawning has been documented in lower Miller Creek, a tributary to Lost River (USBR 2001a) and is suspected in Buck Creek and Rocky Canyon Creeks (Shively et al. 2000b). Sucker spawning was observed in a riffle area above Malone Reservoir in May 2005 (Sutton and Morris 2005).

The Lost River is currently a highly modified water conveyance system used primarily to distribute water stored for irrigation purposes and receive agricultural drainage and surface runoff. The Lost River probably never supported large populations of suckers. However, it was important spawning habitat for LRS and SNS migrating upstream from Tule Lake. There are several diversion dams on the Lost River that block or restrict upstream passage including Clear Lake, Malone, Harpold, Lost River Ranch, Wilson, and Anderson-Rose Dams. A fish ladder was installed on Big Springs Dam in 2007 (C. Korson, USBR, pers. comm. 2007). There are dozens of unscreened diversions along the Lost River (USBR 2001b).

3.1.5 Tule Lake Populations

Historically, sucker spawning migrations from Tule Lake into the Lost River were substantial (USFWS 2002; see Figures 3-5 and 3-6). The Modoc Indians and white settlers captured suckers during these migrations for consumption, livestock food, oil and other uses (Coots 1965; Howe 1969; Andreasen 1975).

At present, populations of LRS and SNS in Tule Lake are a remnant of the historical levels. Sampling at Tule Lake in 1973 and 1990 captured no suckers (Koch and Contreras 1973; Buettner and Scoppettone 1991). However, in 1991, individuals of both species were observed spawning below Anderson-Rose Dam, and sampling at Tule Lake in the early 1990s captured and recaptured several adults of each species suggesting a small population of both species was present (Scoppettone et al. 1995; USFWS 2002). While accurate estimates of the population size are not possible from the low number of recaptured individuals, available information suggests that sucker population sizes for both species were limited to a few hundred individuals of each species in the early 1990s (Scoppettone et al. 1995). Recent fisheries monitoring in Tule Lake in 2006 and 2007 by the Service suggests that adult LRS and SNS populations may be slightly higher than earlier estimates (about 1,000 individuals of each species; Hodge 2007, 2008).

Sampling in the 1990s and 2006-2007 observed suckers of both species spawning in the Lost River below Anderson-Rose Dam (Hodge 2007, 2008). However, documentation of successful spawning was infrequent and during years when larvae were observed they were generally present in small numbers. It is also possible that larvae observed in the lower Lost River may be vagrants from UKL because most of the water in the river during the late spring originates from UKL and is diverted into the Lost River Diversion Channel and then into the Lost River at Station 48. In 2007, an intensive trap-netting effort was made in Tule Lake sumps to assess the presence and relative abundance of juvenile and sub-adult suckers. With over 1,000 hours of effort throughout both Sumps 1A and 1B, only two juvenile suckers were captured suggesting little recent recruitment had occurred and that Tule Lake is primarily a refuge population for adult LRS and SNS and unlikely supports self-sustaining sucker populations (Hodge 2008).

Tule Lake is a fraction of its historic size (see Figure 3-6), and is primarily managed as a water conveyance reservoir for the Klamath Project and wetland habitat for Tule Lake National Wildlife Refuge. It is very shallow and is highly modified. The lower Lost River below Anderson-Rose Dam is channelized and flows are highly regulated. There are no fish passage facilities at the dam and there are a number of unscreened diversions around Tule Lake sumps (USBR 2001a). Degraded water quality conditions, particularly high pH and low dissolved oxygen (DO), occur during the summer as a result of nutrient loading and associated growth and decay of filamentous green algae and rooted aquatic plants (Buettner 2000; Hicks 2001; Beckstrand et al. 2001; USBR 2001a).

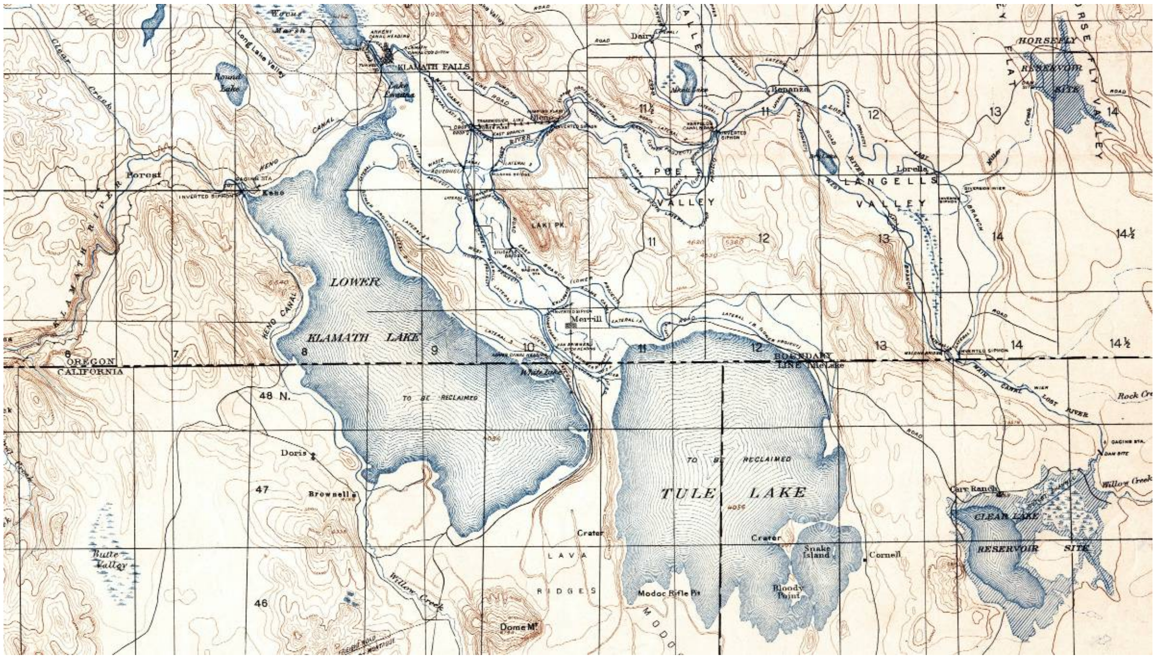


Figure 3-6. 1905 map showing pre-Project water features in the Lost River and Lower Klamath sub-basins.

3.1.6 Keno Reservoir and Link River Populations

Keno Reservoir is a long, narrow, and relatively shallow body of water located between the Link River and Keno Dam and incorporates Lake Ewauna and the upper part of the Klamath River. Most of the water in the reservoir comes from UKL but it also receives winter run-off from the Lost River Diversion Channel, drain water from the Klamath Straits Drain and local run-off.

Keno Dam is operated by PacifiCorp and was first completed in 1931 and rebuilt in 1966 and allows regulation of water levels in the reservoir. Historically, there were two reefs that acted as sills regulating water levels in the upper Klamath River above Keno. One reef is located about 3 river miles below the Link River forming Lake Ewauna and a second about 15 miles farther downstream (Keno Reef). Keno Reef impounded water in Lower Klamath Lake and the Klamath River between the reef and Lake Ewauna (Perry et al. 2005).

Water levels in the reservoir are generally maintained at 4085.4 feet from October 1 to May 15 and at 4085.5 feet during the rest of the year to allow for efficient operation of irrigation facilities in the reach (FERC 2007). There are occasional short-term draw-downs prior to the irrigation season associated with irrigation maintenance.

Before construction of the Link River Dam, there were apparently large spawning runs of suckers migrating up the Link River in March of each year (USFWS 2002). The origin of these runs is not recorded; presumably fish migrated out of Lower Klamath Lake or the Lake Ewauna/Keno reach, as lacustrine habitat was not available below Keno Reef prior to construction of J.C. Boyle Dam. Suckers apparently occupied the Link River even in summer, as evidenced by accounts of stranded suckers when flow to the Link River was cut off by southerly winds producing a seiche (oscillation of the water surface) in UKL that lowered the level at the outlet to below the sill (Spindor 1996; USFWS 2002).

All life stages of listed suckers have been found in Link River in recent years (PacifiCorp 2004; USBR 2000b; Piaskowski 2003). This habitat is primarily a migration corridor for large numbers of larval and juvenile suckers entrained or moving downstream from UKL (Gutermuth et al. 2000b; Foster and Bennetts 2006, Tyler 2007). From 2002 to 2004, Reclamation conducted radio telemetry studies of adult suckers from Keno Reservoir (Piaskowski 2003; Piaskowski et al. 2004; Korson et al. 2008). Many of these fish migrated up the Link River during April and May, perhaps attempting to reach tributaries of UKL for spawning. In 2005, the new Link River fishway became operational. Since then, Reclamation biologists have documented 7 PIT-tagged suckers using the fishway. Some of these fish passed through the fishway and into UKL (Korson et al. 2008). In 2005, 6 radio-tagged LRS passed the ladder into UKL. It is believed that suckers need to be at least 3 years of age so that they are large enough to ascend the cascade reaches in the Link River and use the fishway (Piaskowski 2003).

While low numbers of juvenile suckers occupy habitat throughout the Link River, the lower Link River is an important water quality refuge area for juvenile and adult suckers during periods of poor water quality in Keno Reservoir (Piaskowski et al. 2004). Although water quality in Link River is frequently poor during the summer, and is essentially the same as that in UKL, it is usually better than Keno Reservoir (Piaskowski 2003; USBR, unpublished data). From 2002 to 2004, radio-tagged adult suckers in Keno Reservoir moved into lower Link River during summer when the reservoir had low DO concentrations (Piaskowski 2003; Piaskowski and Simon 2005).

Fisheries surveys in Keno Reservoir have been conducted infrequently and have generally been short in duration (Hummel 1993; ODFW 1996; Piaskowski 2003; PacifiCorp 2004). The only intensive monitoring effort was conducted by Terwilliger et al. (2004) in 2002 and 2003. A detailed review of the fisheries monitoring information is presented in the FERC BO (USFWS 2007a). Larvae and age-0 suckers were most abundant in the upper part of Keno Reservoir and decreased downstream. Juvenile and sub-adult and adult suckers were rare. It is likely that most of the suckers captured were fish entrained from UKL according to entrainment studies at Eastside and Westside Diversion Canals at Link River Dam in 1998 and 1999 (Gutermuth et al. 2000b) and below Link River Dam in 2005 and 2006 (Foster and Bennetts 2006; Tyler 2007).

During 2002, Reclamation captured 172 adult suckers in the upper end of Keno Reservoir during the springtime. Additional suckers were sampled in this area from 2003 to 2006 to assess adult sucker spawning migrations and habitat use in Link River and Keno Reservoir. In 2005 and 2006, catch per unit effort for adult suckers in upper Keno Reservoir was much lower than in 2002 to 2004 (D. Bennetts, USBR, pers. comm. 2007). This may indicate that adult suckers that dispersed below Link River Dam were able to migrate back to UKL through the new fishway at Link River Dam, but the actual reason for the lower trapping success is unknown.

The low numbers of adult suckers in Keno Reservoir appears to be related primarily to poor water quality in the summer (Piaskowski 2003). DO levels reach stressful and lethal levels for suckers during July and August (Piaskowski 2003; Deas and Vaughn 2006; USBR 2007). Fish die-offs including juvenile suckers are a regular occurrence in Keno Reservoir (Tinniswood 2006). Also, there is very little wetland habitat for sucker rearing due to past diking and draining of wetlands along the Klamath River above Keno Dam and water management operations resulting in stable water levels. Larval and juvenile suckers are also lost through entrainment at the Lost River Diversion Channel (Bennetts 2005; Foster and Bennetts 2006; USBR 2007) and presumably other irrigation diversions in Keno Reservoir. The major diversions include the Lost River Diversion Channel, North Canal, and Ady Canal. There are over 50 small irrigation diversions present in the Keno Reservoir (USBR 2001b). Oregon Department of Fish and Wildlife has fish screens on their diversions at Miller Island Wildlife Area; another fish screen is located at Rocking AC Ranch (B. Tinniswood, ODFW, pers. comm. 2007).

3.1.7 Lower Klamath Lake and Sheepy Lake Populations

Lower Klamath Lake (LKL) was seasonally connected to the Klamath River before 1917 (Weddell 2000; Perry et al. 2005; see Figure 3-6). The majority of the LKL wetlands were drained by 1924 with construction of a railway dike across the outlet of LKL in 1907 and closing of the diversion gates under the railroad in 1917 (Weddell 2000). LKL's connectivity to the rest of the Klamath Basin is currently limited to water delivered through Sheepy Ridge from Tule Lake and the Klamath Straits Drain and North and Ady Canals.

There were approximately 85,000 acres of open water and wetland habitat in the LKL and Klamath River area between Keno Reef and Link River before anthropogenic changes began around 1900 (Perry et al. 2005). Large areas of emergent marsh along the shoreline likely provided habitat for larval and juvenile suckers (USFWS 2002). Water levels in LKL probably fluctuated up to 3 feet per year but typically 1 to 1.5 feet before construction of Keno Dam (Weddell 2000; J. Hicks, USBR, pers. comm. 2008). Water levels were generally highest during late winter and spring and gradually receded during the summer and fall. This type of hydrograph supported emergent wetland fringe along the shorelines of the Klamath River by dewatering shoreline areas during the late spring and early summer, resulting in good conditions for germination of emergent plant seeds.

Before 1924, suckers migrated up Sheepy Creek (a spring-fed tributary to Lower Klamath Lake) in sufficient numbers that they were harvested (Coots 1965). In 1960, small numbers of adult suckers were observed moving up Sheepy Creek in the springtime (Coots 1965). Since 1960, few surveys have been conducted in Lower Klamath Lake or its tributaries and no suckers were observed (Koch and Contreras 1973; Buettner and Scoppettone 1991; USFWS 2002).

At present, there are no known populations of suckers in the Lower Klamath Lake sub-basin. The occasional sucker may disperse into Lower Klamath Lake from Keno Reservoir through irrigation canals (USFWS 2002). The Lower Klamath Lake NWR is currently a highly managed agriculture and refuge complex with an extensive network of canals, drains, agricultural fields, and refuge wetland units. There are few permanently flooded refuge units that might support suckers and they are generally very shallow (less than 3 feet deep). Water quality conditions are generally poor during the summer with warm temperatures and low DO (Buettner and Scoppettone 1991; USBR, unpublished data; Mayer 2000).

3.1.8 Klamath River Impoundments: J.C. Boyle, Copco and Iron Gate Populations

Downstream of Keno Dam, the Klamath River consists of three primary reservoirs (J.C. Boyle, Copco No. 1, and Iron Gate) and three riverine reaches (FERC 2007). A more detailed description of the reservoirs and riverine reaches is presented in the biological opinion for the proposed relicensing of the Klamath Hydroelectric Project (USFWS 2007a). Four species of sucker are present in the Klamath River and its reservoirs: LRS, SNS, KLS, and Klamath smallscale sucker (*Catostomus rimiculus).* The high gradient between reservoirs may exclude the two endangered sucker species except during migrations (USFWS 2002, 2007a).

Although previous efforts have been made to survey suckers in the Klamath River reservoirs (Coots 1965; Beak Consultants 1987; Buettner and Scoppettone 1991; PacifiCorp 2004; and others cited in Buettner et al. 2006), the most intensive survey for suckers was performed in 1998 and 1999 (Desjardins and Markle 2000). SNS is the only lake sucker that occurs commonly in the reservoirs below Keno Dam. LRS are rare in all three reservoirs (Buettner et al. 2006; Desjardins and Markle 2000). Although SNS adults are more abundant in Copco No.1 Reservoir, both Copco No.1 and Iron Gate Reservoirs contain primarily larger individuals than J.C. Boyle Reservoir which contains a wide range of size classes including juveniles (Buettner et al. 2006). These fish are probably expatriated from UKL (Desjardins and Markle 2000). Unidentified sucker larvae have been caught in all three reservoirs, and SNS spawn in the Klamath River above Copco No.1 Reservoir; although, there is no evidence that SNS larvae and juveniles consistently survive in the reservoir (Beak Consultants 1987; Buettner and Scoppettone 1991; Desjardins and Markle 2000).

Poor summertime water quality, lack of larval and juvenile rearing habitat, and large populations of non-native fish predators likely limit sucker populations in the Klamath River reservoirs (NRC 2004). The National Research Council (2004) concluded that sucker populations in Klamath River reservoirs below Keno Reservoir do not have a high priority for recovery because they are not part of the original habitat complex of the suckers and probably are inherently unsuitable for completion of life cycles of suckers. However, maintenance of adult suckers in these reservoirs could provide insurance against loss of other subpopulations as long as the reservoirs are present.

Summary

UKL has the largest population of LRS in the Upper Klamath Basin. The LRS population there declined substantially in a series of die-offs in 1995 to 1997. Although at a much lower level, the existing population appears to be stable, and the portion of the population that spawns along the lakeshore increased in the late 1990s. The low amount of recruitment remains a substantial concern, as does the apparent moderate rate of adult survival. There is a substantial population in Clear Lake. However, the breeding population is now composed of smaller, younger fish than were present in the late 1990s. A refuge population of about one thousand adult LRS occurs in Tule Lake. A small number of expatriates from UKL also occur in Keno Reservoir and J.C. Boyle Reservoir.

SNS populations in Gerber Reservoir and Clear Lake are relatively abundant and showing evidence of frequent recruitment. Sampling in recent years indicates a lower frequency of larger adults compared to the 1990s suggesting the addition of smaller individuals into the population but lower adult survivorship. In UKL, the SNS population which had increased substantially in the early 1990s declined sharply between 1995 and 1997 as a result of die-offs. Since 1997 there has been no measurable recruitment, although in 2006 there was substantial production of age-0 SNS. It will be several years before we will know if substantial recruitment from this year class occurs. Small self-sustaining populations occur in the Lost River. Small refuge populations of adult SNS occur in Tule Lake, Keno, J.C. Boyle and Copco No.1 Reservoirs.

3.2 Factors Affecting the Species Environment in the Action Area

The action area encompasses the entire range of the species. The factors affecting the species environment in the action area include: degradation and loss of habitat as a result of Klamath Project facilities and operations; non-Project agricultural and livestock grazing activities; Klamath Hydroelectric Project facilities and operations; non-native fish interactions; and poor water quality (i.e., high pH, high ammonia, low DO) resulting from watershed alterations associated with agriculture, livestock grazing, and forest practices (Eilers et al. 2004; Bradbury et al. 2004; USFWS 2002).

3.2.1 Degradation and Loss of Habitat

Historically, LRS and SNS occupied four lakes: Clear Lake, Tule Lake, UKL, and Lower Klamath Lake and their associated tributaries in the Upper Klamath Basin (USBR 2002; see Figure 3-1, above). Watershed development, including construction of the Klamath Project, associated agriculture and refuge development, and construction of dams on the Klamath River for hydroelectric power, substantially changed sucker habitat. New sucker habitat was created as a result of construction of Gerber, J.C. Boyle, Copco No.1, and Iron Gate Dams and reservoirs, and sucker habitat in Clear Lake has expanded as a result of construction of the dam. In contrast, major reductions in habitat at Tule Lake (75 to 90 percent reduction from pre-development levels) and Lower Klamath Lake (97 percent reduction) occurred as a result of Reclamation projects (USBR 2002). Moderate reductions (66 percent) in sucker habitat have occurred in UKL as a result of diking and draining projects unrelated to those on the Klamath Project (Geiger 2001; Aquatic Scientific Resources 2005). Most of this loss was related to private diking and draining of emergent wetlands. However, approximately 18,000 acres of open water and wetland habitat around UKL is currently being restored and reconnected to the lake.

Changes in lake size resulted in changes in available sucker habitat. In the late 1800s, prior to most watershed development, 223,000 to 330,000 acres (276,000 average) of shallow lake and associated wetland habitat existed (Akins 1970; USBR 2002) compared to 76,000 to 122,000 acres (99,000 average) currently. Overall, suckers' lake and wetland habitat has decreased approximately 64 percent (177,000 acres) over the last century (USBR 2002a). A concurrent, substantial decline in sucker populations over this time period was related in part to the large loss of lake and wetland habitat areas, but was also attributable to suckers' blocked access to spawning and rearing areas, low instream flows, entrainment losses resulting from diversions, and other factors (USFWS 2002).

Review of recent U.S. Army Corps of Engineers section 7 ESA consultations indicate that some relatively minor wetland losses still occur in the Upper Klamath Basin, but effects of these actions on sucker populations are minimized during project planning and consultation (USFWS 2007a). In an attempt to compensate for wetland losses over the last century, both the Federal and State governments and privately funded organizations have purchased former farmed and ranched wetland areas and are reclaiming these areas as wetlands. This is discussed in detail later.

Upper Klamath Lake

Upper Klamath Lake, which is the largest freshwater lake solely in Oregon, is very shallow and has extensive wetlands within and immediately adjacent to the natural lake area (see Figure 3-2). Historically, there were up to 52,000 acres of marshland associated with UKL and up to 65,000 acres of open water at maximum capacity (Aquatic Scientific Resources 2005; Perry et al. 2005). Lake levels were controlled by two basalt reefs in the upper part of the Link River above the current location of the dam (Appendix 1). Prior to construction of the dam and channelization of the reefs, lake levels varied from about 4140 to 4143 feet, with a mean annual variation of about two feet (Boyle 1964; see Figure 3-7). According to Boyle (1964) the pre-dam minimum, recorded, elevation of UKL was 4140.0 feet in September 1908, and the high was 4143.3 feet on April 1907. Reclamation data from 1904 to 1920 shows an absolute minimum of 4139.9 feet for June 1918. This one event was likely due to high wind affecting water levels.

Management of the water surface elevation of UKL by regulating the outflow did not occur until 1919, when a temporary dam was built (Boyle 1964). PacifiCorp (at that time known as the California Oregon Power Co.) constructed Link River Dam and began regulation of water levels in UKL in 1921 under agreement with Reclamation. In addition to construction of the dam, two shallow reefs above the dam were channelized to allow water levels to be lowered below 4140 feet and to increase diversion rates during low lake levels (see Appendix 1). The agreement with Reclamation required PacifiCorp to manage water levels between 4143.3 feet and 4137 feet (see Figure 3-7, below) and PacifiCorp was responsible for damages resulting from any flooding of adjacent agricultural lands that may result from this management (Boyle 1964).

Reclamation generally stored water from October through March and delivered water from April through mid-October. As a result of these operations, average UKL levels have been 1 to 2 feet higher during the spring and early summer and 1 to 2 feet lower during the late summer, fall, and winter than before the dam was constructed (see Figure 3-7). These lake level changes have led to seasonal differences in inundated wetland habitat availability to suckers because the amount of wetland habitat is positively related to lake level (see discussion below in section 3.2.7 Effects of Changes in Lake Levels). However, in the long-term, these lake level changes have not significantly altered the lake-marsh boundary of marshes around UKL (Chapin 1997).

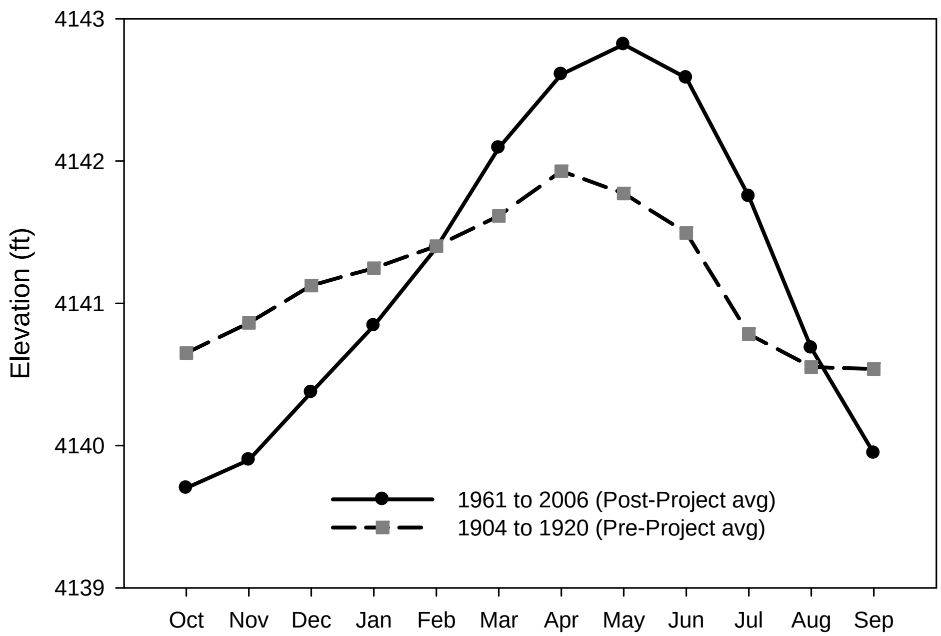


Figure 3-7. Monthly average UKL elevations (Feet, MSL) for the pre-Project (1904-1920) and post-Project (1961-2006) periods.

About 10,000 acres of marsh had already been diked and drained for agricultural uses by private interests around UKL before Link River Dam was constructed and regulation of UKL levels began. Substantial diking and draining of emergent wetlands around UKL continued through 1968 by private interests (Snyder and Morace 1997). Overall, approximately 35,000 acres had been reclaimed and converted to agricultural lands around UKL (Aquatic Scientific Resources 2005). The loss of these wetlands has greatly reduced wetland nutrient reduction potential and production of wetland decomposition products that influence algae growth and water quality, thus reducing the ability of wetlands around UKL to improve water quality conditions in the lake (ODEQ 2002). Also, this conversion resulted in a substantial loss in habitat for larval and juvenile suckers (NRC 2004).

In an attempt to compensate for wetland losses, both the Federal government and private organizations have supported the purchase of former farmed and ranched wetlands and are reclaiming these areas as wetland. The total proposed area is approximately 18,000 acres around UKL including the Williamson River Delta (The Nature Conservancy, 5,600 acres), Wood River Ranch (U.S. Bureau of Land Management, 2,900 acres), Agency Lake Ranch (USBR, 7,159 acres), Barnes Ranch (USBR and USFWS, 2,671 acres), Caledonia Ranch (Jeld-Wen, 240 acres), and Hanks Marsh (Lakeside Farms, 90 acres). The Tulana portion of the Williamson River Delta was reconnected to the lake in 2007, and the Goose Bay portion is scheduled for breaching in fall 2008. All the other properties are currently being operated as wetlands isolated from UKL, therefore they do not provide habitat benefits for the suckers. However, most if not all of these isolated wetlands are tentatively planned for reconnection with UKL in the next decade. It is estimated that several million dollars would be required to finish restoring these areas and reconnecting them to UKL. Based on early action wetland restoration projects on the Williamson River Delta and review of the literature, these habitat should be fully functional in as few as 3 to 5 years (M. Barry, TNC, pers. comm. 2007).

Reclamation has improved wetland habitats at UKL. They were a major partner with the Nature Conservancy in the restoration of 5,600 acres of wetland and open water habitat at the Williamson River Delta (USBR 2007). Reclamation also purchased Agency Lake Ranch (7,100 acres) and one-third of the Barnes Ranch (about 850 acres) for conversion to wetlands and increasing the storage capacity of UKL. Although these properties are currently managed for off-stream storage and seasonal wetlands, they may be reconnected to UKL in the near future providing wetland and open water habitat for suckers and other aquatic organisms.

It is likely that the physical and chemical characteristics of large lakeshore wetlands around UKL historically played an important role in regulating the algal community and associated water quality conditions of the system (Aquatic Scientific Resources 2005). The restoration of these wetlands is expected to provide water quality benefits by resuming a role in nutrient cycling process and possibly reducing the intensity of algal blooms in UKL through production of dissolved organic substances (Aquatic Scientific Resources 2005). However, it’s unknown what level of water quality improvement will result and how long it will take. Because of substantial subsidence in diked and drained wetlands, much of the habitat resulting from the reconnection with UKL will be too deep to support emergent wetlands in the near future and thus is unlikely to benefit larval suckers.

Clear Lake

Historically, Clear Lake was approximately 15,000 acres, with about 5,000 acres of wetlands at elevation 4523 feet (USBR 2002a; see Figure 3-8). Clear Lake Dam was constructed as part of the Klamath Project in 1910 increasing the storage capacity, depth, and area of this lake.

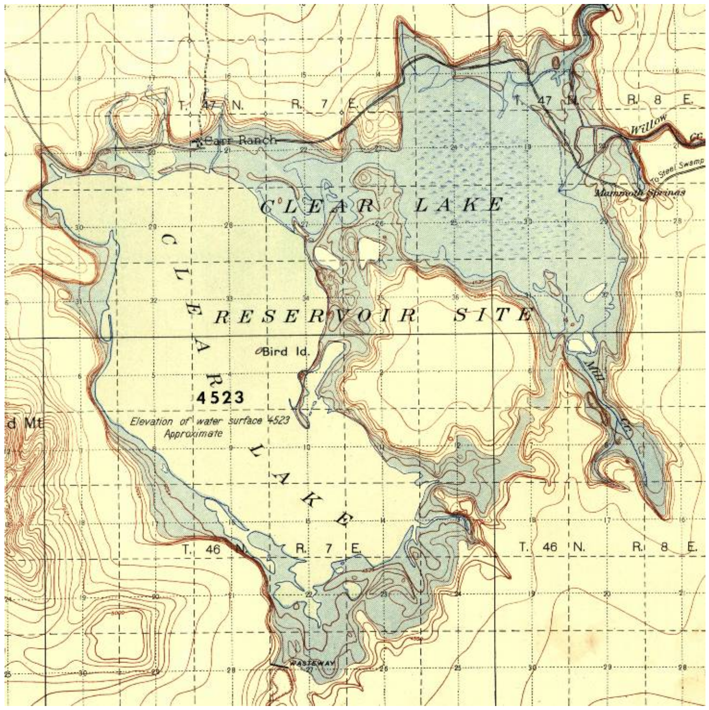


Figure 3-8. Map of Clear Lake made in 1905 before the dam was constructed. Originally the east lobe of the lake was a seasonal wetland.

The primary purpose of the Clear Lake project was to prevent flood waters reaching to Tule Lake so that Tule Lake could be reclaimed for farming. At maximum elevation (4543 feet), the lake covers about 26,000 acres, an increase of approximately 10,000 acres which is greater than a 60 percent increase from its pre-project size. At a minimum elevation of 4519 feet, the surface area of the lake is 8,500 acres. At an elevation of 4528 feet (the average post-Project elevation), there are 21,200 acres of lake habitat, representing a 40 percent increase in area over the pre-Project area (USBR 2002a). Clear Lake lacks emergent wetlands due to substantial fluctuations in water levels associated with Project operation and evaporation and seepage. It is estimated that with more lacustrine habitat and better access to spawning tributaries as a result of Clear Lake Dam construction, sucker populations increased substantially (USFWS 2002).

Tule Lake

Prior to draining, Tule Lake varied substantially in size due largely to high rates of evaporation and seasonal flooding (55,000 to 110,000 acres; Akins 1970; USBR 2002a; see Figure 3-6). During high runoff periods, water from the Klamath River flowed into the Lost River Slough and down the Lost River to Tule Lake (Perry et al. 2005). Much of the historic Tule Lake lakebed was reclaimed for Project agricultural development during the first 60 years of the Twentieth Century and other portions were incorporated into the Tule Lake NWR. Present shallow lake and marsh habitat in two sumps (1A and 1B) range from about 9,500 to 13,000 acres (USBR 2002).

In 2000, Sump 1B (3,550 acres) was drained as part of a wetland restoration project by the Tule Lake NWR. Water levels were actively managed for 5 years to encourage emergent wetland vegetation development. It was reconnected to Sump 1A in 2006. The Refuge also manages another 640 acres of demonstration and experimental marshes (known as “walking wetlands”) and 17,500 acres of agricultural lease lands that were wetland and open water habitat before most of Tule Lake was drained. Historically, large sucker populations (Howe 1969) declined to very low numbers as a result of draining most of Tule Lake for agricultural development (Scoppettone et al. 1995). Not only was the lake habitat reduced to a fraction of its former size, but access to spawning areas in the Lost River was blocked by upstream Project diversion dams.

Gerber Reservoir

Gerber Reservoir was constructed in 1926 as a storage reservoir for the Project (see Figure 3-4). Prior to construction, approximately 3,500 acres of seasonal wetlands existed at the site but there was no permanent lake habitat (USBR 2002a). At maximum elevation of 4836 feet, there are about 4,000 surface acres. No emergent wetlands are present because of large annual fluctuations in water level. Construction of this reservoir resulted in the expansion of SNS populations in the Lost River watershed. A relatively large population of SNS has become established where a small population existed before the reservoir was built (USBR 2002).

Lost River

The Lost River historically flowed 80 miles from Clear Lake to Tule Lake (USBR 2000a) and was connected with the Klamath River by the Lost River Slough originating near Klamath Falls (Perry et al. 2005). In the Langell Valley, water moved through a marsh without a defined channel. This low gradient river was primary spawning habitat for LRS and SNS migrating upstream from Tule Lake. During summer and fall, flows were likely low, particularly in the upper Lost River above Bonanza (USFWS 2002). Small SNS populations have become established in impounded areas of the Lost River including one Project reservoir, Wilson Reservoir, and two non-Project impoundments, Harpold and Big Springs (Shively et al. 2000b; USBR 2001a; ISRP 2005).

Lower Klamath Lake

Lower Klamath Lake once covered 85,000 to 94,000 acres (Foster 1995; Weddell 2000; Perry et al. 2005; Akins 1970; see Figure 3-6), but included only about 30,000 acres of open water habitat. Development associated with the Project eliminated most of this habitat. Currently, there are only 4,700 acres of permanently flooded open water and wetland habitat (Perry et al. 2005). This includes about 2,500 acres in Keno Reservoir, with the remainder in Lower Klamath Lake National Wildlife Refuge (2,225 acres). The Refuge also manages 21,000 acres of seasonal wetlands and 14,000 acres of agricultural lease and cooperative farmland that were part of pre-Project Lower Klamath Lake (USBR 2002). Draining and reclaiming Lower Klamath Lake resulted in the extirpation of sucker populations in LKL. The remaining open water habitat is too shallow to support sucker populations.

Keno Reservoir

Historically, the Klamath River above Keno Reef (at the present location of Keno Dam) and Lower Klamath Lake were part of a large marsh and open-water system whose water levels were controlled by the basalt reef near the town of Keno (Perry et al. 2005). There were large areas of emergent marsh along the shoreline that likely provided habitat for larval and juvenile suckers (USFWS 2002). Before construction of Keno Dam in 1931 water levels fluctuated up to 3 feet per year (Weddell 2000). However, typical annual fluctuations were likely less than 1.5 feet because under high flow conditions when water levels reached a certain elevation they spilled down the Lost River Slough and eventually into the Lost River and Tule Lake (Perry et al. 2005). Water levels were generally highest during late winter and spring and gradually lowered during the summer and fall. This type of hydrograph supported an emergent wetland fringe along the shorelines of the Klamath River above Keno Reef by dewatering shoreline areas during the late spring and early summer, resulting in good conditions for germination of emergent plant seeds.

There were approximately 30,000 acres of open water and 55,000 acres of emergent wetland habitat in the Lower Klamath Lake and Klamath River area between Keno Reef and Link River before anthropogenic changes started in earnest around 1900 (Perry et al. 2005). These wetland and open water areas were interconnected with the Klamath River and supported greater amounts of habitats for sucker larvae and juveniles than exists today. Approximately 15,000 acres of these wetlands and open water habitats existed along the Klamath River from Link River to Keno Reef before development (Boyle 1964). Except for about 1,500 acres located near the Klamath Straits Drain (Tule Smoke property), about 2,400 acres at Miller Island Wildlife Area, and about 125 acres of fringe wetlands scattered along the shoreline of Keno Reservoir, and all the wetlands were reclaimed for private agricultural development through construction of dikes along the river in the early 1900s. Water levels at Miller Island Wildlife Area are actively managed behind levees to maintain the diverse and productive wetland communities (2,400 acres) by the Oregon Department of Fish and Wildlife.

In 1906 and 1907, Southern Pacific Railroad constructed a crossing of the Klamath Straits, including a concrete gate control structure required by Reclamation (Boyle 1964). The closing of the gates prevented the Klamath River from flowing into the Lower Klamath Lake area, as had occurred historically (Boyle 1964). As a result, about 65,000 acres of aquatic habitat were isolated from the river. This action was led by private and Reclamation-sponsored agricultural development in this area (Boyle 1964; Foster 1995). A 1927 dike break along the Klamath River inundated about 5,000 acres of farm lands and was blamed on PacifiCorp's operation of the Klamath River flows at Link River Dam. This, and other damage claims arising out of PacifiCorp's partial control of the fluctuations in the river, led to PacifiCorp's construction of Keno Dam in 1931 (Boyle 1964). The flood control provided by Keno Dam perpetuated the wetland loss associated with agricultural conversion.

In the winter of 1964-1965, flooding occurred in the region that extensively damaged agricultural lands along the Klamath River and the original Keno Dam. As a result, PacifiCorp dredged a channel about 200 feet wide and 15 to 20 feet deep upstream of the dam between river miles 235 and 249. This channel fulfilled the contract with Reclamation to provide a channel capacity of 13,300 cfs to accommodate inflow from Reclamation canals (FERC 2007). In March 2002, dredging was conducted by PacifiCorp in Keno Reservoir to improve access to the fish ladder because debris and sediment were partially blocking the fish ladder exit/water intake. Dredged spoils were placed upon adjacent shoreline areas and farm fields. These dredging activities by PacifiCorp damaged or destroyed an unknown quantity of emergent wetlands in Keno Reservoir.

In addition to the loss of wetlands associated with agricultural conversion and dredging, the relatively constant water levels in Keno Reservoir caused by active water management by PacifiCorp, have led to a loss and degradation of emergent wetlands that provide habitat for larval and juvenile suckers (USFWS 2007a).

Most of the shallow shoreline areas in Keno Reservoir are vegetated with seasonal grasses and submergent macrophytes, except the remnant wetlands (dense stands of bulrush). Although these habitats are seasonally occupied by sucker larvae and juveniles that have moved downstream from UKL, they are of lower quality than diverse, emergent vegetation wetlands that provide abundant food, cover from predation, and protection from wind and wave action which physically harms or stresses fish (Klamath Tribes 1996). Emergent wetland vegetation supports more, larger, and better-fed sucker larvae than submergent macrophytes, woody vegetation, or open water in UKL and Williamson River (Cooperman and Markle 2004). However, larval suckers are not totally dependent on emergent wetland vegetation as documented by good survival in Clear Lake and Gerber Reservoirs where there is little or no suitable wetland habitat present.

There is strong evidence that SNS and to a lesser extent LRS larval sucker access to shoreline areas particularly wetland habitat is related to retention time in UKL (Markle et al. in review). This is important because if larvae are not retained in shoreline habitat they can be carried by wind-driven currents or flow to unsuitable habitat downstream. Larvae entering wetland areas were retained longer in these habitats than in habitat in the Williamson River that lacked emergent habitat. Larvae not finding suitable rearing habitat are more likely to disperse and be entrained out of the lake. This same larval sucker retention dynamics likely applies to Keno Reservoir. Since there is a lack of emergent vegetation habitat in Keno Reservoir, many sucker larvae entering from UKL likely disperse downstream past Keno Dam and are lost to the reproducing populations.

During the larval life stage (April to mid-July) water quality conditions are generally adequate for survival in Keno Reservoir. However, by late July, when larvae transform to juveniles, water quality throughout Keno Reservoir is poor except for a small area near the Link River (FERC 2007; USBR 2007; Deas and Vaughn 2006, Piaskowski 2003). Water quality degrades from decomposing of large quantities of AFA and other organic matter at high water temperatures resulting in DO declines.

The loss of connection to emergent wetlands along the Klamath River and Lower Klamath Lake has likely depleted the ability of this area to cycle nutrients. Emergent wetlands can improve water quality that is high in nutrient content or biological oxygen demand. They sequester nutrients through plant uptake during the growing season as well as removing some of the nutrient load by filtering particulate matter (Gearheart et al. 1995). Wetland vegetation also provides a substrate for microorganisms that break down the organic matter. Wetland vegetation also produce dissolved organic substances that may have an inhibitory effect on blue-green algae growth (Aquatic Scientific Resources 2005). Wetlands may influence blue-green algae growth through other mechanisms including lower pH and lower water transparency. The extent to which the historic wetlands in Lower Klamath Lake and the Klamath River above Keno Reef affected water quality is unknown. Much of the emergent wetlands were probably disconnected by receding water levels during the summer when water quality was poor.

In summary, the loss of thousands of acres of connected wetlands and open water in the Lower Klamath Lake and Klamath River areas between Keno Reservoir and the Keno Reef has greatly reduced the habitat values available to suckers in this area. Prior to its agricultural development, this area likely supported large numbers of suckers and provided habitat that allowed suckers drifting downstream from UKL to survive and grow to a size allowing them to return to UKL. Currently poor water quality conditions during the summer and fall are the most important factor limiting sucker populations in Keno Reservoir.

Klamath River Reservoirs: J.C. Boyle, Copco, and Iron Gate

Lake habitats that support sucker populations were developed along the Klamath River as part of the PacifiCorp Hydroelectric Project. Four reservoirs were constructed, including J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate, which are 420, 1000, 40, and 944 acres, respectively. No lake habitat existed historically in the Klamath River below the Keno Reef. Sucker populations (mostly SNS) have expanded into these created lake habitats. It is believed these populations are maintained by vagrants from UKL (Desjardins and Markle 2000). Populations are small compared to those in UKL, Gerber Reservoir and Clear Lake (USFWS 2002, 2007a). Factors affecting sucker populations in the Klamath River reservoirs are discussed in detail in the FERC biological opinion for the proposed relicensing of the Klamath Hydroelectric Project (USFWS 2007a).

3.2.2 Migration Barriers

Dams block sucker migration corridors, isolate population segments, prevent genetic exchange between populations, and concentrate suckers in limited spawning areas, possibly increasing the likelihood of hybridization between species (USFWS 2002). Dams may also change stream channel, alter water quality, and provide habitat for non-native fish that prey on suckers or compete with them for food and habitat (USBR 2001a). There are seven major Project dams that may affect the migration patterns of listed suckers: Clear Lake, Link River, Gerber, Malone, Miller Creek, Wilson, and Anderson-Rose Dams. Only the Link River Dam is equipped with a fishway designed specifically for sucker passage.

Historically, some larval and juvenile suckers dispersing from UKL to the Klamath River above Keno and Lower Klamath Lake probably reared in this shallow productive environment and returned to UKL and its tributaries to spawn as adults (USFWS 2002). Now most fish moving out of UKL likely perish due to the lack of rearing habitat and poor water quality in Keno Reservoir or disperse downstream beyond Keno Dam. Before the development of PacifiCorp's Klamath Hydroelectric Project, some suckers dispersing into the Klamath River below Keno probably moved back upstream into lacustrine habitat. Suckers that did not return upstream over the reef at Keno were lost downstream. Currently, because of the presence of lake habitats available in J.C. Boyle, Copco No. 1, and Iron Gate Reservoirs, refuge populations exist, consisting of mostly adults (Desjardins and Markle 2000; NRC 2004).

In 2005, Reclamation built a new fishway at the Link River Dam (see Figure 3-9) that meets recommended design criteria and guidelines for upstream fish passage of Federally- listed suckers (USFWS 2005; ODFW 2006). Reclamation installed a passive integrated transponder (PIT) tag detection system in 2005 and upgraded it in 2007. They also installed a fish trap at the top end of the fishway in 2007 to monitor fish passage at the facility. Preliminary monitoring results indicate both LRS and SNS are passing upstream through this fishway (Korson et al. 2008). USGS tracked 6 radio-tagged LRS that originated from UKL and were released in Lake Ewauna that successfully negotiated the fishway (Korson et al. 2008).

Other non-Project diversion dams in the Lost River system that lack fish passage facilities include Harpold Dam and Lost River Ranch Dam. These dams restrict upstream passage to 20 to 25 miles of stream/reservoir habitat during spring and summer (USBR 2007). These small flash-board diversion dams are removed from October until April, allowing access to these areas during fall, winter, and early spring. A removable fish ladder was installed on Big Springs Diversion Dam near Bonanza in 2007 (C. Korson, USBR, pers. comm. 2007). Based on the presence of multiple size ranges of SNS in this reach, this small population appears to be self-sustaining. Therefore, lack of passage may not have a population limiting effect.

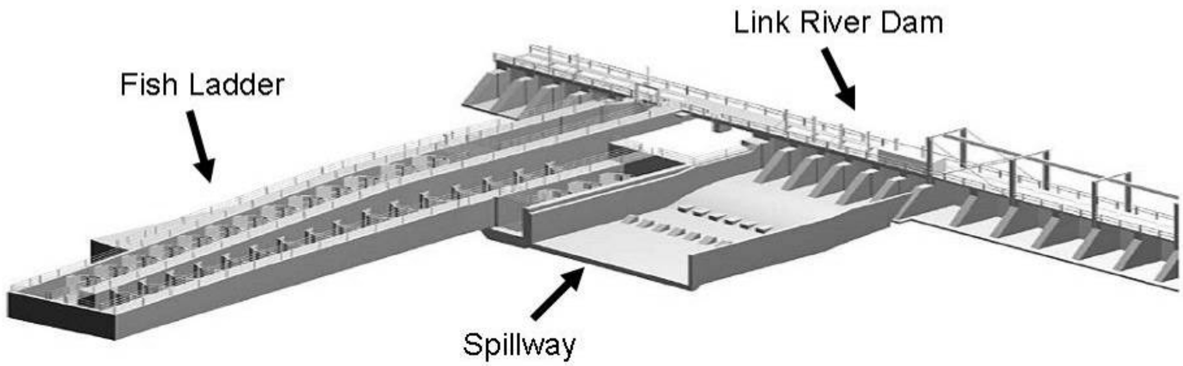


Figure 3-9. Diagram of the Link River Dam showing the spillway and new fish ladder (fishway). The entrance to the ladder is next to the spillway.

Small earthen dams in the Gerber Reservoir and Clear Lake watersheds block or restrict sucker access to portions of the watersheds that contain potential spawning and rearing sucker habitats (USBR 2001a, 2002). Most of these dams are upstream of the major spawning areas. Because sucker populations in Clear Lake and Gerber Reservoir are viable, lack of passage facilities at these dams may not have a population level effect.

Several removable fish ladders have been installed at irrigation diversion dams along the Wood River and Sevenmile Creek in the UKL watershed (USFWS 2002). It is not known if these ladders are passable by endangered suckers. The Service provided funding in 2007 to replace an existing fishway on Sevenmile Creek with a fishway which will allow sucker passage (M. Buettner, USFWS, pers. comm. 2007). However, the Wood River and Sevenmile Creek were historically not major spawning habitat for suckers and few appear to be attempting to migrate past these facilities currently. Therefore, lack of adequate passage facilities may not have a major impact on sucker populations in UKL.

Chiloquin Dam has restricted LRS and SNS spawning migrations in the Sprague River since 1914. This dam has been identified as a major threat to sucker recovery (NRC 2004), and is scheduled for removal in July 2008. A more detailed discussion of this diversion dam is provided later in this document (section 3.2.15 *Ecosystem Restoration and Sucker Recovery*).

3.2.3 Instream Flows

Because the LRS and SNS are typically lake dwellers and riverine spawners, adequate instream flows are necessary for access to and availability of spawning habitat and transport of larvae downstream to lacustrine rearing areas (Buettner and Scoppettone 1990; Perkins et al. 2000a; Cooperman and Markle 2004). Most of the tributaries supporting the major populations of LRS and SNS (Clear Lake, Gerber Reservoir, and UKL) are minimally regulated particularly during the spawning season and therefore have little effect on sucker spawning, egg incubation, and larval emigration (USFWS 2002). However, instream flows that are intensively managed in the Link River, Miller Creek, and Lost River are likely to benefit suckers when there are substantial flows and adversely affect them when flows are stopped (USBR 2001a, 2002a, 2007; USFWS 2002).

Link River

The Link River, at the outlet of UKL, is regulated to meet Klamath Project and PacifiCorp's hydropower operations needs. Link River Dam (see Figure 3-10) is owned by Reclamation but operated by PacifiCorp. PacifiCorp operates Link River Dam under a contract with Reclamation. The Eastside and Westside Power Diversions are operated wholly independent of Reclamation's Project operations. A detailed description of Link River Dam operation and effects on endangered suckers are found in the FERC BO (USFWS 2007a). The Link River is a corridor for larval, juvenile, and adult suckers dispersing downstream of UKL, adult suckers migrating upstream to UKL and its tributaries to spawn, and a water quality refuge during the summer when water quality in Keno Reservoir degrades (USFWS 2007a).

Figure 3-10. Photo of Link River Dam looking upstream. Spillway and fish ladder (fishway) are on the far left and the Eastside hydropower bay on the right side foreground. The reef is upstream of the dam. The two channels that were blasted through the reef are located on each side of the reef near the shoreline.

The Link River contains a series of cascading drops consisting of bedrock and large alluvial material. The main cascade provides a drop of about 15 feet in elevation over a distance of about 450 feet. Nearly 10 feet of the drop is concentrated in a single cascade that is about 100 feet long. The main cascade starts about 300 feet downstream of the dam with the steepest section starting about 500 feet downstream of the dam. Adult sucker passage may be restricted at low flows during the springtime spawning migration when the drop at the cascade is greatest (PacifiCorp 1997; USBR 2000b). Piaskowski (2003) suggested that sub-adult suckers less than 3 years of age would be unable ascend the Link River cascades due to their small size and limited swimming ability.

In 2002, 10 radio-tagged suckers migrated up the Link River during May and 4 moved above the falls to the base of the Link River Dam during spills ranging from 1,010 to 1,475 cfs (Piaskowski 2003). In 2003, 6 of 8 adult suckers migrated above the falls during May at flows ranging from 230 cfs to 830 cfs. In August 2002 and 2003, one adult SNS moved above the falls at dam releases of 280 cfs and 250 cfs, respectively.

To address fish passage conditions in the cascade reach of Link River, Reclamation conducted a hydraulic modeling study (Mefford and Higgs 2006). Conditions supporting fish passage through the cascade become progressively worse at higher flows based on velocity simulations at flows ranging from 1,000 to 4,000 cfs (Mefford and Higgs 2006). Operation of Eastside and Westside powerhouses at Link River Dam likely restricts adult sucker migration at flows less than 300 cfs because of the location of turbine outlets and at flows greater than 3,000 cfs because of the flow hydraulics in the cascade reach. Production and recruitment to the LRS and SNS populations will be negatively impacted because fewer adults are able to migrate to spawning habitat in the Sprague and Williamson Rivers. However, in the recently completed FERC BO, there is a reasonable and prudent measure requiring PacifiCorp to not operate Eastside and Westside Power Diversions when flows in Link River are 500 cfs or less (USFWS 2007a). This should allow better sucker passage up the Link River.

Miller Creek

Miller Creek is located at the outlet of Gerber Reservoir and extends about 9 miles downstream until it enters the upper Lost River (USBR 2001a). SNS, presumably from the Lost River near Bonanza, spawn in the lower reaches of Miller Creek during April and May of some years (USBR 2001a; USFWS 2002).

Langell Valley Irrigation District releases water at Gerber Dam into Miller Creek for irrigation under contract with Reclamation during April through September. A 1 to 2 cfs release occurs during the winter to prevent the outlet valve from freezing. About 5 miles upstream of its confluence with the Lost River, Miller Creek flows are diverted into North Canal by LVID during the irrigation season so little flow reaches the Lost River. However, during wet years when Gerber Reservoir spills, winter and spring flows can be substantial (several hundred cfs). During one of these spill events (1999) substantial numbers of SNS spawned in Miller Creek. Spawning runs are infrequent during non-spill years and passage from the Lost River may be restricted by the shallow water depths at the mouth of Miller Creek (USBR 2001a; ISRP 2005).

Upper Lost River

The Upper Lost River is the section of the river that is between Clear Lake and Bonanza. Flow diversion by LVID from Clear Lake negatively affects any endangered suckers present in the Lost River between Clear Lake and Malone Reservoir when flows are cut off after the irrigation season and from below Malone Dam during the irrigation season. Flows in the Upper Lost River are very low during the fall and winter. However, they do increase downstream from tributary and spring accretions. Lost River flows also increase as a result of weather patterns and low elevation run-off from fall through spring, prior to irrigation season.

It is presumed that most endangered suckers reside in impounded areas or deep pools in the upper Lost River except during the spring spawning period when they migrate upstream to spawn (USBR 2001a; Sutton and Morris 2005; USFWS 2002). These areas generally have higher flows during the spring spawning season from local run-off and tributary and spring accretions. Irrigation releases at Clear Lake that start in April also provide instream flows.

Larval, juvenile, and adult sucker health and survival may be reduced because of stranding, increased predation, potentially harmful water quality conditions, increased stress from crowding and lack of food, and higher incidence of disease and parasites exacerbated by managed instream flows by irrigation districts under contract with Reclamation in the Lost River (USBR 2001a).

Lower Lost River

The Lower Lost River is the section from Bonanza to Tule Lake. Past and present diversions at Clear Lake and Gerber Reservoirs may not have had a negative effect on suckers and their habitat in the Lost River from Bonanza to Wilson Dam because unregulated streams, groundwater springs, and run-off maintain adequate habitat and flows in the fall and winter (USBR 2007). Adequate flow and habitat conditions are likely to occur during the spring and summer with higher river flows augmented by releases from Gerber Reservoir and Clear Lake.

Fall and winter flow diversions at Lost River Diversion Dam to the Klamath River may negatively affect suckers and their habitat in the Lost River downstream of the Dam to Tule Lake. Low flows may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (USBR 2007). However, there are very few suckers if any suckers residing in this reach (USBR 2001a; USFWS 2002).

Historically, populations of suckers in Tule Lake migrated up the Lost River to spawn at Big Springs (rm 45), and probably other shallow riffle areas with appropriate spawning substrate (Coots 1965; ISRP 2005). The construction of Lost River Diversion Dam by Reclamation in 1912 restricted sucker migrations out of Tule Lake to the lower 25 miles of the Lost River. In 1921, construction of the Anderson-Rose Diversion Dam by Reclamation further restricted migrations to the lower 8 miles of the river.

Reclamation and the Service have monitored endangered sucker spawning runs from Tule Lake into the Lost River frequently since 1991 (USBR 1998; Hodge 2007, 2008). Spawning is restricted to one small riffle area below Anderson-Rose Dam. There have been spawning runs every year that spills or releases from Anderson-Rose Dam have occurred. Water releases were required as provisions of earlier biological opinions (USFWS 1992, 2001a). In 2006 and 2007, the Service entered into an agreement with Tulelake Irrigation District to provide releases during the spawning season. Successful egg incubation and survival of larvae to swim-up has been infrequent in recent years. Only two juvenile suckers were captured in Tule Lake in 2007 suggesting recruitment continues to be very low (Hodge 2008).

3.2.4 Watershed Alterations Affecting Water Quality

3.2.4.1 Upper Klamath Basin Watershed: Upper Klamath Lake

UKL was historically eutrophic but is now hypereutrophic (ODEQ 2002). It has been suggested that large scale watershed development from the late 1800s through the 1900s has contributed to UKL's current hypereutrophic condition (Bortleson and Fretwell 1993; Eilers et al. 2001; Bradbury et al. 2004; Eilers et al. 2004; Aquatic Scientific Resources 2005). Accelerated sediment and nutrient loading to UKL consistent with land use practices in the Upper Klamath watershed have contributed to erosion and transport of nutrients to UKL (Eilers et al. 2004). This nutrient loading has resulted in algae blooms of higher magnitude and longer duration (Kann 1997). These blooms have led to extreme water quality conditions (high pH, low DO, and high ammonia) that likely impact fish health and increase the size and frequency of fish die-offs (Perkins et al. 2000b). In recent decades, UKL has experienced serious water quality problems that have resulted in massive fish die-offs, as well as pronounced re-distribution of suckers to the northern portion of UKL during the summer months in response to changes in water quality (Buettner and Scoppettone 1990; Peck 2000; Buettner 1992; Banish et al. 2007).

Nutrient Loading

High nutrient loading to UKL promotes correspondingly high algae production, which in turn, modifies physical and chemical water quality characteristics that can directly diminish the survival and production of fish populations. Accelerated phosphorus loading is likely a key factor driving the massive AFA blooms that now dominate UKL. Through modeling and analysis efforts, Oregon Department of Environmental Quality (ODEQ) (2002) determined that phosphorus reduction would be the most effective means of improving water quality conditions in UKL. In 2002, ODEQ established a TMDL for UKL. This TMDL targets the reduction of phosphorus as a means to reduce AFA production and improve water quality conditions. Although nitrogen is also an important nutrient for structuring algae communities and determining algal productivity, AFA is able to fix atmospheric nitrogen to meet its nitrogen needs in what may otherwise be a nitrogen-limiting environment (ODEQ 2002). Thus, phosphorus loading is particularly important in UKL in determining algal productivity and biomass, which in turn influences water quality conditions affecting native fishes (ODEQ 2002). However, there is debate as to whether external phosphorus load reduction will improve water quality conditions within UKL (NRC 2004) due to internal nutrient loading driven by the release of phosphorus from the lake bed sediments (Laenen and Le Tourneau 1996; Fisher and Wood 2004; NRC 2004; Kuwabara et al. 2007).

External Nutrient Loading

Although high background phosphorus levels in Upper Klamath Basin tributaries existed before development, data from several studies indicates that phosphorus loading and concentrations are elevated above these background levels (Miller and Tash 1967; USACE 1982; USBR 1993a, 1993b; Kann and Walker 1999; Bradbury et al. 2004; Eilers et al. 2004). This accelerated phosphorus loading occurred at the same time as an increase in development and intensive land use activities in the Upper Klamath Basin, including substantial timber harvesting, drainage of wetlands, and agricultural activities (Bradbury et al. 2004; Eilers et al. 2004; ODEQ 2002).

Throughout the Upper Klamath Basin, timber harvesting and associated activities (road building) by Federal, State, tribal, and private landowners have resulted in soil erosion on harvested lands and transport of sediment into streams and rivers adjacent to or downstream from those lands (USFWS 2002). Past logging and road building practices often did not provide for adequate soil stabilization and erosion control. Risley and Laenen (1999) reported that timber harvest and associated roads have contributed to the high sediment and nutrient inputs to UKL from tributary watersheds. However, the magnitude of impact from timber harvest on nutrient and sediment input to UKL is unquantified. Timber harvest peaked in the 1940s at about 800 million board feet (mbf) and ranged from about 400 to 450 mbf from 1970 to 1990 (Risley and Laenen 1999). Since the 1990s there has been a substantial reduction in harvest; in 2003, 200 mbf were harvested in Klamath County. Nevertheless, a high density of forest roads remain in the watershed and many of these are located near streams where they likely contribute sediment (USFS 1994, 1995a, 1995b, 1996, 1997, 1998).

Livestock grazing, the major agricultural activity in the UKL watershed has likely accelerated erosion leading to an increase in sediment and nutrient loading rates to UKL (USFWS 2002). Livestock, particularly cattle, have heavily grazed flood plains, wetlands, forest, rangelands, and riparian areas, resulting in the degradation of these areas. The increase in sediment accumulation and nutrient loading are consistent with the changes in land use in the Upper Klamath watershed occurring over the last century (Eilers et al. 2001; Bradbury et al. 2004; Eilers et al. 2004; Aquatic Scientific Resources 2005). However, the magnitude of impact from agriculture and livestock grazing on nutrient and sediment input to UKL is unquantified. Approximately 35 percent of the watershed above UKL is used for livestock grazing. Cattle production in Klamath County peaked in 1960 with 140,000 animals (Eilers et al. 2001). In the Wood River Valley approximately 35,000 cattle graze on pastures during the summer and fall and less than 1,000 during the other months (Eilers et al. 2001). In the Sprague River Valley approximately 20,000 cattle graze on pastures in summer and approximately 1,500 graze during winter (Eilers et al. 2001). In recent years the number of cattle has been reduced by approximately 50 percent; in 2007 the number of cattle reported in Klamath County was 81,000 (USBR 2007).

Diking and draining of wetlands for non-Project agricultural development accounted for a loss of over 50,000 acres of wetlands in the Upper Klamath Lake watershed (Aquatic Scientific Resources 2005). Of this amount, about 35,000 acres of wetlands immediately adjacent to UKL that provided habitat for fish were converted to agricultural lands from the 1880s to 1960s (Aquatic Scientific Resources 2005; Snyder and Morace 1997). This loss of wetlands has meant a substantial loss of nutrient uptake capacity (Geiger 2001).

The drained wetlands are also a source of nutrients to UKL (Snyder and Morace 1997). Direct phosphorus loading from drained wetland properties surrounding UKL is very high (190 kg/km^2; Kann and Walker 1999). Nutrient loading studies indicate that despite contributing only 3 percent of the water inflow (43,000 acre-feet/year), direct agricultural input from pumps that remove water from the drained wetlands around UKL accounted for 10 percent of the annual external phosphorus budget (20 metric tons/year) and as much as 30 percent of the total during the peak pumping period of February through May (Kann and Walker 1999). However, in recent years about 18,000 acres of drained wetlands are in the process of being converted back to wetland and lake habitat, likely resulting in a decrease in nutrient loading to UKL (Aquatic Scientific Resources 2005).

Internal Nutrient Loading

Internal phosphorus loading is another significant component of the nutrient budget affecting algal bloom dynamics and water quality in UKL (Barbiero and Kann 1994; Leanen and Le Toureau 1996; Kann 1998; Kann and Walker 1999). Nutrient loading studies show that the largest flux of phosphorus to UKL during the summer months comes from internal sources (Kann and Walker 1999). More recent work by Fisher and Wood (2004) has suggested that sediment bacteria could play an important role in the cycling phosphorus between lake sediments and the water column. On average, the internal loading accounts for approximately 60 percent while external loading accounts for approximately 40 percent of the annual phosphorus load to UKL (Walker 2001).

Photosynthetically-elevated pH can be an important mechanism for releasing phosphorus in shallow productive lakes (Jacoby et al. 1982; Sondergaard 1988; Welch 1992). Elevated pH levels can increase phosphorus release from the sediments to the water column by solubilizing iron-bound phosphorus in both bottom and re-suspended sediments (Kann and Walker 1999). Evidence for this exists in UKL where phosphorus associated with hydrated iron oxides in the sediment was the principal source of phosphorus to the overlying water, and iron-phosphorus fractions of lake sediment decreased from May to June and July (Wildung et al. 1977). It appears that elevated pH increases the probability of internal phosphorus loading (Kann and Walker 1999). Under this mechanism, as the bloom progresses and elevated pH increases the flux of phosphorus to the water column, increased water column phosphorus concentration further elevates algal biomass and pH, setting up a positive feedback loop (Kann and Walker

1999). However, other empirical data do not support this mechanism for phosphorus release from the sediments. Fisher and Wood (2004) under laboratory conditions did not find that elevated pH caused phosphorus release using UKL sediments. Also, recent work by USGS researchers (N. Simon, USGS pers. comm. 2008) have shown that sediments in UKL are relatively iron-poor and therefore the amount of iron-phosphorus fractions are relatively small.

The total nitrogen balance indicates that UKL is a seasonally significant source of nitrogen. Kann and Walker (1999) estimated a net negative retention of total nitrogen on an annual basis (average annual negative retention of 140 percent). On a seasonal basis, total nitrogen retention ranges from -260 and -630 percent (Kann and Walker 1999). The main source for this increase to internal nitrogen loading is nitrogen fixation by AFA (Kann 1998). Another potential source is the mobilization of inorganic nitrogen from lake sediments during bacterial decomposition (Kann and Walker 1999).

Algae Productivity and Associated Poor Water Quality

In hypereutrophic lakes with large amounts of nutrient input, algal production increases and algal biomass accumulates until light, nutrients or some other factor limits further growth. As biomass increases, the available soluble forms of nitrogen and phosphorus decrease because the nutrients are progressively accumulated in the algal biomass and are therefore unavailable for further algal production. The nutrient needed for growth that is in the shortest supply, thus becomes the limiting nutrient. When light, nutrients, or other conditions for algae become unfavorable, the production of the algal bloom will cease or rapidly decline, resulting in an algal "crash."

The massive blooms of AFA and the subsequent rapid decline (crash) can cause extremes in water quality including elevated pH, low DO concentrations (hypoxia), and elevated levels of un-ionized ammonia, which can be toxic to fish (Kann and Smith 1993; Kann and Smith 1999; Perkins et al. 2000b; Walker 2001; Welch and Burke 2001; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007). In the process of rapid growth, algal biomass can form extremely dense blooms, which can vary in magnitude depending on the availability of growth-promoting conditions (Kann and Smith 1993; Kann and Smith 1999; Perkins et al. 2000b). During the same bloom conditions and following a bloom crash, particularly when coupled with high rates of nighttime respiration, DO can drop to levels that can be stressful or even lethal to fish. In addition, when dense algae blooms die off, the microbial decomposition of the algae and organic matter in the sediment and water column can further deplete DO and produce increased concentrations of ammonia (Kann and Smith 1993; Risley and Laenen 1999; Perkins et al. 2000b).

The potential for low DO concentration increases later in the growing season (July to September) when the algae blooms have crashed and considerable organic matter has accumulated in the sediments. During this same period, higher water temperatures increase water-column DO depletion rates, as decomposition and respiration take place at a faster rate, and DO concentrations in the water column tends to be lower because the solubility of oxygen decreases as water temperature increases.

Recent water quality and hydrodynamic modeling investigations have demonstrated the importance of wind-driven currents on transport of oxygen–depleted water from the trench along Eagle Ridge into the fish habitat area in the northern third of UKL (Wood et al. 2006; Wood and Cheng 2006; see Figure 3-20). When a severe low DO event lasting for several weeks and a small fish die-off occurred near the end of July in 2003, the concentrations observed in the fish habitat area were very similar to low concentrations measured in the trench. These conditions were associated with higher winds than in 2004, when low DO was found in the Eagle Ridge trench but not in the fish habitat area.

Wetlands may affect water quality through production and release of decomposition products, particularly dissolved organic substances that appear to inhibit AFA growth (Aquatic Scientific Resources 2005). The absence or reduction of this algae species just downstream, at or within marsh environments has been noted at Hanks Marsh (Forbes et al. 1998) and Upper Klamath NWR (Sartoris et al. 1993). Perdue et al. (1981) noted the absence of AFA in UKL at a location heavily influenced by the Williamson River, which transports water originating from the Klamath Marsh. Both wetlands in the lake and reclaimed wetlands behind the dikes as well as winter flooded farm fields are potentially large reservoirs of what may be a valuable blue-green algae suppressant (Geiger 2001; Aquatic Scientific Resources 2005). The loss of in-lake wetlands, diffusing these dissolved organic compounds differently and at different times depending on hydrologic setting, has likely resulted in lower lake concentrations of dissolved organic substances (Aquatic Scientific Resources 2005).

Although the exact mechanisms are not well understood, the relationship between dissolved organic substances ("humics") and inhibition of many planktonic algae species has been established on both a local and national level (Phinney et al. 1959; Perdue et al. 1981; Forbes et al. 1998; Aquatic Scientific Resources 2005). Most parameters exhibited substantial seasonal variations. On a study-wide basis, however, phosphorus, inorganic nitrogen, and chlorophyll-a concentration were similar to lake water. The results of the Forbes et al. (1998) study at Hanks Marsh do not address the flux of material between the pelagic and littoral zones. Some of the data suggest, however, that pelagic conditions influence the outer areas of Hanks Marsh. Conversely, processes within the marsh may form water quality gradients that extend into the pelagic zone.

It is likely that the physical and chemical characteristics of large lakeshore marshes around UKL historically played an important role in nutrient cycling, regulating the algal community and other characteristics of the system (Geiger 2001). Littoral wetlands in UKL have been dramatically reduced in size due to agricultural reclamation. However, approximately 18,000 acres of drained wetlands are in the process of being restored to littoral wetlands, which may improve the lake's ability to regulate the algal community.

Keno Reservoir

Keno Reservoir (Lake Ewauna to Keno Dam reach of the Klamath River) is about 20 miles long and 300 to 2,600 feet wide; maximum depth ranges from 9 to 20 feet and average depth 7.5 feet (USFWS 2007a). The reservoir has a surface area of 2,475 acres and a total storage capacity of 18,500 acre-feet. Water levels are normally maintained within a 0.1 foot range (4085.4 to 4085.5 feet). Summer water quality is extremely poor, with heavy AFA growth, low DO concentrations, and high pH, ammonia and temperature (CH2M Hill 1995; NRC 2004; Deas and Vaughn 2006; USBR, unpublished data).

The Klamath River, including Keno Reservoir, is listed as water quality impaired by Oregon under Section 303(d) of the Clean Water Act, requiring the development of TMDL limits and implementation plans. The Oregon 2002 section 303(d) list reported that the Klamath River from UKL to the Keno Dam was impaired because pH, ammonia, nutrients, temperatures, DO, and chlorophyll-a do not meet applicable standards (ODEQ 2002). 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 impoundment, and agricultural water diversions. Isolating the nutrient loading and the effect of the Klamath Project on water quality from other impacts has yet to be completed; however, TMDL analyses, currently underway will identify these loads by 2009.

Keno Reservoir experiences seasonal poor water quality during summer months with water temperatures exceeding 25° Celsius (C), pH exceeding 10 units, dense algae blooms dominated by AFA, and DO concentrations below 4 milligrams/liter (mg/l). Like UKL, dense blooms of AFA affect the water quality within Keno Reservoir. However, the AFA blooms are typically less intense and are spatially and temporally more variable than those observed in UKL (USBR 2007). Persistent low DO events occur in this reach and can last for several days or even weeks where the DO will remain less than 4 mg/l, and are associated with high levels of un-ionized ammonia (Deas and Vaughn 2006; USBR 2007). These degraded conditions can occur throughout much of the 20 mile-long reach.

The quality of water entering, within, and leaving Keno Reservoir is largely due to poor quality water entering from UKL containing large amounts of organic matter with an associated high biological oxygen demand (BOD) (Doyle and Lynch 2005; Deas and Vaughn 2006). In addition to the high BOD rates of source water from UKL, the bed sediments have high sediment oxygen demand (SOD) rates which further exacerbate the low DO conditions. Doyle and Lynch (2005) found that SOD rates in Keno Reservoir ranged from about 0.3-3.0 grams DO/m^2/day (median value =1.8). The SOD and BOD combined can account for the severe low DO condition that develops in the reach from July into October of most years. Also, low AFA growth would result in little DO being produced to offset DO losses by SOD and BOD.

Particulate organic matter (mostly AFA) that originates from UKL is overwhelmingly the largest source of nutrients relative to other nutrient sources, including agricultural, municipal, wildlife refuge and industrial inputs (USBR 2007). Although the water returned to the Klamath River from the Klamath Project and the Tule and Lower Klamath Lake NWRs typically has higher nutrient concentrations than UKL or the Klamath River, the net nutrient load of the diverted water is reduced as it flows through the Klamath Project and the Refuges (USBR 2007).

Nutrient loads diverted into the Klamath Project and discharged to the Klamath River, from UKL and the Klamath Straits Drain was estimated for the period April to October 2002 (USBR 2007). The estimates show that the Klamath Project and Tule and Lower Klamath NWRs are a net sink for nutrients and provide substantial nutrient reduction of diverted waters. The nutrient load reduction is estimated at 83, 69, 85, 62, and 73 percent for ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus, respectively. The 2002 estimates equates to a net nutrient load reduction of 111, 22, 832, 36, and 78 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus, respectively (USBR 2007). If not diverted, the nutrient load to the Klamath River would be nearly twice the current level.

The operations of PacifiCorp's Keno Dam likely reduce nutrient cycling that would improve water quality in Keno Reservoir. The dam and its impoundment affect water quality primarily by increasing surface area, hydraulic retention time, and solar exposure (FERC 2007). The longer residence time allows temperatures to increase and facilitates photosynthetic and microbial processes that can further degrade water quality, by causing substantial DO and pH fluctuations. The contribution of PacifiCorp's reservoir operations on water quality has not been determined. ODEQ will quantify their contribution when it completes the Klamath River TMDL in 2009 (S. Kirk, ODEQ, pers. comm. 2007).

Maximum water levels in the natural lake controlled by Keno Reef were similar to the currently managed reservoir elevation (Weddell 2000). Historically, the Klamath River and Lower Klamath Lake above Keno Reef fluctuated in elevation more than they do now (typically 1 to 1.5 feet). This annual fluctuation provided conditions that supported a large emergent wetland fringe to Lake Ewauna/Klamath River that is absent today. The absence of wetland fringe, diking and draining of large wetland areas along the Klamath River and the disconnection to Lower Klamath Lake wetlands reduces the potential for nutrient cycling and assimilation in Keno Reservoir. The amount of reduced capacity is unknown.

Poor water quality conditions, especially low DO levels, occur during the summer, restricting endangered suckers to the upper end of Keno Reservoir. Fish die-offs that include endangered suckers occur frequently (Piaskowski 2003; Tinniswood 2006). Poor water quality in Keno Reservoir is largely responsible for the mortality of thousands of juvenile suckers dispersing downstream into the reservoir from UKL. Therefore, LRS and SNS populations are diminished by poor water quality in Keno Reservoir.

3.2.4.2 Lost River Watershed

Clear Lake

Much of the Lost River watershed upstream of Clear Lake is publicly owned under the jurisdiction of the U.S. Forest Service (USFS) (Modoc National Forest) and the Service (Clear Lake NWR). The condition of the watershed is relatively good because of the management focus of the two agencies is on water quality and habitat protection (USFWS 2002). The USFS has consulted with the Service under section 7 of the ESA regarding impacts of their grazing program and protective measures implemented. Several riparian restoration projects have been completed upstream of Clear Lake, improving stream habitat and water quality (USFWS 2002). The State of California removed the Section 303(d) listings for the Upper Lost River in 2006; therefore the Upper Lost River is not currently listed as water quality impaired (NCRWQCB 2006).

In 1992, when Clear Lake elevation reached a minimum of 4519.4 feet in October (see Figure 3-19), suckers showed signs of stress including low body weight, poor development of reproductive organs, reduced juvenile growth rates, and high incidence of external parasites and lamprey infestation (USBR 1994). Fish condition at higher lake levels in 1993 to1995 were improved with increased body weight and fewer external parasites and lamprey wounds (Scoppettone et al. 1995). Although water quality conditions were generally adequate for suckers during 1992, they were degraded in the East Lobe when water depths got very shallow (USBR 1994). The major concern at low lake levels was for low DO and potential winterkill during ice-cover conditions. During the winter of 1992-1993, Clear Lake was ice covered for several months at an elevation of about 4519.5 feet. In that year, DO concentrations remained adequate for sucker survival (USBR 1994).

Water quality conditions in Clear Lake since 1992 have been generally good over a range of water levels and years but low DO conditions were observed during late summer in the east lobe of Clear Lake near the outlet when lake levels are low and water depth is shallow (USBR 1994, 2001a; USBR, unpublished data). These low DO conditions near the outlet occur infrequently and persist for short durations (USBR 2007). There have been no reported fish die-offs in Clear Lake Reservoir (USFWS 2002). Since 2002, the minimum lake level requirement has been 4520.6 feet, which is higher than 1992 when poor fish health was observed. In 2003 to 2005, water levels lowered to near this minimum elevation each year and water quality remained good in the West Lobe where the suckers resided (USBR, unpublished data; Figure 3-19).

Gerber Reservoir

In the Gerber Reservoir watershed, about 75 percent of the land is publicly owned under the jurisdiction of the USFS (Fremont National Forest) and the U.S. Bureau of Land Management (USBLM) (Klamath Resource Area). The condition of the watershed upstream of Gerber Reservoir is relatively good. Both USBLM and USFS have consulted with the Service under section 7 of the ESA on grazing management in the watershed and implemented management actions that protect sucker habitat (USFWS 2002).

Water quality conditions in Gerber Reservoir (i.e., temperature, pH, and DO) were generally adequate for suckers except low DO during portions of some winter months during ice-cover conditions and portions of all summer months (Piaskowski and Buettner 2003). During summer and early fall, weak stratification of the water column develops occasionally in Gerber Reservoir particularly at sites near the reservoir outlet where depth is greatest (Piaskowski and Buettner 2003). When the reservoir is stratified, DO concentrations of less than 4 mg/l were observed at depths generally greater than 4 meters. This stratified condition, and associated hypoxia, typically persists for less than a month and over a small portion of the Reservoir near the dam (Piaskowski and Buettner 2003; USBR, unpublished data). There have been no reported fish die-offs in Gerber Reservoir associated with degraded water quality (USFWS 2002).

Water quality in Gerber Reservoir was degraded during the drought year of 1992 when the reservoir was drawn down very low (Piaskowski and Buettner 2003). In that year Gerber reached a minimum elevation of 4796.4 feet, which is less than 1 percent of its maximum capacity. Suckers in the reservoir at the time showed signs of stress including low body weight, poor gonadal development, and reduced juvenile growth rates (USBR 2001a). In another low reservoir level year (1994) when the reservoir reached only about 10 percent of capacity, water quality conditions were generally good except near the bottom in the vicinity of the dam. Since 2002, the minimum lake elevation requirement for Gerber Reservoir has been 4798.1 feet. Gerber Reservoir water levels have been much higher than this from 2002 through 2007.

Lost River

The current hydrology in the Lost River watershed bears little resemblance to the pre-development condition. Development of the irrigation projects resulted in major losses of natural riparian and wetland areas in the Lost River. Riparian and wetland areas historically helped filter pollutants from runoff to these receiving waters (USEPA 2007).

Most of the land ownership in the Lost River sub-basin below Clear Lake is private. Agriculture and grazing are the primary land uses. The condition of the watershed is relatively good in the areas upstream of Malone Reservoir and generally poor downstream to Tule Lake (USBR 2007). Poor water quality is observed in most of the Lost River downstream of Malone Dam and is listed on the ODEQ 303(d) list for water quality limited streams for the following criteria: chlorophyll-a, pH, ammonia toxicity, DO, temperature, and bacteria. ODEQ plans to develop

TMDLs for the Lost River in Oregon as part of the broader Klamath River TMDL effort. USEPA is proceeding to establish TMDLs for the Lost River in California (USEPA 2007).

During the summer months, water temperatures greater than 25° C, pH values approaching 10 units, excessive growth of aquatic vegetation, and DO concentrations of less than 4 mg/l are frequently observed throughout much of the Lost River downstream of Malone Dam (USBR 2007). Persistent hypoxia (low DO) events can last for several days where the DO will remain less than 4 mg/l, which can be stressful or lethal to aquatic organisms including the endangered suckers. In 2003, an adult sucker die-off occurred in the Harpold Reservoir area (USBR, unpublished data). Fish die-offs including juvenile SNS were documented in Wilson Reservoir during the winter when DO levels got low due to extended ice-cover (M. Buettner, USFWS, pers. comm. 2007).

Most of the flow in the Lost River downstream of Harpold Dam originates from UKL and the severely degraded water quality conditions observed in the Lost River are in large part due to poor quality water entering the Lost River from UKL containing large amounts of organic matter with an associated high BOD (USBR 2007). Also, as with UKL and the Klamath River, the sediments likely have high SOD rates, which consumes oxygen and further exacerbates the severe hypoxia. These hypoxic events are more prevalent in the mainstem Lost River impoundments, particularly in Wilson Reservoir, where the aquatic vegetation and AFA are most abundant (USBR 2007). In general, observed DO concentrations decrease as you move downstream through the Lost River watershed and tend to be lowest in the mainstem Lost River impoundments.

Tule Lake

Tule Lake is classified as highly eutrophic because of high nutrient concentrations and resultant elevated aquatic plant productivity (USFWS 2002). Tule Lake water quality is affected by its various sources of inflow, as well as conditions in the sumps. During the irrigation season, the primary source of water for the sumps is UKL, via the Lost River Diversion Channel and A-Canal. UKL is highly eutrophic as discussed previously, with large near-monoculture blooms of AFA during the summer. Tule Lake experiences poor water quality during summer months, characterized by high water temperature and pH, low DO levels, elevated un-ionized ammonia and nutrient concentration and intensive filamentous green algae growth (USBR 2007). During the winter, most inflow to Tule Lake is from localized runoff below Wilson Reservoir (USFWS 2002).

Water quality can vary seasonally and diurnally, especially in summer. Due to the lake's shallowness and high biomass of aquatic macrophytes and filamentous green algae during summer, DO and pH levels fluctuate widely. Water quality conditions during the winter are relatively good, except during prolonged periods of ice-cover when DO levels decline. A small adult sucker die-off occurred during the winter of 1992-1993 during an extended period of ice-cover and low DO levels (USBR, unpublished data).

Water levels in Tule Lake sumps have been managed according to criteria set in previous biological opinions (USFWS 2002). From April 1 to September 30, a minimum elevation of 4034.6 feet was set to provide access to spawning areas below Anderson Rose Dam, for dispersal of larvae and to provide rearing habitat. For the rest of the year, October 1 to March 31, a minimum elevation of 4034.0 feet is set to provide adequate winter depths for cover and to reduce the likelihood of fish die-offs owing to low DO levels below ice cover. Because of the shallow depths in Tule Lake sumps and relatively small change in water levels, the impact of water level management on water quality is probably small. However, relatively stable water levels have led to substantial degradation and loss of emergent wetlands and associated water quality (USFWS 2002). In response to the loss of emergent wetlands, the Service actively managed water levels in Sump 1B for several years to promote robust emergent wetland plant growth (D. Mauser, USFWS, pers. comm. 2007). Water quality, particularly DO, was better in Sump 1B than Sump 1A during summer 2007 (USFWS, unpublished data).

A variety of pesticides have been detected in waters and sediments around Tule Lake; however the levels are below those known to be acutely toxic to aquatic life (Dileanis et al. 1996). Sedimentation coming from upstream sources may ultimately make the sumps too shallow for suckers (USFWS 2002).

3.2.5 Fish Health

Disease and parasite prevalence were not identified as threats at the time of listing for LRS and SNS. However, recent information indicates that pathogens affect sucker health and survival, especially during adverse water quality events (USFWS 2007b, 2007c). Fish susceptibility to pathogens in the Upper Klamath Basin may, in part, be affected by stressful water quality conditions, as well as a variety of other factors including low water levels and a high biomass of fish (USBR 1994, 2001a). Although adult sucker die-offs that occurred in UKL in the 1990s were likely a response to low levels of DO, disease outbreaks also probably contributed to mortality during these events (Perkins et al. 2000b; NRC 2004).

A number of pathogens have been identified from sick and dying suckers, but Columnaris disease seems to be the primary organism involved (Foott 1996, 1997; Holt and Green 1996, Holt 1997). Columnaris disease is caused by the bacterium *Flavobacterium columnare*, which can cause massive damage to the gills and produces lesions elsewhere on the body. This leads to respiratory problems, an imbalance of internal salt concentrations, and provides an entry route for systemic pathogens that can cause death (USFWS 2007b, 2007c).

Larval and juvenile LRS and SNS from UKL have been examined to determine anomaly rates for fins, eyes, spinal column, vertebrae, and osteocranium, and their possible associations with water quality and pesticides (Pluckett and Snyder-Conn 2000). Approximately 1,400 fish collected in 1993 were ranked on severity of anomalies. One or more anomalies were observed in about 16 percent of SNS and 8 percent of LRS. Anomaly rates greater than 1 percent, greater than rates expected for systems unaffected by industrial pollution, were observed for abnormalities of the spine, opercular bones, and pectoral and pelvic fins in SNS and abnormalities of opercular bones and vertebrae in LRS. SNS exhibited higher rates than LRS for almost all anomalies. There were substantially more anomalies found in larvae and small juveniles than in larger juveniles. This age-related difference could be due to the death of deformed larvae and young juveniles. The anomalies described likely impair swimming, and could adversely affect feeding rates or avoidance of predators and adverse water quality conditions. Based on the high anomaly rates observed in this study, it is possible that juvenile suckers in UKL are more vulnerable to mortality, but no studies have been done to confirm this.

Numerous causes of high deformity rates in fishes have been identified, including genetics, pollutants, water quality, nutritional deficiencies, infectious agents, and physical and electrical shocks. Although no known studies have addressed natural anomaly rates in larval and juvenile fish, the anomaly rates in UKL suckers are much higher than expected for a lake lacking industrial pollutants. Although vertebral and opercular bone anomalies could be genetic in origin, based on their highest occurrences in small suckers, other types of anomalies do not fit the genetic hypothesis. Poor water quality and/or contaminants are also likely to contribute to the frequent high proportions of abnormal suckers in UKL.

Adult SNS and LRS from UKL exhibit a wide range of physical afflictions that included eroded, deformed and missing fins; curvature of the spine; pugheads; multiple types or water mold infections; reddening of the fins and body caused by hemorrhage; cloudiness of the skin caused by decreased mucus production; pigmentation loss; parasitic infections of the body and gills; lamprey wounds; ulcers, cysts; gas emboli in the eyes; protruding eyes and cataracts (Perkins et al. 1997). The frequency of many afflictions was significantly greater in 1997 and 1998 than 1995 and 1996. Of the adult suckers captured from the Williamson River in April and May, 65 to 90 percent of the fish had some type of affliction in 1997 and 1998, whereas only 20 percent had afflictions in 1996. In 1999, cysts were found in 35 percent of adult SNS and 40 percent of all LRS in the lower Williamson River, compared to 2 to 3 percent in 1997 (Perkins et al. 1997; Markle et al. 2000b). The occurrence of the parasitic copepod, *Lernaea* (anchor worm), declined in 1999 to a rate of 40 percent for SNS and 25 percent for LRS compared to 80 percent and 55 percent, respectively, in 1997. Lamprey wounds were found in about 15 percent of SNS and 30 percent of LRS, up from 15 percent and 20 percent, respectively. Various eye afflictions, fin damages, and other deformities were recorded for fish as well, but occurred in only a small fraction of fish captured.

Parasitic infestation rates on juvenile suckers by *Lernaea* and the digenean trematode, *Neascus* (black grub), were recently examined by Carlson et al. (2002). They found that the percentage of age 0 suckers parasitized by *Lernaea* ranged from about 0 to 10 percent in the period of 1994 to 1996 but increased by nearly an order of magnitude to 10 to 40 percent in 1997 to 2000, with both species showing similar patterns. Although *Neascus* infestations also exhibited considerable interannual variability, they did not show a discernable pattern of infestation and were not correlated between the two sucker species. Infestations of *Neascus* were significantly higher on SNS (about 10 to 40 percent) than on LRS (0 to 10 percent) in all years.

Studies of age 0 juvenile suckers captured from the early 1990s through 2004 indicate an increasing prevalence of parasites (i.e., *Neascus* and *Lernaea*; Carlson et al. 2002; Simon and Markle 2004). It is not yet understood how, or if, these external parasites impact sucker populations by the increase in infection rates. Parasites can lead to direct mortality, provide a route for pathogens to enter fish, since they create a wound, and can make fish more susceptible to predation (Robinson et al. 1998). OSU scientists have some evidence that higher incidence of *Lernaea* is associated with a greater decline in fish abundance from August to October and that year class strength in October is negatively related to *Lernaea* numbers in both species (D. Markle, OSU, unpublished data).

Year-old juvenile suckers have been scarce in recent sampling efforts of UKL. Body conditions and general fish health has been indicated as a factor influencing survival and abundance of juvenile suckers. Investigations of several health parameters of juvenile suckers captured in UKL and in the A-Canal fish bypass indicated a general decline in growth occurred in September (Foott and Stone 2005). The poor growth in late summer-early autumn may be a result of reduced feeding (Foott and Stone 2005). Reduced feeding may be a response to many things including stress from seasonal poor water quality events. Poor water quality combined with high fish densities of non-native fish in sucker rearing areas can provide the necessary conditions for explosive parasite infestations, especially for protozoan parasites that have rapid growth.

Several laboratory studies on effects of water quality on suckers have been conducted to determine short-term tolerance (Saiki et al. 1999) and longer term chronic effects (Meyer et al. 2000). These studies determined that larval and juvenile sucker life stages have very high tolerance to high water temperatures, low DO, high pH, and high un-ionized ammonia levels. In the chronic bioassay studies (14- and 30-day), suckers generally did not display sub-lethal responses to low DO, high pH, or elevated ammonia concentrations based on the three traditional endpoints used (growth, whole-body ion content, and swimming performance).

There is only one study where laboratory lethal levels of water quality on suckers can be compared with those measured *in situ*. Martin and Saiki (1999) placed a series of cages containing juvenile LRS at various sites in UKL. Results showed that mortality rates were significantly correlated with increased pH, and un-ionized ammonia, and low DO concentrations. Martin's *in situ*-measured lethal levels for the four water quality parameters showed that laboratory and field results were similar.

Major fish die-off events occurred in UKL during 1995 to 1997 (Perkins et al. 2000b). A small number of dead and moribund suckers were also recorded in 2003 (Foott 2004). Data on annual survival of adult suckers suggests that small adult die-offs may be occurring more frequently but are undetected (Janney and Shively 2007; Janney et al. in review).

Water quality in UKL consistently reaches levels known to be stressful to suckers and periodically reach lethal levels in August and September, resulting in die-offs (USFWS 2002). Fish die-offs have been recorded at UKL since the late 1800s but may have increased in frequency in the last few decades. Small localized fish die-offs have been observed annually on UKL since 1992 when extensive research and monitoring activities began (USFWS 2002). The series of major die-offs in 1995, 1996, and 1997 reduced adult sucker populations of LRS and SNS by an estimated 80 to 90 percent (Perkins et al. 2000b). Adult sucker die-offs in the 1990s were likely caused by stressful and lethal water quality conditions. Perkins et al. (2000b) reported that some adult suckers died several weeks after critically low DO concentrations were observed in UKL.

The several weeks to a month or more delay between the time water quality is critically low and when adult suckers die implicates that fish health, such as infections by pathogens or parasites, is a factor during die-off events. Moribund fish collected during the die-off events were infected by several pathogens and parasites (Foott 1996, 1997, 2004; Holt and Green 1996, Holt 1997).

Juvenile sucker die-offs in UKL undoubtedly occur during poor water quality conditions during late summer as evidenced by collection of dead and debilitated suckers in A-Canal in 1997 (Gutermuth et al. 2000a) and persistently low summer survival rates estimated by Oregon State University (Markle 2007). Additionally, nearly every year there are reports of large concentrations of fish eating birds actively feeding in areas of poor water quality on UKL (D. Simon, OSU, pers. comm. 2007). The birds are likely finding areas where fish are affected by adverse conditions.

Fish die-offs are nearly an annual occurrence in Keno Reservoir and are attributed primarily to poor water quality (Tinniswood 2006). In 2003, during a period of extended hot weather, fish die-offs were reported on the Lost River above Harpold Dam, Keno Reservoir, and J.C. Boyle Reservoir (USBR, unpublished data). Warm temperatures and presumably low DO levels likely stressed the fish making them vulnerable to disease. Recovered fish showed signs of infection by the bacterial pathogen, Columnaris.

3.2.6 Entrainment

Entrainment is defined as the downstream movement of fish into power or irrigation diversions or spillways caused by water management as opposed to passive drift due to wind- or gravity-driven currents or volitional emigration (see Appendix 1). Historically, before construction of Link River Dam and development of the Klamath Project, suckers probably dispersed downstream and reared in Lake Ewauna and Lower Klamath Lake (USFWS 2002). Reports of large runs of suckers up the Link River indicated that many of these fish survived to return to UKL. The rate that suckers leave the lake may be much different now than what it was prior to the development of the Project because of changes in habitat conditions in UKL and tributaries where suckers spawn, changes in lake levels and in the timing and amount of flow at the lake outlet, the channel cut through the reef at the lake outlet, and construction of Link River Dam and Eastside and Westside Power Diversions. Survival of suckers leaving the lake is much lower now because of habitat degradation and loss downstream and blocked passage at Link River Dam (USFWS 2007a). Upstream passage for adult fish was improved in 2005 when Reclamation installed a sucker-friendly fishway at the dam.

Recent field studies and hydrodynamic modeling suggest that larval sucker advection/entrainment may be an important factor affecting larval survival in UKL (Markle et al. in review). This investigation showed that daily larval sucker transport from UKL was inversely proportional to distance from the spawning grounds, and the breaching of the dikes at the Williamson Rive Delta could increase larval retention slightly. The median transport time from the Williamson River to the lake outlet before breaching is 10 to 17 days and after breaching 13 to 18 days (T. Wood, USGS, pers. comm. 2008). The hydrographic modeling also suggested that transport of larvae from eastern shoreline springs (i.e., Sucker Spring), where LRS spawn, to the lake outlet would take about 1 to 2 weeks.

Shoreline retention of larvae seems to be largely a function of its “hydrological roughness” with marshes and small bays providing longer-term retention and promontories providing at least short-term reduction in transport to the south (Markle et al. in review). The diking of marshes in the southern end of UKL has presumably reduced this roughness and decreased retention compared to historical patterns. Retention of LRS and SNS larvae in the lake appeared to be primarily a function of distance from the spawning site to the outlet and size of the retention area available. Larvae produced on eastern shoreline springs have a shorter distance before they become entrained and a smaller retention area than those produced in the Williamson and Sprague Rivers. We surmise that larvae produced farther away from the lake outlet, for example, in the upper Sprague River, are more likely to stay in the lake, all other factors being equal.

As previously discussed, Chiloquin Dam built on the lower Sprague River in 1914, has restricted access of adult LRS and SNS to historic spawning areas as far upstream as Beatty (rm 75). Because most spawning occurs below the dam, larval suckers quickly disperse downstream into UKL (Cooperman and Markle 2004), where they have a higher probability of entrainment. With removal of Chiloquin Dam in 2008, we presume more sucker spawning will occur in upstream areas where it will take longer to emigrate to UKL and therefore fewer larvae are likely to be entrained at Link River Dam. In addition, during some years when many larval and juvenile suckers rear in the Sprague River for weeks or months before emigrating to UKL their survival may be increased (J. Hodge, USFWS, pers. comm. 2007).

Larvae retained in marshes experience a reduction in residual transport south and out of the lake that lasted about a week (Markle et al. in review). Loss from the lake diminished after larvae reach 28 to 32 days, so marshes were an important part of the retention mechanism. However, diked marshes do the opposite. Instead of retaining larvae and providing hydrographic roughness to slow transport, they provide smoother shoreline and likely facilitate transport out of the lake.

As previously discussed, much of the wetland area in UKL (35,000 acres) was diked and drained for agricultural development prior to the 1960s. About 18,000 acres of historic wetlands around UKL are being restored and re-associated with the lake. The most important wetland restoration area providing habitat for larval suckers is the Williamson River Delta. Approximately 3,600 acres of wetland and open water habitat on the Tulana portion of the Williamson River Delta was reconnected during fall 2007. The remainder of the delta on the Goose Bay property will be reconnected during fall 2008 (2,000 acres). Although it will take several years for the wetland plant communities to become fully established, we expect substantial use of this habitat by larval suckers as soon as spring 2008. This habitat should substantially increase larval retention, decrease entrainment, and increase survival. Effects on recruitment rates are uncertain, but increased survival of larvae could boost recruitment following years when juvenile survival is high.

Lake level management also affects the amount of wetland habitat available for sucker larvae rearing. In most years, UKL fills by April or May providing maximum inundation of shoreline emergent wetlands when larvae from the Williamson River first emigrate to the lake. Water levels generally drop continuously after May decreasing water depth and amount of emergent wetland habitat available for sucker larvae. The impact of this change on larval entrainment is unknown. However, water levels during the larval life stage (April to mid-July) are generally higher now than pre-Project because of reservoir storage during the spring (USBR 2002; see Figure 3-9).

Downstream movement of larval suckers is also likely caused by other factors, including wind speed and direction and discharge at Link River Dam. Under prevailing northwest winds, the residual flow in UKL was a clockwise gyre extending as far north as the shoreline between Agency Strait and Pelican Bay and as far south as Buck Island (Wood et al. 2006). East of Bare Island is a broad, shallow flow to the southeast that returns as a narrow, deep, northwest flow through the trench west of Bare Island (Wood and Cheng 2006; see Figure 3-20). The relatively small fraction of the flow that exits the lake is confined to a narrow boundary current along the eastern shoreline that passes east of Buck Island in the south. Virtual particles created in computer simulations leave the lake if they are caught in the eastern shore current, but they will be retained in the lake if they enter the clockwise flow that skirts the north side of Buck Island.

Strong prevailing winds drive a stronger clockwise circulation than weak prevailing winds and particles were more likely to be entrained in the gyre and stay in UKL under strong wind conditions. In the modeling, virtual particles released at Sucker Springs always left the lake under weak prevailing wind conditions, but were more likely to remain in the lake under strong wind conditions (Markle et al. in review). Although strong winds increase the proportion of retained particles, those particles not retained also reach the lake outlet faster under strong wind conditions. Representative travel times for the virtual particles to the lake outlet are 5 to 6 days (from Sucker Springs) or 8 to 17 days (from Williamson River mouth) under strong and weak prevailing wind conditions, respectively (Markle et al. in review).

Discharge at Link River Dam also affects travel time of particles out of the lake (Reithel 2006; Markle et al. in review). Historically, peak discharge out of UKL was in April before most larvae from the Williamson and Sprague Rivers enter UKL (Perry et al. 2005; see Figure 3-11). After the peak runoff, outflows declined substantially during late spring and summer. Since the development of the Project and operation of Link River Dam, releases have generally been lower and with less fluctuation on a seasonal basis than pre-Project. Therefore, based on the flow at the outlet of UKL there could have been a higher percentage of sucker larvae moving downstream all other factors being equal. However, there was more emergent wetland habitat pre-Project providing for larval retention.

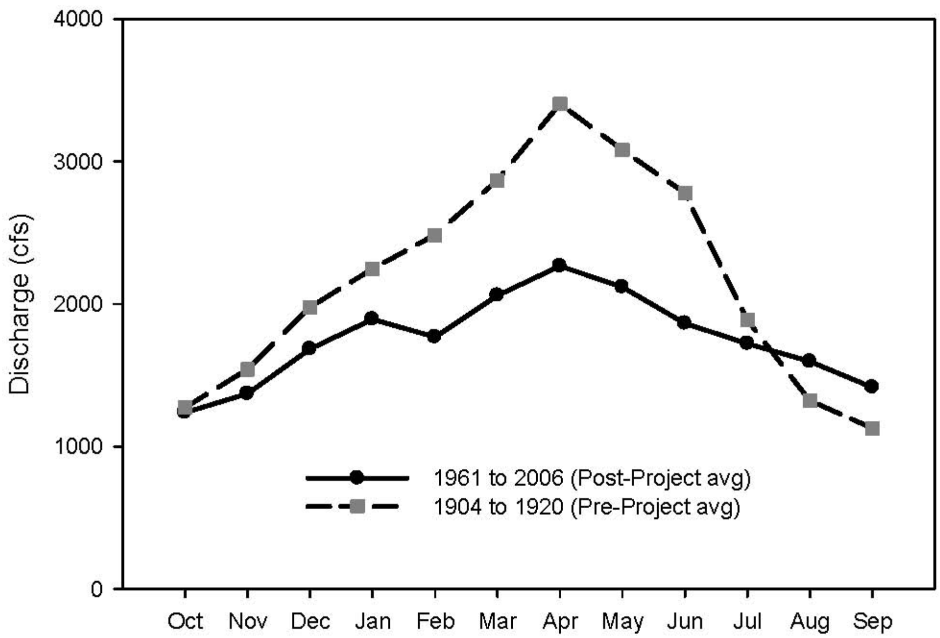


Figure 3-11. Monthly average UKL outflow for the pre-Project (1904-1920) and post-Project (1961-2006) periods.

Studies on larval sucker emigration in the Williamson River estimated approximately 14, 35, and 73 million larvae in 1987, 1988, and 1989, respectively at river mile 6 (Klamath Tribes 1996). However, only 5 million larvae were estimated drifting into UKL near the mouth of the Williamson River in 1989. The reason for the huge decrease in larval estimates at river mile 6 (73 million) and near the mouth of the Williamson River (5 million) is surprising but is suspected that capture efficiency was much lower at the mouth and that the difference was probably not related to mortality between the two locations since transport time is a matter of hours. These estimates do not include larvae produced at the eastside shoreline springs which could be greater than one million.

Estimates for larval entrainment at the outlet of UKL were based on two years of monitoring at the A-Canal in 1997 and 1998 (Gutermuth et al. 1998, 2000a). The combined larval entrainment at A-Canal and Link River Dam was estimated at about 8 million larvae in 1998 (see Appendix

1). Unfortunately, there are no years when entrainment at the UKL outlet and emigration on the Williamson River were concurrently measured. Also, there is considerable uncertainty in the precision of the larval sucker emigration estimates in the Williamson River as well as those for the outlet of UKL (R. Shively, USGS, pers. comm. 2008). Consequently, the impact to the LRS and SNS populations in UKL due to the loss of several million of sucker larvae by entrainment is uncertain.

Downstream movement rates of juvenile suckers from UKL may also be influenced by poor water quality and fish health issues as juvenile suckers captured at Link River in 2006 were heavily infested with external parasites (USFWS 2007b, 2007c; see Appendix 1). Also, peak entrainment was documented during periods of poor water quality in UKL in 1997 and 1998, and many of the fish entrained were in poor health (Gutermuth et al. 2000a).

Sub-adult and adult sucker entrainment at the outlet of UKL appears fairly low, based on studies at A-Canal in 1997 and 1998 and Eastside and Westside power diversions at Link River Dam in 1997 to 1999 (Gutermuth et al. 2000a, 2000b). In 1998, approximately 400 and 14 listed sucker sub-adult/adults were monitored at A-Canal and Eastside and Westside diversions, respectively.

Entrainment also occurs at other diversion dams in the Project including the following: Clear Lake, Gerber, Miller Creek, Malone, Wilson and Anderson-Rose (USBR 2002a). However, Clear Lake Dam was screened in 2003 excluding juvenile and adult suckers but not larvae. The effectiveness of the screen in excluding juvenile and adult suckers was verified in 2003 when fish salvage operations conducted below Clear Lake Dam at the end of the irrigation season captured only three suckers (Bennetts et al. 2004) compared to several hundred suckers captured before the screen was installed (Piaskowski 2002).

Numerous additional point diversions exist in the Project area including: A-Canal (UKL); Sevenmile Canal (Agency Lake Ranch); J-Canal, Q-Canal, Pumping Plant D and R-Canal (Tule Lake sump); and the Lost River Diversion Canal (USBR 1992, 2001a). Reclamation inventoried most non-Project pump and gravity diversions in the Lost River, Klamath River above Keno Dam, and Upper Klamath Lake (USBR 2001b). Reclamation, through its contractors (irrigation districts), has implemented measures to reduce sucker stranding in canals at the end of the irrigation season and has conducted annual canal salvage operations in Project canals (USBR Annual Sucker Salvage Reports 1992-2007).

Reclamation completed construction of a state-of-the-art fish screen at the entrance to the A-Canal in UKL in March of 2003. The A-Canal fish screen was designed to satisfy State of Oregon and Federal fish screen criteria. The screen is designed to protect age 0 (greater than 30 mm long) and sub-adult suckers that can pass through the trash rack openings. The trash racks in front of the A-Canal screen facility has bar spacing of 1 7/8 inch that excludes all adult suckers.

Reclamation conducted canal salvage activities below the A-Canal fish screen in 2003-2004 to evaluate the screen's effectiveness (Bennetts et al. 2004; Bennetts and Korson 2005). In 2003 and 2004, 650 and 80 juvenile suckers were salvaged, respectively, in canals receiving water from the A-Canal. This compares to over 8,000 in 1999 and 7,300 in 2000 (Bennetts et al. 2004). The relatively high number salvaged in 2003 were mostly age 1 juvenile suckers that were likely entrained in 2002 before the screen was built and over-wintered in the canals. However, some of the salvaged suckers during both 2003 and 2004 could have been larvae that passed through the screen and grew in the canal over the summer.

In 2003, Reclamation monitored fish entrainment on the downstream side of the A-Canal fish screens to determine screen effectiveness (Bennetts et al. 2004). No fish were captured from a limited trap netting effort. Larval fish monitoring documented a bypass rate of 30 to 100 percent indicating the screen provides some benefit in excluding larval fish (Bennetts et al. 2004). No attempt was made to identify the species of fish larvae. Borthwick and Weber (2001) observed a total larval fish bypass rate of about 25 percent at a similar fish screen facility on the Sacramento River. Successful bypass at this facility was closely tied to fish species, which was in turn related to fish length. Sacramento suckers, among the larger-sized larval fish sampled, were bypassed more successfully, with about 45 percent being bypassed.

The A-Canal fish screen and bypass facility has two fish bypass structures: 1) the primary return to the lake via a 20-inch diameter Hidrostal pump with a discharge of 10 to 15 cfs, or 2) secondary gravity bypass downstream to the Link River. In 2005, fish-scale loss and physical injury tests were conducted to verify that the Hidrostal pump was fish-friendly (Marine and Gorman 2005). There was no acute mortality associated with operation of the pump and a lack of differences in descaling and other injuries between control and bypassed groups of fish suggesting that the incidence of injury attributable to the pumped bypass for listed suckers is anticipated to be low.

Since the A-Canal screen facility was completed in 2003, Reclamation has monitored fish in the bypass at the beginning of the irrigation season to determine when it is necessary to change from the gravity to the pump bypass and to evaluate the effectiveness of the screen in bypassing fish. The Klamath Irrigation District prefers to operate the gravity bypass as much as possible to minimize pumping costs associated with operation of the A-Canal pump bypass.

Entrainment studies focused on juvenile life stages have been conducted at Gerber Dam, Miller Creek Diversion Dam, and Lost River Diversion Canals (USBR 2007; Bennetts 2005; Bennetts and Foster 2006; Hamilton et al. 2003). Juvenile suckers were captured at all of these diversions. Juvenile sucker entrainment at Gerber Dam was considered relatively low compared to the number of juveniles presumed to be in Gerber Reservoir and does not appear to be a major threat to sucker survival. The study documented substantial entrainment of non-native yellow perch and crappie possibly reducing recruitment and potential negative affects of non-native fish on endangered suckers in Gerber Reservoir (Hamilton et al. 2003). Numbers of entrained suckers were also low at Miller Creek Diversion Dam downstream of Gerber Dam because of the low entrainment there and lack of resident suckers in Miller Creek.

At Lost River Diversion Canal it was difficult to sample suckers because of the lack of velocity; Reclamation conducted limited screw trap operations at Station 48 (outlet of the canal). Substantially more suckers were captured there than in the LRDC because of better capture efficiencies (USBR 2007). Screening of the Miller Hill Pumping Plant on the Lost River Diversion Canal is scheduled for the fall of 2009 by Reclamation and the Klamath Irrigation District (C. Korson, USBR, pers. comm. 2007).

3.2.7 Effects of Changes in Lake Levels

3.2.7.1 Reductions in Habitat Quantity and Quality

Listed suckers utilize a wide diversity of habitats, and habitat use by each species and each life stage is different. The abundance and distribution of both sucker species have been affected by the singular and interacting influences of wetland coverage, water management, establishment of non-native fishes, downstream fish movement, advective wind currents, and water quality. The influence of these factors on each life stage in the Upper Klamath River Basin is discussed below.

Upper Klamath Lake

Listed suckers utilize different habitat types in UKL depending on their life history stage (see Figure 3-12). Adult suckers, predominantly LRS, spawn in shoreline spring areas (Perkins et al. 2000a; Hayes et al. 2002). Larval suckers occupy shallow shoreline areas particularly emergent vegetation (Buettner and Scoppettone 1990; Klamath Tribes 1996; Cooperman and Markle 2004; Terwilliger 2006). Juvenile suckers use a wide range of shoreline habitats including emergent wetlands and open water areas (Terwilliger 2006; Hendrixson et al. 2007a, 2007b). Sub-adult and adult suckers are primarily found in the open water areas except during the spawning season (Buettner and Scoppettone 1990; Peck 2000; Banish et al. 2007; Terwilliger 2006).

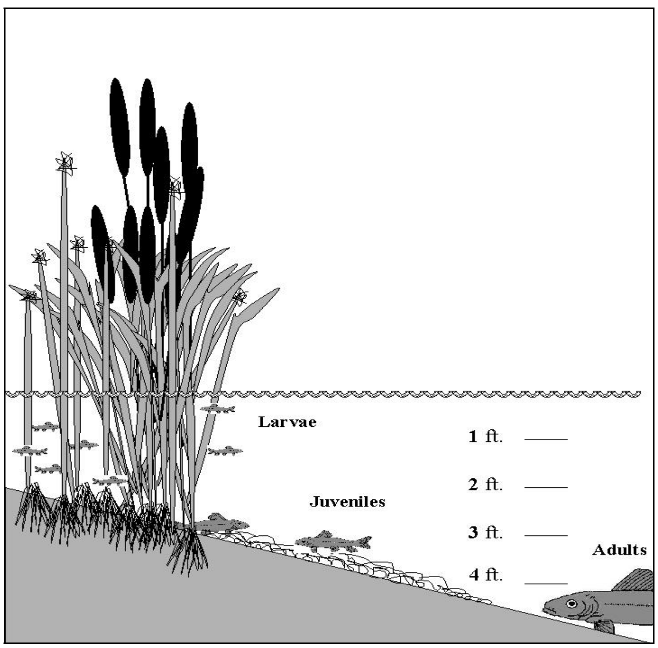


Figure 3-12. Diagram showing habitats of sucker life stages in UKL.

Shoreline Spawning Habitat

A discrete group of LRS and SNS are known to spawn at sites along the eastern shoreline of UKL below Modoc Rim, a prominent fault scarp (Andreasen 1975; Buettner and Scoppettone 1990; Hayes and Shively 2001; Shively et al. 2000a, Barry et al. 2007b). Most of the sites also have associated springs and seeps (i.e., Boulder, Sucker, Silver Building, and Ouxy Springs; see Figure 3-13). Current spawning populations are likely in the thousands of LRS and less than 100 SNS (Barry et al. 2007b; Janney et al. 2007).

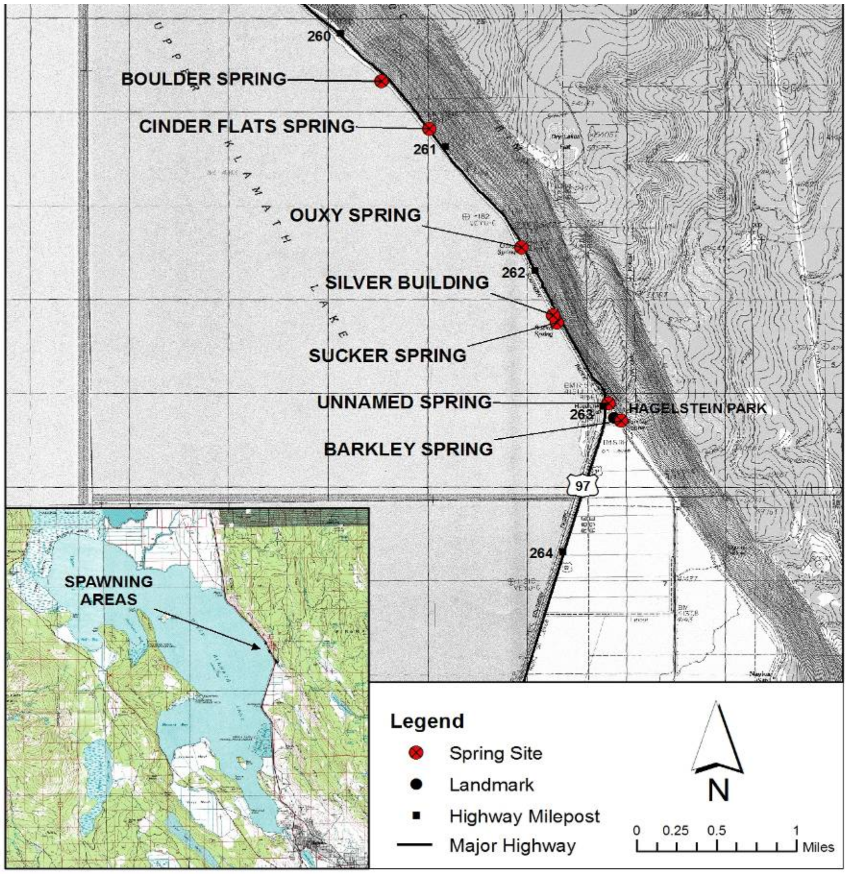


Figure 3-13. Map of the eastern shore of UKL showing springs were suckers have historically spawned.

Shoreline sucker spawning starts in February and extends through May (Perkins et al. 2000a; Reiser et al. 2001; Shively et al. 2000a; Barry et al. 2007b). Eggs are broadcast or slightly buried during spawning, just as they are during river spawning (Buettner and Scoppettone 1990, 1991; Perkins and Scoppettone 1996; Perkins et al. 2000a).

All known shoreline spawning sites in UKL have a substrate of relatively clean gravel, cobble and intermixed rock. These sites are shallow because suitable coarse substrate occurs mostly in the shoreline zone where wave action and exposure to air that keeps the substrate relatively free of algae and fine sediment. At Sucker Springs, gravel and cobble substrates were added in 1987 and 1991 to increase the area of the spawning habitat (Perkins et al. 2000a). Historic spawning sites that are no longer used by suckers include Harriman, Odessa, and Barkley Springs (Andreasen 1975; Markle and Cooperman 2002). It is unclear why these sites are no longer used but it may be linked to over-fishing of stocks that used these springs for spawning. What role, if any, the springs play in either attraction of adult suckers or survival of eggs and embryos is unknown. It is possible that the relatively warmer water temperatures near the larger springs during late winter and early spring might attract suckers.

It is possible that there are undetected spawning sites in the lake. During low lake levels in 1994, OSU biologists surveyed the shoreline for springs and evidence of historic snag fishing (e.g., hooks and weights) that would indicate historical use of these sites by suckers. Four sites were found below Modoc Rim where there was probable historic spawning. However, current use of these sites for spawning is unconfirmed (OSU, unpublished data). More recently, Eilers and

Eilers (2005) assessed near-shore substrate types in UKL and Agency Lake and found gravel, cobble, and mixed rock substrates in a number of areas (e.g., Howard Bay west shore, Bare and Buck Islands, Ball and Coon Points, and the southern end of UKL). Spawning season surveys are needed to determine if any of these areas are used by suckers.

Accessibility of spawning substrates with sufficient water depth could be crucial to spawning success and ultimately could determine the long-term survival of the lake spawning populations (Reiser et al. 2001). This is especially the case since known spawning sites are few in number and small in area, with most being only a few hundred square feet in size.

In 1995, The Klamath Tribes conducted an intensive sucker spawning survey at Sucker Springs (Reiser et al. 2001). Sucker spawning was documented in water depths of 0.6 to 3.8 feet. However, over 95 percent of the sucker embryos found at this site were at depths of 1.0 to 3.5 feet. The limits of the spawning area occur at a lake elevation of about 4139.0 to 4141.5 feet at Sucker Springs and 4139.5 to 4142.5 feet at Ouxy Springs.

Sucker spawning (mostly LRS) currently occurs at a few shoreline areas including Sucker Springs, Silver Building Springs, Ouxy Springs, Cinder Flat and Boulder Springs along the east side of UKL (Hayes et al. 2002). Because spring spawning areas are located along the eastern shoreline of UKL, lake elevation plays an important role in the availability of these spawning habitats. Average inundation of spawning habitat at Cinder Flat, Ouxy, Silver Building and Sucker Springs decreases from 100 percent to 75, 50, 30, and 15 percent at 4143.3, 4142.0, 4141.0, 4140.0, and 4139 feet, respectively (USBR 2002a). Past and current UKL level operations have generally resulted in increasing lake levels during the winter and filling the lake during April or May (USBR 2002a). Generally, elevations have been such that at least 50 percent of the spawning habitat was inundated to a depth of at least 1 foot. However, during past drought years, UKL did not fill and lake levels inundated very little of the shoreline spawning habitat (USBR 2001a). Since Link River Dam was constructed, UKL operations have resulted in average lake levels slightly lower in February (0.3 feet) but generally little spawning occurs during this month (Figure 3-7). Lake levels are very similar to those pre-Project during the major shoreline spawning period of March. During April and May, post-project average elevation of UKL is about 0.5 feet and 1.0 feet higher than pre-Project, respectively.

Larval suckers

Sucker larvae are generally present in UKL from late-March and early April through mid-July, with peak numbers appearing in mid-May to mid-June (Cooperman and Markle 2000; Simon et al. 1996; Simon et al. 2000; see Figure 3-14). Larval sucker habitat in UKL is generally near-shore in water less than 2 feet deep and generally associated with emergent vegetation or some form of structure (Buettner and Scoppettone 1990; Markle and Simon 1994; Cooperman and Markle 2000; Klamath Tribes 1996). Larvae of both LRS and SNS use wetlands, but SNS show a greater affinity to this habitat type (Markle et al. in review). Sucker larvae rearing in emergent vegetation have been reported at densities up to 16 larvae/m^2 (Klamath Tribes 1996). Recent sucker density estimates for the Williamson River Delta averaged 8 larvae/m^2 in 2006 and 3.5 larvae/m^2 in 2007 (H. Hendrixson, TNC, pers. comm. 2008). Emergent vegetation affords early larval suckers with protection from predators (Markle and Dunsmoor 2007) and possibly diverse food resources and protection from waves during storm events (Klamath Tribes 1996; Dunsmoor et al. 2000).

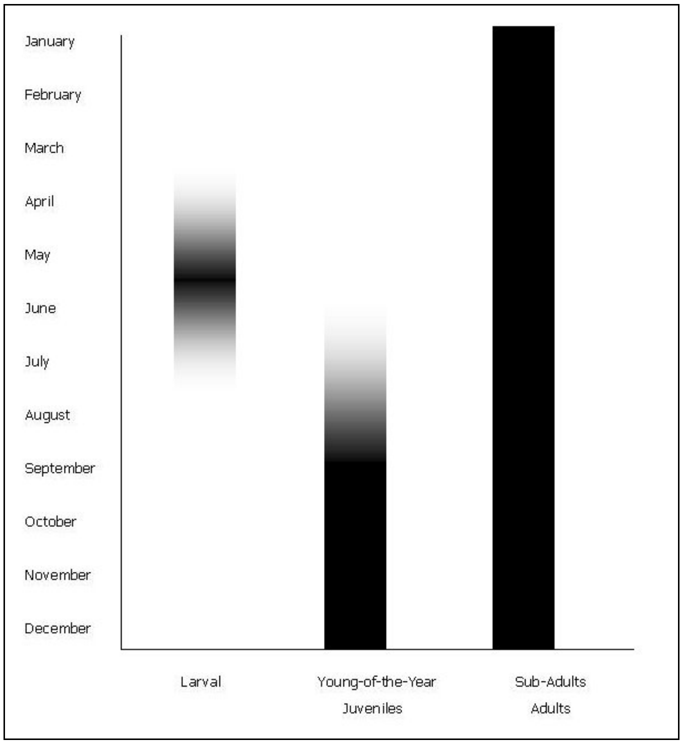


Figure 3-14. Seasonal occurrence of Lost River and shortnose sucker life stages.

Cooperman and Markle (2004) determined that emergent vegetation supported significantly more, larger, and better-fed larvae than submergent macrophytes, woody vegetation, or open water in near-shore areas. The importance of emergent vegetation appears to be related to increased foraging success and reduced predation. Because larvae primarily consume widely distributed planktonic prey, Markle and Clauson (2006) suggested that emergent vegetation was primarily used as a predation refuge rather than a preferred feeding site. Markle and Dunsmoor (2007) documented improved survivorship of larvae when vegetation and water depth were provided for cover. As lake level decreases, so does the area of available emergent vegetation in UKL (see Figure 3-11). Thus, lake elevation in UKL influences larval sucker access to nursery habitat (Dunsmoor et al. 2000; Terwilliger 2006; Markle and Dunsmoor 2007). Klamath Project operations have likely not decreased the amount of larval sucker habitat in UKL because lake levels during the larval sucker period are higher now than they were prior to construction of the Link River Dam (see Figure 3-7).

Due to the large numbers of spawning adult suckers in the Williamson River, the area around the river delta and in nearby Goose Bay is considered to be crucial nursery habitat for sucker larvae (Dunsmoor et al. 2000). Dunsmoor et al. (2000) quantified potential larval habitat along the UKL shoreline in the area around the Williamson River Delta to assess how changes in lake elevation and shoreline morphology influence distribution and availability of larval and juvenile sucker habitats provided by emergent vegetation. Although they found that lake elevation was the major factor affecting the vertical distribution of wetland vegetation, other factors such as slope and aspect were also important and, consequently the spatial distribution of wetland plant species varied within and among the three geographic areas. The relationship between lake elevation and inundated emergent vegetation was relatively linear. Thus, flooded vegetation was most available at full pool level (4143.3 feet) and diminished as lake levels dropped. At about 4139 feet lake elevation, emergent vegetation in the lower Williamson River and to the east and west of the river mouth along UKL becomes essentially dewatered (Dunsmoor et al. 2000).

Table 3-1 summarizes the percentage of emergent wetland that is inundated at various lake elevations based on the analysis by Dunsmoor et al. (2000). These data show there was very little emergent vegetation available to young suckers at lake levels of 4140 feet and below along the Williamson River Delta shoreline, prior to breaching of the dikes at Tulana in 2007.

Table 3-1. Approximate percentage of emergent wetland habitat at three locations on the Williamson River Delta that were inundated at different lake elevations prior to reconnection in 2007 (from Dunsmoor et al. 2000).

UKL Elevation (ft MSL)	Williamson River (Percent)	Goose Bay Shoreline (Percent)	Tulana Shoreline (Percent)
4139	0	0	0
4140	0	3	5
4141	5	10	30
4142	30	45	55
4143	80	85	85

Reiser et al. (2001) used unpublished Reclamation survey data from the north end of UKL and Agency Lake to assess the relationship between emergent marsh habitat and lake level. Assuming that sucker larvae need nursery habitat at least 1 foot deep, almost no suitable habitat would be available to them at a lake elevation of 4139 feet; about 40 percent of the marsh edge would be inundated to 1 foot at 4140 feet; and about 70 percent of marsh edge habitat would be inundated to 1 foot at 4141 feet (see Figure 3-15). If larvae use interior areas of the marsh these values would be even lower.

Fluctuations in larval abundance may result from a number of interacting factors, such as inter-specific interactions with other species, lake management, lake level, seasonal variability in wind patterns, or large-scale processes such as climate changes (Markle and Dunsmoor 2007). Recent information suggests that lake level management may influence non-native fish predation on larval suckers (Markle and Dunsmoor 2007).

Though a direct relationship between larval abundance and lake level from the 1995 through 2005 was not found to be statistically significant, the inverse relationship between larval sucker survival and fathead minnow abundance was significant, and fathead minnow abundance was inversely correlated with July and August lake levels (Markle and Dunsmoor 2007). Markle and Dunsmoor (2007) state that "…it is clear that larval suckers tend to do poorly when fathead minnow do well and that fathead minnows appear to benefit from low summer lake levels." This possibility is further supported by data in Figure 2-23 (page 127) in the Biological Assessment (originally from Markle 2007). These data show that during the first six years of the ten-year period studied (1995 to 2005), larval sucker production increases were associated with higher lake elevations at June 15 the prior year (i.e., larval sucker production was high when lake elevations were high the prior year, and low when lake elevations were low the prior year). At this time this relationship between larval suckers, fathead minnows, and lake levels the previous year is only a correlation and no causal mechanism has been identified. Regardless if this is real or a statistical artifact, it does point out something that lake managers should be concerned with and that is that lake level effects are likely complex and could affect suckers through a variety of ecological processes, and therefore efforts should be made to better understand how lake levels affect the lake ecosystem.

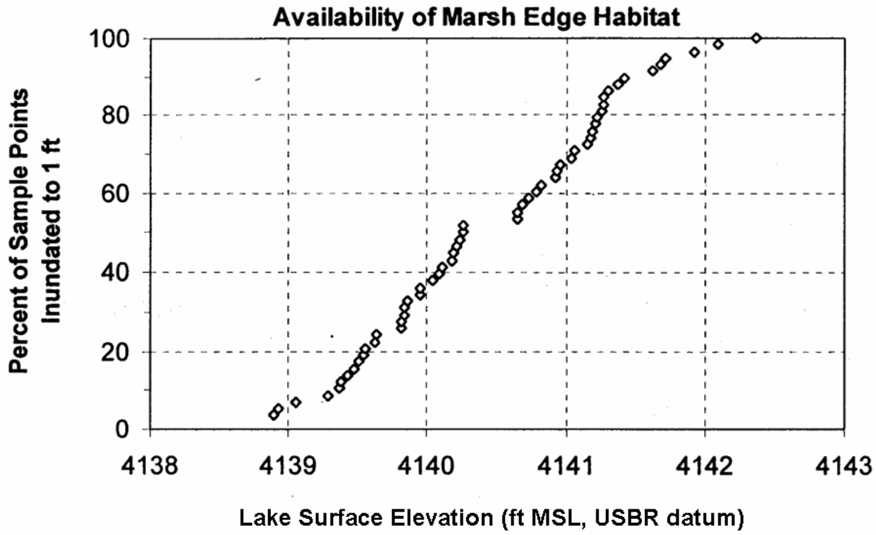


Figure 3-15. Availability of marsh edge habitat based on percentage of sample points inundated to 1 foot vs. UKL elevation (from Reiser et al. 2001)

Markle and Dunsmoor (2007) also provide laboratory studies showing a reduction in encounter rates between larval suckers and fathead minnows should increase larval sucker survival. They showed that more inundated emergent vegetation should reduce encounter rates and suggest that lake management plans should consider targeting reductions in fathead minnow abundance. There is evidence of regular recruitment in Gerber Reservoir and in Clear Lake, and neither of these has emergent wetland vegetation because of substantial changes in lake elevations. It is possible that turbidity provides cover from predators for larvae in these two water bodies or that predator levels are lower than in UKL. It could also indicate that sucker larvae are limited more strongly by factors other than predation in Gerber Reservoir and Clear Lake.

The habitat provided by emergent wetlands in UKL could also reduce advection away from the north end of UKL (Reithel 2006; Markle et al. in review). Hydrodynamic modeling of wind-driven circulation suggests that sucker larvae emigrating from the Williamson River would most likely move east and then south along the shoreline as a result of the circulation (Markle et al. in review; see Figure 3-20). This could be highly important because larvae swept down-lake would be more likely to be lost at the Link River Dam. Because very low DO levels occur in Keno Reservoir in summer (CH2M Hill 1995; NRC 2004; Deas and Vaughn 2006; USBR 2007), any larvae entrained at the dam would likely die in the Keno Reservoir from adverse water quality or be swept farther downstream where habitat conditions are also unsuitable for suckers (FERC 2007; USFWS 2007a).

The advection dynamics suggest that the location in the lake of the larval sucker population will determine its abundance (Markle 2007). The August shoreline abundances of about 70 percent of the SNS juveniles and 35 percent of the LRS juveniles are due to location in the lake. Essentially, the farther north in UKL that larval suckers are distributed, the less likely the larvae are to move downstream from the lake through the Link River. The retention of larvae traveling the prevailing currents of UKL can be influenced by shoreline roughness such as that provided by emergent wetlands and entrance into the internal gyre which has the ability to carry larvae northerly (Markle et al. in review). Increased shoreline roughness (i.e., near-shore wetlands) is available at higher lake elevations, and increased larval sucker entrance into the internal gyre of UKL occurs at lower lake elevations (Markle et al. in review). Both SNS and LRS larvae distribution patterns are affected by both shoreline roughness and entrance into the internal gyre; however our understanding of the gyre and its ability to transport larvae is poorly understood.

In summary, lake level affects the area of available emergent vegetation in UKL that may enhance larval survival particularly SNS by providing a predation refuge and retentive habitat to slow emigration. Markle and Dunsmoor (2007) showed that larval sucker survival from 1995 to 2005 appeared to be constrained by fathead minnow abundance and lake elevation, but the relationship is complex, and the field data were sufficient only to confirm trends identified in the lab. Sucker larvae particularly LRS are transported downstream and out of the lake because winds increase the strength of the eastern shore current that transports them. High lake elevations and greater area of emergent vegetation create retention habitat that could slow larval downstream movement and possibly reduce emigration and entrainment rates at the lake outlet. Past and current operations have resulted in higher lake levels on average during the larval sucker life stage than before Link River Dam was constructed. Therefore, there were no adverse effects except during extremely dry years like 1992 and 1994 when little emergent vegetation habitat was inundated during the larval life stage.

Juvenile Suckers

Larvae grow into juveniles during the summer when they reach 20 to 30 mm TL and become bottom-oriented (Terwilliger 2006). Juvenile sucker habitat particularly SNS is generally in near-shore areas with depths less than 4 feet. There is substantial evidence that emergent vegetation also provides important habitat for juvenile suckers (Reiser et al. 2001; VanderKooi and Beulow 2003; VanderKooi et al. 2006; Hendrixson et al. 2007a, 2007b). Burdick et al. (in review) also found a preference for small substrate (fines, sand, and gravel) and submerged or emergent vegetation based on a patch occupancy approach that accounts for potential inconsistencies in detection probability among sites and sampling occasions. If submerged and emergent vegetation habitats are important for early juvenile suckers, perhaps continuing as a predation refuge, then their habitat availability diminishes as lake elevation recedes. Nearly all emergent vegetation is unavailable to fish at elevations less than 4139 feet (see Figure 3-15). Recent monitoring data suggests that juvenile LRS may have more of an off-shore distribution (D. Markle, OSU, pers. comm. 2008).

Juvenile suckers also occupy a wide range of substrates (Markle and Simon 1993; Reiser et al. 2001; Simon et al. 2000; Simon and Markle 2001; VanderKooi and Beulow 2003; Burdick in review). Investigations of juvenile sucker habitat use in UKL have documented use of different substrates in un-vegetated near-shore areas: mud (fines) and sand (Buettner and Scoppettone 1990); gravel and cobble (Simon et al. 2000; Terwilliger et al. 2004; Terwilliger 2006); sand, gravel, intermixed rocky substrates, and cobble (Hendrixson et al. 2007a, 2007b). Simon et al. (1995) identified coarse substrate habitat (non-fines) as important for juvenile suckers (age-0). The authors indicated that this substrate type likely only extends up to 60 feet from the shorelines and they postulated that rocky substrates become dewatered at about 4138 feet elevation. Near-shore substrates in UKL and Agency Lake vary depending on location, slope, elevation, and distance from shore (Dunsmoor et al. 2000; Simons et al. 2000; Eilers and Eilers 2005). A detailed shoreline substrate survey was conducted by Eilers and Eilers (2005). Mud is the dominant near-shore and offshore substrate in UKL and Agency Lake, with cobble, gravel, and sand, each representing 2 to 4 percent of the near-shore zone (see Table 3-2). Eilers and Eilers (2005) determined that sand and larger-sized substrates (i.e., gravel, cobble, rock, and boulder) were mostly confined to depths less than 6 feet or lake levels greater than 4136 feet, which is 2 feet deeper than Simon et al. (2000). The Eilers and Eilers (2005) survey was much more rigorous than the Simon et al. (2000) effort.

Table 3-2. Dominant UKL and Agency Lake nearshore substrate types and the percent of the shoreline they represent (from Eilers and Eilers 2005).

Lake	Dominate Nearshore Substrate	Percent of Shoreline
Upper Klamath Lake	Mud	58
	Boulder	22
	Clay	6
	Sand	4
	Rock	4
	Cobble	4
	Gravel	2
	Other	<1
Agency Lake	Mud	84
	Sand	13
	Clay	2
	Rock	<1

As the summer progressed, OSU documented a shift in the distribution of juveniles from the northern end of UKL to the shorelines of the southern portion of UKL, generally south of Buck Island (Terwilliger 2006). This pattern of juvenile sucker distribution was remarkably constant from 1994 to 2003 and consistent with the prevailing south-flowing eastern shore current (Wood et al. 2006). Movement of suckers southward through the summer are also associated with increased entrainment of juveniles into the A-Canal and Link River Dam (Gutermuth et al. 1998, 2000a, 2000b; Foster and Bennetts 2006; Tyler 2007).

Juvenile sucker investigations by USGS that were specifically designed to address movement patterns did not provide strong support for a north to south migration of juvenile suckers throughout the summer in 2002, 2003, or 2005, but there was some indication it occurred in 2004. Higher sustained catch rates for both LRS and SNS in the south could be the result of southern migration, lower mortality in the south than the north, or higher capture probability in the south than the north. While larval suckers may drift in a clockwise direction with the prevailing currents (Wood et al. 2006; Markle et al. in review; see Figure 3-20), USGS transect sampling did not suggest juvenile suckers travel with the same summer time trajectory. Higher sustained catches of juveniles in the south may also be a result of spawning at eastside springs, which would provide additional larval input to the southern end of the lake, given larval distribution patterns.

During late summer and early fall, many juvenile suckers appear to leave near-shore areas (Terwilliger 2006). One explanation for this is that juvenile suckers move to deeper offshore habitats to avoid predators following an ontogenetic shift in diet (NRC 2004; Markle and Clauson 2006). In contrast, USGS data suggest a late summer offshore migration did not occur as juvenile suckers were more likely to occupy shallower than deeper habitats during this time period within the range of depths sampled (1.5 to 10 feet; Burdick et al. in review). The seasonal habitat shift by juvenile suckers may also be induced by lake level management (USFWS 2002), or may be a biological response to environmental conditions or changes in physiological demands (USBR 2007), or it may be due to competitive displacement or resource partitioning by non-native fish (VanderKooi et al. 2006). A recent study found that non-native fish were more abundant nearshore than native suckers (VanderKooi et al. 2006) and native suckers were found to prefer to inhabit nearshore, vegetated areas (Burdick et al. in review). The authors state that the prevalence of fathead minnows in their sampling makes it seem "almost certain competition with juvenile suckers for resources existed at some level." However, the literature generally shows juvenile temperate zone fish move offshore in late summer and fall (D. Markle, OSU, pers. comm. 2008).

Effects of lake level on juvenile sucker survival may be most pronounced during very dry years like 1992 and 1994 when end of season elevations were 4137.4 feet and 4136.8 feet respectively. There were very few juvenile suckers collected during these years suggesting that a threshold may have been reached leading to minimal survival (Markle 2007).

As the lake level recedes during the summer, juvenile sucker access to and availability of shoreline habitat decreases. Those fish occupying these areas likely move into deeper open water areas which may increase their predation risk from larger fish predators. Our analysis indicates that operations of the Project have increased the rate of decline of lake levels in the summer and brought lake levels to lower than pre-Project levels from August to February each year (see Figure 3-7). Therefore, the Project has likely caused juvenile suckers particularly SNS to move out of near-shore areas with emergent vegetation and coarse substrates at younger ages than they would prefer each summer. It is unknown whether this has caused increased mortality and lower recruitment.

Adult Suckers

Whereas larvae and juvenile suckers primarily use shallow shoreline habitats, adult suckers and sub-adults are mainly found offshore at greater depths (Terwilliger 2006). For fish that primarily occupy open water, depth and turbidity may provide the only available cover from avian fish predators, such as the American white pelican, osprey, and bald eagle (Banish et al. in review). American white pelicans, which are common in the Upper Klamath Basin, are known predators of adult lake suckers and can consume suckers up to 65 cm FL (fork length) in size (Scoppettone et al. 2006). In Pyramid Lake, Nevada, American white pelicans are a major source of mortality of the cui-ui (*Chasmistes cujus*), an endangered lake sucker (G. Scoppettone, USGS, pers. comm. 2007). Radio tags that were implanted in adult suckers in UKL have been found at pelican loafing areas at Upper Klamath Marsh and bald eagle roost trees (M. Buettner, USFWS, pers. comm. 2007).

Radio telemetry studies by Reclamation and USGS have shown that adult suckers are primarily found at the north end of UKL from June to September (Peck 2000; Reiser et al. 2001; USGS 2003; Banish et al. 2007; Banish et al. in review). During this period, they are found in open water areas of the lake typically at depths of greater than 9 feet and they tend to avoid depths less than 6 feet (Peck 2000; Reiser et al. 2001; Banish et al. 2007; Banish et al. in review). During tracking studies, both LRS and SNS always avoided depths less than 3 feet (Banish et al. 2007). In studies done in 2005 and 2006, LRS selected water depths greater than 9 feet, and SNS often selected depths greater than 6 feet (Banish et al. 2007; Banish et al. in review). Adult suckers are primarily found at water depths greater than the mean depth available in the area where they occur. This suggests they are actively selecting the depths at which they are found.

Because adult LRS and SNS select water depths greater than 6 feet and avoid depths less than 3 feet, their distribution is likely to be affected by changes in UKL elevations. Banish et al. (2007) noted that as UKL elevations dropped over the summer, LRS use of water depths of 6 to 9 feet increased relative to shallower depths. This suggests the suckers responded to low lake levels by moving into deeper water, even though these areas are more likely to experience low DO concentrations (Wood et al. 2006).

As summer progresses UKL levels decline and between August and October levels range between 4138 and 4140 feet post-Project; the mean depth of the lake in summer is only 4 to 6 feet (USBR 2000a). During this time, water quality is poor. As a result, adult suckers are likely to change their distribution in response to these changes and may need to travel and expend more energy in an effort to find suitable depths with sufficient DO concentrations (Banish et al. in review). In the summer, adult suckers need to store energy both to survive the winter, when low temperatures reduce feeding, and to have energy reserves necessary for spawning the next spring.

As lake levels decline, adult suckers are also more likely to be vulnerable to pelicans and other fish-eating birds. The relationship between depth and lake level in the northern portion of UKL indicates that past and present lake level operations have impacted the amount of available habitat in the north end of UKL. Decreasing lake levels through the summer reduces the available habitat for adult suckers. It is unclear what the effects of reduced habitat is on adult suckers, but likely contributes to stress and energy loss.

Adult suckers in UKL move into so-called refuge or refugial areas during periods of poor water quality (Beinz and Ziller 1987; Buettner and Scoppettone 1990; Buettner 1992; Banish et al. in review). Radio-tracking studies by Reclamation and USGS at the north end of UKL in the summer have confirmed use of Pelican Bay and to a lesser degree use of the Williamson River mouth by adult suckers when water quality is poor.

Use of refuge areas was best documented in late July and early August 2003 and again in July and August 2006 (Banish et al. 2007; Banish et al. in review). Tracking of adult suckers fitted with radio transmitters showed adult suckers were generally in the deeper water (mostly 9 feet or more), and then numerous suckers moved into Pelican Bay where the depths are relatively shallow (Banish et al. in review; see Figure 3-16). It is likely that suckers move into Pelican Bay because of better water quality linked to the influence of ground water coming from Pelican Butte and adjacent high elevation areas of Cascades. Use of the refuge area in 2003 coincided with a large-scale low dissolved oxygen event (LDOE) when DO values outside the bay were less than 4 mg/l (Wood et al. 2006; Banish et al. in review).

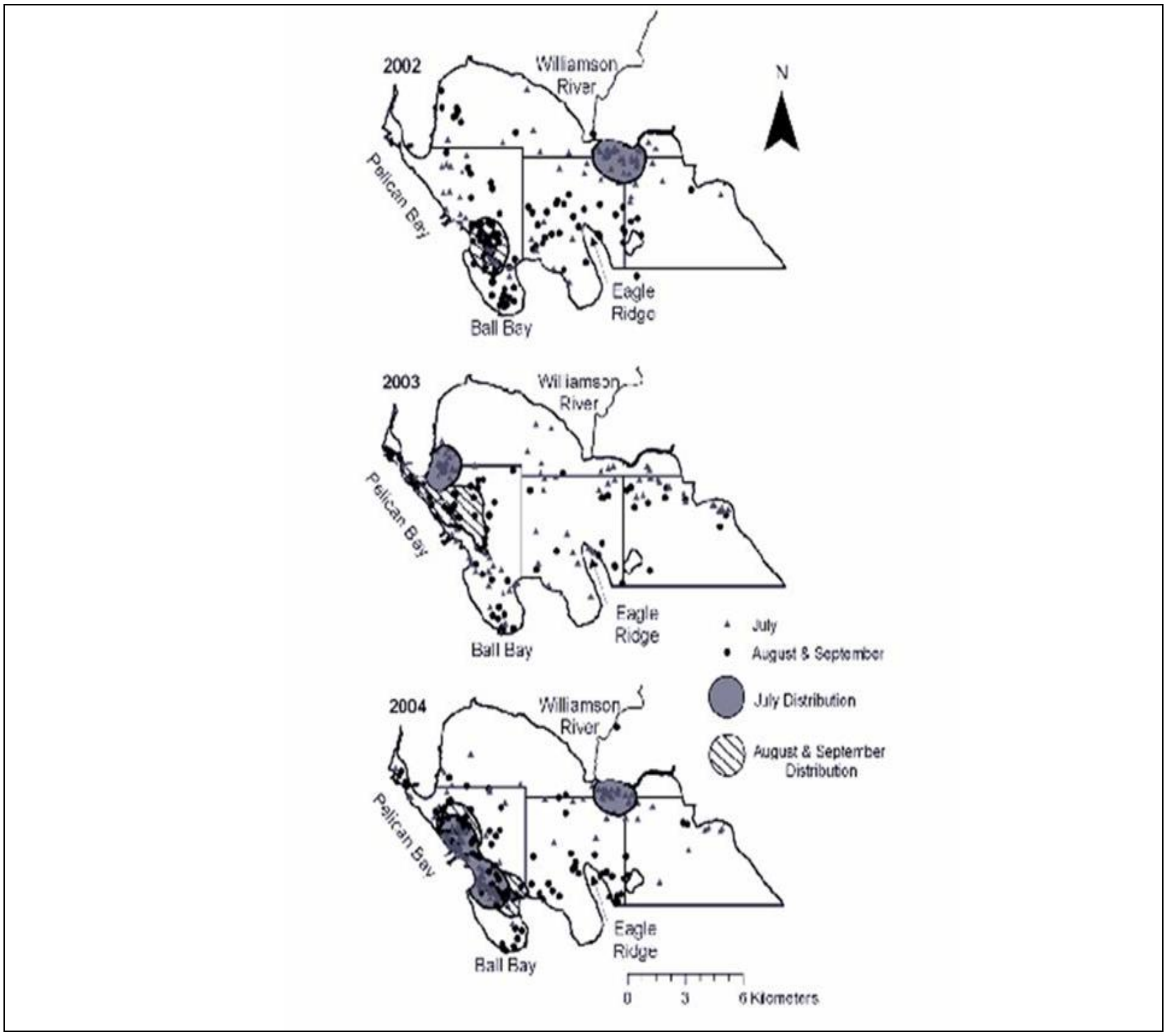


Figure 3-16. Distribution of radio-tagged adult suckers in UKL 2002-2004 (from Banish et al. in review). Note how the distribution of suckers in 2003 was more closely tied to Pelican Bay when compared to 2002 and 2004.

Bottom elevations outside Pelican Bay vary from about 4134 to 4136 feet, and inside they range from about 4134 to 4140 feet (see Figures 3-17 and 3-18), with the exception of Crystal Creek that is at 4131 feet elevation (Figure 3-18). Buettner (1992) found minimum access elevations into Pelican Bay were approximately 4135 feet. Because lake elevations ranging from about 4140 to 4138 feet could occur during the mid to late summer, water depths in Pelican Bay could be 6 feet deep or less. Also, access to the bay could be across areas only 2 to 5 feet deep. If adult suckers avoid depths of less than 6 feet, low lake levels in late summer could adversely affect suckers if they are reluctant to enter shallow areas with better water quality.

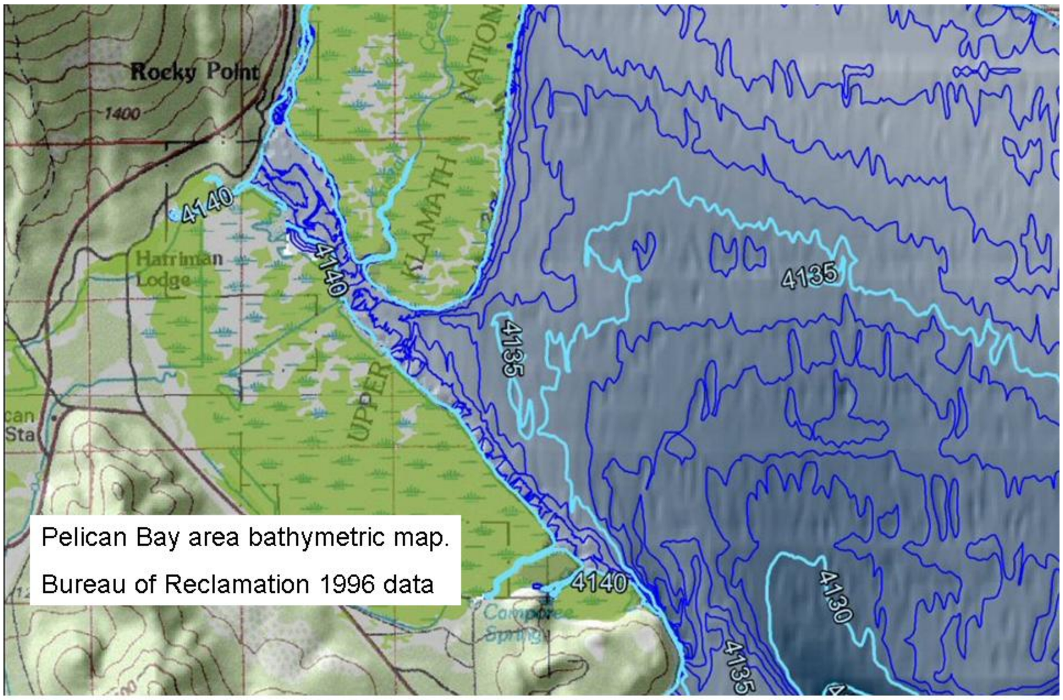


Figure 3-17. Bathymetric map of the Pelican Bay area of UKL. Adopted from Klamath Project website http://www.usbr.gov/mp/kbao/maps/index.html.

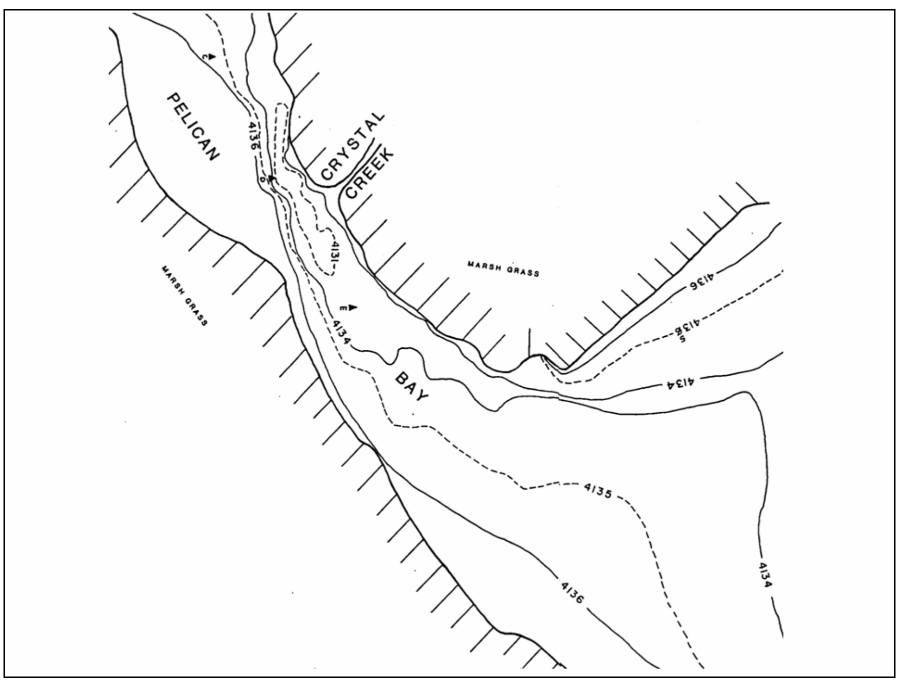


Figure 3-18. Bathymetric map of the inner portion of Pelican Bay (USBR data).

Threats posed by low lake levels could be exacerbated if they cause suckers to aggregate in relatively small areas where pathogens like *Aeromonas* and Columnaris might be readily spread (Banish et al. in review). The radio-tracking data obtained by USGS in 2003 indicates there was some crowding of suckers in Pelican Bay during the LDOE (Banish et al. in review). Dead suckers found during the 1996, 1997, and 2003 die-offs were affected by Columnaris and/or *Aeromonas* (Holt and Green 1996; Holt 1997; Foott 1996, 1997, 2004; Banish et al. in review); although in the 2003 die-off no Columnaris pathogens were identified on suckers (Foott 2004).

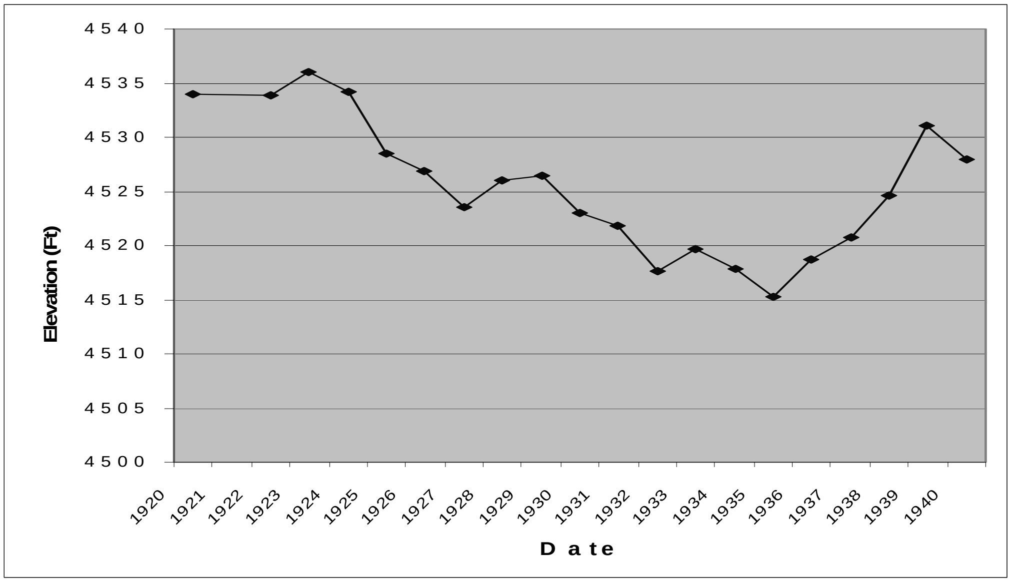
Although LDOE sufficiently severe to cause substantial sucker die-offs are infrequent, these events pose a severe threat because most of the adult sucker population in UKL is relatively small in number and vulnerable to die-offs. Even if the LDOE does not cause acute mortality it could stress suckers sufficiently that they become vulnerable to opportunistic pathogens. Because adult suckers tend to be crowed in Pelican Bay when the water quality is poor, they might be at an increased risk of disease. However, there is no evidence of higher mortality of radio-tagged suckers that moved into Pelican Bay than those that did not. Thus, low lake levels in summer could pose a rare but possibly substantial unquantified risk to both species of endangered suckers.

Adult suckers begin to redistribute throughout the lake after September and demonstrate a wider range of depth requirements (Banish et al. 2007). Lake elevation may be less critical to fish condition from October through February. Most fish, and presumably suckers, become less active during this time of year due to low water temperatures, and water quality conditions throughout the lake are generally good through winter. However, harmfully low DO levels can occur during ice-cover conditions if they persist for long periods. Ice-cover conditions can occur on UKL from November through March, lasting from a few weeks to several months (USFWS 2002). The deletion rate of DO in the water column increases as the depth of the lake decreases because the lower volume of water holds less oxygen relative to the biological oxygen demand of the sediments. Ice-cover also eliminates wind-induced mixing that adds oxygen to the water and prevents stratification. With ice-cover conditions, stratification occurs and near-bottom water may become anoxic (no oxygen) leading to release of high levels of ammonia from the sediments into the water column. When ice cover breaks up, the high ammonia mixes throughout the water column, potentially having a negative effect on sucker growth and health. As a result of this process, there is a higher, although unquantified risk of poor water quality following ice out at lower lake elevations compared to higher lake elevations (USBR 2002).

Little data are available on water quality conditions during ice-cover events; however, in late February of 2008, Reclamation water-quality staff used airboats on the ice to sample over 10 sites in UKL and Agency Lake (J. Cameron, USBR, pers. comm. 2008). The sampling indicated that DO levels were adequate for suckers at all of the stations; although, there were some stations with values near 2 mg/l close to the bottom. DO values near 2 mg/l could be stressful to suckers (Loftus 2001).

Clear Lake

Clear Lake is particularly vulnerable in drought years because net inflows are relatively low as a result of a small watershed, low annual precipitation, agricultural diversions in the upper watershed, and substantial evaporation from its large surface area. During a drought, lake levels can decrease substantially. Following a drought, levels are sometimes slow to recover, persisting for multiple years like events in the 1920s and 1930s (see Figure 3-19).



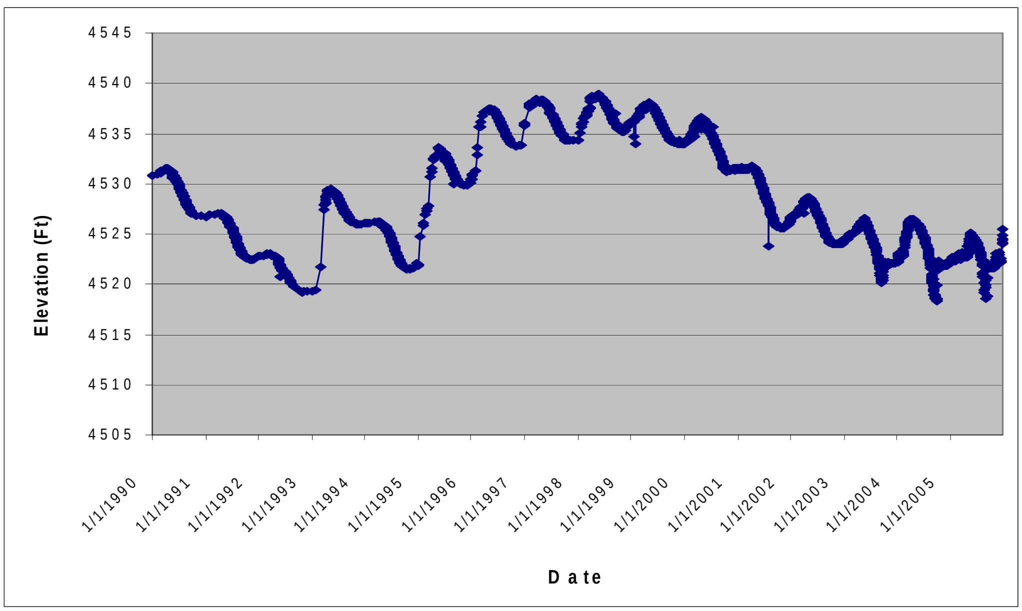


Figure 3-19. Clear Lake elevations on January 1 of each year 1920 to 1940 (upper graph) and 1990-2005 (lower graph) (USBR data). The lowest level was recorded in 1934, when Clear Lake reached an elevation of only 4,514.5 feet (USBR 1994).

Record low lake levels occurred in Clear Lake in the 1930s and in 1992 (see Figure 3-19).   In the 1930s, low water levels persisted for 8 years, reaching a minimum elevation of 4,514 feet, which is just 1 foot above the lowest elevation contour line shown on bathymetric maps (USBR 1994). In 1992, Clear Lake reached a low level of 4,519.4 feet after 6 years of drought, and the east lobe of the lake was dry, except for a small pool near the dam (USFWS 1994c). Clear Lake was also low in 2004 and 2005 after five years of drought (Figure 3-19).

We have no data on the effect of low water levels on LRS and SNS in Clear Lake in the 1930s, except they must have survived to still be present. However, following the low water levels in Clear Lake in 1992, and extended ice-cover in the winter of 1992-1993, Reclamation biologists noted suckers were in poor health (USBR 1994). This was attributed to parasitism, especially lampreys which nearly tripled in abundance from 1992 to 1993, and reduced food availability for suckers (M. Buettner, USFWS, pers. comm. 2005).

During years when the surface elevation of Clear Lake is less than 4524 feet from February through April, access to spawning areas in Willow Creek is blocked (USFWS 2002). In recent years with water operations resulting in minimum lake levels above 4520.6 feet in the fall, water levels have been at least 4524 feet by February due to fall and winter precipitation (USBR, unpublished data).

In 1992, when Clear Lake elevation reached a minimum of 4519.4 feet in October, suckers showed signs of stress including low body weight, poor development of reproductive organs, reduced juvenile growth rates and high incidence of external parasites and lamprey infestation (USBR 1994). Overall fish body conditions were improved with increased body weight and fewer parasites and lamprey wounds at higher lake levels in 1993 to 1995 (Scoppettone et al. 1995). Water level operations since 2002 have resulted in minimum water levels above 4520.6 feet providing adequate habitat for suckers in Clear Lake, as demonstrated by monitoring conducted by USGS from 2005 to 2007 (Leesburg et al. 2007; Barry et al. 2007c; USGS, unpublished data). These investigations documented relatively abundant populations of LRS and SNS with multiple sizes of fish suggesting frequent recruitment.

Gerber Reservoir

During years when the surface elevation of Gerber Reservoir is less than about 4805 feet from February through April, access to SNS spawning habitat in Barnes Valley and Ben Hall Creeks is restricted (USBR 2001a). In 1992 and 1994, water levels were below 4805 feet and no spawning migrations were documented (USBR 2001a; USBLM 2000). Since 2002, Reclamation has proposed water operations that result in minimum lake levels above 4798.1 feet (USBR 2002a). Although water levels have remained well above this level from 2002 to 2007, Gerber Reservoir is typically able to refill to at least 4805 feet by the spring months, so access to spawning tributaries is re-established when suckers typically spawn. However, in dry years these streams typically have very low flows that may not be sufficient to provide upstream passage of spawning adults regardless of lake elevation (USBR 2001a).

Unlike UKL, where larval and juvenile suckers utilize emergent wetland habitat for rearing, no wetland habitat exists in Gerber Reservoir and larvae utilize shallow shoreline areas for habitat (Simon et al. 1995). Low lake levels will reduce the area of shallow shoreline habitat available for larval suckers.

When juvenile and sub-adult/adult rearing habitat shrinks to low amounts during dry years, suckers are likely stressed by poor water quality (high temperature and low DO); increased competition and predation with non-native fish; and increased incidence of disease and parasites (USBR 2001a). Effects of low lake levels on larval and juvenile suckers are likely to be greater than sub-adult/adults since they have lower food reserves, higher metabolism, and lower mobility, and are more vulnerable to predators (USBR 2007). Although lake levels have reached relatively low levels in 1992, 1994, and 2003 to 2005, sucker monitoring activities have documented relatively abundant populations of SNS with multiple size classes and presumably multiple age classes indicating water operations over the last 15 years have not resulted in negative population level effects.

Lost River

Construction and operation of one Project Dam (Lost River Diversion Dam) and two non-Project Dams (Harpold and Big Springs) has created lacustrine habitat that support small resident SNS populations. Past and current operations of these facilities provides adequate habitat to maintain these small self-sustaining SNS population.

Tule Lake

Tule Lake sumps (1A and 1B) water depths under past and current operations are very shallow (less than 5 feet deep). These water level operations appear to provide adequate habitat for larval and juvenile LRS and SNS life stages. However, lack of deep areas in the sumps and the gradual sedimentation that appears to be occurring (USFWS 2002) is detrimental to sub-adult/adult suckers that require water depths greater than three feet to avoid predation by fish-eating birds particularly pelicans. The Service has been investigating options to restore deep water habitat including small-scale dredging and flooding existing agricultural lease lands that have subsided (D. Mauser, USFWS, pers. comm. 2007).

3.2.7.2 Reductions in Water Quality

Upper Klamath Lake

In UKL, water quality poses the greatest risk to suckers during the period from July to mid-October (Kann 1998; Wood et al. 1996; Perkins et al. 2000b; Loftus 2001; Welch and Burke 2001; Wood et al 2006; Morace 2007). Although a number of water quality parameters in UKL regularly reach levels known to be stressful or lethal to suckers and other fish (e.g., pH, ammonia, DO), low DO (or hypoxia) appears to be the most important in terms of fish health (Martin 1997; Martin and Saiki 1999; Perkins et al. 2000b; Loftus 2001; Welch and Burke 2001; Wood et al 2006; Morace 2007). Because fish die over an extended period of time following these events, the actual cause of death in these situations appears to be opportunistic pathogens that infect the fish once they are stressed and weakened by hypoxia (Perkins et al. 2000b; USFWS 2002).

In previous BOs for the Project, it was our opinion that lake levels adversely affected water quality in Project lakes and reservoirs and in UKL in particular (USFWS 2001, 2002). In the *Environmental Baseline* section of the 2002 BO, we explained that there were a number of possible hypotheses potentially linking lake level and water quality. We believed the best available scientific information supported the hypothesis that low lake levels exacerbated poor water quality conditions during the late summer and fall, especially in dry and critically dry water-year types, by increasing the number and extent of areas affected by early morning declines in DO. This effect was likely to increase the frequency and/or magnitude of small-sized fish die-offs. A detailed analysis of the effects of adverse water quality was presented in Appendix E of the 2002 BO.

In developing the 2002 BO, we believed that when conditions are right (i.e., a high biomass of decomposing AFA, warm temperatures, and calm winds) shallow areas of the lake are subjected to stressful or lethal early-morning DO declines or LDOE. Shallow areas of the lake (less than 3 feet) appeared to be at greatest risk of LDOE because the ratio of sediment surface area to water column volume is highest in shallow water, and that would lead to reductions in DO over the night as a result of biological and chemical processes in the sediment and the water column removing DO (Miranda et al. 2001). For these early-morning LDOE to occur, DO losses during the night and early morning had to exceed the amount of DO produced during the day plus any re-aeration that occurred through the night.

In 2002, we thought that shallower areas of UKL would be most susceptible to an LDOE because relatively high sediment oxygen demand (SOD) have been measured (Wood 2001) and because mean depths are shallow Wood (2001) estimated that DO levels in the water column could be reduced to low levels by SOD in less than a day under the right conditions. This conclusion was based on the measurement of SOD in Ball Bay, whereas the measurements in the open waters of the lake were more moderate. Based on observations from continuous water quality monitors that have been placed in the lake since 2002, it appears that LDOE occur in the shallow embayments (Howard Bay in particular and to a somewhat lesser extent, Ball Bay). These embayments tend to develop localized bloom dynamics and the LDOE within them are not necessarily coincident with the most severe LDOE that occur in the open waters of the lake (Hoilman et al. 2008). Consistent with the high SOD measured in Bay Bay (Wood 2001), a likely cause of the LDOE within the embayments is the sinking to the bottom and subsequent decay of a dense layer of AFA. Even more recently, in 2006 and 2007, continuous monitors were placed in near-shore areas of UKL and there were a few observation of short but severe LDOE in the open waters of the lake, but in another case a LDOE along Modoc Rim in 2007 did not seem related to simultaneous conditions in the open waters of the lake. There is some evidence, therefore, that shallow water very close to the shoreline is susceptible to infrequent occurrences of short duration but severe LDOEs (T. Wood, USGS, pers. comm. 2008).

With regard to the open waters of the lake, however, and the adult sucker habitat in the northern third of the lake, the hypothesis that shallow water in UKL is at greatest risk of LDOE is not supported by the latest available data. Instead, LDOE appears to be primarily associated with conditions created in deeper water (Wood et al. 2006; Morace 2007). LDOE are now believed to be mostly caused by a rapid AFA bloom decline (a "crash"), plus conditions that favor net loss of DO from the water column (i.e., BOD and SOD). This appears mostly to occur in areas of the lake where the total depth is greater than about 8 feet, and most of the water column is below the depth to which light can penetrate (Wood et al. 2006).

Limnologists refer to the shallow portion of the water column where photosynthesis occurs as the "photic zone" and the deeper zone where there is little or no photosynthesis as the "aphotic zone." The photic zone is relatively shallow in UKL during the summer (only 5 to 8 feet deep during heavy blooms; Wood et al. 2006) because of the high biomass of AFA present in addition to the suspended solids and colored molecules in the water that absorb and scatter light. Because UKL is so shallow in summer (averaging 6 feet or less), most of the lake volume is in the photic zone and therefore oxygenated. In general, there should be sufficient DO for fish as a result of photosynthesis plus surface re-aeration (DO diffusing into the water from the air). However, an AFA crash could create a LDOE because there would be little DO produced by photosynthesis in combination with increased respiration in the water column and sediment, causing a net loss of DO.

Recent studies suggest that large-scale LDOE in UKL are most likely related to wind-driven circulation (see Figure 3-20). Work by Cheng and Wood, and others with the USGS have found that much of the lake normally circulates in a clockwise manner during the summer months due to prevailing northwest winds (Cheng et al. 2005; Wood et al. 2006). If AFA-rich water occurs in the relatively deep Eagle Ridge Trench (approximately 60-feet deep; Vincent 1968), where the aphotic zone makes up most of the water column, hypoxic conditions can result if DO-consuming processes dominate. When the water in the trench becomes depleted of DO, and is then circulated into the north end of the lake, it can adversely affect adult suckers (Banish et al. 2007). The affect can be particularly severe when coincident with a crash in the AFA bloom because then the water lacks the potential to replenish DO quickly through photosynthesis as well.

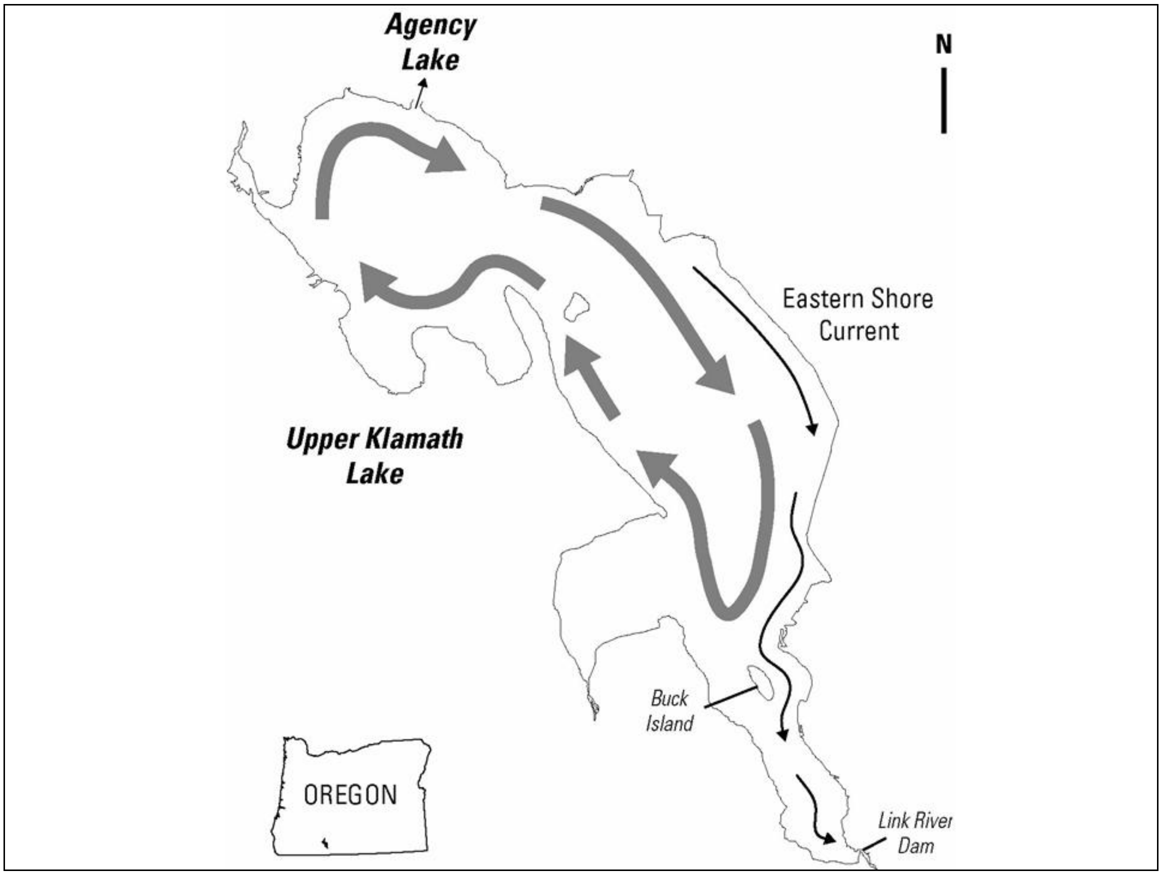


Figure 3-20. Circulation pattern of UKL under the prevailing northwest winds (from Markle et al. in review). Note the eastern shore current that flows south to the lake outlet.

In 2003, Wood et al. (2006) observed an LDOE occurring in late July that lasted for several weeks and covered 15 square miles at the north end of UKL (Wood et al. 2006; see Figure 3-21). During that event, median study-area DO levels were near 2 mg/l, which is likely stressful to suckers (Loftus 2001) because it is close to lethal levels of about 1 mg/l (Martin and Saiki 1999). According to Wood et al. (2006), USGS biologists observed 108 dead adult suckers during the 2003 LDOE event, indicating that conditions did lead to sucker mortality. In addition, 2003 was exceptional because of the relatively high water temperatures which peaked above 28° C for brief periods. Because SOD and other DO-consuming processes are increased at higher temperatures, high lake temperatures likely exacerbated the LDOE. Considering how low DO levels were during the July 2003 LDOE, it is surprising that more adult suckers did not die during that event. It has been speculated that the low mortality might be due to the lower biomass of fish present since many fish were lost in the 1996 and 1997 die-off events (M. Buettner, USFWS, pers. comm. 2005).

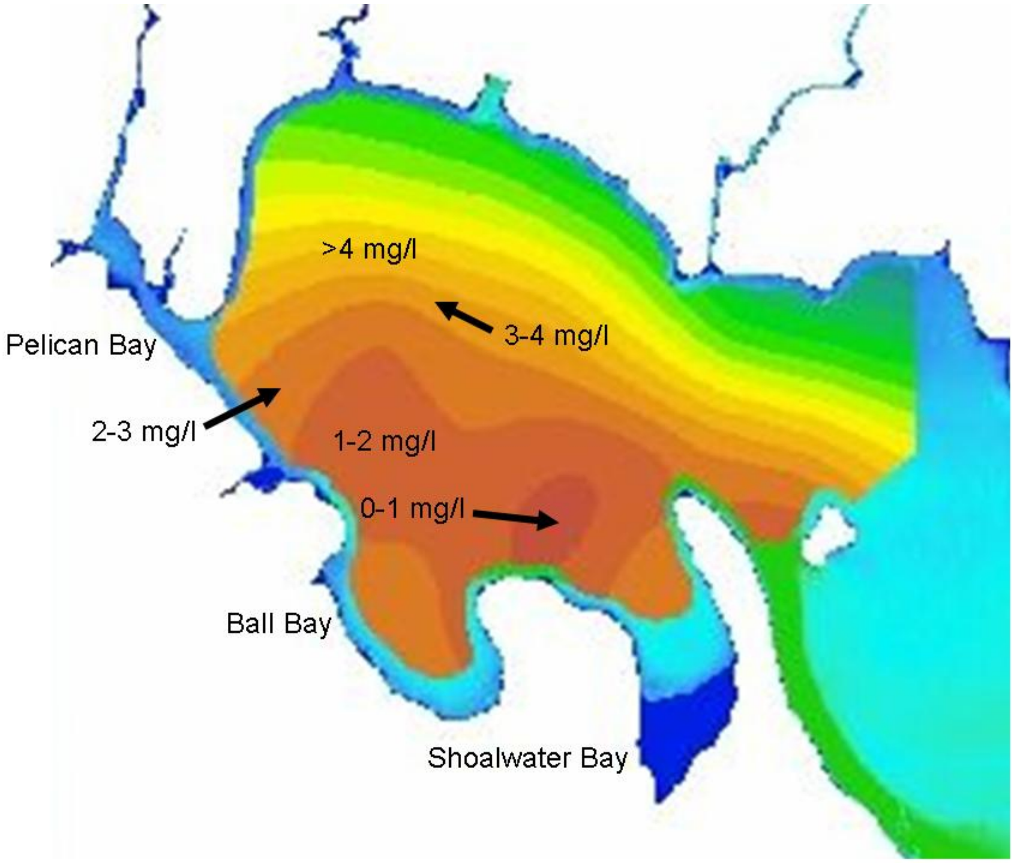


Figure 3-21. Median DO levels at the north end of UKL during Julian week 31, 2003, which began on July 27, 2003 (from Wood et al. 2006).

Short-lived LDOE might also occur during calm periods in the summer when temperature differences between the surface and bottom cause vertical stratification. Stratification isolates bottom water from DO-producing processes in the photic zone. This could allow hypoxic conditions to develop below the stratified zone as DO is removed by respiration processes in the sediment and water column. The 2003 LDOE observed by Wood et al. was not associated with stratified conditions but was due to movement of hypoxic water from the trench into the north end of the lake where the adult suckers reside in the summer (Wood et al. 2006).

Morace (2007), who did an analysis of 17 years of UKL water quality data, could not find a relationship between UKL elevations and DO concentrations. Her analysis was based on data intended to be used for long-term trend analysis and not specifically collected to address lake elevation effects to LDOE. She found that DO levels were most likely to be low when there was a high biomass of AFA. Not surprisingly, according to Morace (2007) the incidence of low DO concentrations is greatest in the Eagle Ridge Trench area of UKL where the deepest water depths occur.

The impact of changes in UKL levels, as a result of water level management, on water quality has been the subject of considerable debate. It has been hypothesized that greater lake depth mitigates for low DO values, improves under-ice and winter water quality, reduces un-ionized ammonia concentrations, reduces AFA biomass by reducing light intensities, delays AFA bloom initiation in the spring, dilutes internal phosphorus loading, dilutes pH, and reduces AFA biomass (USFWS 2002). However, several analyses of existing UKL water quality data has failed to demonstrate a relationship between lake depth and poor water quality (Wood et al. 1996; NRC 2004; Morace 2007).

The National Research Council conducted a scientific evaluation of the USFWS and NMFS BOs on the threatened and endangered fishes of the Klamath River basin (NRC 2002, 2004). This evaluation included analyzing existing data for the Klamath River basin and reviewing the 2001 and 2002 BOs. NRC (2004) concluded that "…there is no substantial scientific support for the USFWS BO recommendations concerning minimum water levels for UKL and there is presently no sound scientific basis for recommending an operation regime for the Klamath Project that seeks to ensure lake levels higher on average than those occurring between 1990 and 2000." Considering the fact that intense AFA blooms have been attributed to causing poor water quality conditions in UKL (Bortleson and Fretwell 1993; Kann 1998; Risley and Laenen 1999; Perkins et al. 2000b; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007), the effect of lake level on algal biomass is of particular importance. Upon analysis of existing data, NRC (2004) found no relationship between UKL level and AFA density (represented by chlorophyll-a concentration), and the idea of reducing algal density by phosphorus dilution with higher lake levels is "not consistent with the irregular relationship between chlorophyll and lake level." There is no apparent association between lake level and the intensity of AFA blooms (NRC 2004).

Also, NRC (2002) was unable to identify a quantifiable relationship between UKL depth and extremes of DO and pH. In fact, the most extreme pH conditions recorded for UKL during the 10-year period from 1990 to 2000 occurred in 1995 and 1996, which were intermediate water depth years, and not during 1992 and 1994 when water levels were the lowest within the historical range of operations for UKL. The years 1995, 1996, and 1997, where extensive fish die-off events were observed, were intermediate lake level years. Further, 1991 was a low lake level year and yet was also a year of good sucker production (NRC 2002).

USGS has conducted extensive analyses of existing water quality data from UKL. Wood et al. (1996) concluded that there was no evidence for a relation between any of the water quality variables considered (chlorophyll-a, DO, pH, and total phosphorus) and lake depth on the basis of seasonal distribution of data or a summary seasonal statistic. The analysis found that low DO, high pH, high phosphorus concentrations, and heavy blooms of AFA were observed each year regardless of lake depth. The USGS repeated this analysis with a 17-year dataset (1990 to 2006) and the inclusion of eleven more years of data did not demonstrate a discernable relationship between lake depth and water quality (Morace 2007). Wood et al. (1996) did find that lower lake levels coincided with an earlier onset of the AFA bloom; however, these findings were not supported by Morace (2007) with the analysis of the more robust 17-year dataset. Both Wood et al. (1996) and Morace (2007) found a relationship between spring temperatures and the timing of the onset of the AFA bloom. The onset of the AFA bloom was delayed when spring air temperatures were cooler (Wood et al. 1996; Morace 2007). These analyses suggest that climatic conditions may have a greater influence on UKL water quality than lake level and other variables considered. This is not to say that water depth has no effect on water quality, but that existing data and analyses have not shown a discernable relationship between UKL elevation and water quality over the range of depths that UKL has been operated at during the period from 1990 to 2006.

USGS has recently developed a hydrodynamic model of UKL that shows that wind-driven currents play a large role in determining the water quality in the lake (Cheng et al. 2005; Wood and Cheng 2006; Morace 2007). This hydrodynamic model, as well as other experiments conducted by USGS, indicated that the deep trench along the western shoreline of UKL is important because it is an area of net consumption of DO (Wood and Cheng 2006; Morace 2007). In the long-term, the hydrodynamic modeling effort and water quality data sets currently being collected by USGS will likely provide more insight than the previous analyses conducted by Wood et al (1996), Morace (2007), and Hoilman et al. 2008 into the complex interactions of processes that influence water quality (Morace 2007).

It is important to note that the data used for the Wood et al. (1996), NRC (2002), and Morace (2007) analyses were collected as part of a monitoring program designed to assess long-term trends in water quality and not to address the relation between UKL water quality and various forcing functions (Morace 2007). The major limitation of the dataset used for these analyses is the two-week sampling interval, which is too infrequent to capture the variation in water quality that occurs within UKL where water quality conditions can vary significantly on time scales as short as a few days (Wood et al. 1996; Morace 2007). Additional water quality data collection conducted by USGS has confirmed that water quality varies significantly in time scales much shorter than the two-week interval of the dataset used for the analyses (Wood et al. 1996; Morace 2007), therefore, the dataset may be insufficient for analyses performed by Wood et al. (1996), NRC (2002), and Morace (2007) to detect a relationship between lake level and water quality in UKL. However, if a particular variable, including lake level, was of overwhelming importance, and particularly if the predominant time scale were a month or more, then these analyses would be able to demonstrate this strong relation (Morace 2007).

Clear Lake

Low lake levels at Clear Lake may result in degraded water quality, including higher water temperatures and lower DO levels. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival except in 1992 when water levels were lowered to 4519.4 feet (USBR 2001a; Hicks 2001). The major concern for harmful and/or lethal water quality conditions is associated with winter ice-cover periods. Low lake levels have an increased risk of low DO and potential winter die-off during ice-cover conditions. During the winter of 1992-1993, Clear Lake was ice-covered for several months at an elevation of about 4519.5 feet with most of the lake less than 5 feet deep. However, DO concentrations during the ice-cover period that year remained at adequate levels for sucker survival (USBR 1994).

In 2002, Reclamation proposed and the Service agreed that water operations resulting in a minimum lake elevation at Clear Lake of 4520.6 feet was acceptable (USBR 2002a; USFWS 2002). Water levels during 2003 to 2005 reached annual minimums near this level but there was no evidence of poor water quality (USBR 2007; USBR, unpublished data).

Gerber Reservoir

At low lake elevations, suckers may become concentrated in the remaining pool and experience stress (USBR 2001a). Low lake levels may result in degraded water quality conditions including high temperatures, high pH values, and low DO levels. However, water quality monitoring over a range of lake levels and years documented water quality conditions that were generally adequate for sucker survival except in 1992, when Gerber Reservoir dropped to a minimum elevation of 4796.4 feet (USBR 2001a; Piaskowski and Buettner 2003). In 2002, Reclamation proposed a minimum elevation of 4798.1 feet is needed to protect sucker at Gerber Reservoir (USBR 2002a) and the Service agreed that operations resulting in lake levels above this level were permissible (USFWS 2002). Water levels have been well above the 4798.1 feet elevation in recent years and there has been no indication of poor water quality conditions or adverse affects of water level management on suckers in Gerber Reservoir.

Tule Lake

Tule Lake Sumps 1A and 1B are part of the Tule Lake NWR. The refuge supports many fish and wildlife species and provides suitable habitat and resources for migratory birds of the Pacific Flyway. Portions of the refuge are also used for agricultural purposes. The refuge receives water indirectly for Project facilities in the form of return flow and drainage. Sump 1A and 1B are refuge facilities that are managed to meet wildlife needs including the needs of endangered suckers. Reclamation, through a contract with Tulelake Irrigation District, manages deliveries to the sumps and pumping out of the sumps for agricultural and refuge uses. It also operates Pumping Plant-D to aid the Tule Lake NWR in maintaining the elevations necessary in the sumps to meet wildlife needs and requirements. Pumping Plant-D is also operated to provide irrigation water to lands dependent on the P-Canal system (Lower Klamath Lake area), including both refuge and private lands. Water delivered from the pumping plant is the sole source of irrigation water for some private lands and part of Lower Klamath NWR.

Tule Lake sumps are very shallow (less than 5 feet deep) and highly eutrophic with high concentrations of nutrients and resultant elevated aquatic plant productivity (USFWS 2002). Water quality in the sumps is very similar to UKL with large fluxes in DO and pH (Buettner 2000; Hicks et al. 2000; Beckstrand et al. 2001). Water levels in the sumps are maintained over a narrow range of elevations. During the spring and summer, water levels are maintained at 4034.6 feet and during fall and winter levels are held at 4034.0 feet. The objective water levels are specified by regulations to facilitate waterfowl production and hunting and protect the Tule Lake area and the reserved sumps that Reclamation leases for agricultural use. Water levels of the sump areas are kept low during the fall and spring to provide flood protection for private lands. The major effect of the relatively constant water levels is on the health of emergent wetlands in the sumps. Specifically, relatively constant water levels have resulted in a narrow band of emergent vegetation along the periphery of the sumps and development of a decadent emergent wetland near the mouth of the Lost River. Emergent wetlands can enhance water quality conditions during the growing season by nutrient uptake (Geiger 2001) and provide cover from predation to larvae and juvenile suckers (Markle and Dunsmoor 2007). Due to current infrastructure of the water delivery system and low levees around the sumps, greater fluctuation in water levels to enhance suckers in the sumps is not feasible.

3.2.8 Fertilizers and Pesticide Use

The application of pesticides within the Project area may affect the following conservation needs of suckers: 1) the need to increase population size; 2) the need to reduce the effects of poor water quality; and 3) the need to provide adequate habitat for all life-stages.

Pesticides and other agrochemicals are used on Project rights-of-way, in Project canals, and on private lands that receive Project water. Agricultural activities on these private properties are considered in this opinion to be interdependent or interrelated to the operation of the Project, if the activities are dependent on Project water or if Project drains are used. However, some agricultural activities would proceed because they use groundwater, dry land farming, and non-Project diversions.

Use of fertilizers in excess of the needs of crops or applied without appropriate Best Management Practices (BMPs) are considered a potential threat to suckers because the likelihood that the chemicals will enter sucker habitat and contribute to water quality degradation is increased. This is especially a problem in parts of the Lost River where suckers reside (e.g., Wilson Reservoir, Tule Lake sumps; USFWS 2002).

The Federal Insecticide, Fungicide, and Rodenticide Act require that risks of pesticides to wildlife be assessed during the pesticide registration process which is administered by USEPA. Under the Endangered Species Act, USEPA must ensure that use of pesticides it registers will not result in unreasonable adverse effects on the environment of listed species. USEPA uses the risk quotient method to assess risk of pesticides to fish and wildlife. Risk to listed species is identified when endangered species Level of Concern criteria are exceeded (USEPA 1986). In some cases pesticide labels are modified to address the Level of Concern. In cases where endangered species concerns are not adequately addressed with label modifications, the USEPA must consult with the Service on particular species and implement use limitations developed through the section 7 process that are either specified in biological opinions or developed from those opinions. USEPA has not consulted with the Service on LRS or SNS and has not instituted any specific use limitations to protect these species or their critical habitat.

The Service's February 9, 1995 BO (FWS log# 1-7-95-F-26; USFWS 2005) provided incidental take coverage for use of the aquatic herbicide acrolein in Project irrigation canals operated by the Klamath Irrigation District and Tulelake Irrigation District. The 1995 BO was amended in 1999 (FWS log#1-10-99-F-103), to include canals operated by Langell Valley Irrigation District. Mosquito control in Project canals by Klamath County Vector Control was also considered in the 1995 BO. The effects of pesticide and fertilizer use on the Federal lease lands near the Tule Lake NWR, is also covered by the 1995 BO and amendments. Because pesticide use on Project rights-of-way and canals have been the subject of consultation, past and present impacts to listed suckers should be minimized.

3.2.9. Klamath Hydroelectric Project

PacifiCorp owns and operates the Klamath Hydroelectric Project (KHP) in the Upper Klamath River. The KHP consists of five main-stem dams (four of which supply powerhouses), two powerhouses at the Federal Link River Dam, and one tributary facility (Fall Creek Powerhouse) (PacifiCorp 2000). The dams are small to medium size, ranging from 25 to 173 feet in height, and impound small to medium-sized, narrow reservoirs. The segment of the Klamath River between Link River Dam (upstream) and Iron Gate Dam (downstream) consists of about 24 miles of river reaches and about 36 miles of reservoirs.

PacifiCorp filed an application under the Federal Power Act with the Federal Energy Regulatory Commission for a new license in 2004. The KHP's license expired in 2006 and it is currently operating under an annual license. The Service consulted on the proposed relicensing of the KHP under section 7 of the ESA and finds that the proposed action is likely to adversely affect LRS and SNS but is not likely to jeopardize these species (USFWS 2007a). The LRS and SNS are likely to be adversely affected because there will be continued potential for entrainment or impingement of larval and juvenile suckers at KHP powerhouse intakes and spillways, false attraction and harm at downstream tailrace barriers, stranding of fish, restricted passage at dams, degradation and loss of instream and wetland habitat, degradation of water quality related to KHP operations, and predation and competition with non-native fishes that thrive in impoundments. For additional discussion see the FERC BO (USFWS 2007a).

3.2.10 Forest Practices

Throughout the Upper Klamath Basin, timber harvesting and activities associated with it (such as road building) by Federal, State, Tribal, and private landowners have resulted in soil erosion on harvested lands and transport of sediment into receiving waters adjacent to or downstream from those lands. Approximate annual timber harvest in Klamath County peaked in the 1940s at 800 mbf and was approximately 400 to 450 mbf from 1970 to 1990 (Risley and Laenen 1999). It declined in the 1990s and was 200 mbf in 2003. Logging and road building practices in the past did not often provide adequate soil stabilization and erosion control. Risley and Laenen (1999) reported that timber harvest and associated roads have contributed to the high sediment and nutrient inputs to UKL from tributary watersheds. However, the impact from timber harvest on nutrients and sediment input to UKL is unquantified.

The Service assumes that forestry practices using accepted BMPs have minimal impacts to listed species, including suckers. However, it remains to be determined whether acceptable BMPs are being fully implemented in areas where they could affect suckers.

Timber management affects listed suckers through a variety of impacts or alterations to watershed structural conditions and functional capacity. The primary pathways for negative impacts are through alterations of stream temperature patterns, hydrologic and sediment regimes, and reduction of channel complexity as well as the structural features that maintain channel complexity. Potential adverse effects also include introduction of pollutants, e.g., fuel and fertilizers, pesticides and herbicides, into watercourses while conducting harvest, site preparation, stand maintenance activities, and wildfire suppression (USFWS 2002).

In summary, forestry activities that adversely affect native fish populations and their habitats are primarily timber extraction and road construction, especially where these activities affect riparian areas. These activities, when conducted without adequate protective measures, alter stream habitat by increasing sedimentation, reducing habitat complexity, increasing water temperature, and promoting channel instability. Although certain forestry practices have been prohibited or altered in recent years to improve protection of aquatic habitats, the consequences of past activities continue to adversely affect native fishes and their habitat.

3.2.11 Urban and Industrial Area Activities

Human population densities in most of the Upper Klamath River watershed including the Lost River sub-basin are relatively low. Small towns like Chiloquin, Bly, and Merrill are unable to afford state-of-the-art wastewater treatment facilities, and thus may contribute to water quality problems. Leaking septic systems located near water bodies have been identified as a problem (Klamath County 1995). Klamath County has prepared an assessment of water resources that provides many recommendations for water quality improvements. The Service is unaware of the current status of these recommendations. The county does have minimum set-back regulations for placement of septic systems and for development. These restrictions should help reduce adverse impacts to aquatic ecosystems.

Residential development in the Klamath Falls area and Merrill has likely had some negative effects on LRS and SNS through reductions in water quality. However, since the largest concentrations of listed suckers are upstream from urban areas, impacts are limited to Keno Reservoir and the Lost River below Merrill. Improvements to the city of Klamath Falls' and South Suburban wastewater treatment facilities are expected to help improve water quality in

Lake Ewauna. The South Suburban Wastewater District had eliminated much of its wastewater effluent by using it for cooling of the Klamath Cogeneration Plant with some also discharging into a treatment wetland. These entities have studied several conceptual strategies for reducing nutrient loading to the Klamath River and are expected to develop water quality management plans as part of the Klamath River TMDL process expected to be completed in 2009. However, the lake is also adversely affected by nearly a half-century of log storage. Bark deposited on the bottom has significant sediment oxygen demand as it decomposes (Doyle and Lynch 2005). Logs are still being stored in rafts downstream of Lake Ewauna and are believed to be contributing to poor water quality in that area.

3.2.12 Non-native Fish Interactions

In the last century, the Upper Klamath Basin has been invaded by about 20 non-native fish species (Logan and Markle 1993; Moyle 2002). Most of these species are not particularly common in the basin, but some are abundant and widespread and their effects on listed suckers are poorly understood.

Non-native fishes can have complex interactions with native fishes, and their relative impact can depend on the presence or absence of altered habitats such as impoundments and on the availability of smaller-scale habitat structure such as substrates (Markle and Dunsmoor 2007). In highly modified habitats like Lost River, Klamath River, and Klamath River reservoirs, non-native fish appear to be dominant and have a greater negative impact on endangered suckers (Shively et al. 2000b; Koch and Contreras 1973; Moyle 2002; Desjardins and Markle 2000). Many of the non-native fish species are more tolerant of habitat degradation and occupy a wider range of habitats than the suckers (Moyle 2002). The degraded habitats have resulted in less shoreline vegetation that provided suckers protection from predation by non-native fish (Markle and Dunsmoor 2007; NRC 2004).

In Gerber and Clear Lake Reservoirs, relatively robust sucker populations co-occur with non-native fishes even in the absence of shoreline vegetation (Scoppettone et al. 1995; Buettner and Scoppettone 1991; Piaskowski and Buettner 2003). In Gerber Reservoir, large populations of yellow perch, crappie, and brown bullhead occur (Piaskowski and Buettner 2003). In Clear Lake, non-native fish species including Sacramento perch, brown bullhead, and pumpkinseed are common in the reservoir and green sunfish, and largemouth bass in the tributaries (Buettner and Scoppettone 1991; Scoppettone et al. 2005). Low water transparency in Clear Lake may reduce predation rates of non-native fishes on suckers. Also, high inter-annual variability in water levels resulting from wet and dry climatic cycles may be better tolerated by native suckers than non-native species.

Competition for resources and predation by non-native fish on suckers in UKL is likely but difficult to quantify. Non-native fishes are the most abundant both numerically and by biomass in UKL (Scoppettone and Vinyard 1991; Logan and Markle 1993; Simon and Markle 1997; Simon and Markle 2001). Markle and Dunsmoor (2007) were able to demonstrate predation by fathead minnow adults on larval suckers in a controlled environment. Their research also showed that as water depth increases, the surface orientation of the sucker larvae and the bottom orientation of the fathead minnows result in enough separation to almost eliminate predation. The shoreline abundance of adult fathead minnows had a negative relationship with annual larval sucker survival, which was consistent with the density relationship found in laboratory studies. There appears to be a positive relationship between June lake level and larval sucker survival likely due to greater inundation of emergent vegetation habitat and reduced interactions with fathead minnows and other non-native predators. Fathead minnows also appear to benefit from low summer lake levels (Markle and Dunsmoor 2007). Juvenile suckers may be displaced from near-shore areas by competition for food and space by high summer densities of non-native fish particularly fathead minnows and yellow perch. Foott and Stone (2005) surmise that competition with non-native fish and other factors could contribute to an overall loss of body condition and fitness going into fall and winter and may leave juvenile suckers without adequate energy stores to survive their first winter, more vulnerable to opportunistic infections, or more sensitive to changing environmental conditions, but this is unconfirmed.

3.2.13 Human-induced Climate Change

Climate change is expected to significantly affect water resources in the western United States by the mid 21st Century (Leung et al. 2004; Barnett et al. 2008). Climate change is generally predicted to result in increased air and water temperatures, decreased water quality, increased evaporation rates, increased proportion of precipitation as rain instead of snow, earlier and shorter runoff seasons, and increased variability in precipitation patterns (Adams and Peck 2006). Several studies have shown declining snow pack, earlier spring snowmelt, and earlier stream runoff in the western United States over the past few decades (Hamlet et al. 2005; Stewart et al. 2005; Knowles et al. 2006). Winter precipitation and snow-pack have been shown to be strongly correlated with streamflow in the Pacific Northwest (Leung and Wigmosta, 1999).

Increasing temperature trends are the major drivers of these observed trends, particularly at the moderate elevations and relatively warm winter temperatures characteristic of the Pacific Northwest (Hamlet et al. 2005; Stewart et al. 2005). Temperatures are uniformly projected to continue increasing over the next few decades, about 0.2˚C per decade globally for the next two decades (Meehl et al. 2007). Projections of changes in precipitation with climate change vary widely among models (California Energy Commission 2005). However, some investigators report that increasing temperatures will result in decreasing April 1st snow packs that will offset any precipitation increases in the region (Wolock and McCabe 1999; Hamlet et al. 2005).

A preliminary analysis of climatologic and hydrologic information for the Upper Klamath River Basin indicates UKL inflows, particularly base-flows, have declined over the last several decades (Mayer 2008). Net inflow to UKL and tributary flow to UKL (an independent measure of inflow) are both strongly dependent on climate, particularly precipitation, as demonstrated in Mayer (2008). Part of the decline in base-flows is explained by decreasing precipitation but there may be other factors involved as well, including increasing temperatures and the resulting decrease in April 1st snow water equivalent; increasing evapotranspiration (ET) and consumptive use; or increasing surface water diversions or ground water pumping above the lake.

Both the Oregon Climate Division 5 temperature dataset and the U.S. Historical Climatological Network temperature dataset for Crater Lake show increasing trends in winter temperatures since the 1970s. Present-day winter temperatures are as warm or warmer than at any time during the last 80 to 100 years. Bartholow (2005) found that water temperatures in the lower Klamath River have been increasing by about 0.5˚ C per decade since the 1960s.

At most snow-course locations in the western U.S., April 1st snow water equivalent (SWE) has been found to be the maximum annual value of snow pack and is highly correlated with streamflow (McCabe and Dettinger, 2002). April 1st SWE in the southern Cascades has declined since the 1930s, based on data from two high elevation sites near Crater Lake (Mayer 2008).

Trends in the April 1st SWE at the two sites may be related to trends in winter temperature as well as precipitation.

One of the most intriguing studies on long-term climate trends in the basin is the study by Petersen et al. (1999) correlating tree-ring growth with annual precipitation and lake levels at Crater Lake. In the paper, the authors view Crater Lake as the "world's largest rain gage" and they create a surrogate record of precipitation and lake levels based on tree-ring growth over the last three hundred years or more. Their results suggest that both precipitation and lake levels have been in a multi-century decline since about 1700.

Much of the decline in UKL net inflows and tributary flows is due to associated trends in climate. The observed changes are consistent with regional observations of climate change-related phenomena throughout the western U.S. Other factors such as increased consumptive use or ground water pumping above the lake may contribute to the decline too. The implications of these declines are that there will be less water available in the system, particularly during the base-flow period. Hydrologic modeling and inflow forecasting based on historic lake inflows may not be representative of future conditions to the extent that it overestimates available water.

In addition to having multiple effects on water resources, such as reducing snow-pack, increasing winter run-off, increasing ET water losses from wetlands and open water, and increasing agricultural water demand, climate change may directly and indirectly affect biological resources in the Klamath Basin. Climate change could exacerbate existing poor habitat conditions for suckers by further degrading water quality. Higher temperatures could increase the incidence of episodes of peak summer temperatures and contribute to the low DO events that are responsible for sucker die-offs. The weather conditions documented during the last three fish die-offs in UKL were characterized by higher than average temperatures (Wood et al. 2006) suggesting that temperature plays a role in the events. Because UKL is shallow, water temperatures tend to closely follow air temperatures so even a week of high air temperatures will affect water temperatures in the lake (Wood et al. 1996).

Higher water temperatures could have multiple adverse effects on suckers including: (1) stressing AFA, causing bloom collapse; (2) increasing respiration rates of microorganisms, thus elevating DO consumption in the water column and in sediments; (3) raising respiration rates for suckers and other fish making it more difficult for them to obtain sufficient DO; and (4) reducing the DO holding-capacity of water which is highest in cold water. The productivity of UKL and sucker growth rates might increase as a result of higher temperatures, but if higher temperatures lead to reduced water quality, the benefits could be negated. Because of the complex nature of the lake ecosystem, it is difficult to predict what ecological changes are likely to occur. However, it seems likely that most of the effects will be negative and therefore will likely exacerbate current poor conditions.

3.2.14 Hybridization

Hybridization is defined as the interbreeding of individuals from two or more populations that are distinguishable by heritable characters (Dowling and Secor 1997). Introgression results when hybridization leads to incorporation of new genes into a "reproductively integrated population" or "gene pool" and requires that the F2 hybrids must be fertile and be capable of mating and backcrossing with the F1 individuals. At the time the LRS and SNS were listed, hybridization and introgression were considered threats. Suckers showing intermediate morphological characters were considered to be hybrids and it was suspected that hybridization was caused by a shortage of spawning habitat as a result of dam construction and habitat degradation (Williams et al. 1985).

Research since listing suggests that hybridization among four Klamath Basin suckers (SNS, LRS, Klamath largescale sucker and Klamath smallscale sucker) does occur (Dowling 2005; Markle et al. 2005; Tranah and May 2006). There is evidence that sucker populations in Clear Lake and Gerber Reservoirs may have experienced extensive hybridization (ISRP 2005; Markle et al. 2005). However, scientists familiar with Klamath Basin suckers do not consider hybridization among the Klamath suckers to be unusual or necessarily adverse (Dowling 1995; Tranah and May 2006). The evidence indicates that hybridization has been common throughout the evolutionary history of suckers, in general, and the Klamath Basin suckers, in particular (Dowling 2005; ISRP 2005). Current thinking among geneticists studying Klamath suckers is that some hybridization is natural and is possibly adaptive. However, it is possible that hybridization rates have increased as a result of land and water development over the past 150 years and increase rates of introgression may pose a threat to these species.

3.2.15 Ecosystem Restoration and Sucker Recovery

Since the early 1990's, the Service, Reclamation, Natural Resources Conservation Service, the State of Oregon, The Klamath Tribes, The Nature Conservancy (TNC), the Klamath Water Users, other partners, and private landowners have been working to improve water quality and aquatic habitat conditions in the upper Klamath River basin and to make progress towards the recovery of the LRS and SNS. The Service and its partners have supported approximately 400 habitat restoration projects in the Upper Klamath Basin, including 50 wetland and 150 riparian projects. The cost of these projects has been shared by many entities, including State and Federal programs such as Partners for Fish and Wildlife, Hatfield Restoration, Jobs in the Woods, and Oregon Resources Conservation Act programs as well as private grant programs and contributions from landowners.

Major habitat restoration efforts focusing on endangered suckers have been completed or initiated. These include: (1) restoration of over 25,000 acres of wetlands adjacent to UKL and in the watershed above the lake; (2) removal of Chiloquin Dam; (3) screening of the outlet of Clear Lake Dam; (4) construction of a new fishway at Link River Dam; (5) screening of the main irrigation diversion of the Klamath Project (A-Canal); (6) 13 fish passage improvement projects, including screening and fishways; and many other actions.

Wetland Restoration

Restoration of the Williamson River Delta, approximately 5,600 acres of open water, deep water wetland, riparian/wet prairie, and upland plant communities is expected to provide substantial benefits toward the recovery of sucker populations in UKL (see Figure 3-22). Based on pilot wetland restoration projects at River Bend and Goose Bay, restoration and reconnection of wetlands at the Williamson River Delta are expected to provide good habitat for larval suckers increasing survivorship and reducing vagrancy and dispersal out of UKL where survival is currently minimal (TNC 2006, 2007a, 2007b; Markle et al. in review). A more detailed discussion of the importance of emergent wetland for suckers is in Section 3.2.7 Changes in Lake Levels (*Larvae)* and Appendix 1.

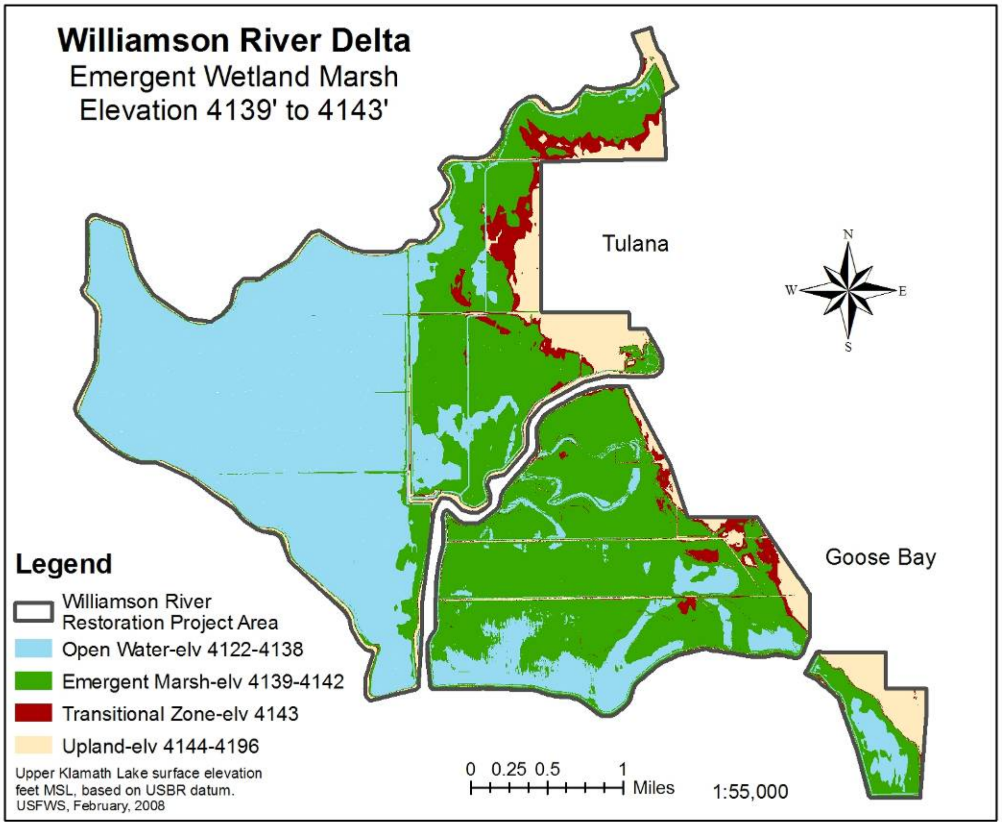


Figure 3-22. Map of the Williamson River Delta restoration project showing distribution of habitat types after completion. In 2007, the Tulana portion of the project was opened to UKL. In 2008, dikes around the Goose Bay area are scheduled to be breached and the area will be opened to the lake.

Levees surrounding the TNC property keep lake and river water from flooding former agricultural lands inside the levees. The agricultural lands within the levees have subsided through the years as a result of repeated cultivation of organic soils. TNC has attempted to restore wetland vegetation prior to levee removal by active water management of isolated fields. At present, TNC estimates approximately 1,000 acres of emergent wetlands will remain in 2008 following levee breaches on the Tulana property which was breached in fall 2007 (Elseroad 2004; M. Barry, TNC, pers. comm. 2007). Elseroad (2004) estimated the surface area to be colonized by emergent vegetation after several years as 2,640 acres for the entire Lower Williamson River Delta (Tulana and Goose Bay). The estimated 2,600 acres of emergent vegetation yet to establish on the Williamson River Delta is a large increase from previous areas of emergent vegetation there, which was only about 15 acres (Dunsmoor et al. 2000). If only a fraction of this habitat is used by larval and juvenile suckers, the habitat increase could result in improved survival of the two earliest life history stages. This becomes especially true if habitat has been a limiting factor for sucker survivorship in UKL.

Recent sucker density estimates for the Williamson River Delta on average were 0.13 juveniles per square meter (TNC 2007a) and between 3.5 and 8.0 larvae per square meter (TNC 2007a, 2007b). Assuming the 2,600 restored acres described by Elseroad (2004) is completely colonized by emergent habitat; it would be capable of supporting approximately 1.4 million juvenile suckers and between about 40 and 80 million sucker larvae. It is unlikely that all of the wetland habitat will be used by age 0 suckers, but this figure suggests its potential to provide nursery and rearing habitat for a large number of larval and juvenile suckers. Because lake levels recede through the summer, much of this emergent wetland habitat will be unavailable to juveniles during August and September because it will be exposed.

Restoration efforts at the Williamson River Delta include reshaping the mouth of the river through several levee breaches and lowering other levee sections to elevations 4141 to 4143 feet and removal of internal levees and drains inside the property. All these changes will divide the inflow from the Williamson River so that portions of the total inflow will reach UKL at different locations (Daraio et al. 2004). The distribution of larval suckers in UKL may be influenced by the reshaping of the delta, particularly if larval suckers are more easily transported to nearby wetlands where they may be retained longer (Markle et al. in review; Markle and Dunsmoor 2007). Additionally, larvae will have better access to emergent wetlands along the northern portion of UKL and Agency Lake.

Agency Lake Ranch and the Barnes properties (9,830 acres) along the northern and northwestern shores of Agency Lake have been acquired by Reclamation and used as water storage areas. The properties will be managed by the Service as an addition to Upper Klamath NWR. Levees along these properties are likely to be breached within the next 10 years. Emergent wetland plant communities have re-established over the last several years with seasonal flooding and draining (USBR 2007). However, because of subsidence much of the property will be too deep to maintain emergent wetland vegetation (greater than 5 feet deep) and will become open water habitat. At maximum lake elevation only about 800 acres are likely to be suitable for the development of emergent vegetation, based on depth preferences of local emergent plant species distributed around UKL (Watershed Sciences 2007; Elseroad 2004).

It is not understood how fish will use these future wetland habitats on the ALR and Barnes properties, but larval and juvenile sucker monitoring in Agency Lake and Klamath NWR (adjacent to ALR and Barnes) have documented very low abundances of listed suckers (Buettner 2002; Terwilliger et al. 2004; Mulligan and Mulligan 2007). However, we anticipate that suckers from the Williamson River will more readily access these areas with the restoration of the Williamson River Delta.

Although the impacts to fish of restoring wetland habitats along northern UKL and Agency Lakes have not yet been studied, it is reasonable to assume that the restoration of wetlands in this area will provide significant benefits to sucker populations because of the improved access from the Williamson River and northern portion of UKL via the re-association of the Williamson River Delta. The extent of the benefits towards sucker recovery remains largely unknown until results of monitoring activities are completed. However, restored wetlands in the Sacramento River have been readily used by native fishes including a sucker species (Moyle et al. 2007).

Chiloquin Dam Removal

In 2008, Reclamation and BIA will remove Chiloquin Dam near the confluence of the Sprague and Williamson Rivers. This will increase fish access to habitats in the Sprague River watershed as far upstream as Beatty where listed sucker spawning and rearing have been recently documented (Tyler et al. 2007; Ellsworth et al. 2007; USFWS, unpublished data). Although continued monitoring will determine the impact of dam removal on suckers in the watershed, the anticipated benefits of dam removal are increasing access to spawning areas at least 70 miles upstream. A re-distribution of spawning suckers from the lower 1 mile of the Sprague River below Chiloquin Dam to spawning habitats in the Chiloquin Narrows (rm 0-10); Ninemile area (RM 20-28), S'Ocholis Canyon (RM 29-33), and Beatty Gap (RM 75-80); and possibly the lower Sycan River, may increase sucker production if spawning habitat in the lower Williamson and Sprague Rivers below Chiloquin Dam was a limiting factor to survival of fertilized eggs (see Figure 3-23). Furthermore, re-distribution of spawning suckers could reduce hybridization rates and limit risks associated with catastrophic events, such as flood scour, that can adversely impact concentrated spawning.

The long-term benefit of Chiloquin Dam removal may be increased sucker populations in UKL. Greater numbers of spawning suckers farther upstream may increase production of young suckers and could improve recruit into the adult population. There is some evidence that larval suckers are able to grow in the riverine environment (USFWS, unpublished data; Ellsworth et al. 2008). Larvae produced farther upstream in the watershed may benefit from the opportunity to grow during migration to the lake environment. Larger larvae and juvenile suckers may demonstrate improved survivorship when compared to smaller larvae upon entering UKL. Probable mechanisms that improve survivorship of larger larvae and juveniles in the lake include reduced competition and reduced predation. Larger individuals may also demonstrate a longer retention time in the northern portion of Upper Klamath and Agency Lakes than smaller individuals (Reithel 2006). Increased retention in northern UKL may reduce the risk of downstream movement and entrainment from UKL (Markle et al. in review).

The re-colonization of fish habitat following a dam removal has been documented outside of the Klamath basin. Catalano et al. (2007) observed 9, formerly truncated species as far as 70 miles upstream of the former dam location following the removal of four low-head dams on a Wisconsin river. Many of the re-colonizing fish, such as the spotted sucker *Minytrema melanops,* were lacustrine species that undergo seasonal migrations similar to the LRS and SNS (Catalano et al. 2007). These observations were made 1 to 2 years following the removal of the final dam suggesting that habitat changes rapidly at formerly impounded sites (Catalano et al. 2007). Following dam removal, previous research suggests a relatively quick shift in the fish assemblage to favor riverine species upstream of the former impoundment (Kanehl et al. 1997; Tuckerman and Zawiski 2007). Kanehl et al. (1997) suggests that the increase in abundance and biomass of certain species resulted from increased reproduction and recruitment rather then immigration from downstream.

Associated with Chiloquin Dam removal is the construction of a pumping station on the Williamson River to replace the irrigation diversion at Chiloquin Dam. There was no fish screen on the diversion until 2000 and even then it was not consistently operated and maintained. The new pumping plant is located in a reach of the Williamson River where sucker larval distribution along the river bank was low compared to the center of the river (Tyler et al. 2004). A new fish screen will be installed as part of the dam removal project to reduce entrainment of sucker larvae and prevent entrainment of juvenile and adult suckers (USBR 2007). Based on similar screens at A-Canal and on the Sacramento River (Bennetts et al. 2004; Borthwick and Weber 2001), up to 50 percent of the larvae could be excluded from entrainment.

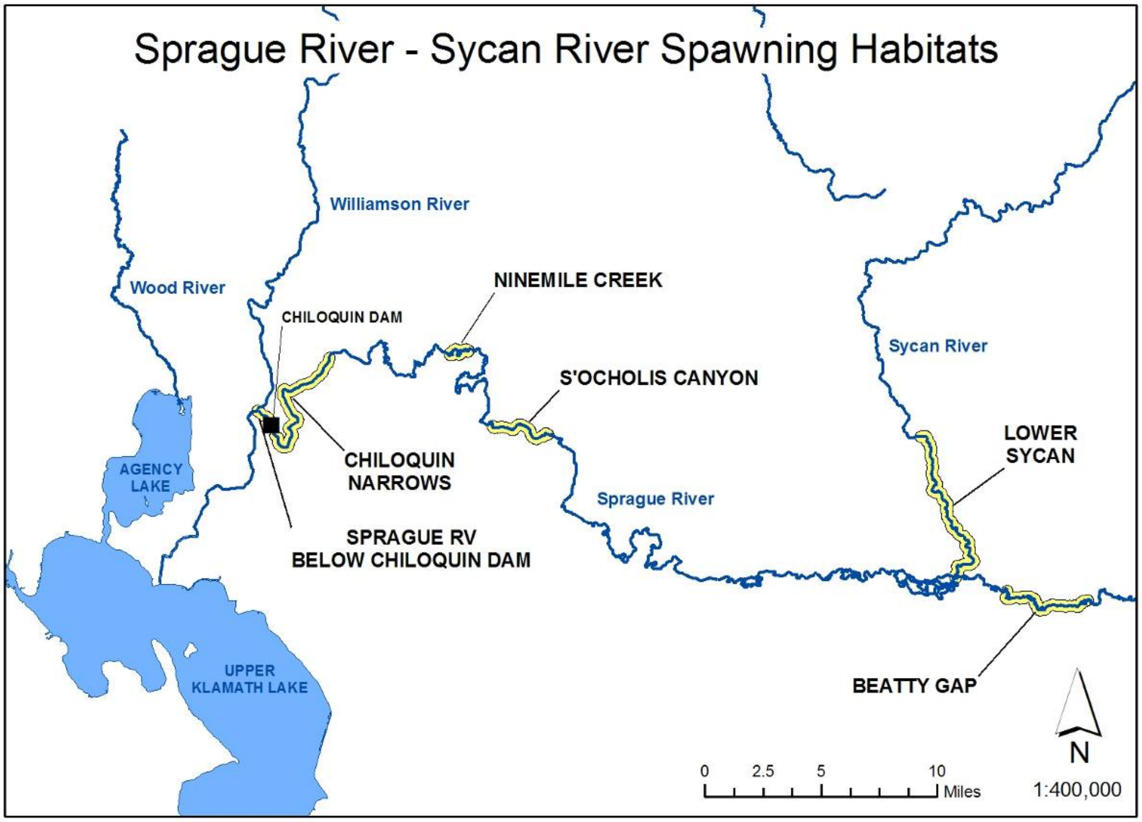


Figure 3-23. Known spawning areas for suckers in the Sprague and Sycan Rivers.

Sprague River Habitat Restoration

The Service, Natural Resource Conservation Service (NRCS), and other state and local entities have focused watershed restoration and land and water conservation activities in the Sprague River watershed since 2002 (D. Ross, USFWS, pers. comm. 2007; J. Regan-Vienop, NRCS, pers. comm. 2007). There have been approximately 500 acres of wetland restored, 100 miles of riparian fencing installed, 5 miles of river channel re-aligned, and four spring complexes reconnected and enhanced. Approximately, 3,000 acres of floodplain habitat has been enrolled in permanent easements under the Wetland Reserve Program and Conservation Reserve Enhancement Program. NRCS has restored over 2,000 acres of wetland habitat and conservation of over several thousand acre-feet of on-farm water. More than 70 percent of the private lands in the Sprague River Valley are partnering with local, State, and Federal agencies on land conservation and natural resource actions (D. Ross, USFWS, pers. comm. 2007).

Barkley Spring Restoration

Barkley Spring is an important historic sucker spawning site along the eastern shore of UKL. Sucker spawning at this site has not been observed since the 1970s (Perkins et al. 2000a). Reclamation, the Service, and the local watershed council are working cooperatively to restore this spring as spawning and rearing habitat for native fishes and endemic mollusks. Barkley Spring restoration efforts are focused on augmentation of spawning substrates, channel reconfiguration, and screening of an agricultural diversion at the spring.

Re-establishment of shoreline spawning sites for suckers was identified as a key strategy for species recovery by the NRC (2004). Re-establishing historic spawning sited may decrease the risk at a population level should other spawning sites fail to produce viable larvae. Re-established spawning sites have the potential to increase sucker populations in UKL by improving reproduction.

Fish Passage Improvements

Reclamation has made significant progress on reducing entrainment and improving fish passage at federally owned facilities since the last Klamath Project BO issued in 2002. Reclamation formed the Klamath Fish Passage Technical Committee in 2002 to help guide efforts to install Federal and State approved fish screens and/or ladders on the Klamath Project and in the Upper Klamath Basin. The KFPTC, composed of biologists, engineers, and water users, have met several times per year to discuss, review, plan, and design fish screen/passage issues and concepts.

A-Canal Fish Screen and Fish Bypass Facility

Reclamation completed construction of a state-of-the-art fish screen at the entrance to the A-Canal in UKL in March 2003 to reduce the high rates of fish entrainment known to occur at this diversion site. LRS and SNS larvae and juvenile life stages were particularly vulnerable to entrainment at A-Canal before the screen was installed (Gutermuth et al. 1998, 2000a).

The screen is designed to protect most age 0 (greater than 30 mm total length) and sub-adult suckers that pass through the trash rack openings. Although the screen mesh openings are large enough to allow larval suckers to pass, the hydraulic conditions that create positive sweeping flows across the screen surface guide many larvae into the bypass and back into UKL. Based on larval sucker entrainment monitoring at the A-Canal in 2003 (Bennetts et al. 2004) up to 50 percent of the larvae were bypassed and 50 percent passed through the screen. Similar results were documented at a screen facility on the Sacramento River in California (Borthwick and Weber 2001). However, because the A-Canal bypass discharges back into UKL just upstream of Link River Dam, it is likely that many of the bypassed larval suckers continue to disperse downstream out of UKL. The fate of juvenile and sub-adult suckers bypassed at A-Canal is also unknown but there is some information suggesting the many return back to UKL. A more detailed discussion of sucker entrainment is discussed in section 3.2.6.

Reclamation conducts annual fish salvage activities in the forebay of the A-Canal fish screen facility when water deliveries are shut off in October. The headgates downstream of the fish screen are closed to terminate water deliveries and then bulkheads are inserted in the canal upstream of the screens to dewater the facility. The result is that fish located in the forebay between the bulkheads and screens are trapped in an isolated pool of water which has no circulation. Water quality can quickly degrade in this forebay area, due to lack of water movement, large concentrations of fish, and generally poor ambient water quality conditions. When water quality deteriorates, trapped fish will likely expire before water levels in the forebay have dropped sufficiently to allow Reclamation staff to salvage suckers.

After the bulkheads are installed, Reclamation installs aeration devices and monitors DO levels in the forebay as water levels are lowered to reduce DO stress. When water depth in the forebay is lowered, Reclamation salvages all fish using backpack electrofishers and beach seines and then returns all collected fish to UKL just outside of the bulkheads. This annual salvage procedure alleviates potential mass mortality of all fish at the fish screen as water is removed.

Link River Fishway

Reclamation constructed a new vertical slot fishway at Link River Dam in December 2004 located between the stilling basin and the Westside Canal with a fish exit in the eastern-most canal gate bay. The new fishway is specifically designed to allow fish like suckers that are not strong jumpers, to easily swim through the slots and migrate above Link River Dam (USBR 2002b). The fishway consists of a chute sloping at approximately 5 percent containing 33 baffles with dual slots and water surface drops of approximately 0.4 feet per baffle and peak velocity across the baffle of approximately 5 feet/second. Limited monitoring has been conducted using radio and PIT tagged fish beginning in 2005 (USBR 2007; Korson et al. 2008), and monitoring is expected to continue, according to Reclamation comments on the draft BO. Several radio-tagged adult suckers released in Lake Ewauna were subsequently detected in UKL. Also, a few PIT tagged fish from Lake Ewauna were detected passing PIT tag antennas positioned in the fish ladder. In 2008, Reclamation plans to operate a fish trap and PIT tag antennas in the ladder to document passage success.

Clear Lake Dam Reconstruction
Clear Lake Dam was replaced by a roller-compacted, concrete dam in 2002 to correct known safety deficiencies und the Safety of Dams Program. As part of this action, Reclamation installed two permanent fish screens in the outlet works of the dam to prevent endangered suckers from Clear Lake from being entrained into the Lost River. The screens are wedge wire with ¼ inch mesh openings and were designed to meet Service criteria in place at that time.

In the 1990s there was a storage limitation in Clear Lake during the winter and spring of 250,000 acre-feet compared to the original flood operations capacity from October 1 to March 1 of approximately 360 TAF because of concern over the failure of the earthen-filled dam constructed in 1910. As a result between 1997 and 1999 approximately 150 TAF of water was released during the winter and spring. After the dam was reconstructed in 2003, it regained its former capacity of greater than 500 TAF at spillway crest elevation of 4543 feet; the corresponding surface area is approximately 26,000 acres (USBR 2001a). This allows more habitat to be inundated during wetter time periods. Before the reconstruction, much of the inflow to Clear Lake had to be released to minimize damage to the dam resulting in a smaller lake area.

Implementation of Requirements and Recommendations of the USFWS 2002 BO
In the 2002 BO, there were three Reasonable and Prudent Alternatives (RPAs) including: (1) reduce effects of adverse water quality and habitat loss; (2) reduce entrainment of suckers at Link River Dam and associated hydropower intake bays; and (3) study factors affecting water quality; implement actions to reduce die-off frequency and increase access to refuge habitat; assess ongoing sucker population monitoring, implement improvements, and develop annual assessment report. Measures implemented to comply with these RPAs are summarized in the biological assessment (USBR 2007; Table 1-2). To address these RPAs, Reclamation funded studies that addressed the effects of adverse water quality and habitat loss which are used in this biological opinion. They also started efforts to reduce entrainment at Link River Dam by evaluation of a surface spill operation. PacifiCorp is modifying its operations of Eastside and Westside facilities to reduce entrainment during the peak juvenile entrainment period. Additionally, several investigations were undertaken to address water quality and potential effects of low lake levels on die-offs.

There were three Reasonable and Prudent Measures (RPMs) and associated Terms and Conditions required to minimize incidental take (USFWS 2002). They include: (1) minimize entrainment throughout the project; (2) monitor, implement, and report water quality in Project delivery area; and (3) minimize habitat alteration in project lakes and reservoirs as a result of project operations. Compliance with the RPMs is reported in the biological assessment (USBR 2007; Table 1-3).

Conservation Implementation Program (CIP) and ESA Recovery Implementation

Through their CIP, Reclamation has annually funded projects since 2004 throughout the Klamath River drainage that included enhancement and restoration of habitat conditions, improved water quality conditions, removed fish passage barriers, reduced entrainment through the installation of fish screens, monitoring, research, and increased water conservation efficiencies (USBR 2007; Tables 1-3 and 1-4).

Over $10 million has been expended on major items funded by CIP and for ESA Recovery Implementation from 2004 to 2007 for both endangered suckers and threatened coho salmon. In the biological assessment, Reclamation lists 31 activities funded during these four years (USBR 2007). In 2007, Reclamation, in partnership with other Federal and State agencies (California and Oregon), participated in a basin-wide technical review process to evaluate and rank 16 proposals submitted under the Fiscal Year 2007 solicitation. Two projects were funded in the Upper Basin benefiting endangered suckers including: Keno Reservoir Treatment Wetlands Feasibility and Fluvial Geomorphology and Vegetation Monitoring – Sprague River. In Fiscal Years 2007 and 2008, Reclamation budgeted $4.8 million for CIP and Endangered Species recovery actions to be expended within the CIP.

3.2.16 Scientific Take under Section 10

Section 10 of the Act authorizes scientific permits for research or to enhance the survival and recovery of listed species and other situations. The Service provides research permits under conditions that are protective of sucker populations. We have no reason to believe that these activities are detrimental to sucker populations. Also, Oregon Department of Fish and Wildlife requires scientific take permits that are reviewed to ensure minimal impact to native fish populations.

3.3 Relationship of the Action Area to Conservation of the Suckers

Conservation of the LRS and SNS is dependent on preserving several viable self-sustaining populations of suckers in as much of their historic range as possible: 1) populations must be of adequate size and of diverse age structure to withstand stochastic events and remain viable; 2) populations must be interconnected for demographic and genetic support; and 3) adequate spawning, rearing, feeding, and over-wintering habitat must be present throughout the species range to support viable populations.

Currently, the largest populations of SNS and LRS are found in UKL and its tributaries (USFWS 2007 b, 2007c). These species rear, feed and over-winter in the lake and are affected by water level management that affects habitat availability including shoreline spawning areas for LRS, emergent wetlands and shallow shoreline areas for larvae and age 0 juveniles, deeper open water habitat for juvenile and adults, and water quality refuge areas. We do not currently believe lake elevations resulting from the proposed action would likely adversely affect water quality in UKL. Substantial entrainment of larval and juvenile suckers occurs at the outlet of UKL. Although we cannot determine all of the factors causing the downstream movement and loss of larval and juvenile suckers at Link River Dam, Reclamation's management of the dam contributes to this loss and therefore represents a risk to the LRS and SNS. See section 3.1.6 for a more detailed description.

Currently, Clear Lake has a relatively large population of LRS and SNS. A potential threat to Clear Lake population is lack of access to Willow Creek, the principal spawning tributary. However, the proposed action is anticipated to provide adequate water depths for sucker spawning access in all years. The effects of fluctuating water elevations at Clear Lake on sucker populations in terms of population size, age-class distribution, recruitment, or decreased fitness are not fully understood. However, available information indicates that the Clear Lake sucker populations have remained viable under the current management regime and we do not anticipate that this will change unless there is a prolonged drought.

There is also a substantial population of SNS (or SNS x KLS hybrids) in Gerber Reservoir. Similar to Clear Lake, the effects of fluctuating water levels on the SNS population in Gerber Reservoir is not fully understood. However, available information indicates that the SNS population has remained viable under the current management regime and we do not anticipate that will change unless there is a prolonged drought.

The long-term survival of suckers in Tule Lake is in doubt because of the lack adult rearing habitat (areas with water depth greater than 3 feet) and lack of flows and spawning habitat in the Lost River under the proposed action. The Tule Lake population of LRS may be crucial to recovery of that species since it represents one of only three LRS populations. Spreading the risk of extirpation among three LRS populations rather than just two populations could significantly decrease the threat of extinction risk to the species.

The Lost River and Keno Reservoir are highly altered systems and currently support small sucker populations. However, because Keno Reservoir is adjacent to UKL and large numbers of suckers disperse there from upstream, it has the potential to provide rearing habitat for a large number of suckers that ultimately migrate back to UKL to spawn along shoreline areas or in the tributaries. Therefore, habitat and water quality improvements in Keno Reservoir are justified.

3.4 Status of Proposed Critical Habitat within the Action Area

Critical habitat for the suckers was proposed in 1994, but has not been finalized (USFWS 1994a; see Figure 3-24). The primary constituent elements identified in the proposal are as follows: (1) water of sufficient quantity and suitable quality; (2) sufficient physical habitat, including water quality refuge areas, and habitat for spawning, feeding, rearing, and travel corridors; and (3) a sufficient biological environment, including adequate food levels, and patterns of predation, parasitism, and competition that are compatible with recovery.

The Project lies within or adjacent to all six of the proposed critical habitat units (PCHU): (1) Clear Lake and watershed; (2) Tule Lake; (3) Klamath River; (4) UKL and watershed; (5) Williamson and Sprague Rivers; and (6) Gerber Reservoir and watershed.

<u>PCHU 1 (Clear Lake and watershed):</u> Water quantity, water quality and physical habitat for spawning, feeding, rearing, and travel corridors are generally sufficient for LRS and SNS. However, during extended drought conditions when Clear Lake recedes to a small size with low lake levels, reduced water quality, primarily low DO, both in summer and in winter below an ice cover are likely to occur. Under these stressful conditions fish are at greater risk of disease parasitism, and fish die-offs. Competition and predation by non-native fish species including Sacramento perch, and brown bullhead likely impact sucker populations particularly at low lake levels. A migration barrier at Clear Lake Dam isolates LRS and SNS populations and prevents genetic exchange with other populations in the Upper Klamath Basin

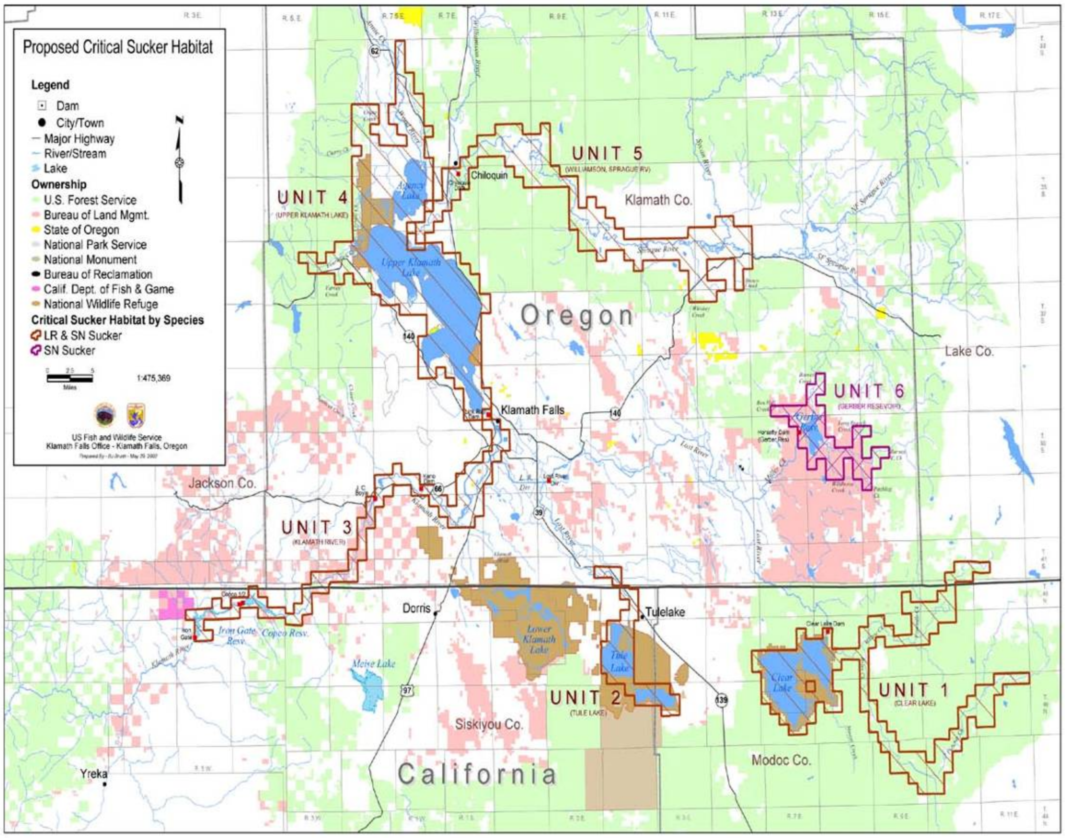


Figure 3-24. Map showing the six proposed critical habitat units for the LRS and SNS.

PCHU 2 (Tule Lake): Physical habitat for feeding and rearing is very limited due to shallow water depths. Spawning habitat is restricted to a small area in the lower Lost River. There are no passage facilities at Anderson Rose Dam and habitat alteration in the Lost River and additional dams without passage have eliminated spawning habitat upstream. Travel corridors in the lower Lost River are restricted by shallow depths affected by sedimentation and low flows during the spawning period. Degraded water quality during the summer including high pH, ammonia, nutrients, and low DO likely negatively impacts sucker populations by restricting their distribution and reducing productivity. Fish die-offs in winter below an ice cover are likely to occur but are not documented. Shallow water depths in Tule Lake sumps likely limits adult habitat and restricts assess to the upstream spawning site. Competition and predation by non-native fish species likely impacts survival of larval and juvenile suckers.

PCHU 3 (Klamath River): Water quality in the Klamath River reservoirs is stressful to suckers during the summer when large blue-green algae blooms and crashes occur (NRC 2004). Fish die-offs are common in Keno Reservoir (Tinniswood 2006). Emergent wetlands and shallow shoreline habitat used by larval and juvenile suckers are extremely limited in the Klamath River reservoirs with the exception of J.C. Boyle Reservoir. Spawning habitat is also lacking or limited due to high gradient and velocity of the river and absence of gravel spawning substrate. Non-native fish populations are also very large in all of the Klamath River reservoirs. Competition and predation by species including fathead minnows, yellow perch, bullheads, crappie, and largemouth bass likely impact sucker populations in the Klamath River reservoirs.

PCHU 4 (UKL and watershed): Seasonal reductions in water surface elevations during summer and fall of dry years negatively impact the quantity and quality of emergent wetland rearing habitat for larval and juvenile suckers, and the loss of deep-water habitats and water quality refuge areas for older fish. Substantial wetland habitat restoration is underway to provide a major increase in high quality habitat at the Williamson River Delta. Water quality conditions are frequently stressful for LRS and SNS due to massive AFA blooms and crashes that result in increased pH and ammonia, and reduced DO. Periodic fish die-offs occur as a result of poor water quality associated with AFA bloom crashes. Loss and entrainment of larval and juvenile suckers at the outlet of the lake is substantial and could negatively impact recruitment. Non-native fish species including fathead minnows and yellow perch likely compete for resources and prey upon suckers (Markle and Dunsmoor 2007). Tributaries to UKL including the Wood River, Crooked Creek, Sevenmile Creek, and Fourmile Creek, the historic spawning habitat for suckers in UKL, are degraded due to channelization and agricultural development.

PCHU 5 (Williamson and Sprague Rivers): Physical habitat in the Sprague and Williamson Rivers used for spawning, larval, and juvenile rearing is degraded due to the lack of habitat complexity. These areas lack riparian vegetation, backwater wetlands, and sinuous river channels. Fish passage is currently restricted by Chiloquin Dam reducing access to upstream spawning habitat. Spawning substrate below the dam is degraded by the lack of recruitment of gravels trapped behind Chiloquin Dam. However, the dam is scheduled for removal in 2008. Water quality in the Sprague River is degraded due to water withdrawals during the summer and sedimentation and nutrient loading from agricultural and forestry practices adjacent to the river. Competition and predation by non-native fish species including yellow perch, largemouth bass, fathead minnows, and brown bullheads likely negatively affect larval and juvenile sucker survival.

PCHU 6 (Gerber Reservoir and watershed): Water quantity, water quality, and physical habitat for spawning, feeding, rearing, and travel corridors are generally sufficient for SNS. However, during extended drought conditions when Gerber Reservoir recedes to a small size with low lake levels, reduced water quality, primarily low DO, both in summer and in winter below an ice cover are likely to occur. Under these stressful conditions fish are at greater risk of disease and parasitism and fish die-offs. Competition and predation by non-native fish species including yellow perch, crappie, and brown bullhead likely impact sucker populations particularly at low lake levels. A migration barrier at Gerber Dam isolates SNS populations and prevents genetic exchange with other SNS populations in the Upper Klamath Basin. The dam also prevents access by LRS.

4.0 EFFECTS OF THE ACTION ON THE SHORTNOSE AND LOST RIVER SUCKERS

This section presents an analysis of the beneficial and adverse direct and indirect effects of the proposed action, together with the effects of other activities that are interrelated or interdependent with that action, on the LRS and the SNS. The following definitions of terms from the statement above are from 50 CFR §402.02. *Indirect effects* are caused by or result from the proposed action and are later in time, but are still reasonably certain to occur. *Interrelated actions* are those that are part of a larger action and depend on that larger action for their justification. *Interdependent actions* have no independent utility apart from the proposed action.

For most of the analysis below, effects to LRS and SNS will be combined because their status, ecology, life history, distribution, and conservation needs are similar. Where known, species-specific differences in effects to the LRS and SNS will be described.

4.1 Basis for the Effects Analysis

The potential major effects of the proposed action on the LRS and SNS can be divided into two categories: 1) effects due to water storage and 2) effects due to diversions (see Figure 4-1). Project dams block fish passage and fragment sucker habitat. Dams also affect the amount of available habitat by controlling water levels. The storage and release of water at Project reservoirs imposes additional effects on water quality by increasing retention time, exposure to sunlight, and thermal stratification. Reservoir stratification also alters other water quality parameters including DO, BOD, pH and production of toxic ammonia. Aquatic plants and algae in reservoirs can affect DO and pH, which in combination with temperature-induced effects can cause acute and chronic health problems in fish. Reservoirs also modify nutrient cycling by acting as a sink or source for nutrients and temperature, metabolism of organic compounds, and nutrient uptake by phytoplankton. Diversion of water for irrigation and flood control can entrain suckers, change the amount of available habitat, and affect water quality. Runoff and drainage from Project agricultural lands and refuges can impair water quality in sucker habitats because of nutrients, organics, sediment, and pesticides that may be present. These effects are analyzed in detail in this section.

4.1.1 Basis for Effects Analysis for Upper Klamath Lake

Lake levels in UKL have been managed since about 1921 to store water in winter and spring and divert it through the summer to provide water to farms and the refuges. Other effects considered in the effects analysis that are not part of the proposed action but would not occur but for the proposed action include such actions as pesticide and fertilizer use on Project-serviced private lands. These are referred to as interrelated or interdependent actions.

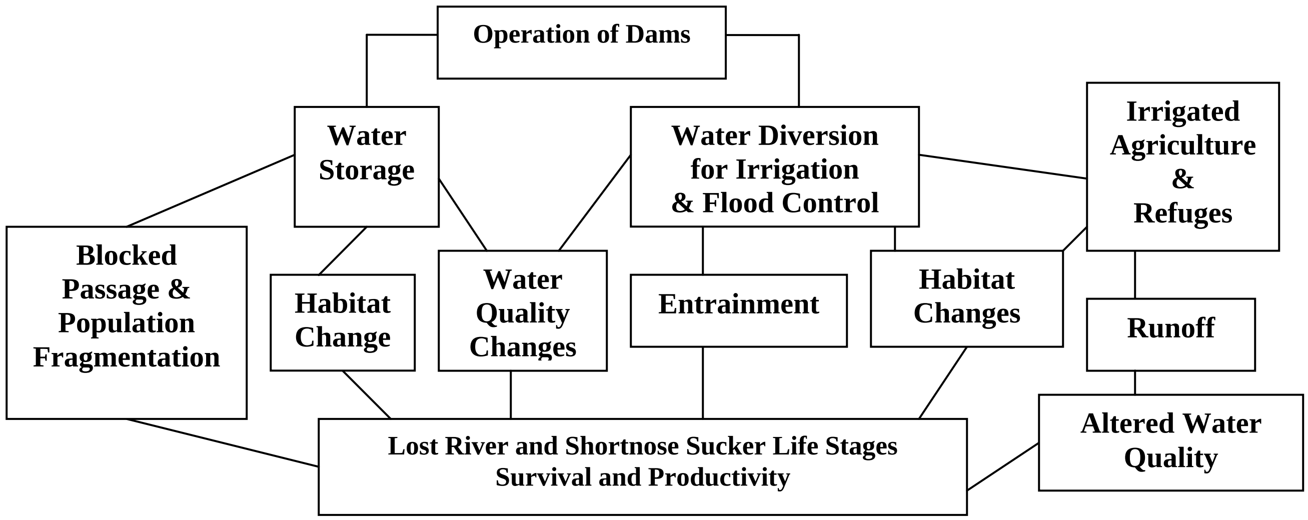


Figure 4-1. Web diagram for the potential effects of the Klamath Project operations on LRS and SNS.

4.2 Scientific Uncertainty as it Relates to the Effects Analysis

The Services have jointly published a policy on standards for use of information under the ESA (USFWS 1994b). This policy calls for review of all scientific and other information used by the Services to prepare biological opinions, incidental take statements, and biological assessments, "…to ensure that any information used by the Services to implement the ESA is reliable, credible, and represents the best scientific and commercial information available." Also, the policy requires the documentation of "…information that supports or does not support a position…"

There is some level of uncertainty associated with any effects analysis on listed species. This is especially true when analyzing the effects the Klamath Project operations have on the LRS and SNS because many types of data (e.g., physical, chemical, and biological) are involved. The accuracy of these data are affected by the types of equipment used, weather conditions during the sampling, sampling interval, calibration frequency, quality control, and many other factors such as climatic variability and climate forecasting that are imperfectly known. In this analysis, we have made numerous assumptions because of insufficient information, and we have attempted to identify uncertainties and account for them where possible.

We must have accurate measurements on the portions of the water budget that are measurable in order to model as accurately as possible the water budget and estimate lake levels under different climatic and hydrologic conditions. This accuracy is especially important because there are portions of the water budget that cannot be accurately measured and estimated (e.g., private diversions). In 2006, the USGS assessed flow data for the gage sites from Link River Dam to Keno Reservoir and found inconsistencies in the data (Risley et al. 2006). However, they were minor compared to the total annual water budget, and therefore we do not anticipate that this error will affect the validity of our analysis of the effects of lake levels on sucker habitat. Nevertheless, this analysis points out that gage error should be regularly assessed and corrected if needed.

4.3 Annual Water Budget for Upper Klamath Lake

This BO focuses on effects of the proposed action on listed suckers in UKL because this area represents the majority of existing suitable habitat and populations for LRS and SNS (USFWS 2007a). The primary effects of the proposed action on UKL are the changes in lake level that will occur as a result of water storage and diversions. These lake level changes affect the quality and quantity of sucker habitat present in the lake. These changes in habitat may affect rates of downstream movement and entrainment of LRS and SNS larvae and juveniles once they are at Link River Dam.

The lake levels resulting from the proposed action will depend on the difference between inflows and outflows. Any changes to either the inflows or the outflows could affect lake levels; therefore, we believe understanding the annual water budget for UKL is an important element of the effects analysis.

Inflow to a lake or reservoir is estimated from the sum of the measured outflow plus the measured change in storage, and the units of measurement are in acre-feet (1 acre-feet = 1 acre flooded to a depth of 1 foot). Inflow is actually measured as net-inflow since upstream diversions are not accounted for in the measurements and some water is lost as a result of evaporation from open water and ET from wetlands.

$$I = O + \Delta S$$

Where: I= inflow to the lake
O= outflow from the lake
ΔS= change in lake storage

Clear Lake and Gerber Reservoir elevations are measured by a single gage located near their respective dams. For UKL, PacifiCorp measures water levels using three gages located at widespread areas of the lake. The USGS operates one gage in UKL. Having three gages on UKL is useful because instantaneous measurements from one gage could be biased by a change in lake level created by the wind either raising or lowering the lake by several tenths of a foot. During extreme events, flows at Link River have temporarily ceased due to strong south winds that lower lake levels at the south end of the lake.

The annual water budget for Project lakes and reservoirs determine in part what habitat conditions will be present for suckers. A schematic diagram of the annual water budget for UKL is shown in Figure 4-2. Basically, the annual water budget for UKL consists of the sum of inflows from tributaries and springs minus losses from the sum of ET and open water evaporation, and discharges to A-Canal diversions and Link River flows. Annual precipitation and runoff is the largest variable in the water budget. The water balance affects lake levels and habitat as well as river flow.

In terms of inflows to UKL, those from the Williamson River are the largest and account for about 60 percent of the annual outflow measured at the Link River. In practice, only a few of the inputs and outputs are actually measured. Springs discharging to the lake are mostly un-gaged, and ET and evaporation losses are estimated. Additionally there are diversions from the lake, such as the one at Running Y Ranch, which are not gaged. These un-gaged inputs or losses are estimated as residuals. Water budgets for Gerber Reservoir and Clear Lake are simpler because they have fewer tributaries and springs, and no wetlands.

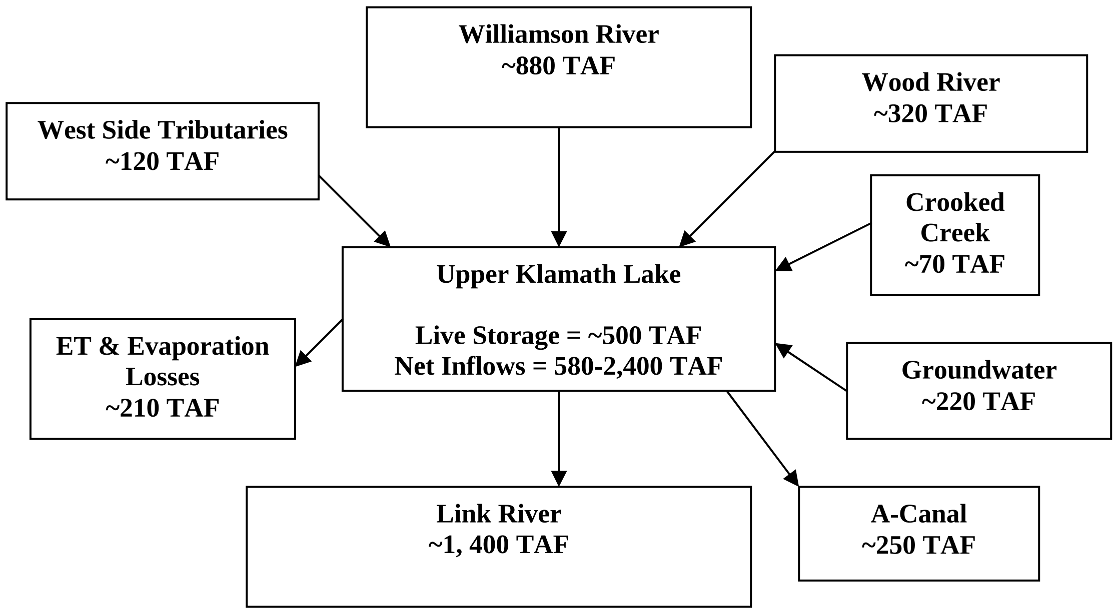


Figure 4-2. Annual water budget for UKL (from Perry et al. 2005). Arrows towards UKL are inflows and those oriented away are losses.

4.4 Use of the Period of Record (POR) to Predict Effects to the LRS and SNS for UKL

Use of historic hydrologic data is important in predicting outcomes in UKL levels over the 10-year consultation period. The period of record (POR) is the time period over which past hydrologic and climatic data will be used for predicting likely future conditions, i.e., the basis for analysis of hydrologic and climatic conditions. Some level of scientific uncertainty is associated with data from the POR because of errors in measurement and unaccounted changes in climate or hydrology. In addition, there is uncertainty that the conditions represented in the POR will be similar to those that will occur over the 10-year consultation period.

Reclamation based their analysis on the 1961 to 2006 POR. After discussions with the Services, Reclamation provided another set of exceedance tables to factor in increased agricultural diversions in the 1985 to 2004 period. For UKL elevations, the difference between the two PORs was a few tenths of a foot. In this BO, we have primarily relied on the 1961 to 2006 POR, because it represents a longer time period and thus likely better shows the effects of climatic variability.

Although the POR is the best available information we have to predict what hydrologic conditions are likely to occur in the future, we cannot precisely predict what lake levels will result from the proposed action. This lack of precision is related to the fact that lake levels are largely dependent on climate, and variations in climate are difficult to predict. Keen (1937) did a 650-year reconstruction of precipitation based upon tree-rings and determined that alternating wet and dry cycles of varying lengths are normal for areas east of the Cascade Mountain Range. A similar study at Crater Lake also showed evidence of varying climate cycles and evidence of relatively low precipitation in the 20th Century (Peterson et al. 1999). Also, Figures 2-18 and 2-19 in the BA show a slight regional trend of declining precipitation and increasing temperature (USBR 2007), which reduces water supplies. Additional support for a scenario of declining precipitation and increased temperatures was documented in a recent hydro-climatology analysis by Mayer (2008).

Another factor that could adversely affect UKL inflows and tributary flows is increased ground water development above the lake. Gannett et al. (2007) reported that pumping in the Klamath Basin began in the late 1940s and early 1950s. They estimated about 17 TAF was pumped from the Upper Williamson River, Sprague River, and Wood River Valleys in 2000.

An analysis of streamflow data from the western U.S. has shown a recent trend of greater flow variability (i.e., higher highs and lower lows), as well as greater persistence where either years of high or low flows are clumped (Pagano and Garen 2005). In the Klamath Basin, the last 17 years appear to show these characteristics. The authors of this study noted the difficulty of managing water resources under these conditions and remarked that smaller reservoirs lacking multiple-year storage would be especially vulnerable. This is the situation with the Project reservoirs.

In conclusion, the Service believes it is appropriate to use the hydrologic data from the 1961 to 2006 POR for our effects analysis. However, we are concerned that there may be a trend of declining precipitation, rising temperatures, and increasing use of water in the Klamath Basin (Mayer 2008), and those changes could affect both the quantity and timing of water in UKL that provide the primary habitats for the LRS and SNS. Consequently, in our analysis of effects of the proposed action on sucker habitats we will be using a conservative approach, as is described in the next section.

4.5 Use of 70 and 90 Percent Exceedances in the Effects Analyses for Upper Klamath Lake

Sucker habitat in Project lakes and reservoirs is affected by water depths (Terwilliger 2006; USFWS 2002). This is especially true in UKL because it is very shallow and may not fill every year. One of the challenges in analyzing the effects of water storage and diversion on the LRS and SNS is predicting what lake levels would occur as a result of the action over the period covered by the consultation in comparison to the no-action condition.

Regarding the UKL levels that will result from the proposed action, Reclamation stated in the BA (USBR 2007, page 115):

> "In many years, Reclamation should be able to store and divert water from UKL and maintain elevations above the biological minimum lake elevations. Fifty percent of the time, end of month lake elevations are one foot or greater than the minimum biological elevations. By September, end of month elevations differ between the 50% exceedance curve and the biological minimum curve by over 2 feet."

In 2002, Reclamation proposed to operate the Project as it had in the 1990s. However, the 10-year period from 1990 to 1999 was unusual because it had 6 years of above-average inflows and two critically dry years that produced record low lake levels. During the period of 2002 to 2007, the region experienced a dry climatic regime and precipitation was below normal. This resulted in end-of-September elevations in UKL that were on average greater than 1 foot lower than would be anticipated if they were predicted based on average conditions over the POR (average is represented by the 50 percent exceedance values).

In the 2002 BO, we did not anticipate the low lake levels that occurred between 2002 and 2007, since we used the average frequency of water year types that had been experienced over the 1961 to 2000 POR in our analysis. We used the average for the POR because we anticipated that it would be a better predictor of climate over the consultation period than the frequency of year types that occurred in the 1990s. Nevertheless, we still over-estimated inflows and lake levels, but not as greatly as had we used the data from the 1990s.

We now recognize that more caution must be used when making hydrologic predictions based on exceedance values. In this BO we will use the 70 percent instead of a 50 percent exceedance value as the basis for our effects analysis for UKL. A 70 percent exceedance value means that 70 percent of the historic observations were equal to or greater than a set value and 30 percent were less. Thus, under a 70 percent exceedance for UKL, the value under consideration would be met in 70 percent of the years. In a 10 year period, 7 years should fall within the 70 percent exceedance value, if climate is similar to the POR. Exceedance values are commonly used by water managers, and a 70 percent exceedance is frequently used where a conservative approach is needed. By using the 70 percent exceedance, it will be less likely that we will have underestimated what lake levels will result from the proposed action.

Although our analysis is based primarily on the 70 percent exceedance, we have also considered the effects of UKL levels based on the 90 percent exceedance, so that the effects of infrequent droughts are also considered. A 90 percent exceedance is a one in ten year event. The use of the 70 and 90 percent exceedances is only for the analysis of effects of the proposed action on UKL. The effects analysis of proposed water level management at other Project water bodies was done differently as described below.

4.6 The No-action Condition in Upper Klamath Lake

In order to analyze the effects of the proposed action on the LRS and SNS in UKL, we compared what is likely to happen under the proposed action to the conditions that would likely exist if the action was not authorized, funded, or carried out. This is not the same as the no-action alternative under NEPA, which assumes that an action will continue as it is currently being implemented.

This analysis was only done for effects of the action on UKL because appropriate modeling was available. This approach is similar to that done in the 2002 BO, as are the analyses for effects of the proposed action on other Project reservoirs. In assessing a no-action condition in UKL, we assumed that Project features such as Link River Dam, Lost River Diversion Channel, and other associated Project features would remain in place, but no water would be diverted into Project canals.

The no-action condition is an abstraction meant only for the purpose of this effects analysis. It is not possible to describe in detail what the no-action conditions would be for the lands included in the Project, because Project operation involves numerous government and private facilities that are intermingled. Some of the water used in the Project comes from Project reservoirs and other water comes from other sources such as private wells. Additionally, assessing what the no-action condition would be involves some subjectivity in making assumptions about Project features, such as how dam gates would be set. Furthermore, if the Project was not authorized, it is likely that irrigation districts and private landowners would take compensatory actions to maintain their agricultural operations, just as they did prior to the Project, that we cannot accurately anticipate. In our analysis below, we have tried to be clear about the assumptions we made in assessing the no-action condition.

In the 2002 BA, Reclamation developed a baseline hydrology model to assess what the no-action condition water surface elevations would be for UKL (USBR 2002a, p. 49). The baseline hydrology represented UKL levels that would result if the Project did not manage the lake (i.e., the Project did not operate but Link River Dam would remain in place). The model also assumed there would be upstream non-Project surface-water diversions and groundwater pumping at current levels. Additionally, it assumed evaporation from open water and ET losses from wetlands would occur, resulting in lower lake elevations.

The baseline hydrology model developed for the 2002 BO is no longer valid since the storage capacity of UKL has been increased as a result of breaching dikes along part of the Williamson River Delta in October, 2007. Additional dike breaching at the delta is proposed in 2008, which will further increase storage. Reclamation estimates that the increased volume of UKL due to dike breaching at Tulana and Goose Bay in the Williamson River Delta will result in an average 0.2 feet (range 0.0 to 0.3 feet) lower lake level, depending on net inflows and time of year (J. Hicks, USBR, pers. comm. 2007). There are plans to open two other reclaimed areas of UKL (Agency Lake and Barnes Ranches) within the 10-year Project span, but Reclamation is currently using these sites for pumped storage, so breaching of the dikes is not likely to substantially change UKL storage (J. Hicks, USBR, pers. comm. 2007).

Reclamation developed a new no-action hydrologic model analysis for UKL which they termed the no-diversion scenario. Under this scenario, no Project diversions would occur. Results of this model were provided to the Service in early January 2008 (J. Hicks, USBR, email dated 1/3/08). Assumptions made in addition to those for the 2002 no-action hydrologic model (e.g., inflows would be net inflows since they would include upstream diversions, ET and evaporation losses) include: (1) UKL will be a level pool (i.e., lake levels would not be affected by the wind); (2) the river gates at Link River Dam will be fully open to maximize spill; and (3) the stage-discharge relationship for the Link River Dam developed by Perry et al. (2005) were used. (Note: this stage-discharge relationship was similar to what it was before the reef was channelized in the 1920s).

If the reef elevation stage-discharge relationship was not used, the fully open gates at the dam would have led to average elevations near 4136 feet, because this is the approximate depth of the channels cut through the reef when the dam was built in 1921. This level is much lower than current elevations and even lower than in the pre-project condition. Reclamation and the Service determined that this low elevation would not lead to a realistic no-action condition assessment.

We determined that it was reasonable to use the pre-project (historical) reef condition/elevation as an approach to modeling and analyzing the no-action condition lake levels. If Reclamation proposed an action to not operate the Project, Reclamation would need to consult on the change in operation, and it is reasonable to assume the Service would require water levels adequate to approximate the natural hydrology because of the adverse effects a lowered lake would have on the listed suckers.

The estimated differences between UKL levels under the no-action condition and lake levels that would result from the proposed action, at 70 and 90 percent exceedances are shown in Table 4-1 and Figure 4-3. A 70 percent exceedance value means that 70 percent of the observations were equal to or greater than a set value and 30 percent were less. A full range of UKL level exceedances are shown in Table 2-9 in the *Proposed Action section.*

Table 4-1. Difference between end-of-month 70 and 90 percent exceedance proposed action levels for UKL and 70 and 90 percent exceedances UKL levels for no-action, reef-in-place modeling (J. Hicks, USBR, pers. comm. 2008). Both based on 1961-2004 POR and corrected for increased storage as a result of breaching of Tulana and Goose Bay on the lower Williamson River.

Month	Proposed Action 70% Exceedance (feet MSL)	No-diversion 70% Exceedance (feet MSL)	Difference Between Proposed Action and No-action 70% Exceedance (feet)	Proposed Action 90% Exceedance (feet MSL)	No-diversion 90% Exceedance (feet MSL	Difference Between Proposed Action and No-action 90% Exceedance (feet)
Oct	4139.0	4140.1	-0.9	4137.9	4139.8	-1.9
Nov	4139.8	4140.3	-0.5	4138.5	4140.1	-1.6
Dec	4141.0	4140.6	0.4	4139.1	4140.4	-1.3
Jan	4141.8	4140.7	1.1	4140.0	4140.5	-0.5
Feb	4142.6	4140.9	1.7	4141.0	4140.6	0.4
Mar	4143.2	4141.0	2.2	4142.0	4140.6	1.4
April	4143.2	4141.0	2.2	4142.5	4140.6	1.9
May	4142.6	4140.8	1.8	4142.0	4140.4	1.6
June	4141.5	4140.5	1.0	4140.6	4140.2	0.4
July	4140.2	4140.1	0.1	4139.5	4139.9	-0.4
Aug	4139.3	4139.8	-0.5	4138.5	4139.7	-1.2
Sept	4139.0	4139.9	-0.9	4138.0	4139.7	-1.7

Based on the model results for the no-action condition in UKL at the 70 percent exceedance, the proposed action UKL levels are likely to be above the no-action condition from December through July and below the no-action condition during the rest of the year (see Table 4-1 and Figure 4-3). The greatest difference between these two conditions is in February through May, when the proposed action elevations are 1.7 to 2.2 feet higher than the no-action condition and in September and October when the proposed action is 0.9 feet lower than the no-action condition. At the 90 percent exceedance (which is similar to conditions during a drought year), the differences are similar to the 70 percent values with the proposed action resulting in higher lake levels in spring but more extreme low levels occur from August to December. Justification for use of the 70 percent exceedance lake levels is described in *section 4.5*.

4.7 Effects of the Action on Habitat Enhancement, Loss, and Degradation

Previous habitat losses as a result of the Klamath Project and other entities such as the degradation and loss of sucker habitats from drainage and agricultural conversions of wetlands and shallow lakes is part of the Environmental Baseline and are described in *section 3.2.1*. Major reductions in the size of Tule Lake and Lower Klamath Lake occurred and management of water levels in UKL facilitated the conversion of much of the wetland habitat around UKL by private interests (USBR 2007; Aquatic Scientific Resources 2005). Klamath Project development also created new habitat with construction of Gerber Dam and expansion of habitat at Clear Lake in the Lost River system.

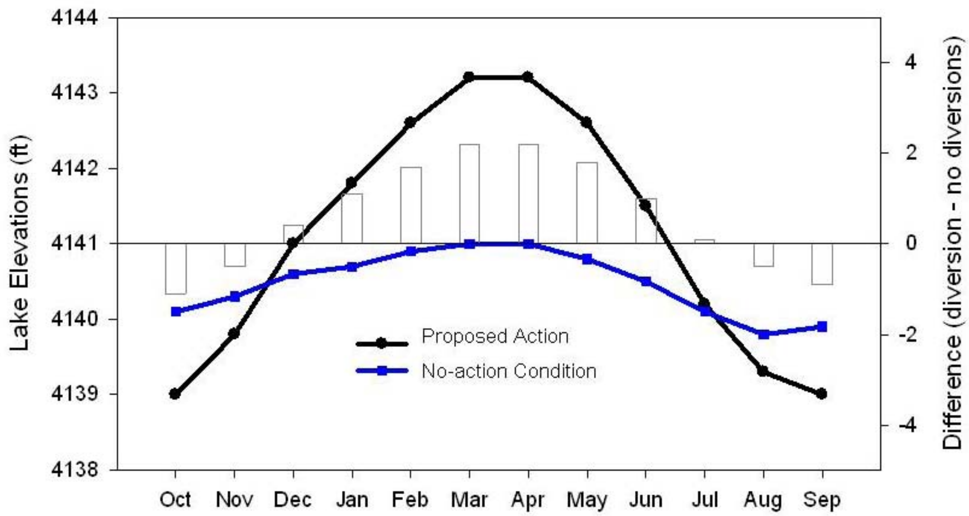


Figure 4-3. End-of-month UKL elevations at the 70 percent exceedance resulting from the proposed action and from the no-action condition.

As a result of the proposed action, we expect that wetland and lake habitat in UKL will increase relative to the no-action condition and that should benefit the LRS and SNS. It is likely that one of the Project storage facilities, Agency Lake/Barnes Ranch (9,830 acres) will be reconnected to UKL in the next several years, providing additional wetland and open water habitat for the listed suckers. Reclamation has also been a major partner in the restoration of 5,600 acres of habitat at the Williamson River Delta owned by The Nature Conservancy. Elsewhere in the Project, it is unclear if habitat improvements will be made as a result of the proposed action.

We do not anticipate that the proposed action will result in future loss of habitat from agricultural activities because the area of agricultural lands served by the Project has been relatively constant since the late 1940s. There have been few changes to the Project infrastructure since that time and there are no current plans to increase the size of the Project (USBR 2000a, 2007).

4.8 Effects of the Action on Sucker Movements

As described in the status and baseline section, the suckers must be able to move about to survive. Adult suckers must find suitable spawning habitats, avoid adverse water quality, and find food resources. Most sucker larvae drift downstream from riverine habitats where they were born to lake habitats where they rear. Juvenile suckers relocate themselves to find suitable habitats, avoid predators, and reduce competition. Dams that block these movements could adversely affect reproduction and survival of suckers. Therefore, below we will analyze the effects of the continued operation of the Project on sucker movements.

The proposed action will continue operation of the seven primary Project dams, only one of which, Link River Dam, provides suitable passage for suckers. As a result, we anticipate that there will likely be adverse effects to the LRS and SNS, and that some incidental take is likely to result. The fishway at the Link River Dam only allows adult suckers to pass the dam (Korson et al. 2008), but smaller juvenile and sub-adults will likely remain isolated downstream where their survival will be reduced by poor habitat and water quality conditions. Clear Lake, Gerber, Miller Creek, Malone, Wilson, and Anderson-Rose dams have no fish passage facilities. Sucker populations upstream and downstream of these dams are physically isolated and, therefore, genetic exchange between populations is restricted (only downstream exchange is possible). However, there is no evidence that loss of genetic variability has occurred (Dowling 2005). The dams also prevent passage to potential spawning, rearing and water quality refuge habitat and the return of suckers that move downstream back to upstream habitat.

Hybridization between sucker species trapped below dams may also occur at higher frequencies, because spawning fish are restricted to small and perhaps inadequate spawning areas. This may be happening below Anderson-Rose Dam in the lower Lost River (USFWS 2002). It may also be happening below Chiloquin Dam (a non-Project facility) because it reduces passage of suckers to upstream spawning sites (Ellsworth et al. 2007). The dam is slated for removal in 2008, so that effect will be removed. There is evidence that hybridization has been common throughout the evolutionary history of suckers in general, and among Klamath Basin suckers in particular, and that this hybridization is possibly adaptive (Dowling 2005; ISRP 2005). It is unknown whether hybridization rates have increased as a result of Project operations.

Based on the numbers of suckers recently observed in the spawning runs up the Lost River from Tule Lake (Hodge 2007; M. Buettner, USFWS, pers. comm. 2007), up to 300 adult suckers are forced to spawn in restricted spawning habitat below Anderson Rose Dam. As a result there could be increased rates of hybridization because of cross-fertilization of eggs, eggs and embryos could be dislodged by spawning activities and drift downstream into pools where they could be smothered by silt, and other possible adverse effects. Also, see discussion under section 5.10 on inadequate instream flows below Anderson Rose Dam.

There is little potential spawning habitat in the Lost River upstream of Anderson Rose Dam because construction of Lost River Diversion Dam inundated historic spawning habitat near Olene, and because of loss and degradation of historic spawning habitat at Big Springs near Bonanza and other locations in the Lost River and its tributaries. Therefore, there will be minimal population level effects related to the continued lack of passage at this dam under the proposed action. Because the Lost River from Lost River Diversion Dam to Anderson Rose Dam does not support sucker populations, there is no effect of lack of upstream passage on upstream populations. This is not to say that suckers do not move downstream through this reach. Larval and juvenile suckers from UKL and possibly the Lost River above Lost River Diversion Dam may move downstream through this reach. However, because of the lack of suitable rearing habitat in this reach they likely move downstream into Tule Lake or J-Canal.

Continued operation of Lost River Diversion Dam without upstream fish passage facilities will not affect downstream sucker populations, because there are currently no resident sucker populations in the Lost River below the Dam, adult suckers returning from Tule Lake are blocked by Anderson Rose Dam, and there is minimal spawning habitat upstream of Wilson Reservoir. The number of suckers entrained at Lost River Diversion Dam and not able to return to upstream populations is believed to be small compared to the number produced upstream. A small population of SNS has been documented in Wilson Reservoir under past and current Project operations without fish passage. Continued operation of Lost River Diversion Dam without upstream fish passage facilities will have minimal effects on upstream SNS populations.

In the upper Lost River continued operation of Malone Dam without upstream fish passage facilities may prevent a small number of SNS adults from migrating upstream from Harpold Reservoir and the Bonanza area to potential spawning habitat above Malone Dam. However, there is no evidence of suckers attempting to migrate past Malone Dam. This small self-sustaining population of SNS will continue to spawn in lower Miller Creek, Big Springs near Bonanza and other locations. Therefore, the proposed action without fish passage at Malone Dam will not negatively affect overall SNS sucker population status in the Lost River. Although fish monitoring data is sparse for Malone Reservoir, because Clear Lake was screened in 2003 and few fish are presumably entrained, and the reservoir is almost completely drained at the end of each irrigation season, it is unlikely that many suckers reside there or the Lost River between Malone and Clear Lake. Continued operation of Malone Dam with no upstream passage facilities will have minimal effects on upstream sucker populations.

Because there appears to be few suckers in Malone Reservoir, there is no evidence of suckers attempting to pass the dam, and no fish passage is available at Malone Dam to allow downstream fish to access this reach, there is minimal effect on downstream sucker populations as a result of continued operation of Clear Lake Dam without fish passage facilities. Because there is a fish screen in the outlet structure at Clear Lake Dam, and larval and juvenile entrainment is low compared to the number produced in Clear Lake, there is minimal population level effect on upstream sucker populations as a result of continued operation of Clear Lake Dam without fish passage facilities.

At Miller Creek, continued operation of Miller Creek Diversion Dam and Gerber Dam without upstream fish passage facilities will not negatively effect downstream sucker populations. There are no resident sucker populations in Miller Creek, and SNS from the Lost River that spawn in the lower portion of Miller Creek in some years use areas well below the dams. There is also no evidence of adult suckers attempting to migrate upstream of Gerber Dam and Miller Creek Diversion Dam. Because entrainment of larval, juvenile, and sub-adult/adult suckers at Gerber Dam appears to be small compared to the numbers present in Gerber Reservoir, continued operation of Gerber Dam without upstream fish passage facilities will not have a population level effect.

Because the Link River Dam fish ladder is designed to only provide upstream passage for adult suckers, some juveniles and sub-adult/adult suckers at Link River Dam may be lost annually to the populations upstream since they cannot return to upstream rearing habitat. Based on the numbers of juveniles documented in entrainment studies described in the *Environmental Baseline section (see section 3.2.6)*, over 100,000 juveniles per year might be affected by a lack of passage at the dam. Most of these suckers will likely die from poor water quality before growing large enough to be able to effectively use the ladder.

4.9 Effects of the Action on Instream Flows

As a result of the proposed action, we anticipate that there will be some incidental take of LRS and SNS because of insufficient instream flows below some Project facilities. Effects of these changes on the LRS and SNS vary with each Project facility and time of year, as discussed below.

Flows at Link River Dam

Reclamation and PacifiCorp operate Link River Dam for multiple purposes. The Link River below the dam is primarily a corridor for all life stages of suckers dispersing downstream, adult suckers migrating upstream to spawn, and juvenile, sub-adult and adult suckers seeking refuge from poor water quality in Keno Reservoir (USFWS 2007a). In the FERC BO (USFWS 2007a), the Service required PacifiCorp to not operate Eastside and Westside Power Diversions, if included in the license, when flows are 500 cfs or less below Link River Dam. Continued operation of Link River Dam spillway and fishway with minimum releases of 500 cfs or less (if Project inflow is less) at the spillway and fishway will have minimal effects on suckers in the Link River. However, if Project inflows are less than 500 cfs, the Service assumes that the minimum releases will be at least 300 cfs based on modeled flows at Link River Dam under the proposed action. Continued operation of Link River Dam spillway and fishway with minimum releases of at least 300 cfs under the proposed action will have minimal effects on suckers dispersing downstream from UKL because there will be adequate depth, cover, and velocity to minimize predation by fish eating birds and fish predators. These releases will also be adequate for upstream passage of adult suckers migrating back to UKL, for juvenile and sub-adult/adult suckers residing in the lower Link River, and for those seeking refuge there when water quality is poor during the summer in Keno Reservoir.

Flows below Project Dams in the Lost River System

The Project intensively manages instream flows in the Lost River system, but this management does not affect instream flows in the sucker spawning tributaries to Clear Lake and Gerber Reservoir, where the primary populations of LRS and SNS occur. Project operations do affect instream flows in Miller Creek below Gerber Reservoir and in the Lost River below Clear Lake, Malone, Wilson, and Anderson-Rose Reservoirs. Flow diversions for irrigation are made in the Lost River below Clear Lake and Miller Creek below Gerber Reservoir from April through September. From October through March water is stored in Clear Lake and Gerber Reservoirs and no releases are made. Consequently, flows in the upper Lost River (Clear Lake downstream to Bonanza) are very low during fall and winter because there are only small accretions coming from springs and occasional runoff events. However, farther downstream flows do increase from tributary and spring accretions.

The regulation of flows in the Lost River drainage under the proposed action results in lower flows during the non-irrigation season (October to March) than during the no-action condition because water is stored outside the irrigation season. During the irrigation season (April to September) flows in some reaches below dams are higher under the proposed action than the no-action condition due to irrigation releases (i.e., Clear Lake and Gerber Dam). In other reaches, flows are low below project diversion dams during the irrigation season because water is diverted in Project canals (i.e., Malone Dam, Miller Creek Diversion Dam, Lost River Diversion Dam, Anderson Rose Dam).

Sucker spawning has been documented in the Lost River below Anderson Rose Dam, in the Lost River near Bonanza and above Malone Dam, Miller Creek, Big Springs, and other locations (USBR 2001a). Under the proposed action, flows in the Lost River system during spring months of some years are sufficient to allow sucker spawning in some reaches of the Lost River (Sutton and Morris 2005; USBR 2001a). We suspect that larval, juvenile, and sub-adult/adult sucker health and survival may be reduced because of stranding, increased predation, potentially harmful water quality conditions, stress from crowding and lack of food, and higher incidence of disease exacerbated by water management in the Lost River (USBR 2007). Continued regulation of flows at Clear Lake, Gerber Dam, Miller Creek Diversion Dam and Malone Dam will result in flow patterns downstream of the dams that differ in magnitude, timing and duration compared to the no-action condition. However, this change will not have a population level effect on SNS populations in the Lost River (i.e., Wilson Reservoir and Harpold Reservoir) because there will be adequate instream flows from tributaries and spring accretions under the proposed action.

Flow diversion in the Lost River at Wilson Dam during fall, winter, and spring resulting in lower flows under the proposed action may adversely affect suckers and their habitat in the Lost River downstream of the dam to Tule Lake. Low flows may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality and fish die-offs. However, there are no resident sucker populations in the Lost River below Lost River Diversion Dam to Tule Lake. Thus, continued flow diversion at Lost River Diversion Dam under the proposed action will not have a population level affect.

LRS and SNS from Tule Lake spawn in the lower Lost River below Anderson-Rose Dam when spills or releases occur during April and May (USBR1998; Hodge 2007, 2008). Since 1991, when sucker spawning run monitoring began, sucker spawning migrations were documented in all years monitored except 1992, when no flow releases were made. Larval suckers produced from spawning activities below Anderson-Rose Dam were only documented in 3 out of 10 years. Also, only two juvenile suckers were captured from intensive fish monitoring activities in Tule Lake sumps in 2007 (Hodge 2008). Under the proposed action there are no flow releases below Anderson Rose Dam during the irrigation season (April to November) except for spill events from local runoff. Therefore, the proposed action will result in inadequate flows for sucker spawning, egg incubation, larval rearing and emigration in the Lost River below Anderson Rose Dam. Providing adequate flows below the dam during key periods would minimize this adverse effect.

4.10 Effects of the Action on Entrainment of LRS and SNS at Project Facilities

As a result of the proposed action, we expect that entrainment rates of LRS and SNS at Project facilities, especially those at the UKL outlet (i.e., A-Canal and Link River Dam spillway and fishway) will be higher than under the no-action condition, and that those entrainment losses will adversely affect LRS and SNS and result in incidental take.

Entrainment is defined as the downstream movement of fish past or through Klamath Project water management structures as a result of water management operations as opposed to downstream movement resulting from passive drift of larvae and juveniles due to wind-driven currents and natural flow out of the lake or volitional migration.

Klamath Project operations likely increase movement of suckers from UKL, leading to their potential loss to the reproducing population, as explained below and in Appendix 1. Specifically, the Project stores and later diverts water from UKL for a variety of Project purposes. These operations result in changes in lake levels and increases of flows at the outlet of the lake that differ from the no-action condition. These lake level and flow alterations could increase movement of juvenile and sub-adult/adult fish downstream of UKL, as discussed below. In addition, Project operations cause entrainment of larvae into the A-Canal, where they are also lost to the population. Below, we first discuss how we separated Project-caused entrainment effects at the Link River Dam spillway and fishway for larvae, juveniles, and sub-adult/adults from movement of these life stages that would be expected without the Project. Then we provide an estimate of entrainment losses at both the Link River Dam spillway and fishway and A-Canal that are attributed to Project operations, as well as an assessment of the significance of these losses (see Appendix 1).

Losses of Larval Suckers at Link River Dam Spillway and Fishway

Loss of larval suckers at the UKL outlet likely results from the interplay of multiple factors (Markle et al. in review; see discussion in *Environmental Baseline*). Larval suckers have limited swimming ability, are surface oriented, and many are likely carried down-lake to the outlet facilities by currents. USGS modeling using data from measurements of currents in UKL (Cheng et al. 2005), indicates that sucker larvae could be swept from spawning areas to the lake outlet in about one week (Reithel 2006; Markle et al. in review; T. Wood, USGS, pers. comm. 2008).

Most LRS and SNS larvae in UKL enter the lake along the eastern shoreline, either from shoreline spawning or from emigration out of the Williamson River. This makes them vulnerable to down-lake transport "advection" by the "Eastern Shore Current," that typically flows south along the eastern shore of UKL to the lake outlet (*see Figure 3-20 in the Environmental Baseline section*) and likely carries larvae along the shoreline toward UKL outlet facilities (Reithel 2006; Markle et al. in review; T. Wood, USGS, pers. comm. 2008). Based on the USGS modeling, flows from the UKL outlet (which equal the sum of discharge from Link River spillway + fishway + A-Canal + Eastside and Westside hydropower diversions) could also affect the advection rate and the number of larvae captured in outlet flows. Higher springtime flows increase drift rates and therefore increase downstream movement at higher rates than would occur during lower outlet flows (Reithel 2006; T. Wood, USGS, pers. comm. 2008).

Information regarding UKL's hydrography suggests that larval suckers, particularly LRS, can also be retained in the wind-generated gyre located farther offshore than the Eastern Shore Current (Markle et al. in review). Under prevailing northwest winds, the residual flow in UKL is a clockwise gyre extending as far north as the shoreline between Agency Strait and Pelican Bay and as far south as Buck Island (Wood et al. 2006; see Figure 3-20 in *Environmental Baseline Section*). Strong prevailing winds drive a stronger clockwise circulation than weak prevailing winds, and consequently particles (e.g., drifting larval suckers) are more likely to be transported in the gyre and stay in UKL under strong wind conditions. Modeling shows that virtual particles released at Sucker Springs (a major LRS spawning area along the eastern shoreline of UKL) always left the lake under weak prevailing winds, but showed variable retention (0 to 60 percent) under strong winds. Overall, retention was greater for virtual particles released from the Williamson River (the major SNS and LRS sucker spawning tributary for UKL) than for particles released from Sucker Springs.

Once at the outlet of UKL, larvae could be entrained at the A-Canal, where some would pass through the fish screen and some would be by-passed back into UKL via the pump by-pass system (Bennetts et al. 2004). The outlet of the pump by-pass flume is near the west bank of the outlet channel of UKL, just downstream from the A-Canal headgates, and about 1/3 mile upstream of the Link River Dam (see Figure 4-4). Based on available larval entrainment evaluations at the A-Canal fish screen in 2003, up to about 50 percent of the larvae will pass through the fish screen and enter A-Canal and the other 50 percent be by-passed back to UKL (Bennetts et al. 2004). Evaluations at a similar fish screen facility on the Sacramento River with larvae of another sucker species yielded similar results (Borthwick and Weber 2001). Of those larvae that are by-passed back to the UKL, we assume that few larvae (less than 25 percent) will return to the lake and that most (greater than 75 percent) will be trapped in the flow moving towards the Link River Dam (USFWS 2007a), because the by-pass outlet deposits larvae just upstream of Link River Dam spillway in an area of low velocity near the shoreline opposite the entrance of the A-Canal (Wahl and Vermeyen 1998).

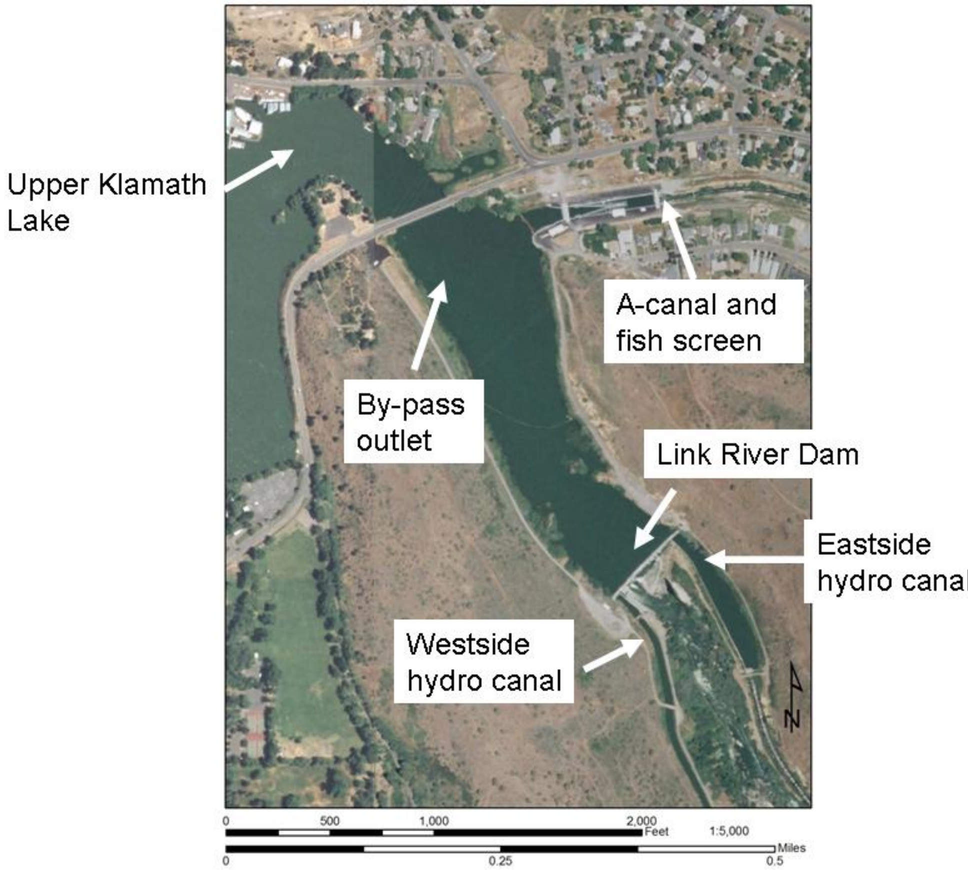


Figure 4-4. Aerial photo of the UKL outlet area showing the A-Canal and fish screen, the approximate location of the pump by-pass outlet, the Link River Dam, and the two associated hydropower canals.

To assess the effects of the proposed action on larval entrainment, we compared lake elevations associated with the proposed action to modeled elevations with no storage or diversion operations (i.e., our no-action condition, described above; see Table 4-1 and Figure 4-3). We focused on the period from April through mid-July because that is when larval suckers are present in UKL. During the April through June primary larval sucker life history period, UKL elevations will likely range from 1.0 to 2.2 feet higher under the proposed action compared to the no-action condition at 70 percent exceedance. During July, elevations resulting from the proposed action are likely to be similar to the no-action condition. Therefore, lake levels under the proposed action are substantially higher during most of the larval period, providing more inundation of preferred shoreline emergent vegetation habitat (Cooperman and Markle 2004) than under the no-action condition, and thus benefiting the fish. With more larval habitat available, more LRS and SNS larvae are likely to be retained and not leave the lake through advection (Markle et al. in review). Based on the depth distribution of emergent vegetation habitat at the Williamson River Delta where the highest densities of larvae are found (Cooperman and Markle 2004), under the proposed action end of May elevation of 4142.6 feet, approximately 94 percent of the habitat is inundated and thus available in the delta area (Elseroad 2004).

As previously described, larval suckers are relatively poor swimmers, and therefore are susceptible to advection caused by wind-driven currents and to a lesser extent by flow out of UKL. Advection forces are greater near the outlet of the lake at higher flows. In the modeling, this results in greater losses of drifting particles from the lake, so presumably this affects weakly-mobile larval suckers, as well (Reithel 2006).

Consistent with our use of 70 percent exceedance for the effects analysis on UKL levels, we use 30 percent exceedance for flows at the UKL outlet (A-Canal and Link River Dam) for the effects analysis on sucker entrainment. Under this scenario, in a 10-year period, 7 years should have flows lower than the 30 percent exceedance value, and 3 years higher. By using the 30 percent exceedance for flow, it will be less likely that we will have underestimated what quantity of water passes out of the lake.

Flows out of UKL under the proposed action are anticipated to be less than the no-action condition during a portion of the larval entrainment period (using the conservative 30 percent exceedance for flows). Predicted average monthly flows are approximately 270 and 240 cfs lower under the proposed action compared to the no-action condition during April and May, respectively (see Figure 4-5). During these months, we do not expect higher entrainment of larvae at Link River Dam spillway and fishway from increased advection because flows are not increased by the proposed action. During June, predicted average flows are 280 cfs higher under the proposed action than the no-action condition. However, because lake levels are higher under the proposed action than the no-action condition, more emergent wetlands are inundated, providing more rearing habitat for larval suckers (particularly SNS) and fewer fish will be passively drifting to the outlet of UKL. Also, many larval suckers will be larger and better swimmers than those present in UKL during April and May, and thus less likely to passively drift and become entrained.

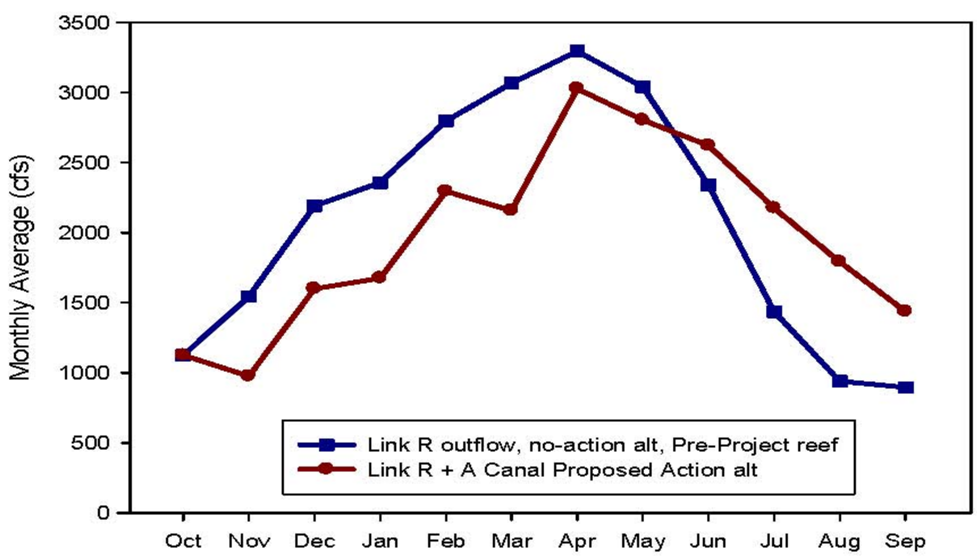


Figure 4-5. Average monthly flows at the UKL outlet that are likely to result from the proposed action (30 percent exceedance, 1961-2006) compared to the modeled no-action condition with reef in place.

The preceding analysis indicates that the proposed action would not result in more entrainment through Link River Dam than would result under the no-action condition. Therefore, the larval sucker entrainment at the outlet of UKL that is attributable to the proposed action is only that related to operation of the A-Canal. Therefore, entrainment losses caused by the proposed action are expected to be equal to the present A-Canal entrainment losses (estimated to be 1.65 million larvae per year) plus the larvae that are bypassed at the A-Canal screens and subsequently become entrained at Link River Dam spillway and fishway (estimated to be between 0.5 and 0.7 million larvae per year). The total larval entrainment loss caused by proposed Project operations at UKL is estimated to be between 2.2 and 2.4 million larvae per year (see Appendix 1).

We assume greater than 99 percent of the entrained larvae die when they enter project canals because they are either entrained into pumps or diverted into fields, die from poor water quality in parts of the Project, die from habitat loss and predation at the end of the season when Project canals are emptied, or other sources of mortality. A very small fraction of the entrained suckers are salvaged at the end of the season. In 2003 and 2005, 85 and three suckers were salvaged, respectively, from the A-Canal (Bennetts and Foster 2008).

Losses of Juvenile Suckers at Link River Dam Spillway and Fishway

Based on studies at the outlet of UKL, most juvenile sucker loss from the lake resulting from emigration and entrainment at the UKL outlet occurs during the July through October period, with a peak in August and September (Gutermuth et al. 1998, 2000a, 2000b; Foster and Bennetts 2006; Tyler 2007).

As the summer progresses, the distribution of juveniles in near-shore areas appears to shift from the northern end of UKL to the shorelines of the southern portion of UKL, generally south of Buck Island. This pattern was remarkably constant in OSU cast net surveys from 1994 to 2003 (Terwilliger 2006). It is also consistent with a hypothesis that if juveniles are either drifting or swimming with the south-flowing eastern shore current, they will end up at the south end of the lake. Entrainment of juveniles during the mid- to late-summer into the Link River Dam spillway and fishway, Eastside and Westside powerhouses, and into the A-Canal before it was screened (Gutermuth et al. 1998, 2000a, 2000b; Foster and Bennetts 2006; Tyler 2007), suggests a possible southward movement of suckers through the summer as previously noted. However, USGS has not documented strong evidence for a seasonal southward movement of juvenile suckers (Hendrixson et al. 2007a, 2007b). There may be multiple explanations for an apparent southward movement, such as changes in habitat/depth preferences, varying survival rates, gear selection, changes in water quality, and others.

Because a large number of juveniles are located in the southern end of the lake during the summer, it is logical to assume some of these would be vulnerable to processes that remove them from the lake, i.e., entrainment and/or emigration. In August and September when lake levels are lower, water velocities near the outlet of UKL are typically still relatively high and may be attractive to fish. During July and September 1998 surveys, velocities up to 2 feet/s were measured in near the outlet of UKL (Wahl and Vermeyen 1998; see Figure 4-6). These flows are relatively high compared to the 1.1 feet/second critical swimming speed for juvenile suckers (Delonay and Little 1997). If these fish were involved in some sort of density dependent, passive dispersal, or are otherwise attracted to currents, they might easily follow velocity vectors at the outlet of the lake because of outflows.

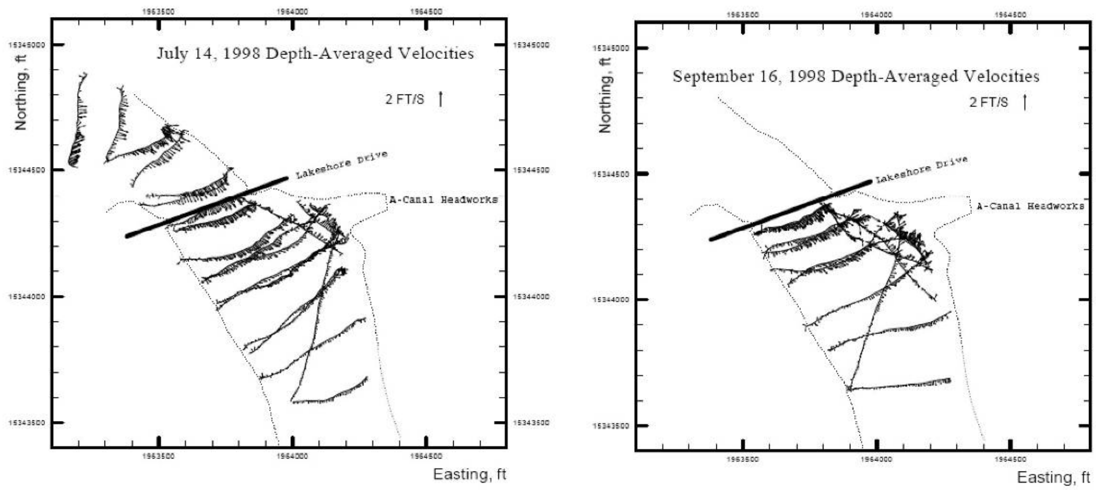


Figure 4-6. Current velocity vectors at the outlet of UKL near the A-Canal in July and September 1998 (from Wahl and Vermeyen 1998). The relative length of the vectors is proportional to the flow and the direction is oriented in the direction of the flow.

In the July through October, primary juvenile sucker entrainment/emigration period, flows out of UKL are higher at the outlet under the proposed action than under the no-action condition (based on the 30 percent flow exceedance; see Appendix 1). July, August, September, and October average flows are 740, 850, 540, and 2 cfs higher under the proposed action than under the no-action condition, respectively (see Figure 4-5). Therefore, juvenile suckers near the outlet of the lake could be more susceptible to being attracted to the Link River Dam and A-Canal outflows and subsequently lost from the lake. Gutermuth et al. (2000b) documented that juvenile sucker entrainment was generally proportional to the volume of flows in the Eastside and Westside canals, thus suggesting that the rate of entrainment is greater at higher flow. Entrainment/emigration is also more likely to occur now, in comparison to the pre-project condition, because when Link River Dam was constructed, deep channels were cut through the reefs at the outlet of the lake (USBR 2001a; see *Environmental Baseline section* and Appendix 1). Juvenile suckers historically may have been less likely to pass over a shallow reef because they would have been exposed to fish-eating birds.

The overall contribution of the Project to loss of juvenile suckers at the outlet of UKL is difficult to partition from natural emigration, advection related to wind-generated currents, and transport of debilitated fish that might die from disease or predation even if they remained in the lake. However, we assume, based on the evidence discussed above, that since flows at the outlet are about 50 percent higher during the period when the largest numbers of juveniles are present and that entrainment is proportional to the flow, that an increase of about 50 percent of the juvenile entrainment through the Link River Dam spillway is related to Project operations.

Historically, some of the suckers leaving UKL would have reared in Lake Ewauna and Lower Klamath Lake and then returned to UKL as adults. However, with the degradation and loss of lake and wetland habitat due to agriculture conversion, railway construction, constant water level management after construction of Keno Dam, and degradation of water quality, sucker survival is minimal in Keno Reservoir. Water quality in the Keno Reservoir is poor every summer and fish die-offs are frequent (Piaskowski 2003; USBR 2007; see *Environmental Baseline section*). Therefore, it seems reasonable to conclude that most juvenile suckers that end up in Keno

Reservoir will die. Adult suckers in Keno Reservoir can re-enter UKL via the new fishway, but smaller suckers are unlikely to be able to ascend the Link River cascades and use the fishway.

The proposed action is expected to increase loss of juvenile suckers at the UKL outlet by approximately 50 percent compared to the no-action condition. Thus, with an average annual loss of 85,000 juveniles at Link River Dam spillway and fishway, an increase of 50 percent would be equal to 28,000 fish entrained as a result of Project operations. Using a more conservative approach where all juvenile suckers that are by-passed from the A-Canal fish screen moved downstream and PacifiCorp operation resulted in 25 percent returning to UKL, average entrainment at Link River Dam spillway and fishway would be equal to 44,000 juveniles (see Appendix 1).

Losses of Sub-adult/Adult Suckers at Link River Dam Spillway and Fishway

As with the juveniles, most sub-adult/adult entrainment occurs during the July through October period (Gutermuth et al. 2000a, 2000b). Because flows at the outlet are about 50 percent higher during the main sub-adult/adult entrainment period (using the 30 percent exceedance values) and that entrainment is proportional to flow (Gutermuth et al. 2000b), we assume that an increase of 50 percent of the sub-adult/adult entrainment through the Link River Dam spillway and fishway is related to Project operations.

The proposed action is expected to increase sub-adult/adult entrainment by approximately 50 percent. Thus, with an average annual entrainment of approximately 80 sub-adult/adults at Link River Dam spill gates and fishway, a 50 percent increase would be 28 fish. Using a more conservative approach where all sub-adult/adult suckers bypassed at A-Canal moved downstream and PacifiCorp operation resulted in 25 percent returning to UKL, average entrainment at Link River Dam spillway would be 37 sub-adult/adults. Further, because there is a new fishway on Link River Dam, some of the adult suckers (but probably not sub-adult suckers) would return to the lake.

In summary, our analysis attempts to separate entrainment losses of suckers (i.e., loss of suckers from the reproducing population due to effects of the Project) from downstream movement of suckers that would occur even without the Project. Estimated entrainment rates (due to the Project) of larvae at A-Canal and Link River Dam spillway and fishway based on two years of data are in the low millions per year (estimated at 2.2 to 2.4 million), which is probably not a significant amount compared to rates of productivity at this life stage. Entrainment rate of juvenile suckers is estimated at 28,000 to 44,000 juveniles, or about 5 percent of the annual juvenile sucker mortality. Estimated annual entrainment for sub-adult/adult suckers is less than 50 fish per year, or less than 1 percent of the sub-adult/adult population in UKL. Also, some of these fish probably return to UKL through the new Link River Dam fishway.

We anticipate that several sucker recovery actions that have been or are soon to be implemented will compensate for the various sources of larval and juvenile suckers mortality, including entrainment, and improve recruitment and population status. These include removal of Chiloquin Dam and installation of a new screen downstream of the dam; wetland restoration around UKL, and especially at the Williamson River Delta; and wetland, riparian, and instream habitat restoration upstream in the Sprague River, where some in-stream rearing of larval and juvenile suckers has been recently documented.

Entrainment of LRS and SNS at Other Project Facilities

Entrainment of larval, juvenile and sub-adult/adult suckers is also likely to occur at other diversions in the Project. The outlet at Clear Lake was screened in 2003. However, the ¼ inch mesh screen will not prevent larval sucker entrainment. Although we have no data from this site, we anticipate annual entrainment of up to 100,000 larvae because the location of the outlet is relatively close to the mouth of Willow Creek where larvae would enter the lake. We also estimate up to 100 small juvenile suckers will pass through the screen every year. However, this level of entrainment likely represents less than one percent of the larvae and juvenile suckers produced each year in Clear Lake. Because this entrainment loss is so small, it likely has a minimal effect on sucker populations in Clear Lake.

The outlet at Gerber Reservoir is not screened; however, based on entrainment monitoring and survey of fishes in Miller Creek downstream of the dam, few juvenile and sub-adult/adult suckers are entrained (Hamilton et al. 2003). We estimate that up to 10,000 larvae, 1,000 juveniles and 100 sub-adult/adults are entrained annually. The Service estimates that larval and juvenile sucker losses likely are less than one percent of the annual production larvae and juvenile suckers in Gerber Reservoir. The number of sub-adult/adult suckers entrained at Gerber Dam represents a small fraction of the populations in Gerber Reservoir (less than 1 percent). Therefore, continued operation of Gerber Dam without screens will have minimal population level effects.

The North Canal and West Canal, and the East Malone Lateral, are located downstream of Gerber Reservoir and Clear Lake, respectively. Based on previous canal salvage efforts, sucker entrainment into these diversions appears to be small. Also, since we assume that all suckers entrained into these diversions originate from Clear Lake and Gerber Reservoirs, the entrainment effects have already been accounted for. Therefore, continued operation of North Canal, West Canal, and East Malone Lateral will have no effect on sucker populations.
Although we lack supporting data, it is likely that a small number of larvae (perhaps up to 100) and juvenile suckers (perhaps up to 10) will be entrained annually at West/Highline Pump from a small self-sustaining SNS population in the Lost River upstream of Harpold Reservoir as a result of the proposed action. The Service believes this entrainment is discountable compared to the number of larvae and juvenile suckers produced annually in this reach. Continued operation of the West/Highline Pump will have minimal effect on the SNS sucker population in the Lost River upstream of Harpold Reservoir.

Water is diverted into the Lost River Diversion Channel from Wilson Reservoir throughout the year. A small number of suckers are likely entrained into the Channel that are lost to the upstream population. However, the Service believes this amount is a small fraction (less than 1 percent) of the number of larvae and juveniles produced annually or sub-adult/adults residing in Wilson Reservoir. Thus, continued diversion of water from Wilson Reservoir into the Lost River Diversion Canal will have a minimal effect on sucker populations.

The effects of entrainment losses at Project diversions within the Lost River Diversion Channel, Miller Hill Pumping Plant and Station 48, have already been accounted for at the Lost River Diversion Channel. There are also diversions in the lower Lost River downstream of Lost River Diversion Dam (J-Canal and Adams Pumps) that entrain fish whose effects are already attributed to the Lost River Diversion Channel. Diversions around Tule Lake including the Q-Canal, R-Canal, R-Pump, N-12 Lateral, and Pumping Plant D appear to entrain few suckers, based on the low numbers in Tule Lake. The Service assumes most suckers in Tule Lake originate from upstream sources where entrainment losses have already been accounted for. Therefore, there are minimal effects to sucker populations with continued operation of diversions around Tule Lake.

The Sevenmile Creek diversion for Agency Lake Ranch/Barnes Ranch was screened in 2001. In 2004, Reclamation staff sampled the outlet of the screen using a rotary screw trap and documented fish entering the impoundment that were too large to pass through the fish screen (R. Piaskowski, USBR, pers. comm. 2004). Although few suckers were collected in the 2004 assessment, the data provided evidence that the screen was not functioning as designed. Other studies have shown few suckers occur in that part of the lake (Buettner 2002; Mulligan and Mulligan 2007). Based on the entrainment data and information on sucker abundance in the vicinity, we estimate annual entrainment losses at this diversion are small (perhaps up to 100 juvenile suckers). These numbers are discountable compared to the number of juveniles produced in UKL and thus, there is no population level effect of entrainment.

Reclamation, through its contractors (irrigation districts), has implemented measures to reduce sucker stranding in canals at the end of the irrigation season, and proposes to continue annual salvage operations in Project canals to reduce stranding and die-offs of suckers. Reclamation also proposes to continue working with other agencies and stakeholders to determine if and where other efforts to reduce entrainment are needed.

Reclamation, the Service, and other agencies recognize that there are a large number of unscreened diversions in the Upper Klamath Basin. Consequently, Reclamation is working with other agencies, including the Service and ODFW, to identify and screen diversions where there is substantial risk to listed suckers. Reclamation and the Service believe screening non-Federal diversions in UKL will provide the greatest benefits to endangered sucker populations where they are most abundant, populations are relatively robust, and the number of juvenile suckers in UKL is particularly vulnerable to entrainment if private diversions on UKL remain unscreened. Reclamation initiated a process for the UKL Fish Screen Program by issuing a grant to ODFW and leveraging Federal and State funds to provide 90 percent of the cost of constructing fish screens for willing landowners.

Although the level of entrainment has been substantially reduced by the new facilities at the A-Canal intake, operation of Project diversions that entrain LRS and SNS continues to have an adverse effect on the conservation needs of the species. We estimate that up to approximately 2.5 million larvae, 45,000 juveniles, and 200 sub-adult/adult suckers die as a result of Project related entrainment each year. The exact number of fish that die is unknown and likely varies each year depending on production, diversion and flow rates, and other factors. Ongoing operation of Project diversions in the Lost River system have minimal entrainment effects on sucker populations because Clear Lake outlet is screened and the number of suckers entrained at Gerber Dam and other project diversions are small compared to the number produced each year. Continued operation of Project diversions downstream of Clear Lake and Gerber Dam will have no affect on sucker populations because entrainment losses have already been accounted for. In the Lost River below Lost River Diversion Dam and Tule Lake continued operation of Project diversions will have minimal effects on sucker populations because fish entrained at these facilities came from sources upstream that have already been accounted for.

4.11 Effects of Lake Management on LRS and SNS Habitat

As a result of the proposed action, we expect that there will be an increase in larval sucker habitat and in lake-shore spawning habitat in UKL, but juvenile, sub-adult, and adult habitat will be reduced during the summer and fall in comparison to the no-action condition. An increase of habitat for larval suckers and for shoreline spawning likely benefits suckers; reductions in habitat for all life stages could be adverse. Current information is insufficient to conclude with certainty that habitat modification related to Project management of UKL levels will result in incidental take of LRS and SNS. Water levels resulting from the proposed action at Clear Lake and Gerber Reservoir will likely have beneficial effects to LRS and SNS when lake levels are higher than the no-action condition. When levels are very low, such as during a prolonged drought, there is likely to be adverse effects.

4.11.1 Upper Klamath Lake

Reclamation's operation of the Project, including the proposed action, affects water levels in UKL and alters it from no-action condition levels. Under continued operations, lake levels generally will be higher in the spring and lower in late summer, fall, and winter than the no-action condition (see Table 4-1 and Figure 4-3).

The proposed management of UKL will affect the habitat available for each of the life-stages of the suckers, including larvae, juveniles, sub-adults, and adults, in different ways. Each life-stage has different habitat needs and different critical seasons when they use that habitat, as described in the Environmental Baseline section.

Effects of UKL Management on Shoreline Spawning Habitat (February to May)

Sucker spawning, mostly LRS, currently is known to occur at several shoreline areas, including Sucker Springs, Silver Building Springs, Ouxy Springs, Cinder Flat and Boulder Springs along the eastside of UKL (Perkins et al. 2000a; Hayes et al. 2002). Accessibility of spawning gravels with sufficient water depth may be crucial to spawning success and ultimately could determine the long-term survival of the lake spawning populations (Reiser et al. 2001). This is especially the case since known spawning sites are few in number and small in area, with most being only a few hundred square feet in size.

Table 4-2. UKL elevations that are predicted to occur as a result of the proposed action at the 70 percent exceedance and under the no-action condition during months when lakeshore spawning is likely to occur (from Table 4-1). Average percent of shoreline spawning area inundated to a minimum depth of 1 foot is shown in parenthesis based on data in USBR (2002a).

Month	UKL Elevations Proposed Action 70 Percent Exceedance (feet MSL)	UKL Elevations No-action 70 Percent Exceedance (feet MSL)	Difference Between Proposed Action and No-action 70% Exceedances (%)
February	4142.6 (91%)	4140.9 ((73%)	18
March	4143.2 (98%)	4141.0 (50%)	48
April	4143.2 (98%)	4141.0 (50%)	48
May	4142.6 (91%)	4140.8 (44%)	47

At the 70 percent exceedance, water depths at the shoreline spawning sites are higher as a result of the proposed action than the no-action condition in all months during which spawning occurs (February to May; Table 4-2). In dry years at or above the 90 percent exceedance, or in cold winters when run-off is late, low lake levels can occur during the spawning season and sucker spawning habitat might be limited (see Table 4-3).

Table 4-3. UKL elevations that are predicted to occur as a result of the proposed action at the 90 percent exceedance and under the no-action condition during months when lakeshore spawning is likely to occur (from Table 4-1). Average percent of shoreline spawning area inundated to a minimum depth of 1 foot is shown in parenthesis based on data in USBR (2002a).

Month	UKL Elevations Proposed Action 90 Percent Exceedance (feet MSL)	UKL Elevations No-action 90 Percent Exceedance (feet MSL)	Difference Between Proposed Action and No-action 90% Exceedances (%)
February	4141.0 (50%)	4140.5 (37%)	13
March	4142.0 (74%)	4140.6 (40%)	34
April	4142.5 (90%)	4140.6 (40%)	50
May	4142.0 (74%)	4140.4 (35%)	39

This could have unquantified adverse effects, because spawning would be concentrated and therefore eggs might be laid on top of one another, so that embryos are smothered or hatching is compromised. However, the amount of spawning habitat available under the proposed action is higher than under the no-action condition at the 90 percent exceedance; thus, possible adverse effects would be due to relatively rare events. The most likely events that would result in reduced availability of spawning habitat would be those created if UKL levels were low in October and the lake did not fill through the winter, either because there was little precipitation, or cold weather reduced melting of the snow pack. At this time, we lack data with which to conclude that incidental take occurs as a result of low lake levels.

Effects of UKL Management on Larval Sucker Habitat (April 1 to July 15)

Larval sucker habitat in UKL, especially for SNS, is generally shallow, near-shore areas, particularly with emergent vegetation (see *Environmental Baseline section* for detailed discussion). This type of vegetation likely affords larval suckers with some protection from predators (Markle and Dunsmoor 2007), possibly more-diverse food resources (Cooperman and Markle 2004), and protection from turbulence during storm events (Klamath Tribes 1996).

While emergent vegetation likely provides multiple benefits to sucker larvae in UKL, both Clear Lake and Gerber Reservoir lack emergent vegetation, and there is no evidence that this absence has an adverse effect on recruitment. Consequently, while the evidence suggests emergent vegetation is beneficial to larval suckers, it might not be essential. Fish larvae, because of their small size, limited mobility and sensory capabilities, and dependence on relatively high food intake, are highly vulnerable to environmental factors. Thus, their numbers vary considerably from year to year as a result of a multitude of causes (see discussion in *Environmental Baseline section*).

As lake levels decrease, so does the area of available emergent vegetation in UKL, as exemplified by potential vegetation at the Williamson River Delta (see Table 4-4). Thus, UKL elevation influences larval suckers' access to nursery habitat (Dunsmoor et al. 2000; IMST 2003; Terwilliger 2006; Markle and Dunsmoor 2007).

Table 4-4. Acres of potential emergent vegetation habitat at the Williamson River Delta under different UKL elevations. Based on data in Elseroad (2004) and a GIS analysis of topographic data and assuming there is little or no emergent vegetation below 4139 feet.

UKL Elevation (feet, MSL)	Tulana Emergent Wetland Area (acres)	Goose Bay Emergent Wetland Area (acres)	Total Williamson Delta Emergent Wetland Area (acres)
4143	1080	1560	2640
4142	850	1390	2240
4241	580	1080	1660
4140	290	550	870
4139	0	0	0

Although emergent wetland habitat exists at some locations on all sides of UKL, the area at the Williamson River Delta has been determined to be the most important. It is adjacent to the major source of larvae emigrating from spawning areas in the Williamson and Sprague Rivers (Dunsmoor et al. 2000), and it consistently has the highest densities of larvae in UKL (Terwilliger et al. 2004).

Elseroad (2004) estimated the potential emergent wetland habitat at the newly restored Williamson River Delta based on data for the depth distributions of emergent vegetation in UKL and information on water-depth tolerances for wetland plants from the literature (see Table 4-4). It is likely that extensive new areas of emergent wetland habitat will be available for larval suckers as soon as summer 2008, because TNC has actively managed some areas near the Williamson River Delta for emergent vegetation growth before reconnection to UKL (M. Barry, TNC, pers. comm. 2007). Also, based on early action wetland restoration projects at the Delta and other properties around UKL and a literature review of similar restoration projects, emergent wetland development typically occurs quickly without active intervention because seeds are often present in the wetland soils and are brought in by wind or water. The area of potential emergent habitat at the Williamson River Delta ranges from about 2,600 acres at 4143 feet to 0 at 4139 feet (see Table 4-4). Prior to restoration, there were only about 15 acres of emergent wetlands around the Delta (Dunsmoor et al. 2000), so there will be a large increase in potential larval habitat beginning in the spring of 2008.

Based on the available information, emergent vegetation appears important to the survival of larval suckers in UKL; however, it is unknown how important the habitat is or how much is needed to ensure that sucker populations are viable. Nevertheless, there is support for a conclusion that as the area of larval habitat inundated approaches zero it could reduce larval survival by: (1) exposing larvae to predators; (2) possibly increasing advection rates by exposing larvae to currents that would carry them towards the lake outlet; (3) reducing feeding success; and (4) exposing larvae to physical damage and mortality by wave action. Based on wetland habitat inundation information by Dunsmoor et al. (2000) and Reiser et al. (2001) there will be little or no habitat available at or below 4139 feet (see *Environmental Baseline section*). Under the proposed action, there is substantially more emergent wetland habitat inundated at the 70 percent exceedance levels compared to the no-action condition for the entire larval period of April through July (see Table 4-5). Table 4-5 was developed based on lake levels that would result from the proposed action and no-action conditions (Table 4-1) and estimates of the area of wetlands inundated at different lake levels from Table 4-4.

Table 4-5. UKL elevations and percent of the area of emergent vegetation at the Williamson River Delta that will be inundated (in parentheses) as a result of lake level changes under the proposed action and no-action condition based on 70 percent exceedances during the months that sucker larvae are in UKL. The percent area was calculated by linear estimation.

Month	UKL Elevations (Feet, MSL) Proposed Action 70 Percent Exceedances (percent inundated)	UKL Elevations (Feet, MSL) No-action 70 Percent Exceedances (percent inundated)	Difference Between Proposed Action and No-action 70 Percent Exceedances (percent inundated)
April	4143.2 (100)	4141.0 (56)	44
May	4142.6 (94)	4140.8 (51)	43
June	4141.5 (74)	4140.5 (44)	30
July	4140.2 (39)	4140.1 (34)	5

In drought years (90 percent exceedance and greater) the proposed action could increase risk to the suckers as a result of insufficient larval habitat, but this is unlikely because in most months (with the exception of July where there is a slight reduction in habitat) there will be more habitat available under the proposed action than under the no-action condition (see Table 4-6), and there will be large areas of inundated wetlands at the Williamson River Delta as shown above in Table 4-4. Table 4-6 is similar to Table 4-5, except that 90 percent exceedances were used.

Table 4-6. UKL elevations based on the proposed action and no-action condition 90 percent exceedances and percent of emergent vegetation at the Williamson River Delta that is inundated (in parentheses) during months that sucker larvae are present in UKL. The percent area was calculated by linear estimation.

Month	UKL Elevations (Feet MSL) at Proposed Action 90 Percent Exceedances (percent inundated)	UKL Elevations (Feet MSL) at No-action 90 Percent Exceedances (percent inundated)	Difference Between Proposed Action and No-action 90 Percent Exceedances (percent inundated)
April	4142.5 (93)	4140.6 (46)	47
May	4142.0 (81)	4140.4 (41)	40
June	4140.6 (46)	4140.2 (36)	10
July	4139.5 (18)	4139.9 (28)	-10

Effects of Lake Management on Juvenile Habitat (July 15 to October)

The effects of lake level management on juvenile sucker habitat are dependent on the importance of the habitat to juvenile productivity and survival, and how the habitat is affected by lake level. Habitat use by juvenile suckers has been characterized in UKL as near-shore and off-shore occurring over a variety of substrate compositions (i.e., mud, sand, gravel, cobble, mixed rock, boulders) and emergent wetlands (Terwilliger 2006; Burdick et al. in review). Data suggest that juveniles are more likely to occupy shallow habitats for at least part of the summer. Sites with submerged and emergent vegetation were more likely to be occupied by juvenile suckers than sites with no vegetation (Burdick et al. in review). Simon et al. (1995) and Eilers and Eilers (2005) documented that diverse non-mud substrates that were found to be important juvenile rearing habitats become dewatered at an elevation of about 4138 feet, and that emergent wetland habitats used by juveniles only extend out to an elevation of 4139 feet.

Near-shore habitat use, as indicated by sucker catch per unit effort in different areas stratified by substrate type, has varied between different investigations and years, suggesting that juvenile suckers may not be selective for a particular near-shore substrate type (Buettner and Scoppettone 1990; Terwilliger et al. 2004; Hendrixson et al. 2007a, 2007b). Available data on habitat utilization based on the presence or abundance of juvenile suckers may not necessarily be indicative of their preferred habitat, because they could be displaced by competitive or predatory interactions (VanderKooi et al. 2006). Catch data are difficult to interpret because of trapping gear selectivity and changes in behavior as the fish grow, affecting their vulnerability to each type of gear. Additionally, collection gear do not all work equally well over all substrate types, causing bias. Emergent wetlands are the most difficult type of habitat to sample because the plant stems interfere with nets. Additionally, juvenile sucker collections are difficult to analyze statistically because there are many zero catches and few large catches; therefore, data do not fit normal distributions (D. Markle, OSU, pers. comm. 2008).

Because juveniles are associated with a greater variety of near-shore habitat types than larvae and also use off-shore habitats, juveniles are less likely to be adversely affected by low lake levels. Also, because near-shore habitats used by juvenile suckers cover most of the shoreline, such habitat is less likely to be limiting as lake levels decline, because more of it is available than for larvae. Under the proposed action at the 70 percent exceedance level, lake levels from July through October, the period when juvenile suckers use near-shore areas, are 0.1, -0.5, -0.9, and -0.9 feet lower than the no-action condition, respectively, resulting in reduced shoreline habitat availability (see Table 4-1 and Figure 4-3). However, since we believe juvenile suckers naturally move off-shore into deeper water later in the year (September and October) to avoid fish-eating bird predators and to access better food sources (Markle and Clauson 2006), there is minimal lake level effects on juvenile suckers during this time period. Also, recent monitoring data suggests LRS juveniles may occupy mostly off-shore areas (D Markle, OSU, pers. comm. 2008).

Similar to larvae, juvenile suckers may be at some risk from reduced habitat availability during drought years (90 percent exceedance) when the lake levels drop below 4138 feet, as a result of increased predation, reduced feeding success, disease associated with crowding, and increased competition for food and space (USFWS 2002; VanderKooi et al. 2006). Although we believe one or more of these factors may be affecting juveniles, at this time there is limited empirical data supporting a cause and effect relationship. Nevertheless, we believe there is sufficient information to conclude that lake levels between July and October that are less than 4138 feet pose an unquantified risk to juvenile suckers owing to factors related to a loss in habitat. Because the proposed action is anticipated to result in minimum lake levels above 4138 feet in September and October 90 percent of the time, over the next 10 years there will likely be only one year that minimum UKL elevations will drop below 4138 feet, if climate is similar to what it was during the POR. Such infrequent events should not have a substantial effect on sucker populations.

Effects of UKL Management on Sub-adult and Adult Habitat (June to October)

Whereas larval and juvenile suckers primarily use shallow shoreline habitats, sub-adult and adult suckers are almost always found off-shore at greater depths, except when adults are spawning.

Several studies have described the apparent depth preference for adult suckers in the northern portion of UKL during the summer (see *Environmental Baseline section* for discussion of summer habitat use by adults).

Adult suckers, including sub-adults, are found in open water areas of the lake environment, typically at depths of greater than 3 feet (Peck 2000), and prefer water depths greater than the mean depth available in the area (Reiser et al. 2001; Banish et al. 2007). Adult suckers were generally observed using water depths greater than 10 feet for LRS and greater than 6 feet for SNS, but neither species used water depth greater than 25 feet (Banish et al. 2007). Lack of use of deep water is probably related to poor water quality conditions in these deeper areas during the summer months.

The relationship between depth and lake level in the northern portion of UKL (the area of the lake north of Bare Island where suckers are normally found during the summer) indicates that lake levels under the proposed action will reduce the amount of available preferred adult habitat, and consequently, there could be some adverse affect to adult suckers through reduction of habitat. Table 4-7 was developed based on known UKL bathymetry developed by Reclamation and estimated UKL levels that would result from the proposed action and no-action condition listed above in Table 4-1.

Table 4-7. UKL elevations predicted to occur as a result of the proposed action and no-action condition at the 70 percent exceedance during summer months when adults occupy open-water areas of the northern portion of UKL. Percent area of UKL with depths greater than 3 feet is shown in parenthesis.

Month	UKL Elevations (Feet, MSL) Proposed Action 70 Percent Exceedance	UKL Elevations (Feet MSL) No-action 70 Percent Exceedance	Difference Between Proposed Action and No-action 70 Percent Exceedances (percent)
June	**4141.5 (99%)**	**4140.5 (94%)**	**5**
July	**4140.2 (91%)**	**4140.1 (90%)**	**1**
August	**4139.3 (74%)**	**4139.8 (88%)**	**-14**
September	**4139.0 (67%)**	**4139.9 (89%)**	**-22**

The proposed action will result in lake levels approximately 1.0 feet higher in June and 0.1 feet higher in July, and 0.5 and 0.9 feet lower in August and September, respectively, than the no-action condition at the 70 percent exceedance (see Table 4-7). The lower lake levels in August and September probably have minimal effect on adult sucker populations because there are still substantial amounts of habitat present. For example, at an elevation of 4139 feet there is at least 10,000 surface acres with depths greater than 6 feet and slightly more at a depth greater than 3 feet (see Table 4-8) at the northern end of the lake where most adult suckers are concentrated in summer.

During drought years (i.e., those at 90 percent exceedance or greater), September lake levels of approximately 4138 feet will result in approximately 50 percent of the available adult habitat in the northern portion of UKL being lost (see Table 4-9). Under these conditions, the shallow depths could make adult suckers more vulnerable to avian predators such as white pelicans (see *Environmental Baseline* for discussion of bird predation on adult suckers). We have little data to support this hypothesis; however, this is a reasonable assumption based on known consumption of suckers by white pelicans (see *Environmental Baseline*).

Table 4-8. Area (acres) of UKL north of Bare Island present at elevations from 4138 to 4143 feet at depth ranges of greater than 3 and greater than 6 feet. Data from Reiser et al. (2001).

UKL Elevations (Feet, MSL)						
Depth Range (feet)	**4143**	**4142**	**4141**	**4140**	**4139**	**4138**
>3	25,780	25,390	23,560	20,080	16,580	13,270
>6	20,080	16,580	13,270	12,540	11,710	10,710

Table 4-9. UKL elevations that are predicted to occur as a result of the proposed action at the 90 percent exceedance and under the no-action condition during summer months when adults occupy the open water areas of the northern portion of UKL. Percent area with depths greater than 3 feet is shown in parenthesis.

Month	UKL Elevations (Feet MSL) Proposed Action 90 Percent Exceedance	UKL Elevations (Feet MSL) No-action 90 Percent Exceedance	Difference Between Proposed Action and No-action 90 Percent Exceedances (percent)
June	**4140.6 (95%)**	**4140.2 (91%)**	**5**
July	**4139.5 (79%)**	**4139.9 (88%)**	**-9**
August	**4138.5 (60%)**	**4139.7 (83%)**	**-23**
September	**4138.0 (53%)**	**4139.7 (83%)**	**-30**

An additional potential threat of low lake levels on adult suckers is increased spread of disease. If low lake levels cause suckers to aggregate at high densities there could be an increased risk that pathogens like the bacteria *Aeromonas* and Columnaris will be spread during poor water quality conditions, and consequently the fish would be at an increased risk of mortality (see discussion below in this section). We have no data to support this hypothesis; however, it is a reasonable assumption based on known factors that cause disease outbreaks on fish, as discussed in the Environmental Baseline, and the fact that suckers do aggregate in Pelican Bay during low DO events. If there is a risk of this happening it would increase at lower lake levels.

An additional and somewhat related concern for effects of low lake levels on adult suckers is access to water quality refuge areas during periods of poor water quality. During low DO events, adult suckers seek water-quality refuge areas, particularly Pelican Bay (Bienz and Ziller 1987; Buettner and Scoppettone 1990; Banish et al. 2007; see discussion in *Environmental Baseline*). Water depths in Pelican Bay could be 6 feet deep or less during the mid to late summer when water quality is most likely poor (see *Environmental Baseline*), and access to the bay could be across shallow areas only 2 to 5 feet deep. If adult suckers avoid depths less than 6 feet, low lake levels in late summer could pose an unquantified risk to them if they are reluctant to enter shallow areas with better water quality. However, adult suckers might show less avoidance of shallow water in Pelican Bay than other areas since there are high densities of submergent macrophytes that could provide cover (M. Buettner, USFWS, pers. comm. 2007).

Effects to Sucker Habitat in UKL (November to March)
It is anticipated that UKL levels are less critical to suckers from November through March because they begin to redistribute throughout the lake after water quality in the lake improves and lake levels increase through the winter (USBR, unpublished data; Banish et al. 2007).

The primary concern during the winter is low DO conditions that could occur during prolonged ice-cover because no DO enters the water from the atmosphere and, if the ice is snow-covered, there is little light for photosynthesis. Ice-cover conditions can occur on UKL from November through March, lasting from a few weeks in most years to several months in the coldest winters (such as the cold winter of 2007-2008 when most of the lake was ice covered into late March). Low lake levels in winter could increase the risk of low DO levels because the depletion rate of DO in the water column increases as the depth of the lake decreases (Welch and Burke 2001). We have no information that indicates that low DO concentrations in winter pose a high risk to suckers. Fish become less active during the winter because cold water temperatures slow metabolism. Therefore they need less DO than in the summer. Additionally, going into the winter, DO levels are generally high in sucker habitat and there are substantial inflows of water from tributaries and springs with high DO concentrations. Reclamation has monitored DO in UKL through the winter at the Link River Dam for several years; the lowest readings were greater than 4 mg/l (USFWS 2002).

Another possible concern under ice-cover conditions is a buildup of ammonia, which could accumulate in the water column if low DO conditions occur in the sediment. The effect on suckers depends on how much of the ammonia is in the toxic un-ionized state, which is determined by the pH with a larger percent occurring at high pH values (USEPA 1999). During the winter, pH is much lower than during the summer. These conditions could be made worse under low lake levels since the amount of water would be less per unit area of sediment. We have no data to quantify this potential adverse effect to suckers. However, there have been no known large winter fish die-offs documented in UKL (M. Buettner, USFWS, pers. comm. 2007).

4.11.2 Effects of Lake Level Management on LRS/SNS Habitat in Clear Lake
Reclamation does not propose any changes in management of Clear Lake (USBR 2007). Therefore our effects analysis is similar to the 2002 BO (USFWS 2002). Low lake levels associated with prolonged drought is the primary threat to the LRS and SNS in Clear Lake (USFWS 2002, 2007b and 2007c). Clear Lake is particularly vulnerable to drought because net inflows are relatively low as a result of a small watershed, low annual precipitation, agricultural diversions in the upper watershed, and substantial evaporation and seepage from its large surface area (USFWS 2002, 2007b and 2007c). During a drought, elevation in Clear Lake can decrease substantially and following a drought levels are sometimes slow to recover persisting for multiple years like events in the 1920s and 1930s as shown in *Environmental Baseline Section 3.2.7.1* (see Figure 3-19).

Low lake levels could adversely affect LRS and SNS by limiting access to Willow Creek (USFWS 2002; USBR 2007). A minimum lake level of about 4124 feet is believed necessary to provide access to the creek. Without access to this tributary, we anticipate that there will be little or no reproduction because there is no known spawning habitat in the Lake. However, except in drought years, lake levels will be above this elevation during the spawning season.

At low lake levels, the size of Clear Lake decreases substantially and is reduced to a few percent of capacity. The area-capacity relationship of Clear Lake shows that at an elevation of 4515 feet, the area of the lake is 6,800 acres, but at 4513 feet its area is near zero. Suckers concentrated in shallow water could experience increased incidences of disease, parasitism (especially lamprey), and bird predation (there is an active pelican rookery at Clear Lake; see discussion in *Environmental Baseline* section). It is also reasonable to assume that the resulting high densities of fish could deplete the food supply, causing additional stress and possible mortality. However, it should be noted that suckers survived the lowest lake levels ever recorded at Clear Lake in the 1920s and 1930s, and thus sucker populations there show considerable resilience.

We anticipate that the minimum proposed Clear Lake elevations will provide adequate protection from drought in most years. However, Clear Lake levels will need to be carefully monitored to ensure that they do not drop below minimum requirements, especially during multi-year droughts. During drought conditions the lake level will continue to decline as a result of evaporation and seepage, even if no water is released under Project operations. If the lake level at the beginning of a drought is low, lake levels the next year may be even lower, and the lake could go dry in consecutive drought years. Reclamation has developed a reservoir operations model for Clear Lake from which future storage can be predicted based on previous inflow and stage relationships and outflow. Based on the POR, the model indicates a low probability of consecutive dry years and little chance of the lake going dry if proposed minimums are met in the preceding year and additional water releases are controlled to ensure that subsequent minimums are maintained. We believe the model needs to be re-examined with more recent data and incorporate possible changes in inflows and evaporation that could occur under the current warming and drying trend.

The effects of low water elevations on population size, age-class distribution, recruitment, or decreased fitness are not fully understood. However, available information indicates that the Clear Lake sucker populations have remained viable under the current management regime (see the discussion of Clear Lake under the *Environmental Baseline*) and we have no information to indicate that this status will change unless there is a prolonged drought.

4.11.3 Effects of Lake Level Management on SNS Habitat in Gerber Reservoir

Reclamation does not propose making changes in management of Gerber Reservoir, and therefore our analysis will be similar to the 2002 BO (USBR 2007). The primary threat to the SNS population in Gerber Reservoir is an extended drought. Such a drought would result in low lake levels that may result in a die-off during the late summer and fall, as well as in the winter during prolonged ice-cover conditions. The proposed minimum lake elevations are anticipated to provide adequate protection from such conditions in most years. However, lake levels will need to be monitored to ensure that they do not drop below minimum requirements, especially during multi-year droughts. During drought conditions, the lake levels will continue to decline as a result of evaporation and seepage, even if no water is released under Project operations. If the lake level at the beginning of a drought is low, lake levels the next year may be even lower, and the lake could go dry in consecutive drought years.

Although we do not anticipate sucker mortality events to result from the proposed action at Gerber Reservoir, habitat will be restricted as lake level declines. Potential adverse effects to suckers due to low lake levels include increased competition for food, higher predation, and reduced fitness. Summer water levels in Gerber Reservoir less than 4800 feet significantly reduce juvenile and adult sucker habitat and likely result in increased competition for food, higher predation, and reduced fitness due to parasites and disease (USBR 2002a). At a lake level of 4815 feet, there are about 2,000 acres with adequate depth to support adult suckers. At 4800 feet, the surface area of the lake decreases to about 750 acres. The minimum summer lake levels proposed by Reclamation (USBR 2002a) remain above 4800 feet in most summer months. In the summer of 1992, mechanical aeration was needed to maintain water quality as lake levels dropped to a minimum of 4796.4 feet. SNS showed signs of stress including low body weight, poor gonad development, and reduced juvenile growth rates, but there was no mass mortality (M. Buettner, USFWS, pers. comm. 2005).

The effects of low water elevations at Gerber Reservoir on the resident SNS population in terms of population size, age-class distribution, recruitment, or decreased fitness are not fully understood. However, available information indicates that the Gerber Reservoir sucker population has remained viable under the current management regime (see the discussion of Gerber Reservoir under *the Environmental Baseline section*).
Sucker access into Barnes Valley and Ben Hall creeks, the principal spawning tributaries for the Gerber SNS population, requires a minimum spring (February through April) elevation of about 4805.0 feet. The minimum proposed lake levels for the spawning period will exceed this level in all months and water-year types except in February and March of the dry water-year type when the lake level will drop to 4804.2 feet. However, the lake level (4808.3 feet) in late April during the dry water-year type will allow for sucker passage into these spawning tributaries. Therefore, we anticipate the proposed action will provide adequate water depths for SNS access to spawning tributaries in all water-year types.

4.11.4 Effects of Lake Level Management on LRS/SNS Habitat in Tule Lake

Reclamation does not propose any changes in management of Tule Lake. Therefore we assume that it will be operated as it has since 1992, and our analysis will be similar to the 2002 BO (USBR 2007). Under the proposed action, water deliveries to Tule Lake limit the amount of water with acceptable water quality for suckers and most other fish. During severe winters with thick ice-cover, only small, isolated pockets of water with depths greater than 3 feet exist, increasing the risk of winter die-offs.

The long-term survival of suckers in Tule Lake sumps is unlikely unless actions are taken to restore natural flows and habitat in the lower Lost River and Tule Lake. The lack of flows downstream of Anderson-Rose Dam, the only known spawning location for Tule Lake suckers, have not allowed for successful spawning and juvenile cohort development. Tule Lake supported large and productive sucker populations before the Project was constructed. This is based on harvests reported near the beginning of the 20th Century. The Tule Lake population of LRS may be crucial to recovery of that species since it represents one of only three LRS populations. Maintaining multiple populations of LRS and SNS is one of the identified conservation needs of the two species. Spreading the risk of extirpation among three LRS populations rather than just two populations could significantly decrease the threat of extinction risk to this species.

4.12 Changes in Water Quality in LRS and SNS Habitat as a Result of Lake Level Management

As a result of the proposed action, we do not anticipate that there will be a measurable effect on UKL water quality in comparison to the no-action condition. Water quality in Clear Lake and Gerber Reservoir could be reduced as a result of the proposed action if water levels get very low as a result of a prolonged drought; that could adversely affect the LRS and SNS. Such low lake levels are unlikely to occur during the next 10 years because they are relatively rare events.

4.12.1 Upper Klamath Lake

The primary concern regarding the effect of the proposed action on water quality in UKL is the effect lake depth (as represented by lake level) has on water quality. As described previously in Section 3, *Environmental Baseline*, poor water quality in UKL has been linked to catastrophic sucker die-offs (Perkins et al. 2000b). Multiple, large-scale die-off events have been documented in the recent past in UKL, with the most recent in 1997, when thousands of adult suckers died (Perkins et al. 2000b; Loftus 2001; Welch and Burke 2001). The last known documented sucker die-off in UKL was in 2003, when over 100 dead adult suckers were found by USGS scientists (Wood et al. 2006). Although 2003 was the last documented water-quality-related die-off, USGS has noted that adult mortality rates, estimated from mark and recapture analyses, indicate that other recent years with no obvious die-off had similar or higher mortality rates (E. Janney, USGS, pers. comm. 2007). This suggests that more suckers may be dying from poor water quality and other causes than previously thought. Further, low annual juvenile sucker survival has also been suggested to be partially related to poor summer-time water quality (Terwilliger et al. 2004; Markle et al. in review).

Proof that poor water quality is a major factor affecting juvenile survival every year is lacking, but such data would be difficult to collect because juveniles are widely distributed, could be affected by acute events that might be difficult to monitor, and any moribund juvenile suckers could be quickly eaten by fish-eating birds such as grebes, terns, gulls, and pelicans. These predator/scavengers are abundant and likely could quickly respond to die-off events when fish are more easily obtained.

Because conditions that create large die-offs can occur in any year (although large die-offs are unlikely to happen every year), it is anticipated that additional die-offs will occur in the future. However, the likelihood of a die-off in a given year is relatively low due to a restricted series of events that must occur to produce a die-off (see discussion of fish die-offs in the Environmental Baseline section for more information).

In UKL, water quality poses the greatest risk to suckers during the period from July to mid-October (Kann 1998; Wood et al. 1996; Perkins et al. 2000b; Loftus 2001; Welch and Burke 2001; Wood et al 2006; Morace 2007). Although a number of water quality parameters in UKL regularly reach levels known to be stressful or lethal to suckers and other fish (e.g., pH, ammonia, and DO), low DO (or hypoxia) appears to be the most important (Martin 1997; Martin and Saiki 1999; Perkins et al. 2000b; Loftus 2001; Welch and Burke 2001; Wood et al 2006; Morace 2007). Because fish die over an extended period of time following the adverse water quality events, the actual cause of death in these situations appears to be opportunistic pathogens that infect the fish once they are stressed and weakened by hypoxia (Perkins et al. 2000b).

USGS has conducted extensive analyses of existing water quality data from UKL. Wood et al. (1996) concluded that there was no evidence for a relation between any of the water quality variables considered (i.e., chlorophyll-a, DO, pH, and total phosphorus) and lake depth on the basis of seasonal distribution of data or a seasonal summary statistic. The analysis found that low DO, high pH, high phosphorus concentrations, and heavy blooms of AFA were observed each year regardless of lake depth. In 2007, the USGS repeated this analysis with a 17-year data set (1990 to 2006), and the inclusion of eleven more years of data did not demonstrate a discernable relationship between lake depth and water quality (Morace 2007). These analyses suggest that climatic conditions may have a greater influence on UKL water quality than lake level and other variables considered. This is not to say that water depth has no effect on water quality, but that existing data and analyses have not shown a discernable relationship between UKL level and water quality over the range of depths that UKL has been operated at during the period from 1990-2006.

The National Research Council (2002) was also unable to identify a quantifiable relationship between UKL depth and extremes in DO, pH, and chlorophyll-a. The 10-year period that NRC (2002) analyzed from 1990 to 2000 was within the historical range of operations of UKL. The years of 1995, 1996, and 1997, where extensive fish die-off events were observed, were intermediate lake level years. Further, 1991 was a low lake level year and yet was also a year of good sucker recruitment (NRC 2002).

The proposed action results in UKL levels that are within the range of lake elevations during the 1990 to 2006 time period where analyses have shown no discernable relationship between UKL elevation and water quality (Wood et al. 1996; NRC 2004; Morace 2007). Considering the complexity of factors and interactions influencing water quality in UKL, one would not expect to find a direct relationship between lake level and water quality. In fact, it appears that many variables are of nearly equal importance. The lack of statistically significant strong correlations between water quality conditions, lake level, and climatic factors does not necessarily show that these factors do not influence water quality (Morace 2007). Rather, water quality conditions within UKL are a result of complex interactions between several processes that affect water quality (Morace 2007).

Based on the most recent information regarding UKL water quality, there is no discernable relationship between water quality parameters (e.g., DO, pH, ammonia, temperature) that could affect suckers, and UKL elevations. Therefore, we conclude that UKL elevations that would occur under the proposed action are unlikely to be so substantial as to pose a threat to the LRS and SNS.

4.12.2 Effects of Lake Level Management on Clear Lake Water Quality

At Clear Lake, lower water levels may result in degraded water quality, particularly lower DO levels. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (USBR 1994, 2001a, 2007).

Shallow lakes at relatively high elevations such as Clear Lake must have minimum winter lake levels to reduce the threat of low DO levels under ice. In October 1992, the water surface elevation of Clear Lake was as low as 4519.4 feet before the onset of a hard winter, and no fish die-offs were observed, although suckers showed poor condition factors in the following spring (USBR 1994). We assume 4519.0 feet is the minimum October surface elevation at which the sucker populations can survive through the winter. The minimum proposed lake level for Clear Lake during the winter period (October to February) is 4520.6 feet. Therefore, the proposed action is anticipated to provide adequate water depths for protection against winter-kill of suckers in all water-year types.

In Clear Lake, low lake levels during droughts do create conditions that stress suckers (USFWS 2002), but this may be due to other factors besides water quality. For example, a high biomass of fish and other aquatic organisms confined to a small volume of water could lead to increased rates of parasitism and disease (USFWS 2002). Water quality in such a situation could be harmful to fish because of the low DO levels that might result when too many organisms are confined. Additionally, under such conditions nutrients would be at higher concentrations and that could lead to algae blooms which could create more variable DO levels. Consequently, very low lake levels in Clear Lake resulting from the proposed action could pose an unquantified risk to listed suckers from adverse water quality.

4.12.3 Effects of Lake Level Management on Gerber Reservoir Water Quality

In Gerber Reservoir, lower lake levels may result in degraded water quality including higher pH values and lower DO levels. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were generally adequate for sucker survival (USBR 2001a, 2007; Piaskowski and Buettner 2003).

Gerber Reservoir could experience hypoxic conditions if ice covered the surface for several months. In October 1992, the water surface elevation of Gerber Reservoir reached a minimum of 4796.4 feet before the onset of a hard winter and no winter fish die-offs were observed. However, suckers showed poor condition factors in the following spring. Therefore, we assume 4796.4 feet is the minimum October surface elevation at which the sucker populations can survive through the winter. The minimum proposed elevation for the winter period (October to February) is 4798.0 feet. We anticipate that the proposed action will provide adequate water depths for protection against winter-kill of the SNS in all water-year types.

4.12.4 Effects of Lake Level Management on LRS/SNS Habitat in Tule Lake Water Quality

In Tule Lake, water quality monitoring during the summer over several years documented water quality conditions that were generally adequate for sucker survival (USBR 2001a, 2002; Hicks et al. 2000; Beckstand et al. 2001; USFWS unpublished data). However, under the proposed action, lower lake levels during winter may result in degraded water quality conditions, particularly low DO levels that are stressful or lethal to fish. During severe winters with thick ice cover, only small, isolated pockets of water with depths greater than 3 feet exist, increasing the risk of winter die-offs. Such conditions occurred in the winter of 1992-1993, when several dead adult suckers were documented (USBR 2001a). Low winter lake levels pose an unquantified risk to sucker populations in Tule Lake.

4.12.5 Effects of Project Operations on Water Quality in LRS/SNS Habitat in Lost River and Keno Reservoir

Run-off and drain water from Project lands is likely to contain nutrients, organics, and sediment. If these enter sucker habitat, they could have adverse effects to the LRS and SNS. The effects would most likely be due to low DO levels from decay of algae and macrophytes, and from organics that decompose and use DO. Suspended sediment could also affect sucker habitat by making it too shallow.

Adverse effects to the LRS and SNS from Project runoff and drainage are most likely to occur in the Lost River system and Keno Reservoir because these habitats are downstream from large areas of agriculture including most of the Klamath Project.

Water quality degradation in the Lost River system is being addressed by a TMDL (which is regulated by the states with oversight from USEPA under section 303 of the Clean Water Act) under development by USEPA and the states of California and Oregon. A draft TMDL for the California portion of the lower sub-basin (including Lower Klamath Lake and associated Klamath Straits Drain) was released in March 2007 (USEPA 2007). A TMDL for the Oregon portion of the Lost River system is under development and will be part of a TMDL for the

Oregon portion of the Klamath River. The draft TMDL for the lower Lost River links a high biomass of algae and macrophytes to excessive levels of nutrients, especially nitrogen, and this causes substantial variations in DO and pH. Consequently, the California portion of the lower sub-basin is listed for low DO (USEPA 2007).

Numerous reaches of the Lost River, Tule Lake, and the Klamath Straits Drain experience seasonally-low DO levels that likely stress suckers (i.e., values less than 4 mg/l) (USEPA 2007). Extremely low DO concentrations have been measured in Wilson Reservoir, at Anderson Rose Dam, and in the Klamath Straits Drain. Figure 4-7 shows median DO values for 26 water quality stations in the Lost River. Eight stations had DO values of 1 mg/l or less, which is likely to be acutely lethal for suckers (Saiki et al. 1999).

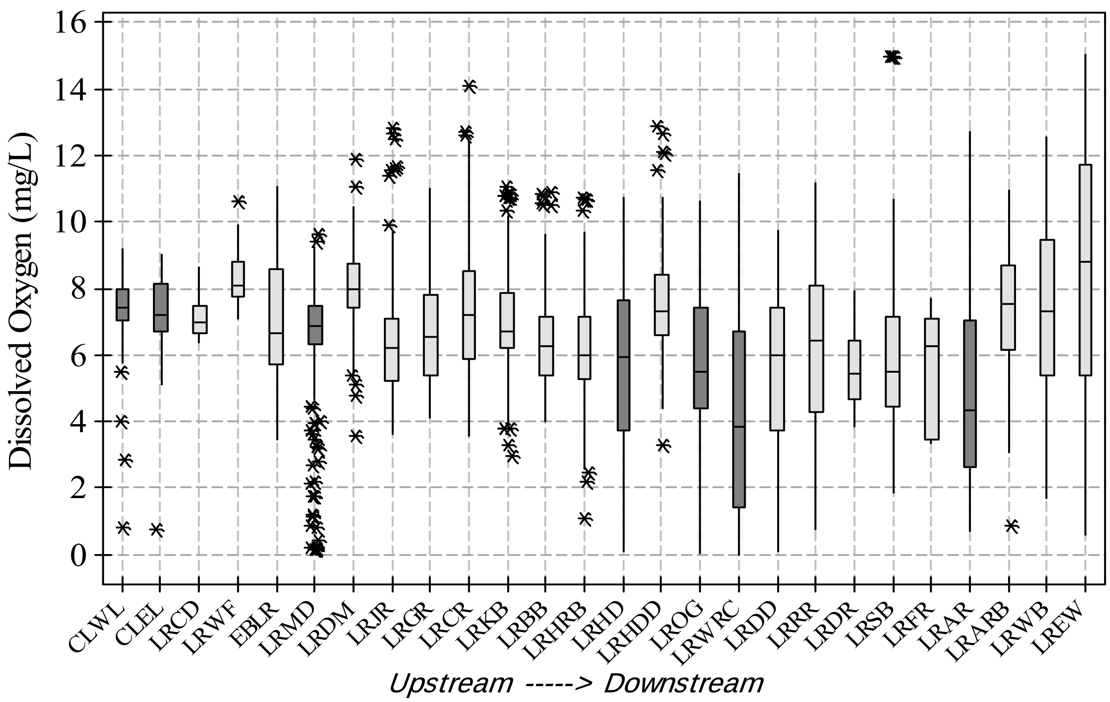


Figure 4-7. Graph of dissolved oxygen data from Lost River water quality monitoring locations, 1993 to 2005. Dissolved oxygen data is represented as a box (median, 25th and 75th percentiles) and whisker plot with outliers represented with an asterisk (USBR 2007).

Figure 4-8 shows seasonal changes in DO levels in the Klamath Straits Drain, a part of the drainage system of the Project that empties into the Klamath River above Keno. DO levels in the Klamath Straits Drain are mostly below 4 mg/l from July through September. Although DO levels in the Klamath Straits Drain are sufficiently low to stress suckers, no suckers are likely present in the Drain and DO levels in the Keno Reservoir are similar or worse than the Drain during the summer (FERC 2007), so effects of the Drain to suckers are unclear.

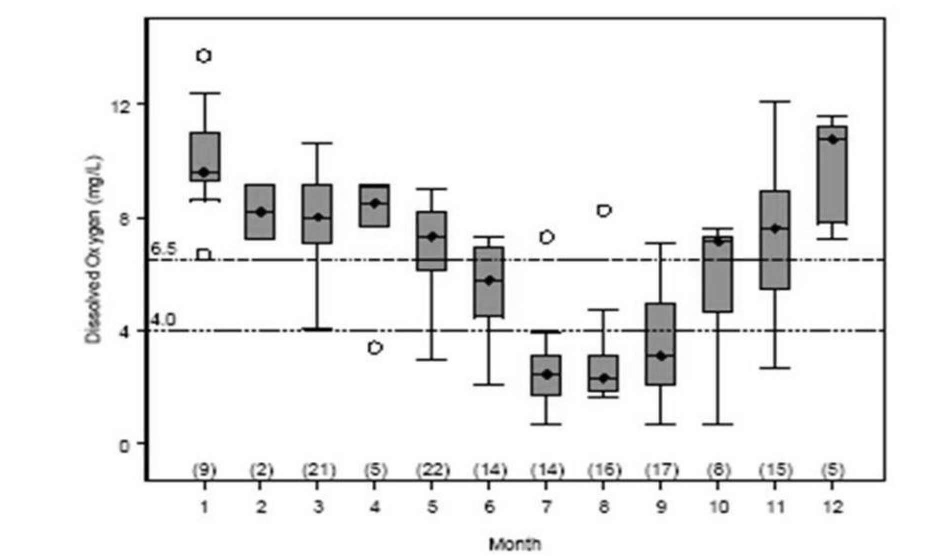


Figure 4-8. Monthly variation in DO levels in the Klamath Straits Drain (from USEPA 2007). The dashed lines at DO levels of 6.5 and 4 mg/l represent the upper and lower range for Oregon's DO standards.

TMDLs contain pollutant load allocations and specific management recommendations and these are listed on Table 6 and 7 of the draft lower Lost River TMDL (USEPA 2007). The draft TMDL for the lower Lost River has a load allocation of 50 percent of 1999 levels for dissolved inorganic nitrogen and biochemical oxygen demand. The Service believes that if Reclamation works with Project water users to address pollutant loading and implements California and Oregon TMDL recommendations pertaining to Project effects, those effects to the LRS and SNS will be minimized.

Water quality in Keno Reservoir is strongly influenced by the amount of organic matter (primarily in the form of blue-green algae) originating from UKL and exceeding the assimilative capacity of the reservoir, resulting in a considerable oxygen-demanding load on the system during the summer (FERC 2007; USBR 2007; Deas and Vaughn 2006). High pH and un-ionized ammonia are also associated with the heavy transfer of blue-green algae from UKL (Deas and Vaughn 2006). Isolating the nutrient loading and effect of the proposed action on water quality in Keno Reservoir from municipal, industrial, and other non-Project sources has yet to be completed; however, TMDL analyses currently underway in Oregon will identify these loads. The proposed action results in about 50 percent more water and an associated volume of decomposing algae from UKL than would the no-action condition during the July through October period (the major AFA bloom period); this poses an unquantified risk to suckers in Keno Reservoir.

4.13 Effects to LRS and SNS from Fertilizers and Pesticide Use in the Project

As a result of the proposed action, we anticipate that there will be an increase in fertilizer and pesticide use on Project lands in comparison to the no-action condition. This use will likely reduce water quality in the lower Lost River, Tule Lake, and in the Keno Reservoir. Although this could have adverse effects on the LRS and SNS, we lack sufficient information on the effects to conclude that water quality reductions result in incidental take.

Pesticides and other agrochemicals are used on private lands within the Project. Most agricultural activities on these private properties (i.e., those that are dependent on the Project for water) are considered in this opinion to be either interdependent or interrelated to the operation of the Project, as discussed in Section 2, Proposed Action, if the activities are dependent on Project water or drains. Although some Project water users might use wells or even use water from Keno Reservoir with their own water right for crop production, such use could still be either interdependent or interrelated to the proposed action if Project water provides the primary economic basis for the operation.

In their BA, Reclamation provided no information about pesticide or use on private lands within the Project and there was no analysis of how pesticides might affect the LRS and SNS. Because there are no recent data on pesticide use or its effects to listed species in the Project area, this analysis will be based on what limited information is available. This analysis will focus on Tule Lake because it contains listed suckers and serves as a sump for thousands of acres of row-crop agriculture where pesticide use regularly occurs. Over 70 percent of the row crop production in the Project is in the area that drains into the sumps (USBR, comments to Service 3/14/08). Thus, if pesticide residues from row crops are likely to affect listed suckers it should be most apparent in Tule Lake. There is likely to be relatively little use of pesticides upstream of UKL, Clear Lake, and Gerber Reservoir because pesticides are not normally applied to pastures or forest lands, which are dominant land uses in these watersheds.
The risk to the suckers posed by pesticide use is dependent on many factors, e.g., toxicity, mobility, persistence, amount applied, application method, location of application relative to nearby water bodies, and etc. There is no doubt that at least trace amounts of pesticides reach the Tule Lake sumps. In the late 1980s and 1990s, Sorenson and Schwarzbach (1991) and Dileanis et al. (1996) detected low levels of pesticides in the sumps, and the nation-wide assessment by USGS from 1992 to 2001 found pesticides at low concentrations were nearly ubiquitous in the Nation's streams and rivers, even in undeveloped watersheds (Gilliom et al. 2006).

In this assessment, we used various sources to develop a list of potential agricultural pesticides that could affect suckers. Because pesticide use data are available for all California counties, we developed a list of pesticides used in Siskiyou County that could adversely affect LRS and SNS based on data in the PAN Pesticide Database (http://www.pesticideinfo.org/). The California pesticide use database for Siskiyou County shows that 800,000 pounds of the most-frequently used 50 pesticides were applied county-wide in 2005, which is most recent data available. The top five pesticides used in Siskiyou County, in terms of gross pounds applied, accounted for 85 percent of the usage, suggesting that only a few pesticides make up the bulk of the applications and most of the products are infrequently used. Potatoes, a major crop planted in the Project, ranked highest in terms of amount applied and accounted for about 1/4 of total pounds of pesticides used in the county.

Although Oregon has recently instituted a pesticide reporting program called "PURS," data won't be available until July 2008. Because similar crops are raised in the Klamath Basin on both sides of the Oregon/California border, we assume that pesticide use in Oregon is similar to that reported in California. Additional information on frequently used pesticides in the Tule Lake area was also obtained from interviews with two pesticide applicators, i.e., Basin Fertilizer and Macy's Flying Service by Marco Buske (Klamath Basin Refuges Integrated Pest Management Coordinator) in 2006.

Table 4-10. List of pesticides potentially used in the Project area that meet at least one of the two criteria listed above. What criteria they meet is indicated by the superscript number: 1= acute fish toxicity and 2= persistence.

Fungicides Names		Herbicides Names		Insecticides/Miticides Names		Other Chemicals Names	
Chemical	Trade	Chemical	Trade	Chemical	Trade	Chemical	Trade
Azoxystrobin[1]	Quadris	Diuron[1]	Diuron	Carbaryl[1]	Sevin	Diquat dibromide[1&2]	Reglone
Chlorothalonil[1]	Bravo	Fenoxaprop[1]	Puma	Chloropyrifos[1]	Lorsban	Metam-sodium[1]	Vapam
Cymoxanil[1]	Curzate	Hexazinone2	Velpar	Cyfluthrin[1]	Baythroid		
Mancozeb[1]	Dithane, Manzate	Oxyflurofen[1]	Goal	Disulfoton[1]	DiSyston		
Mefenoxam[1]	Ridomil	Pentimethalin[1&2]	Prowl	Imidacloprid[1&2]	Provado, Admire		
Captan[1]	Agrox	Hexazinone2	Velpar	Indoxacarb[1&2]	Avaunt		
		Oxyflurofen[1]	Goal	Malathion[1]	Malathion		
		Pentimethalin[1]	Prowl	Oxamyl[1]	Vydate		
				Permethrin[1]	Pounce		
				Endosulfan[1]	Endosulfan		
				Dimethoate[1]	Roxion		

From this long list of pesticides, some chemicals were eliminated that did not fit at least one of the following two criteria: 1) moderate or higher acute toxicity to fish or have known chronic reproductive toxicity to fish; and 2) be persistent (greater than 100 day half-life) in either soil or water. The remaining products are listed in Table 4-10.

Based on information in Table 4-10, it is clear that there are many fungicides, herbicides, and insecticides/miticides used in the upper basin that potentially could affect suckers in the Project area. Of the pesticides that have a high potential to affect the LRS and SNS, metam-sodium is of most concern because of the large amounts applied (see Table 4-11) and the compound's known high toxicity to fish, as describe below.

Metam-sodium is a soil-injected fumigant used to die-off nematodes that attack potatoes. It rapidly degrades into methyl isocyanate and other chemicals that are highly toxic to fish (LC_{50} = 250 part per billion; USEPA 2004; Haendel et al. 2004). If metam-sodium is used appropriately, risk to fish is likely minimal because methyl isocyanate is highly volatile and thus little would likely enter water. However, some contamination of fish habitats by run-off or ground water could still occur. Detection of methyl isocyanate at levels that are toxic to fish is a problem because of the low concentrations involved and other factors (Haendel et al. 2004).

For this analysis, it is important to know if pesticides from Project lands are present in sucker habitats at concentrations that would cause acute or chronic adverse effects to LRS or SNS either at an individual or population level. Since we lack data on pesticide concentrations in sucker habitat, we believe the best way to analyze for effects are to use a weight-of-evidence approach.

Table 4-11. Pesticides reported used in Siskiyou County in 2005 that are listed in Table 4-10, and pounds used, application rate, and acres applied (from http://www.pesticideinfo.org/).

Chemical Name	Total Pounds Applied	Application Rate (pounds per acre)	Acres Treated
Metam-sodium	221,000	150	1,500
Hexazinone	172,000	1	11,300
Mancozeb	8,400	1	6,700
Chlorothalonil	6,600	1	6,900
Captan	5,600	2	2,800
Diuron	3,900	1	1,100
Chlorpyrifos	3,300	<1	5,000
Endosulfan	2,200	2	800
Malathion	1,800	1	1,800
Dimethoate	600	<1	2,000
Diquat dibromide	400	<1	700
Permethrin	400	<1	2,000
	Total = 426,000		

Evidence of harmful effects of pesticides to suckers could be varied and include: water and tissue monitoring, bioassays such as cholinesterase inhibition, studies on health or abnormalities, reported die-offs or population declines, lack of reproduction, behavioral studies, and etc. A variety of studies have been made on the Tule Lake sumps to assess pesticide impacts to fish and wildlife. Studies conducted up to the early 1990s showed clear evidence of adverse impacts to wildlife, but these impacts were primarily linked to the use of highly toxic and persistent chemicals such organochlorine pesticides (e.g., DDT, toxaphene, dieldrin, and endrin), or secondary poisoning from zinc phosphide or strychnine rodenticide baits. These chemicals are no longer permitted for use in the U.S. and thus are not going to be applied.

The most-recent pesticide sampling in Tule Lake and the lower Lost River was done in 2007 by Reclamation and no toxic pesticides were detected at levels considered harmful to fish (Cameron 2008). While this suggests pesticides may not be present in concentrations that would adversely affect suckers, a lack of detection of toxic pesticides does not necessarily mean they would not have adverse effects on LRS or SNS because of the low concentrations necessary to cause harm. The highly toxic pesticides like metam-sodium, mentioned above, and cyfluthrin (a synthetic pyrethroid insecticide used on alfalfa and potatoes), can harm fish at concentrations in the parts per billion range. Such low concentrations would not likely be detected even if the chemical was present at harmful concentrations. Further, many of the newer pesticides rapidly break down and thus would be difficult to monitor.

Little has been done with fish in terms of assessing effects of pesticides in Tule Lake, but Snyder-Conn (USFWS, pers. comm. 2006) assessed general health of tui chubs in the late 1990s and concluded that those from Tule Lake sumps were actually in better health and had fewer parasites and other skin and tissue problems than ones from most other water bodies in the upper Klamath Basin. Monitoring of adult sucker in Tule Lake in 2007 and 2008 noted similar observations that the fish appeared healthy with few parasites and other physical afflictions (J. Hodge, USFWS, pers. comm. 2008). A toxicological unit analysis, which was recently done by Haas (2007) on the additive risk of pesticide use on the Federal Lease Lands on the Tule Lake

NWR, concluded that effects were not likely to be at adverse levels to listed suckers. While none of these studies are conclusive, they do provide some evidence suggesting a lack of adverse effects from pesticides on the listed suckers in Tule Lake.

We know that current sucker populations in Tule Lake sumps are small and dominated by adults similar to those sampled in the 1990s (J. Hodge, USFWS, pers. comm. 2007). Also, it is unlikely that this population is expanding because there is little or no successful reproduction. While the low numbers and lack of apparent recruitment could be related to pesticide contamination, it is more likely due to the lack of suitable spawning and rearing habitats and inadequate attraction flows below Anderson Rose Dam (see discussions under sections 4.9 and 4.10). Although some sucker spawning has occurred below Anderson Rose Dam in the past, and was most recently observed in 2007 (J. Hodge, USFWS, pers. comm. 2008), it is infrequent owing to poor habitat conditions, lack of attraction flows during the spawning season, and unsuitable flows after spawning has occurred.

Based on the above discussion, we conclude that trace amounts of pesticides are reaching Tule Lake sump as gas or aerosols, attached to dust, through drain water, or other routes. Once in the sump, they volatilize, degrade, settle to the bottom with sediment, or remain in the water column where they would be highly diluted. Based on ecological fate analyses for pesticides used on the Federal lease Lands (USFWS 1995), we anticipate when label directions are followed and when appropriate buffers are in place, pesticide use does not likely pose a threat to the LRS and SNS.

The following are some conclusions regarding possible effects of pesticide uses on suckers in the Tule Lake sumps:

- Pesticides are used in the watershed above Tule Lake and some are known to be highly toxic to fish.
- Pesticides at low levels have been detected in the Tule Lake sumps in the past and are likely present at least in trace amounts there today.
- There is no evidence that pesticides, either when analyzed individually or when the potential effects of similar products are added together, are currently having an adverse effect on suckers in the sumps.
- We cannot be certain that low level chronic or even occasional acute effects to suckers do not occur because the types of studies necessary to assess these effects have not been done. However, when label directions are followed and appropriate buffers put in place, pesticide use in the Project is unlikely to pose a threat to the LRS and SNS.

4.14 Summary of Effects Analysis

The following is a summary of the analysis of effects of the proposed action on LRS and SNS:

1. *Scientific Uncertainty as it Relates to the Effects Analysis.* Understanding scientific uncertainty is important for this effects analysis because of a lack of data, measurement error, faulty assumptions, and other factors can affect the analysis. For example, in order to account for uncertainty in the hydrologic record, we used the conservative 70 and 90 percent exceedances for UKL levels that would likely result from the proposed action in our effects analysis. In 2002, we used the 50 percent exceedance levels for the lake and underestimated how low the lake would go because of a drought that occurred during the implementation period.

2. *Importance of the Period of Record for Hydrologic Analysis of Lake Levels.* The basis for hydrologic effects analysis for UKL is the 1961 to 2006 POR. Although the POR is the best basis for predicting what hydrologic conditions will occur over the next 10 years, actual conditions could be affected by climate cycles and climate change, changes in water use, and other factors that might not be evident in the POR. There is evidence for a long-term reduction in precipitation and increased temperature that, if continued, would reduce inflows to the lake. Another factor possibly affecting inflows is groundwater pumping in the watershed above the lake.

3. *Use of "No-action Condition" to Assess Effects of Proposed Action.* In order to analyze the effects of the proposed action on listed species, we compared it to the conditions that would exist if the action was not authorized, funded, or carried out. We called this the "no-action condition." In assessing a no-action condition, we assumed that Project features such as dams would remain in place, but no water would be diverted into Project canals. Water would be stored in Project reservoirs, but gates in the dam that control water levels in the reservoir would be set and not changed or managed so that spill will occur at the same elevation throughout the year.

4. *The No-action Condition for UKL.* At the 70 percent exceedance, the proposed action UKL levels are likely to be above the no-action condition from December through July and below the no-action condition during the rest of the year. The greatest difference between these two conditions is in February through May, when the proposed action elevations are 1.7 to 2.2 feet higher than the no-action condition and in September and October when the proposed action is 0.9 feet lower than the no-action condition. At the 90 percent exceedance the differences are similar to the 70 percent values, with the proposed action resulting in higher lake levels in spring but more extreme low levels occurring from August to December.

5. *Effects of the Action on Habitat Enhancement, Loss, and Degradation.* As a result of the proposed action, we expect that wetland and lake habitat in UKL will increase relative to the no-action condition, which should benefit the LRS and SNS. It is likely that one of the Project storage facilities, Agency Lake/Barnes Ranch (9,830 acres) will be reconnected to UKL in the next several years, providing additional wetland and open water habitat for the listed suckers.

6. *Effects of the Action on Sucker Movements.* As a result of the proposed action, we expect that there will be little or no change in how migration barriers affect LRS and SNS movements in comparison to the no-action condition. As a result we anticipate there will likely be adverse effects to the LRS and SNS and some incidental take is likely to result.

7. *Effects of the Action on Instream Flows.* As a result of the proposed action, we expect that instream flows will differ from those that would occur under the no-action condition. We anticipate that there will be some incidental take of LRS and SNS because of insufficient instream flows below Anderson Rose Dam on the Lost River.

8. *Effects of the Action on Entrainment of LRS and SNS at Project Facilities.* As a result of the proposed action, we expect that entrainment rates of LRS and SNS at Project facilities, especially those at the UKL outlet (i.e., A-Canal and Link River Dam spillway and fishway) will be higher than under the no-action condition, and that those

entrainment losses will adversely affect LRS and SNS and result in incidental take. Substantial numbers of suckers (approximately 2.5 million larvae, 45,000 juveniles, and 200 sub-adult/adults) are likely to be entrained at Project facilities each year. Most of those losses will be at the UKL outlet. Although fewer LRS and SNS are being entrained at the A-Canal because of the new fish screen, some by-passed suckers, especially larvae, will be entrained at the Link River Dam, which is only 1/3 mile downstream.

9. *Effects of Lake Management on LRS and SNS Habitat.* As a result of the proposed action, we expect that there will be an increase in larval sucker habitat and in lake-shore spawning habitat in UKL, but that juvenile, sub-adult, and adult habitat will be reduced during the summer and fall in comparison to the no-action condition. An increase of habitat for larval suckers and for shoreline spawning likely benefits suckers; reductions in habitat for all life stages could be adverse. Current information on the effects of reduced LRS and SNS habitat in UKL is insufficient to conclude whether or not incidental take is occurring. Water levels resulting from the proposed action at Clear Lake and Gerber Reservoir will likely have beneficial effects to LRS and SNS when lake levels are higher than the no-action condition. When levels are very low, such as during a prolonged drought, there is likely to be adverse effects.

10. *Changes in Water Quality in LRS and SNS Habitat as a Result of Lake Level Management.* As a result of the proposed action, we do not anticipate that there will be a discernable effect on UKL water quality. Water quality in Clear Lake and Gerber Reservoir could be reduced as a result of the proposed action if water levels get very low as a result of a prolonged drought, and that could adversely affect the LRS and SNS. Such low lake levels are unlikely to occur during the next 10 years because they are relatively rare events.

11. *Effects to LRS and SNS from Fertilizers and Pesticide Use in the Project.* We anticipate that, as a result of the proposed action, there will be an increase in fertilizer and pesticide use on Project lands, which we view as being inter-related or interdependent to the proposed action. This use will likely reduce water quality in the lower Lost River, Tule Lake, and in the Keno Reservoir. Although this could have adverse effects on the LRS and SNS, we lack sufficient information on the effects of the proposed action to conclude that water quality reductions result in incidental take.

4.15 Conclusion

As we found in previous BOs for the Klamath Project (USFWS 2001, 2002), we have determined that the proposed action has multiple effects, some positive and some negative, on the listed suckers. The main difference between this analysis and previous ones is that we now believe that data are insufficient to link operational water levels in UKL to effects on water quality. Additionally, the proposed action in comparison to the no-action condition will provide more shoreline spawning habitat and more larval habitat in UKL. Juvenile habitat in UKL is likely to be reduced under the proposed action, especially during low inflow years. It is unclear if reductions in juvenile habitat at operational levels have adverse effects. However, there is sufficient information to conclude that the lowest lake levels pose some risk to suckers because of habitat loss and associated effects. Clear Lake is especially vulnerable to prolonged drought because of its large surface area and shallow depth, and low inflows.

Based on a variety of evidence, entrainment at Link River Dam spillway and fishway poses a risk to listed suckers because it likely contributes to the low levels of recruitment that both species are currently experiencing, especially the SNS. However, it is likely that the effect this has on SNS or LRS populations is currently minimal. Meanwhile, over the period of this consultation, major habitat restoration projects will be completed at the Williamson River Delta, and removal of Chiloquin Dam will greatly improve upstream passage for suckers. These improvements should provide accruing benefits during the period of the proposed action.

5.0 CUMULATIVE EFFECTS

Cumulative effects are those impacts of future State and private actions that are reasonably certain to occur within the area of the action subject to consultation. Future Federal actions will be subject to the consultation requirements established in section 7 of the Act and therefore, are not considered cumulative to the proposed action.

The following non-Federal activities are proposed in the action area:

1) The completion of the water adjudication process for Klamath Basin in Oregon is expected in 2010, providing for more efficient water management in the Klamath River Basin and more opportunities to enhance water quantity and quality in habitats occupied by endangered suckers.
2) In 2008, the Goose Bay section of the Lower Williamson River Delta (approximately 2,000 acres of emergent wetlands) will be restored back to functioning wetland, riparian, and lake habitats supporting suckers and enhancing water quality in UKL.
3) The State of Oregon is enlarging its fish screening program in the Klamath Basin to complement completion of the adjudication process. Following adjudication, diversions will require water measurement devices and fish screens.
4) The Klamath Watershed Partnership (formerly the Klamath Watershed Council) and its partners are scheduled to complete all 7 sub-basin watershed assessments in the next few years, providing a roadmap for watershed restoration needs to support healthy aquatic ecosystems and aid in the recovery of listed suckers and other at-risk species.
5) Following completion of the sub-basin watershed assessments and revision of the Lost River and Shortnose Sucker Recovery Plan, there will be greater interest and investment in specific habitat restoration projects by state and private interests, including Oregon Watershed Enhancement Board, The Nature Conservancy, and others.
6) With the completion of the Lost and Klamath Rivers TMDL in California and Oregon in the next few years, private, municipal, and industrial entities contributing to the degradation of water quality in those rivers 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 Klamath River.

Most of the non-Federal actions will improve water quantity, water quality, and habitat in areas supporting listed suckers, including UKL and Keno Reservoir. Screening will reduce entrainment of suckers and improve overall survival. Habitat restoration will increase the amount and quality of areas important for completion of life cycles. Water quality improvement Projects will address a major factor limiting listed sucker recovery in the Upper Klamath Basin. If water quality is improved in Keno Reservoir, this area may be able to support a substantial population of suckers or provide habitat to support larval and juvenile suckers that eventually inhabit UKL as adults.

6.0 CONCLUSION

The implementing regulations for section 7 of the Act (50 C.F.R. 402) define "…jeopardize the continued existence of…" to mean "…to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, and distribution of that species."

After reviewing the current status of the LRS and SNS, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's opinion that the proposed action is not likely to jeopardize the continued existence of the LRS or SNS, and is not likely to destroy or adversely modify proposed critical habitat for these species. The Service reached these conclusions based on the following synthesis of findings presented in previous sections of this BO.

Basis for the No-Jeopardy Determination

1. *The primary adverse effect to LRS and SNS populations caused by the proposed action is likely to be annual entrainment losses of several million larvae and tens of thousands of juveniles. However, these species produce large numbers of larvae and juveniles each year, and are adapted to high larval and juvenile mortality rates, so this loss is unlikely to pose a serious risk to the affected populations of the LRS and the SNS.*

   - The action area contains three large sucker populations for SNS (at Clear Lake, Gerber Reservoir, and UKL) and two for LRS (at Clear Lake and UKL) that likely number in the thousands to tens of thousands for each species in each water body.

   - The LRS and the SNS have high fecundity: tens to hundreds of thousands of eggs are potentially produced per female in one season. Therefore, it is likely that each of the large SNS sucker populations in Clear Lake, Gerber Reservoir, and UKL, and large LRS populations in Clear Lake and UKL, produce millions of larvae in most years. This life-history strategy is common in fish and is thought to be an adaptation to low natural survival rates of larvae.

   - High fecundity and a potentially long life expectancy facilitate LRS and SNS population resilience to adverse conditions. This has enabled sucker populations to survive and rebound from adverse conditions such as low lake levels, poor recruitment, and multiple die-off events involving adults.

   - Although large numbers of larval LRS and SNS are likely entrained in Project facilities every year, the estimated amount of larvae lost at Link River Dam is likely small relative to the numbers produced by the UKL population. This loss likely does not pose a serious risk to populations of the LRS and the SNS because very large numbers of larvae are likely to exist each year in Clear Lake, Gerber Reservoir, and UKL for SNS, and in Clear Lake and UKL for LRS, even after entrainment losses. Also, most of this impact is to UKL populations, which are the largest. These losses may be somewhat offset by additional larval habitat created by habitat restoration projects at the north end of the lake and in the tributaries, efforts by Reclamation to reduce incidental take, and other recovery actions.

2. *The primary threats to LRS and SNS populations in UKL are low adult survivorship and lack of recruitment into the adult population. Neither of these threats is conclusively linked to Project operations.*

   - The most serious risk to UKL sucker populations is from water quality-related mortality of adults. Based on current data, the proposed action does not appear to affect water quality-related adult mortality in UKL either directly or indirectly; rather, they appear to be largely related to climatic factors. Knowledge of some factors related to larval and juvenile survival is improving, but the degree to which habitat modification by Project operations affects survival of these age classes remains uncertain.

3. *UKL water levels under the proposed action should provide adequate habitat for all sucker life stages in most years.*

   - In most years, UKL levels resulting from the proposed action should provide adequate habitat for all sucker life stages, and are higher than under the no-action condition during the spring and early summer when spawning occurs and larvae are present. These levels are similar to those proposed in 2002. Lower lake levels in the late summer and fall resulting from Project operations, although below the no-action condition, do not appear to pose a substantial risk to suckers because juvenile and sub-adult/adult suckers occupy a variety of habitats and these habitats are thought to be plentiful even at lower lake levels.

   - There is some risk of very low UKL levels related to severe drought, but these events should be rare and are unlikely to occur during the 10-year term of the proposed action.

4. *The primary threat to LRS and SNS populations in Clear Lake is loss of habitat as a result of severe drought and Project operations. LRS and SNS in Clear Lake survived the drought of the 1920-1930s, which was the worst in hundreds of years, according to tree-ring analyses. Safeguards are in place in the proposed action to halt diversions if the lake level gets too low.*

   - The most serious threat to suckers in Clear Lake is a prolonged drought that would totally eliminate their habitat. Suckers in Clear Lake survived the "Dust Bowl" drought of the 1920 and 1930s even though their habitat was drastically reduced in size. An analysis of tree-rings in the region, which are indicators of precipitation, shows that the Dust Bowl drought was the most severe in hundreds of years. Therefore, it is unlikely that there will be a more severe drought during the term of the proposed action. Also, under the proposed action, safeguards are in place as part of Clear Lake operations that were designed in the 1990s (based on an operations model that used historic inflow and diversion data and estimates of seepage and evaporation) that reduces or halts diversions from Clear Lake if water elevations get too low.

   - USGS monitoring shows that sucker populations in Clear Lake are sizeable and experience regular recruitment; thus, they appear to be doing well. We do not anticipate that there will be a change in population dynamics as a result of continued operations because no change in operations is being proposed.

5. *Project operations do not pose a serious risk to suckers in Gerber Reservoir. Recent sampling shows the SNS population is substantial and experiences regular recruitment; the same operations will continue under the proposed action.*

   - USGS monitoring of adult sucker populations in Gerber Reservoir indicates that the population of suckers there likely numbers in the thousands and is comprised of a diverse size-structure indicating regular recruitment. We do not anticipate that there will be a change in population dynamics as a result of continued operations because no change in operations is proposed.

6. *Loss of LRS and SNS genetic diversity, although a concern for any imperiled species, appears not to be at risk from the proposed action.*

   - Studies on LRS and SNS genetics have found high levels of diversity, which contributes to maintaining population resiliency in response to adverse conditions. These high levels of genetic diversity were found in LRS and SNS populations exposed to past Project operations for about 100 years.

   - Removal of Chiloquin Dam in 2008 could reduce LRS/SNS hybridization rates by providing each species access to more spawning habitat, which could reduce the incidence of cross-fertilization of eggs.

7. *Water quality in the Keno Reservoir is likely to adversely affect large numbers of young suckers that are either entrained or naturally move downstream into the reservoir annually. Although the Project likely contributes to this loss, the magnitude of this effect is not likely to affect persistence of LRS and SNS populations in UKL.*

   - Studies in Keno Reservoir show that large numbers of larval and juvenile suckers are either entrained or naturally move downstream from UKL to the reservoir every year.

   - Water quality in Keno Reservoir is so poor each summer, especially with respect to low DO levels, that most of these suckers are likely to die.

   - Entrainment of juvenile suckers to the reservoir may be increased as a result of the proposed action because Project operations increase flows in summer in comparison to the no-action condition. Channels cut into the reef at the UKL outlet in early years of the Project may contribute to these entrainment rates. As a result of the new A-Canal fish screen, entrainment there has been reduced. Now only larvae are entrained into the canal, and this entrainment of larvae has likely been cut by 50 percent by the A-Canal screen facility.

8. *Improving environmental baseline conditions are helping to offset adverse effects caused by the proposed continued operation of the Project.*

   - The adverse effects of the proposed action are likely to be at least partially offset by increased sucker reproduction and survival as a result of the following Project-related actions that are likely to occur: (1) removal of Chiloquin Dam, which will improve LRS and SNS access to upstream spawning sites, potentially resulting in greater production of larvae; (2) installation of a new state-of-the art fish screen on the Williamson River for the Modoc Point Irrigation District; (3) reconnection of several thousand acres of larval habitat at the Williamson River Delta, which is anticipated to increase LRS and SNS larval survival and help reduce their losses at the UKL outlet and; and (4) other beneficial actions that are likely to occur that will improve habitat conditions for the LRS and the SNS as a result of on-going habitat restoration in the Sprague River and elsewhere through efforts by Reclamation, the Service, The Klamath Tribes, the Klamath Water Users Association, and others.

In summary, the above findings support a conclusion that implementation of the Project, as proposed, is compatible with the survival and recovery needs of the LRS and the SNS as described in the *Status of the Species/Environmental Baseline* section of this document.

Basis for the Non-Adverse Modification Finding

The Non-Adverse Modification finding above is based on an analysis of the effects of the proposed action, taken together with any cumulative effects, on the primary constituent elements (PCEs) of proposed LRS and SNS critical habitat.

The PCEs identified in the critical habitat proposal (USFWS 1994a) are as follows: (1) water of sufficient quantity and suitable quality; (2) sufficient physical habitat, including water quality refuge areas, and habitat for spawning, feeding, rearing, and travel corridors; and (3) a sufficient biological environment, including adequate food levels, and patterns of predation, parasitism, and competition that are compatible with recovery.

Based on the analysis presented in the effects section of this BO, effects to the PCEs as a result of the proposed action, taken together with any cumulative effects, are compatible with the survival and recovery needs of the LRS and the SNS for the following reasons.

PCEs 1 and 2. The temporary reductions of water levels in Project reservoirs as a result of the proposed action that could preclude sucker use of important seasonal habitats will not result in population-level adverse effects to the species numbers, distribution, or reproduction. Water storage in Project reservoirs will result in both seasonal increases and decreases in habitat; thus, there will likely be a variety of both beneficial and adverse effects to sucker habitat. The proposed action will reduce the likelihood that serious habitat losses will occur during drought because snow pack, tributary inflows, weather, lake levels, and diversions will be closely monitored, and diversions will be curtailed when minimum reservoir surface water levels are anticipated.

Current data do not support a conclusion that the proposed action has a discernable effect on water quality in UKL. Water quality conditions under the proposed action in Clear Lake and Gerber Reservoir are likely to be adequate for suckers, except during rare drought years when lake levels get very low. Such events are unlikely to occur during the 10-year term of the proposed action. Regular reductions in water quality as a result of the proposed action are most likely to occur in only a few small reservoirs such as Wilson Reservoir, which are habitat only for a few suckers and thus would not affect the recovery of the overall LRS and SNS populations in the action area.

PCE 3. The sucker's biological environment is most likely affected by the Project as a result of changes in water depth in Project reservoirs. Changes in depth could affect ecological processes in Project reservoirs including predation and competition rates, reproduction and growth of introduced fish, impacts of parasites and disease, abundance of food, etc. These ecological processes are likely to be primarily affected by climate and other factors, and relating them to Project operations is therefore difficult. Based on a variety of information, mostly from UKL, we were unable to conclusively connect lake levels with most ecological processes. Therefore, except under rare severe droughts, normal Project operations are not expected to substantially affect key ecological processes that might affect sucker recovery.

Overall, implementation of the proposed action over the next 10 years is likely to provide habitat conditions that in most years should provide adequate habitat for all sucker life stages in a manner that is compatible with LRS and SNS recovery. Under the proposed action, higher water levels than under the no-action condition will be provided in UKL during the spring and early summer, when LRS and SNS spawning occurs and larvae are present. Lower lake levels caused by the proposed action in the late summer and fall, although below the no-action condition, do not appear to pose a substantial risk to suckers because juvenile and adult suckers occupy a variety of habitats and these are plentiful even at lower lake levels.

7.0 INCIDENTAL TAKE STATEMENT

This Incidental Take Statement applies to incidental take of the LRS and/or the SNS resulting from the operation of the Project for the 10-year period April 1, 2008, through March 31, 2018. The exemptions provided under this Incidental Take Statement apply to the action agency and its designees, along with any applicants identified under the proposed action. It replaces the Incidental Take Statement for all previous BOs addressing Reclamation's operation of the Project with the exception of the 1995 BO on the use of pesticides that is still in effect.

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with this Incidental Take Statement.

The measures described below are non-discretionary, and must be implemented by Reclamation so that they become binding conditions of Project implementation for the exemption under 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity that is covered by this Incidental Take Statement. If Reclamation (1) fails to adhere to the terms and conditions of the Incidental Take Statement through enforceable actions, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to the Service as specified in this Incidental Take Statement in accordance with 50 CFR § 402.14(i)(3).

This Incidental Take Statement exempts take of the LRS and SNS caused by Project activities that are carried out in accordance with the following measures and terms and conditions, as applicable. This Incidental Take Statement does not address the restrictions or requirements of other applicable laws.

7.1 Form and Amount or Extent of Take

Over the 10-year term of the proposed action, take of LRS and/or SNS adults, sub-adults, juveniles, and larvae is likely to occur as a result of Project-related operations and other activities in the form of capture, kill, wound, harm, and harass. The amount of anticipated take is summarized in Table 7-1 and further discussed below.

Table 7-1. Summary of incidental take likely to occur as a result of the proposed action.

Cause of Take	Type of Take	Approximate Maximum Amount or Extent per Year
Entrainment Losses at Project Diversions	**Harm and Wound**	**2.5 million larvae, 45,000 juveniles, and 200 sub-adults/adults total LRS and SNS**
Reduced Instream Flows Below Project Facilities	**Harm**	**Eggs from 300 adult LRS and SNS**

1. Incidental Take caused by Entrainment at Project Facilities
As a result of entrainment at the A-Canal, Link River Dam spillway, and other Project features described in the Environmental Baseline and Effects sections of this BO, we estimate that take of larval, juvenile, and sub-adult/adult suckers in the form of **harm** and **wounding** will likely occur as a result of entrainment of LRS and SNS. Up to 2.5 million larvae, 45,000 juveniles, and 200 sub-adult/adult suckers per year are likely to be entrained into Project facilities (Table 7-1). Most larval suckers entering Project canals will die since only a small fraction (less than 1 percent) are salvaged later as larger individuals. We assume most LRS and SNS entrained at the Link River Dam spillway and fishway, owing to Project-related flows that are above the no-action condition, will die because of poor water quality in Keno Reservoir. Only adult suckers that are in the Keno Reservoir will be able to return to UKL via the new Link River Dam fishway, because smaller suckers are unlikely to be able to use the fishway.

During seasonal salvage operations in Project canals up to approximately 2,000 juvenile suckers will be captured and returned to UKL or Tule Lake. Some mortality (approximately 15 percent) of any surviving juvenile suckers will likely occur as a result of capture, handling, and hauling during salvage. We did not include these in the Table 7-1 because they were already included in the entrainment estimates presented above.

2. Incidental Take caused by Reduced Instream Flows below Project Facilities
The Service anticipates take in the form of **harm** will likely occur as a result of insufficient flows below Anderson Rose Dam. We estimate that up to 300 suckers will either not spawn because there are no attraction flows, or if they spawn, the eggs could be desiccated, flushed downstream into pools where they would likely be smothered by sediment, or, if spawning occurs in a limited area, there could be increased rates of hybridization and other adverse effects. We anticipate that there will be a loss (**harm**) of eggs equivalent to that produced by 300 adult female SNS and LRS (Table 7-1). Justification is presented in the Effects section.

7.2 Effects of the Take
In the accompanying BO, the Service determined that this level of anticipated take is not likely to result in jeopardy to the LRS and the SNS, or in adverse modification of proposed critical habitat for the LRS and the SNS.

7.3 Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of the LRS and the SNS as a result of implementing the proposed action.

1. Minimize the take of the LRS and the SNS as a result of entrainment by Project facilities.
    a. Develop and implement entrainment reduction measures at Project facilities.
    b. Trap-and haul entrained suckers that would otherwise move downstream below Link River Dam and die to UKL for release if an evaluation shows that survival of these suckers would be increased by doing so.
    c. Continue annual canal salvage operations when canals are drained at the end of the irrigation season if an evaluation shows survival of affected suckers would be increased by doing so.
2. Minimize the take of the LRS and the SNS as a result of reduced in-stream flows below Anderson Rose Dam

7.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, Reclamation must comply with the following terms and conditions, along with the monitoring requirements outlined below, to implement the reasonable and prudent measures described above.

In all of the following terms and conditions, adaptive management is used to provide Reclamation with desired flexibility while providing maximum benefit to suckers.

Term and Condition 1. *Minimize Entrainment of LRS and SNS at Project Facilities*

Reclamation shall take actions under its authority to continue to implement measures to reduce entrainment of the LRS and the SNS at Project facilities. Reduction of entrainment has been a requirement of previous Incidental Take Statements and/or Reasonable and Prudent Alternatives for the Project and a number of actions have already been undertaken to minimize take including construction of fish screens at the A-Canal, Clear Lake, and Agency Lake Ranch. Despite these actions, entrainment resulting from Project operations continues to occur.

This term and condition consists of several elements and sub-elements as described below.

Element A. Entrainment Minimization at the A-Canal and Link River Dam

Sub-element A1. A-Canal Entrainment Reduction

Although entrainment losses of suckers have been reduced by previous Reclamation actions, annual take of several million sucker larvae still occurs at the A-Canal. It is unknown how effective the by-pass flume is because its effectiveness has not been studied. The flume outlet is close to the Link River Dam and by-passed suckers might drift or swim downstream through the dam and be lost to the population because of poor habitat conditions downstream. Also, many suckers can become trapped in the forebay area every year. These suckers must be salvaged at the end of the irrigation season. Some likely die while trapped in the forebay, during the salvage dewatering process, or during actual salvage, and a few might be overlooked and not salvaged.

It does not appear there is a structural solution to the ongoing entrainment of larvae at the A-Canal because the screen was built to Service specifications and it appears to be operating as designed. Therefore, a non-structural approach (such as restoration of habitat in the upper part of UKL or in Sprague River and supplementation with wild-caught larvae reared in ponds), will likely be needed to minimize the effect of the losses. It may be possible to minimize the take that is occurring at the forebay through a structural retrofit, but until the feasibility of doing that is evaluated, continued salvage in the forebay is necessary.

Reclamation shall undertake the following to implement s*ub-element A1. A-Canal Entrainment Reduction*:

A. Determine the most practicable way to minimize larval sucker entrainment, or otherwise reduce the effect, at A-Canal, and implement necessary corrective actions.

B. Determine the fate of suckers by-passed by the flume and take necessary actions to increase effectiveness of the fume to by-pass suckers into an area where they are less likely to be further entrained.

C. Determine why suckers and other fish are being caught in the forebay and take practicable actions to reduce this effect if justified.

Sub-element A2. Link River Dam Entrainment Reduction

Reclamation shall undertake the following to implement s*ub-element A2.Link River Dam Entrainment Reduction:*

A. Conduct a surface versus bottom spill test at Link River Dam during summer of 2008. The purpose of this test will be to determine whether or not a change in operation of the Link Dam river gates could reduce sucker entrainment. The Service will be included on the technical team to review and approve the experimental design plan for the study. The contractor (North State Resources) is scheduled to complete the study plan by June 1, 2008. A report on the study results will be provided to the Service by March 2009.

B. If studies indicate there are substantial benefits of a feasible surface-spill, Reclamation shall implement a plan to change spill from bottom to surface and manage the dam in this manner.

C. Assess effectiveness of other measures to reduce take of suckers at the dam including non-structural options. Possible actions for evaluation might include, but should not be limited to: (1) increasing hydraulic roughness along the eastern shoreline of UKL using jetties or groins, small islands or shallow areas, or other means; (2) implementing additional marsh and riparian-zone restoration in areas where sucker larvae occur in UKL and tributaries; (3) rearing of wild-caught larvae and juveniles in lake-side or off-lake, predator-free pens or ponds; and (4) reducing Link River flows at night when juvenile suckers are being entrained. Reclamation shall provide the results of this assessment to the Service and shall implement appropriate actions based on this assessment, in coordination with the Service.

D. Short-term actions are needed to reduce take of juvenile and adult suckers until studies are completed and actions to further reduce take are implemented based on those studies. The Service believes the most practicable short-term action to minimize take as a result of entrainment at the dam is to implement a trap-and-haul operation in the Link River above the dam. Therefore, from July to October 2008, Reclamation shall utilize the fish

bypass flume in the A-Canal Fish Evaluation Station (FES) to acquire suckers for relocation to points farther north in UKL that may benefit individual survival.

Suckers will be treated according to a jointly-developed fish handling protocol described below. Reclamation shall communicate regularly with the Service regarding numbers and condition of captured suckers. An annual report will be prepared and delivered to the Service before January 31st each year. Reclamation shall explore fish holding capabilities at the FES to facilitate treating fish disease and parasites of captured individuals and if practicable, determine the effectiveness of salvage and treatment. A draft report on necessary steps to make the FES a fish holding facility and the potential uses for such a facility will be provided to the Service before January 31, 2009.

E. In addition to those suckers caught at the FES, Reclamation should use rotary screw-traps, fyke nets fitted with live boxes, or other types of nets to trap juvenile suckers in Link River to be hauled back to UKL. Since there are few suitable locations for these traps, we suggest that Reclamation should work with PacifiCorp to collect suckers in one of their power canals. Previous studies by Gutermuth et al. (2000b) captured large numbers of juvenile suckers using fyke nets in the Eastside and Westside Power Canals, indicating that the canals might be an effective location to capture suckers. Captured suckers will be handled according to procedures described below under Project-wide Sucker Salvage.

Because production of young-of-the year suckers is quite variable from year to year and in some years is quite low, it may not be practicable to implement a trap-and-haul operation every year. Therefore the Service will work with Reclamation to determine under what conditions the operation must be done. Nevertheless, development and testing of the collection facilities will need to be evaluated as soon as possible so implementation of the trap-and-haul operation can begin when numbers of juveniles justify the operation.

Element B. Sucker Entrainment Reduction at Other Project Facilities
Take of suckers through entrainment continues to occur at other Project facilities. Although installation of fish screens has been the preferred way to address entrainment, there may be other options that are more cost-effective. In coordination with other agencies and the Tribes, Reclamation will develop and implement a comprehensive plan to minimize, or otherwise reduce the effect of, entrainment. Because there are few practicable structural solutions, Reclamation should consider a full range of options as mentioned above.

Element C. Salvage of Suckers at Key Locations
Although entrainment in the Klamath Project has been considerably reduced as a result of the new A-Canal fish screen, millions of larval suckers pass through this screen into the Project, where most are likely lost. Reclamation has been implementing a required annual salvage program, and has relocated thousands of salvaged juvenile suckers to UKL. While the existing canal salvage program has been very effective, we believe improvements can be made in the program that could both increase numbers of suckers salvaged and improve their survival. Therefore, Reclamation shall continue to implement their annual salvage program and make improvements that can increase the numbers and survival of salvaged LRS and SNS.

There are two sub-elements of the salvage program:

1. Increase the numbers of suckers salvaged in Project canals.

2. Improve survival of salvaged suckers.

Evaluating the effects of disease and parasites on salvaged suckers is critical to increasing their survival. Salvaged fish should be examined and treated for disease and parasites and then held for observation to determine the effectiveness of these treatments. The Service is developing draft guidance for examination and treatment of the suckers for disease and parasites and will share the guidance with Reclamation by April 15, 2008, so it can be used by Reclamation beginning in 2008, if feasible. The Service and Reclamation shall work together to develop a protocol by July 30, 2008 and it shall be adopted in all future salvage efforts if it proves beneficial.

Treated salvaged fish shall be tagged or marked and released back into the environment once treatment and observation is completed. To increase survival rates, biologists conducting salvage operations shall minimize handling and holding stress on salvaged suckers as their health and condition prior to collection may be compromised by heavy pathogen infestations and poor water quality.

Lack of recruitment to the adult population of suckers in Tule Lake may be a limiting factor to that population. Each year, Reclamation shall release into Tule Lake those juvenile suckers salvaged from the J-Canal on the Lost River. It is hoped that the salvaged suckers will be of a size that they can be individually marked for later identification and evaluation of population level response to this action.

Salvaged sucker release efforts shall start in November-December 2008. Salvage of suckers from the A-Canal forebay is described above under Element A.

Term and Condition 2. *Minimize the Take of LRS and SNS as a Result of Reduced Instream Flows below Anderson Rose Dam.*

Reclamation shall take actions under its authority to minimize the effects of reduced instream flows below Anderson Rose Dam. Based on previous releases at the dam, we believe that a steady flow of 30 cfs for 5-7 weeks, beginning April 15, is usually adequate for successful initiation of spawning, incubation, and hatching. Therefore, Reclamation shall provide a steady flow of 30 cfs at Anderson Rose Dam beginning April 15, 2008, and continuing each year if required by the Service. Supplemental flows of 30 cfs from Anderson-Rose Dam are not required after June 15 of any year.

Flow releases at the dam can be returned to seasonally-normal flows each year when monitoring confirms that larvae have emigrated downstream. Monitoring of the results is described below under section 7.5. For 2008, the Service will monitor spawning and larval production, but has requested water quality monitoring support from Reclamation.

During dry years when flows in the lower Lost River are unlikely to be adequate for spawning, Reclamation and the Service shall confer to determine whether provision of flows is necessary.

To assess the effectiveness of the releases, Reclamation shall undertake a 2-4 year field study to assess if the flows are adequate for spawning, incubation, and hatching. The field study shall begin this spring. A draft report on the findings of the field study and recommendations for future instream flows shall be provided to Service by December 31, 2010, unless the Service and Reclamation agree to another deadline. Based on the results of those studies, Reclamation should take practicable actions to improve spawning success at the dam if it is warranted and determine if the required flows should be sustained.

7.4.1 Scheduling of Terms and Conditions

Although planning and several actions under the RPMs will begin in 2008, it may take a year for Reclamation to get all of the above-described sub-elements underway because of the need to address staffing and budget issues. The 2008 priorities shall be: 1) minimize take of suckers by-passed at the flume; 2) implement the trap-and-haul program; 3) reduce take at the A-Canal forebay; and 4) increase numbers and improve survival of salvaged suckers. As explained below, the Service will work with Reclamation to determine priorities and develop an implementation schedule for these actions. Reclamation will need to ensure the requests for funding and staffing are done in advance, so that actions can be completed according to the implementation schedule.

To facilitate the timely implementation of these terms and conditions, as well as associated monitoring, Reclamation has already agreed to work with the Service to develop an expanded implementation work-plan/table no later than June 30, 2008. This work plan shall include, but is not limited to: 1) individual tasks, 2) initiation dates, 3) proposed costs, 4) estimated completion dates, and 5) reporting products and deadlines.

A summary of the status of RPAs and RPMs from the Service's 2002 BO shall be included in this work plan with the intent of clarifying priorities. The draft table due on June 30 shall include, at a minimum, schedules and products for the four priorities listed above for fiscal year 2008 and 2009. It is anticipated that all activities relating to this 2008 BO shall be included in the June 30 work plan; however, if additional time is needed to develop schedules and budgets for years 2010-2018, this information shall be provided to the Service no later than December 31, 2008. This work plan shall be updated yearly as noted in section 7.5.1 below and its requirements amended to the BO.

7.5 Monitoring and Reporting Requirements under the Terms and Conditions

When incidental take is anticipated, the terms and conditions must include provisions for monitoring to report the progress of the action and its impact on the listed species as specified in the Incidental Take Statement (50 CFR §402.14(i)(3)). However, monitoring the amount or extent of take of suckers due to entrainment, adverse water quality, and habitat loss as a result of the proposed action is difficult or impossible for the following reasons:

a. There is a low likelihood of finding dead or injured larvae, juveniles, and adults and determining the source of mortality or injury.

b. Any delayed mortality and rapid rate of fish decomposition make it unlikely that the source of mortality can be accurately identified.

c. Dead suckers might sink to bottom of water bodies making them difficult to detect.

d. There is a high probability of scavenging of suckers whose behavior is altered by being stressed, injured, or are dead, by predators, especially fish-eating birds that can eat all but the largest suckers that not able to easily escape or are at or near the surface.

e. Because of their small size, sucker larvae and juveniles are especially difficult to collect and identify and are not likely to be seen and recognized and thus have to be collected using specialized gear.

f. Doing the monitoring necessary to overcome the above obstacles is both difficult and expensive and the results uncertain.

g. Taking the above findings into consideration, monitoring of the impacts of incidental take shall be conducted by Reclamation as follows:

1a. *Entrainment Reduction at Project Facilities*

Reclamation shall develop a draft sucker entrainment monitoring plan that estimates losses of suckers at Project facilities by December 1, 2008, or at a mutually agreeable date soon thereafter, for the Service's review, comment, and approval. The plan needs to focus on quantifying as much of the entrainment take as is feasible. Implementation of this plan shall begin as soon as the plan is approved by the Service.

1b. *Juvenile Sucker Trap-and-Haul Operation at Link River Dam Outlet*

Reclamation shall develop and implement a Service-approved plan to quantify the number of suckers trapped, sorted and hauled at the outlet of UKL and evaluate the fate of these suckers to determine the potential benefits of hauling suckers back to UKL. Because fish health has been implicated as a factor affecting entrainment rates of juvenile suckers and could be a factor in their survival once trapped, suckers collected during the trap and haul operation shall be examined and treated for parasites and pathogens, if they are present, and the fish held sufficiently long for observation before being released at a safe location in UKL. The Service will work closely with Reclamation to develop a fish-health assessment and treatment protocol.

As long as the trap-and-haul project is implemented, Reclamation shall provide the Service with a summary report by January 31 of each year describing what was done and whether or not it was successful. The report shall include what improvements will be made the following season.

1c. *Project Canal Salvage*

Reclamation shall develop and implement a Service-approved plan to quantify and evaluate the fate of salvaged suckers salvaged that were released back into UKL by August 1, 2008. Reclamation shall provide the Service with a summary report by January 31 of each year describing what was done regarding salvage of suckers in Project canals and whether or not it was successful. The report shall include what improvements will be made, if any, the following season.

2. *Instream Flows at Anderson Rose Dam*

To quantify the number of adult suckers attempting to spawn in the Lost River below Anderson Rose Dam and to assess the effectiveness of the releases in supporting spawning and incubation, Reclamation agreed to support USFWS monitoring of sucker populations in Tule Lake in 2008.

Support may be in the form of water quality monitoring at select sites, assistance with expenses, or other forms agreed upon by Reclamation and USFWS. Reclamation shall assume the fisheries monitoring program at Tule Lake from USFWS in 2009. Before assuming the monitoring, Reclamation and USFWS shall work jointly to develop the future monitoring plan for Tule Lake. Based on the results of those studies, Reclamation shall take practicable actions to improve spawning success at the dam if it is warranted.

7.5.1 Adaptive Management and Development of Annual Work-plan Associated with Take Monitoring

Adaptive management is an important element of an overall strategy to minimize take of listed suckers as a result of Project operations over the next ten years and beyond. Although considerable new information on the LRS and SNS is produced each year, it is challenging to effectively incorporate this information into operation plans and to set funding priorities to ensure that the Project is operated in a manner that is most compatible with the conservation needs of the two listed suckers. For those reasons, Reclamation should make every effort to ensure that new information is made available in a timely manner and appropriate information is incorporated in annual work plans and efforts to minimize take.

One way to ensure information is available for adaptive management is to work with affected parties to develop an annual work plan for studies, monitoring, and other activities related to the terms and conditions and monitoring requirements and management of the suckers, and provide it to the Service for review and comment by January 15 of each year. Development of the annual work plan should rely on the most recent information from USGS, OSU, The Klamath Tribes, TNC, the Service and other sources. Bi-annual meeting of a small focus group whose purpose is to assess the progress of obtaining and exchanging information is also recommended. Reclamation will need to anticipate upcoming projects and budget for them in advance. Because reports from studies and other activities can take a year or more to be completed, Reclamation may need to use drafts and other information even though they might not be in a final form. The annual work plan should include information on previous year's take minimization efforts and if they were successful or not, and use this information to develop the next year's work plan.

7.6 Reporting Requirements

Prior to January 31st of each year for the duration of this action, Reclamation shall provide annual monitoring reports of the estimated take of LRS and SNS that occurred in the previous year, and any other reports required by the terms and conditions above. These reports shall be submitted at least 15 days prior to the due date in draft form to allow review and comment by the Service. All comments shall be addressed in the final reports. These reports shall be submitted to:

Field Supervisor
Klamath Falls Fish and Wildlife Office
U.S. Fish and Wildlife Service
1936 California Avenue
Klamath Falls, OR 97601

8.0. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The term "conservation recommendations" is defined as suggestions from the Service regarding discretionary measures to: (1) minimize or avoid adverse effects of a proposed action on listed species or critical habitat; (2) conduct studies and develop information; and (3) promote the recovery of listed species. The recommendations provided here relate only to the proposed action and do not necessarily represent complete fulfillment of Reclamation's section 7(a)(1) responsibilities under the Act.

1. Continued Support and Funding for Restoration Activities that Increase and Improve Sucker Habitat

A. *Support and Fund Restoration.* We recommend that Reclamation continue to support habitat restoration activities, and the monitoring of restoration activities, in the Upper Klamath Basin that may benefit suckers, including wetland habitats, stream restoration, and riparian corridors in the northern portions of Upper Klamath and Agency Lakes. We recommend Reclamation provide copies of annual reports from Reclamation's contractors to the Service on research and monitoring activities. The progress reports could be supplemented with an annual report of funded activities as they relate to UKL.

B. *Fund a Full-time Reclamation Restoration Coordinator Position.* We recommend that Reclamation fund a full-time restoration coordinator position to work with the Service and other entities in the basin on restoration activities. A coordinator could work in partnership with the Service, Indian Tribes, other agencies, and local groups to: 1) leverage funding to address watershed restoration needs for listed species affected by Reclamation's activities; 2) simultaneously show interagency strength in partnership building which will ultimately bring additional funds to the Klamath Basin; and 3) enhance communication so progress can be made to restore watersheds and recover listed species that are affected by Project operations. Currently there is too few full-time agency staff dedicated towards restoration in the basin to fulfill all of the duties needed to have the best possible restoration program.

2. Improve Water Quality in Keno Reservoir, Project Reservoirs, and the Lost River

Reclamation has monitored water quality in the Project area for many years, so it has substantial data on where water quality problems exist as a result of Project operations. Reclamation has even funded specific studies to investigate options for improving water quality such as the pilot oxygenation study (Burleson Consulting, Inc. 2002) and the organic loading assessment (Deas and Vaughn 2006). Also, Reclamation is a designated management agency under the UKL TMDL process (ODEQ 2002) and is required to develop and implement best management practices to meet water quality criteria established by the TMDL.

With all of this information, Reclamation is now in a good position to take actions to improve water quality in sucker habitats. Therefore, we recommend that Reclamation, with available assistance of the Klamath Tribes, appropriate State agencies, EPA, PacifiCorp, and water quality experts from USGS, state universities, and one or more water quality experts designated by

Reclamation representing its contractors, licensees, or permittees, develop and implement a water-quality improvement plan for the Project.

We recommend that the plan describe or provide: (1) an assessment of the effects of Project management on water quality; (2) a list of all Project features that adversely affect water quality and likely lead to take of suckers, and a description of the extent and cause of those effects; (3) a description of measures aimed at reducing adverse effects of Project implementation on water quality and an implementation schedule; and (4) a monitoring plan to measure effectiveness of the plan.

3. Coordination and Work with Indian Tribes, States, and USEPA on TMDL Implementation

We recommend that Reclamation coordinate and work cooperatively with the affected Indian Tribes, States of Oregon and California, and the U.S. Environmental Protection Agency, to meet future load allocations resulting from the upcoming Lost River TMDLs and Klamath River TMDLs.

4. Continue Fish Passage Studies and Implement Priority Actions to Improve Sucker Passage throughout the Project

We recommend that Reclamation continue to work with Service, Tribal, State, and other agency biologists to identify and rectify fish passage concerns in the Upper Klamath Basin. We recommend that Reclamation continue to host, inform, and invite Tribal and agency participation in regularly scheduled fish passage meetings. It would be helpful if Reclamation produced regular reports on fish passage activities.

5. Support of Upper Klamath Lake Hydrodynamic Model Development

We recommend that Reclamation support hydrodynamic modeling of UKL that has led to an improved understanding of how adverse water quality events occur in the NW lobe of UKL and it has lead to development of hypotheses that suckers may be carried southward along the eastern shore to a point where emigration/entrainment at the outlet of UKL is potentially unavoidable by larval suckers. We recommend that Reclamation support further refinement and proofing of the hydrodynamic model to account for present and future lake changes such as the addition of The Nature's Conservancy Tulana Farms property to UKL in 2007 and the future additions of Agency Lake and Barnes Ranch properties to Agency Lake. Refinement of the hydrodynamic model could help identify target areas for shoreline restoration and modification activities that may benefit suckers in UKL.

6. Assess and Enhance Sucker Spawning Success at UKL Shoreline Sites and Tributaries

We recommend that Reclamation work with Service, Tribal, and other agency biologists to assess the condition of all known spawning sites in UKL, and in the Sprague, Sycan, Williamson, and Wood Rivers. A search for new sites should also be undertaken, both in UKL and in the tributaries. Information should be obtained on substrate type, water depth, water velocity, water temperature (shoreline springs), and other useful parameters. Once the information has been gathered, we recommend that a meeting be held to discuss if any of the sites could benefit from gravel enhancement or other actions. Discussion should identify any needed course of action and propose potential projects and or additional studies. A report should be developed describing the information obtained and recommended actions.

7. Sucker Life Cycle Modeling to Assist Adaptive Management

We recommend that Reclamation continue to support and fund the development of the sucker life cycle model under development by OSU fisheries scientist, Dr. Selina Heppell. We believe development of the model can help inform sucker management and recovery. The model needs to be completed and tested so it will be useful, then it needs to be used to help inform take-reduction efforts.

8. Sucker Population Monitoring at UKL, Gerber, and Clear Lake Reservoirs

We recommend that Reclamation work with Service, Tribal, and other agency biologists to continue current monitoring of sucker populations. Such monitoring is invaluable both to assess the current conditions of LRS and SNS populations but to show trends so we can determine if populations and increasing or declining. Annual monitoring of all stages of suckers is needed in UKL, but less frequent monitoring of adults only is needed in Clear Lake and Gerber Reservoir.

9. A-Canal Fish Evaluation Station Assessment

We recommend that Reclamation investigate potential uses for the space at the fish evaluation station located at the head-works of the A-Canal. Currently there are no laboratories or fish holding facilities on UKL that can be used to study lake ecology and sucker biology. We believe the A-Canal fish evaluation station could be useful for undertaking a variety of studies that would aid in the management and recovery of suckers.

10. Organize and Hold Regular Meetings of a Climate and Hydrology Working Group to Discuss Upper Basin Hydrology and Effects of Human-Induced Climate Change

We recommend that Reclamation organize and hold annual or biannual meetings with State, Federal, and Tribal technical staff to review hydrologic (both surface and groundwater) and climate data to assess what hydrologic conditions have been like to assess data used in inflow forecasting, and to determine if climate/hydrologic changes are occurring that should be factored into management of the Project. Such information might also be useful to ecosystem restoration efforts. Initial meetings should look closely at existing hydrologic and climate monitoring to assess their adequacy. Reports should be developed as a result of the meetings so that managers are aware of relevant climate/hydrologic changes and recommendations from the working group.

11. Review Existing Reservoir Management Models for Clear Lake and Gerber to determine if they are Accurate

We recommend that Reclamation review reservoir management models for Clear Lake and Gerber Reservoir to determine if they are accurate. The models for these reservoirs were developed a decade ago and they may need to be updated using recent data on water use, ET losses, and other relevant information. We would appreciate being involved in this effort.

9.0. REINITIATION NOTICE

This concludes formal consultation on Reclamation's proposed operation of the Project from April 1, 2008, to March 31, 2018. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required when discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that cause an effect to the listed species or critical habitat that was not considered in this opinion; or (4) a new species is listed or critical habitat designated may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

Examples of situations that the Service believes might meet one of the prescribed reinitiation thresholds would be:

1) There is a catastrophic fish kill or declining trends in LRS and SNS indicate that their status is worse than what was considered in 2008 when the BO was developed.
2) There is a series of critically-dry years so that UKL levels are less than the 90 percent exceedance used in our effects analysis.
3) Prolonged drought leads to Clear Lake or Gerber Reservoir water levels that are lower than were anticipated in our effects analysis.
4) New information substantially changes our conclusions regarding the effect the Project has on water quality or sucker habitat in UKL.
5) Assumptions made in our conclusion section regarding the benefits of habitat restoration, removal of Chiloquin Dam, and others prove to not be accurate.
6) If the 1993 recovery plan for the LRS and SNS is revised and new information presented about recovery needs for the species that could change our conclusion about Project effects on recovery.

If you have questions regarding this opinion, please contact the Field Supervisor of the Klamath Falls Fish and Wildlife Office at (541) 885-8481.

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PERSONAL COMMUNICATIONS

C. Banner, Oregon Department of Fish and Wildlife, Corvallis, Oregon 2007
M. Barry, The Nature Conservancy, Klamath Falls, Oregon 2007
P. Barry, USGS, Klamath Falls Field Station, Klamath Falls, Oregon 2007
D. Bennetts, USBR, Klamath Area Office, Klamath Falls, Oregon 2007
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Appendix 1

Klamath Project Entrainment Analysis For Upper Klamath Lake

Executive Summary

This Appendix examines how the Klamath Project (Project) may affect entrainment loss of endangered Lost River and shortnose suckers, primarily larvae and juveniles from Upper Klamath Lake (UKL). Downstream movement of suckers from UKL via the Link River must have occurred prior to the development of the Project, but the influence this has on population status may differ between historic and current conditions because of the following changes: 1) sucker habitat has been reduced and degraded in UKL, its tributaries, and Lake Ewauna, and is now absent in Lower Klamath Lake; 2) UKL levels, discharge rates, and timing have changed; 3) the historic reefs at the outlet of UKL were channelized; and 4) the proportion of annual larval and juvenile sucker production moving downstream could be different because of habitat and lake level changes. Survival of suckers that moved downstream from UKL was more likely under historic conditions because habitat and water quality downstream from UKL was better, and sub-adult and adult suckers could readily move between UKL and Lake Ewauna and Lower Klamath Lake historically. Currently, most of the suckers that move downstream of UKL are lost to the reproducing population of suckers because they do not survive to return to UKL.

Our analysis attempts to separate entrainment losses of suckers (i.e., loss of suckers from the reproducing population due to effects of the Project) from downstream movement of suckers that would occur even without the Project. Estimated entrainment rates (due to the Project) of larvae at A-Canal and Link River Dam spillway and fishway based on two years of data are in the low millions per year (estimated at 2.2 to 2.4 million), probably not a significant amount compared to rates of productivity at this life stage. Entrainment rate of juvenile suckers was estimated for one year to be 28,000 to 44,000 juveniles, or about 5 percent of the juvenile mortality experienced in that year (1998). Entrainment of sub-adult/adult suckers at Link River spillway and fishway (fish ladder) in 1998 was estimated to be approximately 30 to 40 suckers.

Existing information is inadequate to accurately assess the influence entrainment loss has on sucker population status. The entrainment information is based on only a few years of data and there is likely to be substantial error in any entrainment estimates because of the way such a study needs to be done. Likewise, production estimates for larvae and juveniles are limited, although juveniles are represented by more years, and are subject to substantial error when extrapolated to the entire lake. Recently completed or soon to be completed sucker recovery projects, including restoration of the Williamson River Delta, removal of Chiloquin Dam and installation of a new fish screen on the Williamson River, and reconnection of the Sprague River with its floodplain, are expected to substantially improve sucker production and survival, and reduce entrainment by holding young suckers in the tributaries or at the north end of the lake. The estimated number of sub-adult/adult suckers entrained under current and continuing Project operations per year (less than 50) appears to be small compared to the total population size in UKL and some of these fish can return to UKL via a new fishway at Link River Dam.

At this time, we can only conclude that losses of larval and juvenile suckers at the UKL outlet pose an unquantified risk. We do not believe these losses represent a population level effect. The

affect entrainment loss has on sucker population viability is in part dependent on population size and status. The shortnose sucker (SNS) is most susceptible to adverse effects because of low adult survival, and low and variable recruitment. To fully assess the influence of entrainment loss on sucker populations, additional information is needed that quantifies larval and juvenile survivorship, movement, and nursery habitat requirements.

Introduction

This Appendix examines effects of the Klamath Project (Project) on shortnose and Lost River sucker (LRS) populations through loss attributed to downstream movement and entrainment of larval and juvenile suckers at the Upper Klamath Lake (UKL) outlet facilities. This analysis is based on studies quantifying sucker entrainment in the late 1990s by Gutermuth et al. (1998, 2000a, 2000b).

Downstream movement of larval and juvenile suckers from UKL via the Link River (Figure 1, below) must have occurred prior to the development of the Klamath Project. Under historic conditions, these fish reared in nursery and other suitable habitats in Lake Ewauna and Lower Klamath Lake and grew to adulthood, then migrated upstream to spawn in UKL tributaries or shoreline springs (USFWS 2007a). Some sub-adult and adult suckers also moved between UKL and Lake Ewauna and Lower Klamath Lake. The corridors that connected these water bodies were blocked by construction of Link River Dam in 1921, which did not have an effective fishway until Reclamation installed a state-of-the-art facility in 2005 (Figure 2, below). Recruitment of suckers that currently move below UKL is minimal because of limited larval and juvenile survival in downstream habitats (e.g., Lake Ewauna/Keno Reservoir) associated with seasonally-poor water quality (USFWS 2002; Piaskowski 2003; NRC 2004; Deas and Vaughn 2006; USFWS 2007a, USBR 2007), and a paucity of suitable nursery habitat (USFWS 2007a). Therefore, it is anticipated that most larval and juvenile suckers moving downstream through UKL outlet facilities are lost to the population (Markle et al. in review).

Analysis

Effects of the Klamath Project on Sucker Entrainment

Three terms describe interactions between sucker larvae, juvenile, and sub-adult/adults and UKL outlet facilities: 1) entrainment, which is loss of fish through a water management structure as a result of water management operations, 2) advection, which is passive drift of larvae due to gravity- and wind-driven currents (flow), and 3) emigration, which is movement that is volitional and thus is at least partly under the control of the fish. Because the contribution of each category of loss from UKL via the Link River and associated water control structures cannot be easily separated, we use the term downstream movement to describe the downstream movement of suckers from UKL, regardless of the mechanism involved, and entrainment to describe that portion of downstream movement that is caused by the Project.

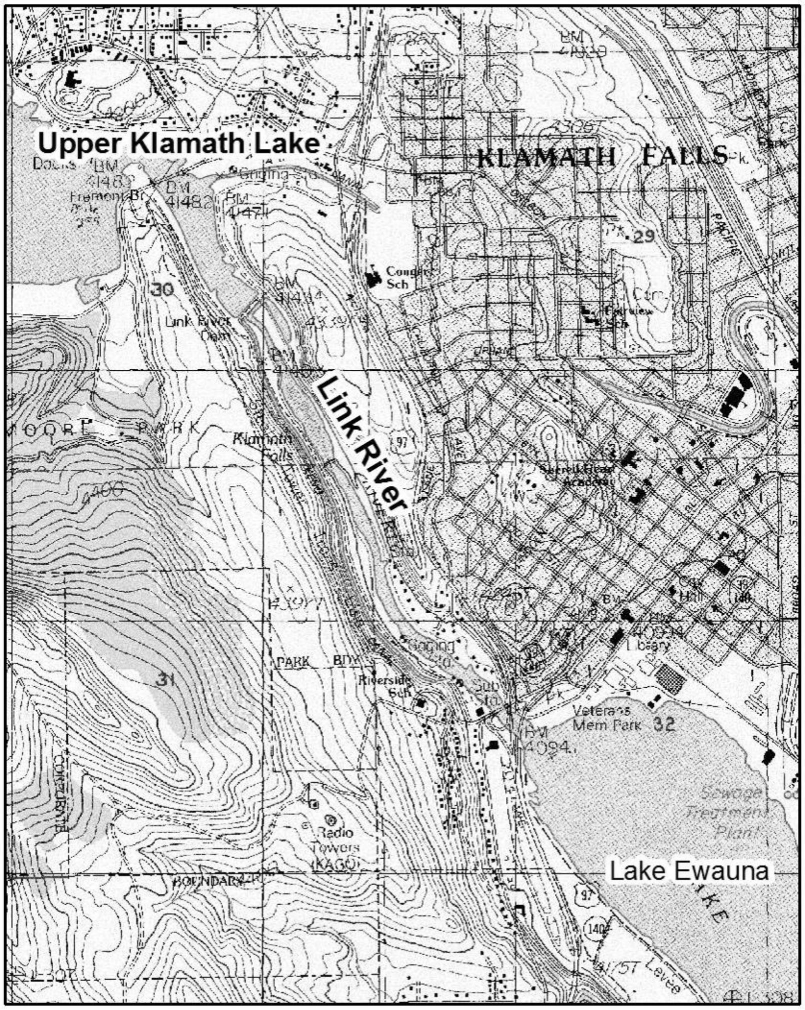

Figure 1. Area map showing the southern end of UKL, Link River, and Lake Ewauna which forms the upper part of the Keno Reservoir. Note that Link River begins upstream of the Fremont Bridge.

Klamath Project operations likely cause increased movement of suckers downstream of UKL, leading to their loss from the reproducing population in UKL. This loss is a form of entrainment related to water management operations. Specifically, the Project stores and later diverts water from UKL for a variety of project purposes. These operations result in lake levels and flows at the outlet of the lake that differ from the no-action condition, some of which increase movement of juvenile fish downstream of UKL. In addition, Klamath Project operations cause entrainment of larvae into the A-Canal, where they are also lost to the population. Below, we first discuss how we separated out Project caused entrainment effects at the Link River Dam spillway and fishway for larvae, juveniles, and sub-adult/adults from downstream movement of these life stages that would be expected without the Project. Then we provide an estimate of entrainment losses at the Link River Dam spillway, fishway and A-Canal that are attributed to Project operations, and an assessment of the significance of these losses.

Figure 2. Photo of Link River Dam. Spill gates and fishway are on the far left and the Eastside hydropower bay on the right side. The reef is upstream of the dam. The two channels that were blasted through the reef are located on each side of the reef near the shoreline.

Losses of Larval Suckers at Link River Dam Spillway and Fishway

Loss of larval suckers at the lake outlet likely results from the interplay of multiple factors (Markle et al. in review). Larval suckers have limited swimming ability, are surface oriented, and many are likely carried down-lake to the outlet facilities by currents. USGS modeling of currents (Cheng et al. 2005) indicates that larvae could be swept from spawning areas to the lake outlet in as few as five days (Reithel 2006; Markle et al. in review). Because of the "Eastern Shore Current," water typically flows south along the eastern shore of UKL to the lake outlet (see Figure 3) and it likely carries larvae along the shoreline toward UKL outlet facilities (Reithel 2006; Markle et al. in review). Based on the USGS modeling, flows from the UKL outlet (which equal the sum of discharge from Link River Dam spillway + fishway + A-Canal + Eastside and Westside hydropower diversions) also could affect the advection rate and the number of larvae captured in outlet flows. Advection losses may increase when there are higher springtime flows that increase larval drift rates and elevate downstream movement to higher levels than occur during lower outlet flows (Reithel 2006).

The lake's hydrography suggests that larval suckers can also be retained in the wind-generated gyre located farther offshore than the Eastern Shore Current (Markle et al. in review). Under prevailing northwest winds, the residual flow in UKL is a clockwise gyre extending as far north as the shoreline between Agency Strait and Pelican Bay and as far south as Buck Island (Wood et al. 2006; see Figure 3). Strong prevailing winds drive a stronger clockwise circulation than weak prevailing winds, and consequently particles (i.e., drifting larval suckers) are more likely to be transported into the gyre and stay in UKL under strong wind conditions. Modeling shows that virtual particles released at Sucker Springs (a major Lost River sucker spawning area along the eastern shoreline of UKL) always left the lake under weak prevailing winds, but showed variable retention (0 to 60 percent) under strong winds. Overall, retention was greater for virtual particles released from the Williamson River (the major Lost River and shortnose sucker spawning tributary for UKL) than for particles released from Sucker Springs.

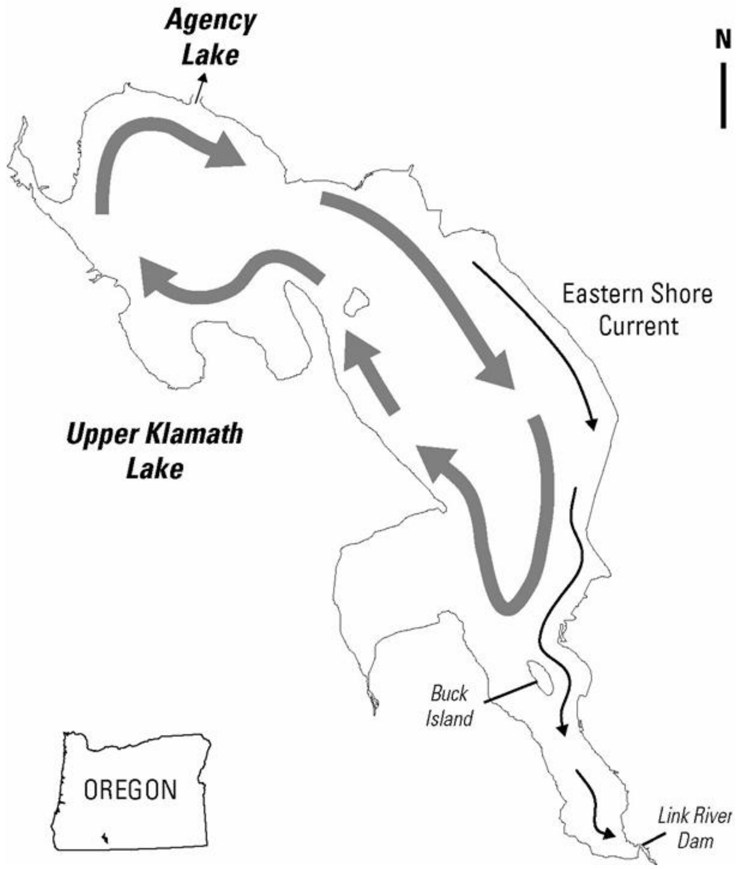

Figure 3. Diagram showing generalized circulation of UKL under the prevailing NW wind. Note the Eastern Shore Current flowing south to the lake outlet. From: Markle et al. in review.

Once at the outlet of UKL, larvae could be entrained at the A-Canal, where some would pass through the fish screen and some would be by-passed back into UKL near Link River Dam via the pump by-pass system (Bennetts et al. 2004). The outlet of the pump by-pass flume is near the west bank of a constricted channel at the outlet of UKL and just downstream from the A-Canal headgates (see Figure 4). Based on limited larval entrainment evaluations at the A-Canal fish screen in 2003 (Bennetts et al. 2004), and more extensive evaluations at a similar fish screen facility on the Sacramento River with larvae of another sucker species (Borthwick and Weber 2001), up to about 50 percent of the larvae pass through the fish screen and enter A-Canal and the other 50 percent are by-passed back to UKL. Of those larvae that are by-passed back to UKL, we assume that few larvae (less than 25 percent) will return to the lake and most of them (greater than 75 percent) will be transported in the flow moving towards the Link River Dam, because the by-pass flume deposits larvae only 1/3 mile upstream of Link River Dam in an area of low velocity near the shoreline opposite the entrance of the A-Canal (USFWS 2007a).

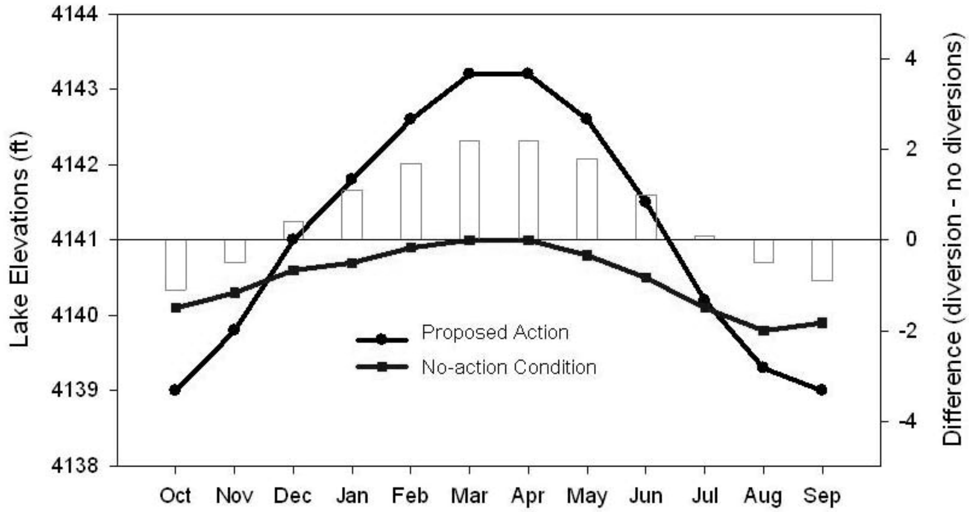

Figure 4. End –of-month UKL elevations at the 70 percent exceedance resulting from the proposed action and from the no-action condition.

Since larval suckers are present in UKL from April through mid-July, we compared lake levels associated with the proposed action with modeled elevations with no storage or diversion operations (i.e., our no-action condition, for more description see the Effects of the Action section in the BO) (see Figure 4). During the April through June primary larval sucker life history period, UKL elevations range from 1.0 to 2.2 ft higher under the proposed action compared to the no-action condition. During July, elevations with the proposed action are 0.1 feet higher than the no-action condition. Therefore, lake elevations are substantially higher during the larval life stage providing more inundation of preferred shoreline emergent vegetation habitat (Cooperman and Markle 2004). With more larval habitat available, more fish are likely to be retained and not leave the lake through advection (Markle et al. in review). Based on emergent vegetation habitat near the Williamson River where the highest densities of larvae are found (Cooperman and Markle 2004), under the proposed action, end of May elevation of 4142.6 feet, approximately 90 percent of the habitat is inundated in the Williamson River Delta (Elseroad 2004). End of May elevations under the no-action condition is 4140.8 feet which inundates only about 60 percent of the emergent wetland habitat in the Williamson River Delta.

As previously described, larval suckers are poor swimmers and susceptible to advection caused by wind-driven currents and to a lesser extent by flow out of UKL. Advection forces are greater near the outlet of the lake at higher flows resulting in larger losses of drifting particles and presumably larval suckers than at lower flows (Reithel 2006). Flows out of UKL under the proposed action are less than the no-action condition in April and May (using the 30 percent exceedance). Average monthly flows are approximately 270 and 240 cfs lower under the proposed action compared to the no-action during April and May, respectively (see Figure 5). In June average monthly flows are 280 cfs higher under the proposed action compared to the no-action. We do not expect an increase in entrainment of larvae at Link River Dam spillway and fishway from increased advection during April and May because flows are not increased by the Project during the months that larvae are in UKL. In June, with higher flows under the proposed action than the no-action there may not be an increase in entrainment because there is more emergent habitat available for larval sucker retention and less dispersal and passive drift. Also, most larvae have grown and become better swimmers and are less likely drift with lake currents.

Therefore, the entrainment losses of sucker larvae that are caused by Project operations at this time are only those associated with the A-Canal.

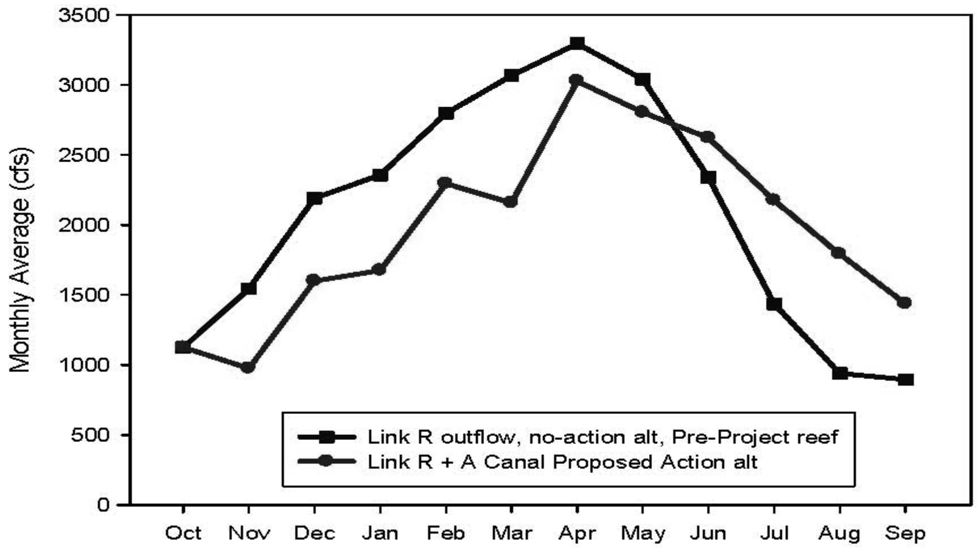

Figure 5. Modeled Link River monthly flows (30 percent exceedance, 1961-2006), including A-Canal diversions. Based on Reclamations modeling of the no-action condition and proposed action at the 30 percent exceedance.

Losses of Juvenile Suckers at Link River Dam Spillway and Fishway

Based on studies at the outlet of UKL, most juvenile sucker entrainment occurs during the July through October period, with a peak in August and September (Gutermuth et al. 1998, 2000a, 2000b; Tyler 2007; Foster and Bennetts 2006). UKL levels during the primary juvenile sucker entrainment period of July through October are generally lower under the proposed action (using the 70 percent exceedance) than the baseline resulting in reduced shoreline habitat availability. Lake levels under the proposed action are 0.1 feet higher in July and 0.5, 0.9, and 0.9 feet lower than the no-action condition for August, September, and October, respectively (see Figure 4). The effect of this reduction in shoreline habitat availability is unknown, however; because juveniles are associated with a greater variety of habitat types than larvae, juveniles are less likely to be adversely affected by receding lake levels above 4138 feet. Also, because near-shore habitats used by juvenile suckers cover most of the shoreline, habitat is unlikely to be limiting as lake levels decline to 4138 feet. However, as lake levels decline below 4138 feet, coarse substrates and wetland vegetation habitat will be less available and mud will be more dominant. Juveniles are likely to be adversely affected by very low lake levels because they require greater water depths than larvae and are present when the lake recedes to lower elevations. Similar to larvae, juvenile suckers may be at some risk from reduced habitat availability at the lowest lake levels (i.e., those below 4138 feet) as a result of increased predation, reduced feeding success, and increased entrainment (see *Effects Section* in the BO). Therefore, we assume that lake levels between July and October that are less than 4138 feet pose a low and un-quantified risk to juvenile suckers owing to a possible loss in habitat. The proposed action is expected to result in minimum lake levels being above 4138 feet 90 percent of the time.

As the summer progresses, some research suggests that the distribution of juveniles in near-shore areas moves from the northern end of UKL to the shorelines of the southern portion of UKL, generally south of Buck Island. This pattern was remarkably constant in OSU cast net surveys from 1994 to 2003 (Terwilliger et al. 2004) and consistent with the prevailing south-flowing eastern shore current (Wood et al. 2006). In 2004, USGS evidence for a hypothesized pattern of movement of juvenile suckers starting at the northern end of UKL and moving south over time was seen (Hendrixson et al. 2007a). Movement of suckers southward through the summer as previously noted are also associated with increased entrainment of juveniles into the A-Canal and Eastside and Westside powerhouses of the Link River Dam (Gutermuth et al. 1998, 2000a, 2000b). However, USGS has not documented strong evidence for a seasonal southward movement of juvenile suckers in 2002, 2003, and 2005 (Hendrixson et al. 2007b; Burdick et al. in review).

There is some evidence that larval sucker advection is an important mechanism affecting inter-annual differences in abundance and distribution of juveniles in August (Markle et al. in review). The latitude of the center of distribution of juvenile suckers was almost always north of the latitude of the center of abundance in UKL, suggesting that abundance was usually greater in the south end of the lake, a pattern consistent with downstream advection during the larval life stage. Inter-annual differences in abundance were strongly and positively related to latitude of the center of juvenile sucker distribution, accounting for greater than 70 percent of the variation in SNS abundance and greater than 30 percent for LRS. Inter-annual differences in juvenile sucker abundance were not related to suspected important water quality variables or lake levels. There also was no tendency for preferred substrates to have a northerly distribution within the lake and thus, the patterns are most likely due to advection and not strictly habitat.

During September and October, many juvenile suckers appear to leave near-shore areas, so habitat availability is less likely a factor affecting them. Markle and Clauson (2006) suggested that the transition from near-shore to offshore was gradual, occurring over a broad size range (40 to 90 mm total length). However, it is not certain whether this shift in habitat use is the result of reduced depth and habitat quality associated with lower lake levels or changes in the ecological requirements of the juveniles (Terwilliger et al. 2004). Recent evidence suggests that LRS juveniles are mostly associated with offshore habitat (D. Markle, OSU, pers. comm.).

Because a large number of juveniles are located in the southern end of the lake during the summer, they would be more likely to be attracted to the outlet of the lake. In August and September when lake levels are lower, velocities in narrow channel at the outlet of UKL are typically still high and may be attractive to fish. Velocities were relatively high near the outlet of UKL (up to 2 ft/s) during July and September 1998 surveys (Wahl and Vermeyen 1998; Figure 6, below). These flows are relatively high compared to the 1.1 ft/s critical swimming speed, for juvenile suckers (Delonay and Little 1997). If these fish were involved in some sort of density dependent or passive dispersal, they might easily follow velocity vectors through either the A-Canal or Link River outflows.

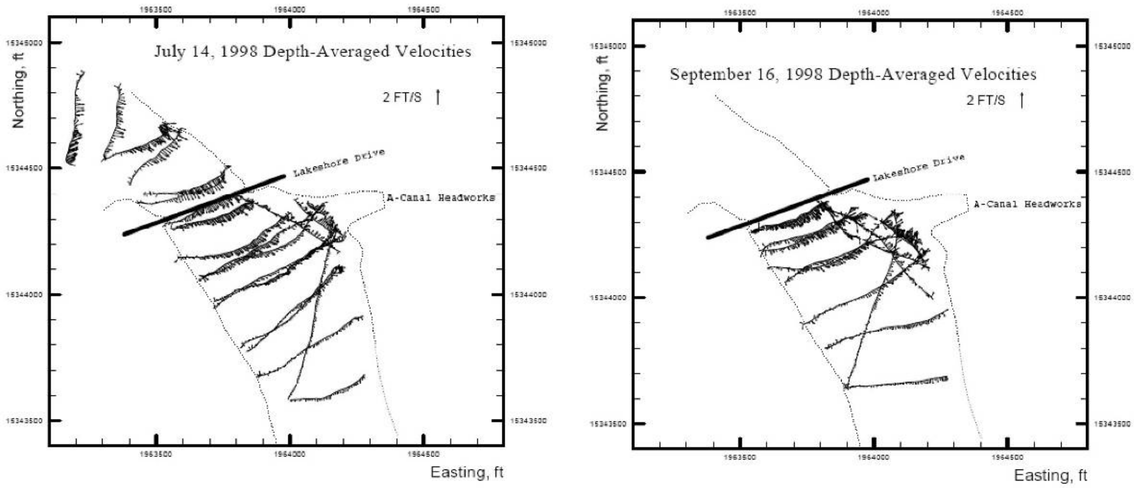

Figure 6. Current velocity vectors in the outlet channel of UKL near the A-Canal in July and September 1998 (from Wahl and Vermeyen 1998). The relative length of the vectors is proportional to the flow and the direction is oriented in the direction of the flow.

In the July through October primary juvenile sucker entrainment period, flows out of UKL are higher at the outlet under the proposed action than under the no-action condition (based on the 30 percent exceedance; see Figure 5). July, August, September, and October average flows are 740, 850, 540, and 2 cfs higher under the proposed action than under the baseline, respectively. Therefore, juvenile suckers in the southern end of UKL could be more susceptible to being attracted to the outlet area and subsequently entrained. Gutermuth et al. (2000b) documented that juvenile sucker entrainment was proportional to the volume of flows in the Eastside and Westside Power Diversions, thus suggesting that the rate of entrainment is greater at higher flow. Entrainment is more likely to occur since Link River Dam was constructed because of the deep channels cut through the reefs at the outlet of the lake to allow water diversions at low lake levels (USBR 2001). Suckers are more likely to readily move downstream through these channels than over the historic reef that would have shallow depths and higher velocities. Historically, juvenile fish may have avoided this shallow area because of exposure to fish eating bird and fish predators.

The overall contribution of the Project to loss of juvenile suckers at the outlet of UKL is difficult to partition from natural emigration, advection related to wind-generated currents, and transport of debilitated fish that might die from disease or predation even if they remained in the lake. We assume, based on the evidence above, that since flows at the outlet are about 50 percent higher during the main juvenile downstream movement period under the proposed action (at the 30 percent exceedance level) than the no-action and that entrainment is proportional to the flow, that a 50 percent increase in juvenile movement through the Link River Dam spillway is entrainment, or related to the Project.

Historically, some of the suckers leaving UKL would have reared in Lake Ewauna and Lower Klamath Lake and then returned to UKL as adults. However, with the degradation and loss of lake and wetland habitat due to agriculture conversion, railway construction, and constant water level management after construction of Keno Dam, and degradation of water quality, sucker survival is minimal in Keno Reservoir. Therefore, most juvenile suckers that move into Keno Reservoir are likely to die.

Other Factors Affecting Juvenile Downstream Movement Deserving Further Study

Other factors that may affect juvenile downstream movement at the outlet of UKL are fish health and poor water quality. Gutermuth et al. (1998, 2000a) noted that many of the entrained suckers at A-Canal were debilitated and others were dead. This was particularly true in 1997 when a sucker die-off was documented in association with a period of poor water quality in UKL (Perkins et al. 2000b). In 1998, most juveniles were relatively active but many had physical afflictions and external parasites that may be an indicator of stress or disease. Peak entrainment was associated with poor water quality conditions including low DO and high water temperature (Gutermuth et al. 2000a). In 2007, a large concentration of juvenile suckers was documented at Barkley Spring area while sampling elsewhere in UKL captured few suckers (J. Hodge, USFWS, pers. com. 2007) suggesting juvenile fish may have moved there to avoid poor water quality.

While it has been suggested that juvenile sucker entrainment may be the result of stressed and debilitated fish seeking to avoid poor water quality, this is not entirely consistent with the entrainment data that documented very low day-time entrainment rates and high catch rates at night (Gutermuth et al. 2000a; Bennetts et al. 2004; Bennetts and Korson 2005). However, fish with reduced fitness may move more passively at night similar to larval suckers. Fish stressed by poor water quality may also suffer from other afflictions including parasites and pathogens. In 2006, several thousand juvenile suckers downstream of Link River Dam were captured during August through early October (Tyler 2007). A sample of about 500 suckers caught in the Link River in August 2006 was transported to a holding facility for observation and fish health surveys. Although these fish were believed to be in relatively good condition, all fish died within a few weeks at the holding facility where water quality conditions were good. Fish health surveys identified heavy infestations of protozoan parasites on fish collected below Link River Dam (C. Banner, ODFW, pers. comm. 2007).

Several fish parasites have been identified in juvenile suckers from UKL. Poor water quality and high fish densities in juvenile sucker rearing areas may result in heavy parasite infestation rates. These factors can severely weaken or kill young fish. The fathead minnow, a non-native species, is the dominant fish and occupies the same near-shore areas as juvenile suckers (Markle and Dunsmoor 2007). It is surmised that with high fish densities in near-shore sucker rearing areas, that parasite infestations and other diseases can quickly spread and reach levels that stress and kill fish. Juvenile suckers can be killed by heavy infestations of protozoan parasites as has been observed in aquaria and hatchery environments. Because most juvenile downstream movement occurs during August and September when numbers of juvenile fish are at a peak in shoreline rearing areas (Hendrixson et al. 2007a; Terwilliger et al. 2004), and water quality conditions are poor, it's plausible that many of these fish are stressed and sickened by poor water quality and pathogens including protozoan parasites and that results in more passive drift.

Suckers in the southern end of UKL are particularly vulnerable to movement out of UKL. Many of these fish may have died from disease or predation by fish-eating birds had they not moved downstream of UKL. Because of the persistent poor recruitment of suckers in UKL, those juveniles not entrained may die due to disease and predation. Further, suckers may lose in competition for food and space with other species such as the fathead minnows (Markle and Dunsmoor 2007), which increase in abundance later in the summer. Finally, all these factors could contribute to an overall loss of body condition and fitness going into the fall and winter months. This may leave juvenile suckers without adequate energy reserves to survive their first winter, make them more vulnerable to opportunistic infections, and more sensitive to changing environmental conditions (Foott and Stone 2005). Additional research is needed to understand the importance of fish health to survival and recruitment, and the effects of entrainment and downstream movement on sucker population status.

Losses of Sub-adult/Adult Suckers at Link River Dam Spillway and Fishway

As with the juveniles, most sub-adult/adult entrainment and downstream movement at the outlet of UKL occurs during the July through October period (Gutermuth et al. 2000a, 2000b). Since flows at the outlet are 50 percent higher on average during the main sub-adult/adult entrainment period and that entrainment is proportional to flow (Gutermuth et al. 2000b), an increase of 50 percent of the sub-adult/adult entrainment through the Link River Dam spillway is related to the Project.

Quantification of Entrainment Effects

Larvae

Once larvae reach the Link River Dam facilities, they are either entrained by A-Canal or the hydropower diversions, or move past the river gates in the dam spillway or fishway. The number of larvae moving downstream of the dam was estimated in the 2007 FERC BO for the Klamath Hydroelectric Project (USFWS 2007a), and is helpful for analyzing the effects of the Klamath Project on the LRS and SNS. The basis for that analysis is the following:

- Studies have not been conducted to quantify the total downstream movement of larvae at UKL outlet (A-Canal and Link River Dam) facilities. We have no downstream movement rates at the spillway and fishway, so those must be estimated based on studies at other facilities.
- There are only 2 years of larval sucker entrainment estimates for the A-Canal which is adjacent to Link River Dam facilities (see Figure 7). Larval sucker entrainment at the A-Canal was estimated at $3.3x10^6$ (95 percent CI = 1.3 $x10^6$ to 5.4 $x10^6$) in 1996 and $1.7x10^6$ (95 percent confidence limits = 0.7 $x10^6$ to 2.9 $x10^6$) in 1996 (Gutermuth et al. 1998, 2000a).
- Gutermuth et al. (2000b) concluded that larval entrainment at the Eastside Power Diversion was generally proportional to the volume of flow diverted into the power canal, therefore, if entrainment rates were known at one facility they could be calculated for the other based on the proportion of flow though each facility.

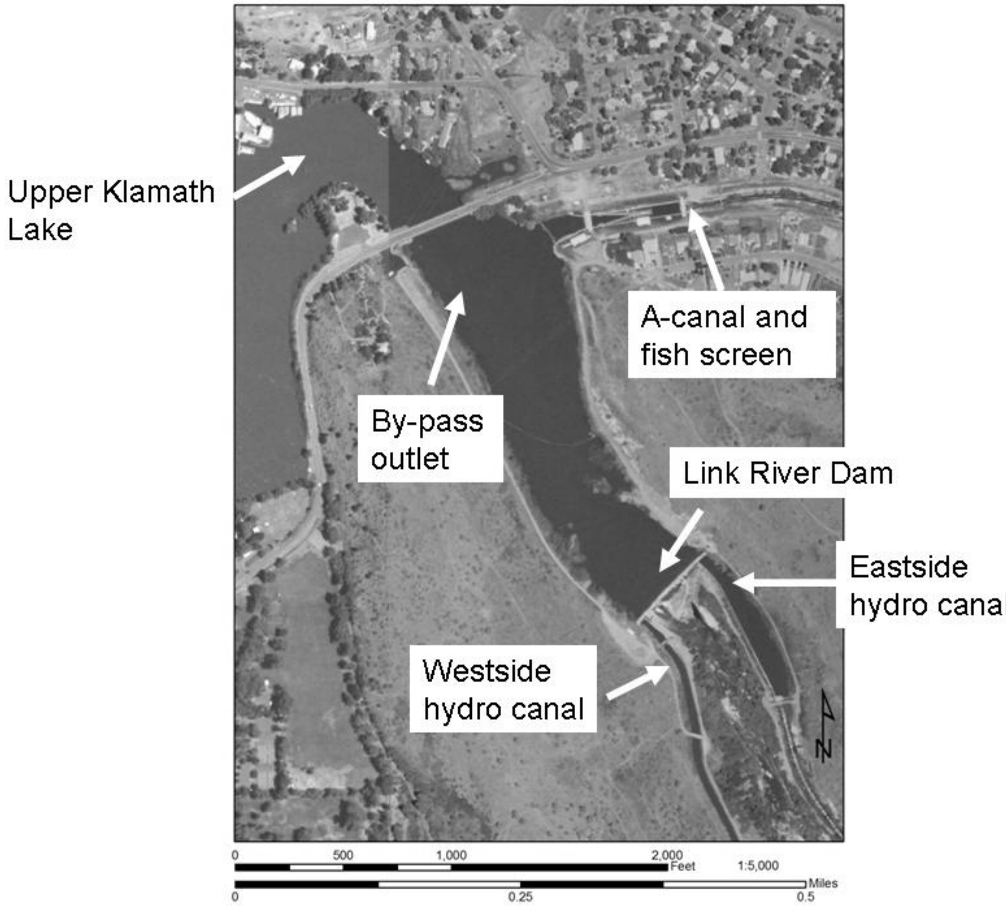

Figure 7. Aerial photo of the UKL outlet and the Link River showing the A-Canal and fish screen, the approximate location of the pump by-pass outlet flume, the Link River Dam, and the two associated hydropower canals.

- Larval entrainment through A-Canal and Eastside + Westside diversions is thought to be similar because the mean diversion rates were similar for both locations during the April through July larval emigration period (USFWS 2007a; FERC 2007).
- During the April through July larval emigration period, approximately 40 percent of the flow on average passes through the Link Dam spillways, fishway, or auxiliary water structure, and approximately 60 percent through the hydropower diversions.
- Now that A-Canal is screened, approximately 50 percent of the larvae are entrained into the canal and 50 percent by-passed (Bennetts et al. 2004; Borthwick and Weber 2001). Using only the higher and more conservative 1996 entrainment rates for A-Canal, this would mean that 1.65×10^6 larvae are entrained into the A-Canal and another 1.65×10^6 are by-passed.
- We assume that 0 to 25 percent of the by-passed larvae return to UKL (up to 0.4×10^6) and 75 to 100 percent would be entrained at Link River Dam (at least 1.25×10^6).
- Of the by-passed larvae that are entrained at Link River Dam, we assume that 40 percent are entrained over the spillway and fishway and 60 percent are entrained in the Eastside and Westside power canals.

Using the above assumptions and the 1996 A-Canal entrainment rates, and assuming that A-Canal is screened and 25 percent of the larvae will get back to UKL, the current and continuing total entrainment and downstream movement of larvae at the lake outlet would be:

> Sucker larvae entrainment and downstream movement at the outlet to UKL = $1.65x10^6$(A-Canal) + $3.3x10^6$ (Eastside and Westside) + $2.2x10^6$ (Link River Dam spillway and fishway) + 1.25 $x10^6$ (A-Canal by-passed fish entrained at Link River Dam spillway and fishway—0.5 $x10^6$ + Eastside and Westside—0.75 $x10^6$) = 8.4 $x10^6$
>
> Sucker larvae entrainment and downstream movement at current Project facilities (A-Canal, Link River Dam spillway and fishway) = $1.65x10^6$(A-Canal) + 2.2 $x10^6$ (Link River Dam spillway and fishway) + 0.5 $x10^6$ (portion of the by-passed larvae entrained through Link River Dam spillway and fishway) = $4.4x10^6$

Using the above assumptions and the 1996 A-Canal entrainment rates, but assuming no larval suckers by-passed at A-Canal screen return to UKL, the current and continuing total larval sucker entrainment and downstream movement at the lake outlet would be:

> Sucker larvae entrainment and downstream movement at the outlet to UKL = $1.65x10^6$ (A-Canal) + $3.3x10^6$ (Eastside and Westside) + $2.2x10^6$ (Link River Dam spillway and fishway) + $1.65x10^6$ (by-passed larvae from A-Canal that pass over Link River Dam spillway and fishway —$0.7x10^6$ + Eastside and Westside—1.0 $x10^6$) = 8.8 $x10^6$
>
> Sucker larvae entrainment and downstream movement at current Project facilities (A-Canal and Link River Dam spillway and fishway) = $1.65x10^6$(A-Canal) + $2.2x10^6$ (Link River Dam spillway and fishway) + 0.7 $x10^6$ (portion of the by-passed larvae entrained through the Link River Dam spillway and fishway) = $4.6x10^6$

If the Eastside and Westside diversions are screened under a new FERC license, the number of larvae entrained at these diversions will be the same as under current conditions. However, approximately 50 percent will pass through the screens and enter the turbines and 50 percent will be by-passed downstream into Link River and ultimately Keno Reservoir, where they will be lost to the reproducing population.

The accuracy of these estimates are affected by a number of factors, such as accuracy of canal flow measurements, calibration of flow meters used in the plankton net, effects of algae clogging nets and affecting flow meter operation, accuracy of estimated spatial and temporal variability in larval density, and how well samples were preserved and larvae correctly identified. Most of these possible factors were not evaluated in the study by Gutermuth et al. (1998, 2000a, 2000b); however, they did mention problems with the gear, clogging by algae, problems with preservation of samples, and damage to larvae making identification difficult. Therefore caution needs to be exercised in use of the estimates. This is not meant as a criticism of the Gutermuth et al. study, but is more a realization that any study quantifying larval abundance will have uncertainties that affect interpretation of research results. Additionally, these data only represent two years, which is a short time and therefore is very unlikely to provide information on long-term temporal variation in entrainment. Temporal variation is likely to be high. For example, Cooperman (2004) described variability in catch data for juvenile suckers in UKL for a 10-year data set that ranged from 5 times for larval trawl data to $7x10^4$ times for cast net data for juveniles (also see Table 1). This suggests there is considerable inter-annual variation in larval and juvenile production and survival in UKL.

Project Induced Larval Entrainment Loss

The portion of larval sucker entrainment at current Project facilities that is caused by proposed action is only that amount of larval entrainment associated with the A-Canal because we identified no increase in larval entrainment over the no-action condition that occurs from Project operations at the spillway and fishway (see Larval Suckers at Link River Dam Spillway and Fishway section, above). Therefore, larval entrainment losses caused by the proposed action are expected to be equal to the present A-Canal entrainment losses (estimated to be 1.65 $x10^6$ larvae per year) plus the larvae that are bypassed at the A-Canal screens that subsequently get entrained at Link River Dam spillway and fishway (estimated to be between 0.5 and 0.7 x 10^6 larvae per year). The total larval entrainment loss caused by proposed Project operations is estimated to be between 2.2 and 2.4 million larvae per year. If FERC requires screening under the new license, the entrainment loss at Link River Dam spillway and fishway remains the same as under current operations. If the power canals are decommissioned then all the larvae will pass downstream at Link River Dam spillway and fishway.

Juvenile Entrainment

Prior to construction of the Link River Dam in 1921, lake levels and Link River flows were controlled by two natural reefs located upstream of the dam (Boyle 1964; Perry et al, 2005; see Figure 8). When Link River Dam was built, a channel 100 feet wide and 8 feet deep was cut through the upper reef shelf at the upper end of the historic Link River and two similarly-deep channels were blasted through each side of the lower reef (partly visible in Figure 2; USBR 2001; Boyle 1964). During the summer, the pre-project water depth across the reefs was shallow (0 to 2 feet deep; USBR 2001) and this limited the flow capacity of the channel. Therefore, the three channels were cut through the reefs to ensure flows would be adequate for irrigation diversions during the summer when lake levels were declining (Boyle 1964). Not only did the reefs reduce flow but they likely created a partial barrier to downstream movement of juvenile, sub-adult, and adult suckers. After the reefs were cut, water depths in the channels varied from 12 feet at full pool to 6 feet at elevation 4137 feet (USBR 2001). This likely increased fish passage across the reefs created conditions whereby juvenile sucker downstream passage likely increased through the spillway, fishway and hydropower canals (USFWS 2002b).

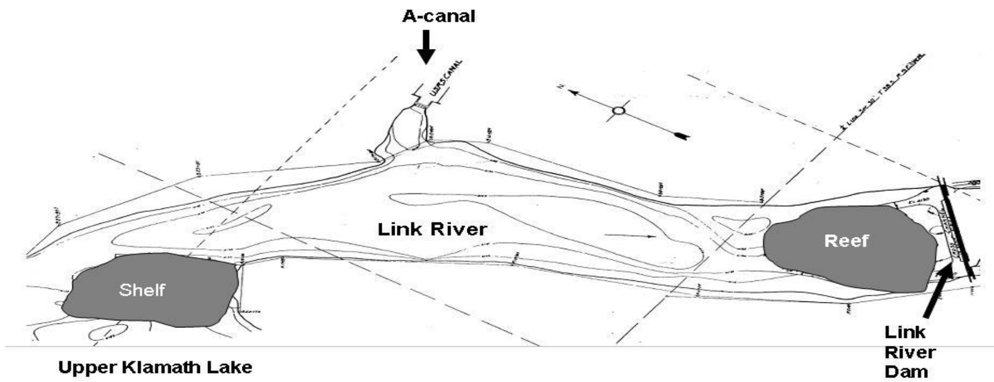

Figure 8. Diagram showing the upper Link River from the outlet of UKL to the dam. Rock reefs are shown at the river mouth and near the dam. Adapted from Wahl and Vermeyen (1998).

Juvenile sucker entrainment at the A-Canal was measured by Gutermuth et al. (2000a) in 1997 and 1998. The highest rate occurred in 1998, when estimated entrainment was nearly 250,000 juveniles. Gutermuth et al. (2000b) also sampled the Eastside and Westside Hydropower Canals from 1997-1999. The highest estimated juvenile entrainment in the two canals for this period was approximately 83,000 in 1998. With these data, and results from Gutermuth et al. (2000b) showing that entrainment may be a function of discharge, it is possible to estimate downstream movement at the Link River Dam spillway and fishway, which lacked data. Total facility downstream movement in 1998 as estimated for the FERC BO (USFWS 2007a) is based on the following assumptions and calculations:

- Estimated total juvenile entrainment at the two hydropower canals in 1998 = 83,000 (Gutermuth et al. 2000b)
- Estimated total juvenile entrainment at the A-Canal in 1998 = 246,000 (Gutermuth et al. 2000a)
- Gutermuth et al. (2000b) concluded that entrainment at the Eastside and Westside Power Diversions was generally proportional to the volume of flow diverted into the canals.
- During the July through October juvenile downstream movement and entrainment period, ~80 percent of the flow on average passes through Eastside and Westside Power Diversions and 20 percent through the Link River Dam spillways, fishway, or auxiliary water structure (USFWS 2007a)
- Losses based on the proportion of flow would equal 83,000 for the Eastside and Westside Power Diversions (80 percent of flow) and 21,000 for the Link River Dam spillway and fishway (20 percent of flow; USFWS 2007a)
- Total loss of juveniles at the UKL outlet in 1998 = 83,000 (Eastside and Westside Power Diversions) + 246,000 (A-Canal) + 21,000 (Link River Dam spillway and fishway) = 350,000
- Total loss of juveniles at A-Canal and Link River Dam spillway and fishway

(Project facilities) in 1998 = 246,000 (A-Canal) + 21,000 (Link River Dam spillway and fishway) = 267,000

The entrainment studies by Gutermuth et al. (2000a, 2000b) were completed prior to screening of the A-Canal in 2003. Now, some of the juvenile suckers that are by-passed by the facility are likely to continue downstream and become entrained in the Link River Dam facilities and some would likely move upstream and back into UKL. The percentage of by-passed juvenile suckers moving back to UKL and the percentage entrained through Link Dam facilities is unknown. However, in 2005, a pilot assessment project, using six radio-tagged juvenile suckers, found that of the four suckers that survived the by-pass, two returned to UKL and two moved downstream through Link Dam facilities (T. Tyler, USBR, pers. comm. 2007). While this pilot project was not intended to provide a statistically valid test of the by-pass, it did show that some juvenile suckers can return to the lake after going through the by-pass facility.

This information can be used to consider effects of the fish screen on entrainment and to adjust the 1998 entrainment estimates. Assuming the fish screen prevents all juvenile sucker entrainment into A-Canal (likely a valid assumption since the screen was designed to exclude 30 mm suckers, which is the lower size limit for juvenile suckers) we need to make an assumption about what proportion of the by-passed juveniles return to UKL. Based on the radio-tagged juvenile sucker data, we assume that 50 percent of the fish by-passed return to the lake and 50 percent are entrained at Link River Dam.

Also, since 2002, PacifiCorp has shut down Westside Power Canal and operated Eastside Power Canal at minimum operational flows at night (200 cfs) from mid-July through mid-October in order to try to reduce sucker downstream movement when it is highest at night (FERC 2007). Although there have been no investigations to determine if these operations have resulted in reductions in sucker downstream movement, in the FERC BO (USFWS 2007a) we assumed this operation resulted in 25 percent of the juvenile suckers approaching the dam returning to UKL. Also, many of the fish that would have entered Eastside and Westside at night probably pass over the Link River Dam spillway or through the fishway. We assume PacifiCorp's operation results in 50 percent of the juveniles passing over the Link River Dam spillway and fishway and 50 percent at Eastside when the power canal is operated at full capacity during the day and at 200 cfs at night.

Estimated total juvenile sucker entrainment and downstream movement at Link River Dam under the proposed action based on the analysis used in the FERC BO (USFWS 2007a) would be:

- Estimated total juvenile sucker entrainment at the two hydropower canals in 1998 = 83,000 (Gutermuth et al. 2000b)
- Estimated juveniles passing through Link River Dam spillway in 1998 = 21,000 (USFWS 2007a)
- Estimated total entrainment at the A-Canal in 1998 = 246,000 (Gutermuth et al. 2000b)
- A-Canal screens exclude all juvenile suckers (246,000) and 50 percent of the fish by-passed returned to UKL (123,000) and 50 percent are entrained at Link River Dam (123,000; USFWS 2007a)
- Estimated numbers of juveniles dispersing towards the dam = 83,000 (Eastside and Westside) + 123,000 (A-Canal by-passed fish) + 21,000 (Link River Dam spillway) = 227,000
- PacifiCorp current operation of Eastside and Westside diversions result in 25

percent of the juveniles approaching the dam returning to the lake (USFWS 2007a)

- Total estimated entrainment and downstream movement of juvenile suckers at the outlet of UKL under current PacifiCorp operations = 227,000 (total juvenile entrainment and downstream movement without PacifiCorp's change in operation to protect juvenile suckers) – 25 percent (57,000; number of juvenile suckers returning to UKL as a result of PacifiCorp's operations) = 170,000
- Under PacifiCorp's operations of low flow releases at Eastside at night we assumed that 50 percent of the juveniles would move downstream through the spillway (85,000) and 50 percent would be entrained at Eastside (85,000)(USFWS 2007a)

Estimated current and continuing total juvenile sucker entrainment and downstream movement at Link River Dam with all fish by-passed at A-Canal passing downstream would be:

- Estimated numbers of juveniles dispersing towards the dam = 83,000 (Eastside and Westside) + 246,000 (A-Canal by-passed fish) + 21,000 (Link River Dam spillway and fishway) = 350,000
- PacifiCorp current operation of Eastside and Westside diversions result in 25 percent of the juveniles approaching the dam returning to the lake (USFWS 2007a)
- Total estimated entrainment and downstream movement of juvenile suckers at the outlet of UKL under current PacifiCorp operations = 350,000 (total juvenile entrainment and downstream movement without PacifiCorp's change in operation to protect juvenile suckers) – 25 percent (87,500; number of juvenile suckers returning to UKL as a result of PacifiCorp's operations) = 262,500
- Under PacifiCorp's operations of low flow releases at Eastside at night we assumed that 50 percent of the juveniles would move downstream through the spillway (131,000) and 50 percent would be entrained at Eastside (131,000)

Based on the 1998 data and necessary assumptions, we determined that juvenile downstream movement and entrainment through the spillway of the dam and fishway would now be approximately 85,000 to 130,000. The accuracy of this estimate is affected by many factors, such as, accuracy of canal flow measurements, effects of algae and debris clogging screw trap and fyke nets in the A-Canal, the accuracy of estimated spatial and temporal variability in juvenile density, and how well samples were preserved and juveniles correctly identified.

Unlike larvae that are probably well-mixed in the water column and therefore making it easier to get representative samples, juveniles could swim toward the bottom of the canal where they would be difficult to catch in a suspended net. Although the fyke nets and rotary trap used to sample juvenile suckers at A-Canal were larger than the plankton nets used to sample larvae, the fyke nets only sampled about 1/3 of the water flow and the rotary trap only about 1/6 of the flow (Gutermuth et al. 2000a). Sampling occurred on only two days each week, so if numbers of juveniles was highly variable from day to day, that variability might not have been accounted for in the sampling. Furthermore, these data only represent two years, and it is known that annual production varies widely from year to year (see Table 1, below). Therefore caution needs to be exercised in use of the estimates.

More recently in 2005 and 2006, Reclamation operated a rotary fish trap in the Link River below the dam (Tyler 2007). Catches were highest in 2006 when 3,500 juvenile suckers were collected between 10 August and 5 October. The numbers of suckers collected were relatively high, considering that Link River is about 50 feet wide and several feet deep where the sampling was done and the trap sampled only 9 square feet, only a small fraction of the flow was sampled and trapping was not done every day. This information suggests that catches in 1998 used for this analysis are not unusual, although they probably represent years with above average production.

While we are unable to estimate confidence limits for the juvenile entrainment and downstream movement estimates discussed above, some error is associated with any study like this.

Project-Induced Juvenile Entrainment Loss:
The proposed action is expected to increase juvenile movement downstream by approximately 50 percent (see Juvenile Suckers at Link River Dam Spillway and Fishway section, above). Thus, with an average downstream movement of 85,000 juveniles at Link River Dam spillway and fishway (150 percent), a 50 percent increase would be 28,000 fish entrained. Using a more conservative approach where all juvenile suckers that are by-passed from the A-Canal fish screen moved downstream and PacifiCorp operation resulted in 25 percent returning to UKL, average entrainment at Link River Dam spillway and fishway would be 44,000 juveniles. If FERC requires screening under the new license, and PacifiCorp continues to operate Eastside and Westside with minimal nighttime operations during the July to October peak juvenile downstream movement period, the entrainment loss at Link River Dam spillway and fishway remains the same as under current operations. PacifiCorp may also be required to trap and haul all juvenile suckers that enter the screening facility during the July to October period back to UKL. This should not affect the number of suckers entrained at Link River Dam spillway and fishway. If the power canals are decommissioned then all the juveniles will move downstream through Link River Dam spillway and fishway.

Sub-adult/adult Entrainment
As previously mentioned, prior to construction of the Link River Dam, two natural reefs in the Link River controlled lake levels. During the summer, the pre-project water depth across the reef was shallow (0 to 2 ft deep; USBR 2001c) and created a partial barrier limiting downstream movement of sub-adult and adult suckers. When the Link River Dam was built, deep channels were dug through the upper and lower reefs increasing the depth and capacity of the upper Link River (USBR 2001a; Boyle 1964). This likely increased access across the reefs and enhanced conditions whereby sub-adult and adult sucker downstream movement increased through the spillway, fishway and hydropower canals (USFWS 2002).

Sub-adult and adult sucker entrainment at the A-Canal was measured by Gutermuth et al. (2000a) in 1997 and 1998. The highest rate occurred in 1998, when estimated entrainment was 411 sub-adult/adult endangered suckers. Gutermuth et al. (2000b) also sampled the Eastside and Westside hydropower canals from 1997-1999. The highest estimated sub-adult/adult sucker entrainment (LRS and SNS) in the two canals for this period was 14 in 1998. Sub-adult/adult entrainment was higher in 1997 at both the A-Canal and Eastside and Westside diversions, but because many of the fish entering the facility were dead or debilitated as a result of a die-off event in UKL, these data were not used for entrainment estimates (USFWS 2007a). Since both the A-Canal and Eastside and Westside Power Diversions had trash racks with openings of 2 5/8 inches and 2 ¾ inches, respectively, larger adults were excluded from the diversions in the previous entrainment studies. With these data, and results from Gutermuth et al. (1998) showing that entrainment may be a function of discharge, it is possible to estimate downstream movement at the Link River Dam spillway and fishway. Total facility sub-adult/adult entrainment in 1998 as estimated for the FERC BO (USFWS 2007a) is based on the following assumptions and calculations:

- Estimated total listed sucker sub-adult/adult entrainment at the two hydropower canals in 1998 = 14 (Gutermuth et al. 2000b)
- Estimated total entrainment at the A-Canal in 1998 = 411 (Gutermuth et al. 2000a)
- Gutermuth et al. (2000b) concluded that entrainment at the Eastside and Westside power diversions was generally proportional to the volume of flow diverted into the canals.
- During the July through October sub-adult/adult primary emigration period, ~80 percent of the flow on average passes through Eastside and Westside diversions and 20 percent through the Link Dam spillway and fishway, or auxiliary water structure (USFWS 2007a)
- Losses based on the proportion of flow would equal 14 for the Eastside and Westside diversions (80 percent) and 4 for the Link River Dam spillway and fishway (20 percent; USFWS 2007a)
- Total loss of sub-adult/adults at the UKL outlet in 1998 = 14 (Eastside and Westside diversions) + 411 (A-Canal) + 4 (Link River Dam spillway and fishway) = 429
- Total loss of sub-adult/adults at A-Canal and Link River Dam spillway and fishway (Project facilities) in 1998 = 411 (A-Canal) + 4 (Link River Dam spillway and fishway) = 415

Information below can be used to consider effects of the fish screen on entrainment and to adjust the 1998 entrainment estimates The entrainment studies by Gutermuth et al. (2000a, 2000b) were completed prior to screening of the A-Canal in 2003. Now, some of the sub-adults/adult suckers that are by-passed by the facility are likely to continue downstream and become entrained in the Link River Dam facilities while some would move upstream into UKL. Assuming the fish screen prevents sub-adult/adult sucker entrainment into A-Canal (likely a valid assumption since the screen was designed to exclude 30mm suckers), we need to make an assumption about what proportion of the by-passed sub-adult/adults return to UKL. The percentage of by-passed sub-adult/adult suckers moving back to UKL and the percentage entrained through Link Dam facilities is unknown. However, based on a pilot project using radio-tagged juvenile suckers that documented 50 percent of the by-passed fish returning to UKL and 50 percent moving downstream past Link River Dam (D. Bennetts, USBR, pers. comm. 2007), it was assumed that sub-adult/adult suckers would respond similarly. Also, with construction of the A-Canal fish screen facility, new trash racks were installed with smaller openings of 1 7/8 inches.

Also, since 2002, PacifiCorp has shut down Westside Power Canal and operated Eastside at minimum operational flows at night (200 cfs) from mid-July through mid-October to try to reduce sucker entrainment when it is highest at night (FERC 2007). Although there have been no investigations to determine if these operations have resulted in reductions in sucker entrainment, in the FERC BO (USFWS 2007a) we assumed this operation resulted in 25 percent of the sub-adult/adult suckers approaching the dam returning to UKL.

Estimated total sub-adult/adult sucker entrainment at Link River Dam under the proposed action based on the analysis used in the FERC BO (USFWS 2007a) would be:

- Estimated total sub-adult/adult entrainment at the two hydropower canals in 1998 = 14 (Gutermuth et al. 2000b)
- Estimated sub-adult/adults passing through Link Dam spillway and fishway in 1998 = 4 (USFWS 2007a)
- Estimated total sub-adult/adult entrainment at the A-Canal in 1998 = 411 (Gutermuth et al. 2000b)
- A-Canal screens exclude all sub-adult/adult suckers (411) and 50 percent of the fish by-passed returned to UKL (205) and 50 percent are entrained at Link River Dam (205; USFWS 2007a)
- Estimated numbers of sub-adult/adults dispersing towards the dam = 14 (Eastside and Westside) + 205 (A-Canal by-passed fish) + 4 (Link River Dam spillway and fishway) = 223
- PacifiCorp current operation of Eastside and Westside diversions result in 25 percent of the sub-adult/adults approaching the dam returning to the lake (USFWS 2007a)
- Total estimated entrainment of sub-adult/adult suckers at the outlet of UKL under current PacifiCorp operations = 223 (total sub-adult/adult entrainment without PacifiCorp's change in operation to protect suckers) – 25 percent (56; number of sub-adult/adult suckers returning to UKL as a result of PacifiCorp's operations) = 167
- Under PacifiCorp's operations of low flow releases at Eastside at night we assumed that 50 percent of the juveniles would be entrained through the spillway and fishway (84) and 50 percent at Eastside (84; USFWS 2007a)

The accuracy of these estimates are affected by a number of factors, such as, accuracy of canal flow measurements, effects of algae and debris clogging screw trap and fyke nets in the A-Canal, the accuracy of estimated spatial and temporal variability in sub-adult/adult sucker density, and how well samples were preserved and fish correctly identified.

Unlike larvae that are probably well-mixed in the water column and therefore making it easier to get representative samples, sub-adult/adult suckers could swim toward the bottom of the canal where they would be difficult to catch in a suspended net. Although the fyke nets and rotary trap used to sample juvenile suckers at A-Canal were larger than the plankton nets used to sample larvae, the fyke nets only sampled about 1/3 of the water flow and the rotary trap only about 1/6 of the flow (Gutermuth et al. 2000a). Sampling occurred 2 days each week, so if numbers of sub-adult/adults were highly variable from day to day, that variability might not have been accounted for in the sampling. Therefore caution needs to be exercised in use of the estimates.

Project-Induced Sub-adult/adult Entrainment Loss

The proposed action is expected to increase sub-adult/adult downstream movement by approximately 50 percent (see Sub-adult/adult Suckers at Link River Dam Spillway and Fishway section, above). Thus, with an average downstream movement of 84 sub-adult/adults at Link River Dam spillway and fishway, 50 percent would be 28 fish entrained. Using a more conservative approach where all sub-adult/adult suckers bypassed at A-Canal moved downstream and PacifiCorp operation resulted in 25 percent returning to UKL, average entrainment at Link River Dam spillway and fishway would be 37 sub-adult/adults. Further, because there is a new fishway on Link River Dam, some of the adult suckers, but probably not sub-adult suckers, would return to the lake.

Estimation of Population Level Effects of Entrainment

This section discusses the significance of the Project induced entrainment losses described above to the health of the LRS and SNS populations. We summarize, below, the available information on the abundance of each life stage in comparison to the losses caused by the proposed action.

Larvae

Intensive larval sucker sampling studies were conducted during 1987, 1988, and 1989 in the lower Williamson River to identify the timing and numbers of larval suckers emigrating downstream in the Williamson River system (Buettner and Scoppettone 1990; Klamath Tribes 1996). Estimated total numbers of emigrating sucker larvae at river mile 6 were approximately 7, 20, and 73 million for 1987, 1988, and 1989, respectively.

The above estimates of larval production do not include those produced at the shoreline springs located on the east side of UKL. No estimates have been made on numbers of larvae produced at these sites, but it could represent at least one million larvae based on the number of adult suckers monitored there and known fecundity rates for female suckers (Perkins et al. 2000a; Barry et al. 2007b).

The above estimates for the Williamson River larval production exhibit considerable variation. The Klamath Tribes (1996) concluded that the 1987 and 1988 data likely underestimated the true amount of larval production because only three nets 0.5 m in diameter were used to sample the river channel which is >150 ft wide, and therefore only a small percentage of the channel was sampled. They adjusted the estimates using the methods from 1989 to estimate 14 million larvae in 1987 and 35 million in 1988. In the 1989 study by the Tribes, 27 nets were used so nearly an order of magnitude more of the channel width was sampled.

Although it is likely that the 1989 study (Klamath Tribes 1996) was an improvement over the earlier studies because more nets were used, there are multiple factors that could cause inaccuracies in the 1989 estimates including: having to interpolate between sample dates to account for days when no sampling occurred; inaccuracy in net flow meter readings; inaccuracy in estimates of river discharge; and inability to sample the entire channel.

More recently, USGS has been doing larval sucker sampling in the Sprague River and Williamson River to obtain entrainment abundance indices (catch per unit effort) to evaluate success of the Chiloquin Dam removal project on sucker spawning success, but they have not tried to estimate total numbers of sucker larvae emigrating because of reduced level of effort compared to earlier emigration studies and problems associated with data extrapolation as discussed below (Ellsworth et al. 2008).

In comparing estimates of larval production in the Williamson River and shoreline spawning sites and sucker losses at the lake outlet, it is important to consider that between the time larvae are sampled near the spawning areas and when they reach the outlet, which may take a week or two (Reithel 2006), natural mortality rates from predation, starvation and other factors could be 10 to 80 percent/day (Houde 2002). In a week's time, at 10 percent loss/day, the numbers of larvae could decrease by half. Markle et al. (in review) assumed natural mortality rates of 9 percent per day for SNS and 3 percent per day for SNS.

An accurate estimate of population level effects of sucker entrainment at the UKL outlet is not possible because of a lack of accurate data on the losses as well as insufficient information on population sizes and factors affecting the populations. Loss of up to 9 million sucker larvae out of UKL of which up to about 2 million annually are the responsibility of the Project may appear substantial, but many more are likely produced because of the high fecundity of adult sucker females. Each female SNS and LRS can produce up to 72,000 and 236,000 eggs per year respectively (Perkins et al. 2000a) and there are thousands of reproductively active females in the population (Janney et al in review). This loss probably does not have a population level effect. Further, Cowan and Shaw (2002) suggest that most evidence indicates little or no correlation between larval production and recruitment. Houde (1994) theorizes that most freshwater fish year classes are determined in the juvenile period. Loss of juvenile suckers is a greater concern because each juvenile represents a larva that survived among the hundreds or thousands that did not survive representing recruitment into the population.

Juveniles

Simon and Markle (2005) have been estimating numbers of juveniles present in UKL since 1995, using bottom trawls and cast nets, with their most recent report covering the 1995-2004 period. Table 1, below shows estimated total number of juvenile LRS and SNS combined in UKL 1995-2004 (Simon and Markle 2005, Table 6). These data show that there is considerable interannual variation in numbers and in most years there is a substantial decline in numbers of juvenile suckers from August to October.

Table 1. Estimated numbers of juvenile LRS + SNS in UKL, 1995-2004, times 1,000 (Simon and Markle 2005, with rounding).

	Year									
Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
August	NA	420	80	670	1,100	310	120	380	55	60
September	290	10	2	30	170	90	20	190	15	60
October	50	85	1	20	180	60	20	100	10	3

Similar to the other studies discussed above, these estimates are subject to error. A major challenge with sampling for juvenile suckers is they are not randomly distributed. They can occur in schools resulting in a clumped distribution. Therefore, many collections have zero catches while others have very high catches. Also, the sampling interval for this study was every 3 weeks, which might be too long to accurately describe changes in juvenile sucker numbers that could change substantially over a few weeks time. The non-random distribution and the sample interval which create variation in catch results means that any lake-wide extrapolation based upon these data is likely to have considerable error.

Based on the above discussion, we estimate approximately 170,000 to 262,000 juvenile suckers were lost at the Link River Dam and associated hydropower canals in 1998. The losses associated with the Project would be 28,000 to 44,000 juveniles. Highest catches of juvenile suckers in 1998 by Gutermuth et al. (2000b) in the two hydropower diversions was from mid-August to mid-September. Based on the data in Table 1, juvenile sucker numbers dropped rapidly during this period and in1998, ranging from an estimated 670,000 in August to 30,000 in September and 20,000 in October. If we assume the entrainment loss of juveniles due to the Project was 28,000-44,000, this represents approximately 5 percent of the loss of juveniles when numbers dropped from 670,000 to 20,000 present in UKL. This percentage is an estimate based on data with a great degree of variability, and annual variation would likely be great if we had similar data among years with which to compare. Additional entrainment studies are needed to arrive at better estimates. Therefore, its significance is difficult to determine and expected to vary greatly among years. Due to the great deal of variability in estimates associated with this analysis, it is difficult to determine the significance of the entrainment loss on UKL population status.

Sub-adult/adults

Based on recent adult sucker population monitoring in UKL at Eastside shoreline spawning areas (Barry et al. 2007a; Hayes et al. 2002) and Williamson and Sprague Rivers (Barry et al. 2007b; Janney and Shively 2007), current LRS and SNS populations are likely in tens of thousands (USFWS 2007b; ISRP 2005). With estimated entrainment losses due to the project of 28-37 sub-adult/adults per year at Link River Dam this loss represents less than 0.1 percent of the adult populations. Further, with a new fishway at Link River Dam many of these fish may return to UKL as surmised by the relatively low numbers of adults sampled in Lake Ewauna in 2005 and 2006 (USFWS 2007a). Therefore, entrainment losses of sub-adult/adult suckers probably do not have a population level effect.

<u>Conclusion</u>

Because the data discussed above are few, subject to unknown amounts of error, and show considerable seasonal and interannual variability, caution must be exercised in making a determination about the effects these losses have on LRS and SNS populations. Although losses of larvae were estimated to be in the millions, the production of larvae is likely much higher. Also, there is generally no relationship between larval sucker production and ultimate year-class strength. Losses of juveniles were also high, but at least in some years production (i.e., 1991) is also very large. Losses of sub-adult/adults are small because of the small number entrained and fish passage facilities are present to allow them to return to UKL. However, any loss of adults has more of an effect on the population that would an equal number of juvenile suckers.

When comparing losses of larvae with production estimates from the Williamson River, extrapolation across time is problematic because the data weren't collected on a yearly basis, and because of high levels of interannual variability in larval production. Therefore, direct comparisons of losses and production estimates for larvae are not possible.

For juvenile suckers, data are available for both estimated losses and production in the same year, 1998. However, a great deal of variation is seen among years in the estimates used in this analysis.

We can conclude that larval and juvenile suckers are being lost at the lake outlet at the A-Canal, the hydroelectric canals, and the Link River Dam, and these losses appear to be a small percentage of the production estimates, although losses and production are highly variable and affected by many factors. What effect these losses might have on LRS and SNS populations depends in part on the status of the populations. In a recent demographic analysis of adult sucker populations in UKL, Janney et al. (in review) stated: "The overall fitness of the Upper Klamath Lake SNS population should be of concern given the low observed survival rates and marked temporal variability in survival." Survival rates for LRS were higher and showed less variability than for SNS, and therefore that species is doing better in UKL than the SNS.

Obviously, low and variable adult survival is a problem for any imperiled species if it continues. Increasing recruitment is one possible way to offset low adult survival, but when larval and juvenile sucker survival is low, recruitment is also going to be low. Based on the data from Simon and Markle (2005), survival rates of juvenile suckers in UKL can be very low and in some years was below detection (Table 1, above). Janney et al. (in review) state that the slowly increasing and homogenous size structure of UKL sucker populations indicates low recruitment.

This suggests that factors that affect recruitment, like losses at the lake outlet, are of concern. Also, since the SNS is showing a downward trend in status (USFWS 2007b), the effect is going to be most pronounced on that species. Based on this, there is an unquantified risk to the SNS from the losses of juvenile at the A-Canal and Link River Dam spillway and fishway.

Screening of A-Canal in 2003 reduced losses of juvenile suckers; however, it's unclear how much of a reduction has actually occurred. No suckers greater than 30 mm are likely entering the canal because that is the design criteria for the screen (USBR 2007). Unfortunately because the pump by-pass flume for the screen is near the Link River Dam, and flow is toward the dam (see Figure 8), it's likely that a high percentage of larval suckers and a substantial proportion of by-passed juvenile suckers are lost at the dam and associated hydropower diversions. Consequently losses of juvenile suckers at the dam are likely higher now than previously and, part of the loss can be attributed to PacifiCorp's operations of the hydropower facilities at the dam (USFWS 2007a). In their section 7, biological opinion on the effects of the Klamath Hydroelectric Project on listed species, the Service stated that the company had to screen the canals to reduce take of suckers, if they continued to operate the two facilities. If the company chooses to not operate the hydropower facilities, flows will be higher at the Link River Dam spillway and fishway and all of the losses will be attributed to the operation of those spillway and fishway (Klamath Irrigation Project effect). Based on the proposed action, the flows out of UKL are about 50 percent higher under the proposed action than the no-action (using the 30 percent exceedance) during the July through October primary entrainment period. Assuming entrainment is proportional to flow, this equates to approximately 28,000 to 44,000 juvenile suckers (Link River Dam spillway and fishway).

We anticipate that removal of Chiloquin Dam in 2008 and installation of a new fish screen downstream of the dam, and habitat restoration around the lake, and especially at the Williamson River Delta, and upstream in the Sprague River where some in-stream rearing of larval and juvenile suckers has been recently documented, will partially compensate for the various sources of mortality of larval and juvenile suckers including entrainment and improve recruitment.

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