PACIFICORP ENERGY
A DIVISION OF PACIFICORP

825 NE Multnomah Street, Suite 1500
Portland, Oregon 97232

September 10, 2009

Via Electronic Mail Only
Ms. Dorothy Rice
Executive Director
State Water Resources Control Board
1001 I Street, 15th Floor
Sacramento, CA 95814

Subject: **Withdrawal and Resubmittal of Section 401 Water Quality Certification for PacifiCorp Energy's Klamath Hydroelectric Project (FERC No. 2082), Siskiyou County**

Dear Ms. Rice:

In February 2004, PacifiCorp (now PacifiCorp Energy) applied to the Federal Energy Regulatory Commission for a new major license for its Klamath Hydroelectric Project (Project) on the Klamath River in California and Oregon. In conjunction with that application, PacifiCorp Energy on March 29, 2006, requested that the State Water Resources Control Board (SWRCB) certify the California portions of the Project pursuant to section 401 of the federal Clean Water Act (33 USC § 1341, California Water Code § 13160, and 23 C.C.R. Chpt. 28). This request was withdrawn and simultaneously resubmitted to the SWRCB on February 28, 2007, and again on February 22, 2008. More recently, on July 11, 2008, PacifiCorp withdrew its application to facilitate settlement negotiations for a long-term settlement of the project. By letters dated August 22, 2008 and September 22, 2008, the SWRCB requested that PacifiCorp resubmit its application for water quality certification so that the certification process could continue. The application was resubmitted to the SWRCB on September 26, 2008.

PacifiCorp Energy hereby withdraws and resubmits, as of the date of this letter, its request for certification of the California portions of the Project pursuant to section 401. The resubmitted application is identical to the application that was resubmitted on September 26, 2008, and is being resubmitted electronically.

Please acknowledge receipt of this letter and confirm acceptance of the application. Also, please confirm that this date marks the commencement of the one year period for acting on the certification application, as specified in section 401 of the Clean Water Act.

Pursuant to applicable statutes and regulations, PacifiCorp Energy is providing notice of the resubmitted application to the Executive Officer of the North Coast Regional Water Quality Control Board, via copy of this letter.

If you have any questions on the application, please feel free to contact me at (503) 813-6170.

Sincerely,

Tim Hemstreet
Klamath Licensing Manager

cc: Ms. Catherine Kuhlman, NCRWQCB
Ms. Jennifer Watts, SWRCB
Ms. Marianna Aue, SWRCB
Mr. Robert Donlan, Ellison, Schneider & Harris

Application for Water Quality Certification
Pursuant to Section 401 of the Federal Clean Water Act
for the Relicensing of the Klamath Hydroelectric Project
(FERC No. 2082) in Siskiyou County, California

Klamath Hydroelectric Project

(FERC Project No. 2082)

Prepared for:

State Water Resources Control Board
Division of Water Quality
Water Quality Certification Unit
1001 I Street, 15th Floor
Sacramento, CA 95814

Prepared by:

PacifiCorp
825 N.E. Multnomah, Suite 1500
Portland, OR 97232

February 2008

CONTENTS

Appendices

Tables

Figures

EXECUTIVE SUMMARY

PacifiCorp's Klamath Hydroelectric Project (Project) is located in the middle of one of the region's most diverse and complex aquatic ecosystems. In many ways, the Project forms the dividing line—and provides a buffer—between two different aquatic environments. Above the Project is Upper Klamath Lake, a hypereutrophic lake and one of the most productive large lakes in North America. Severe water quality impairment in Upper Klamath Lake has been documented extensively during the past century. Upper Klamath Lake is the "driver" of flow and water quality in the Upper Klamath River and, during many parts of the year, dictates water quality throughout the entire river to the estuary at the Pacific Ocean.

In addition to Upper Klamath Lake, water quality in the Project area is affected by irrigation diversions for agricultural uses, and by discharges from agriculture, municipal, and industrial operations. Downstream of the Project is one of the most important salmonid fisheries on the West Coast. The Klamath River supports a commercial fishery, Native American uses, and a recreational fishery. The Iron Gate fish hatchery is a significant contributor to the Klamath River salmonid fishery, producing on an annual basis 5,000,000 to 8,000,000 Chinook salmon, 71,000 coho salmon, and 200,000 steelhead juveniles. During warmer parts of the year, hatchery operations depend on cool water stored in the hypolimnion of Iron Gate reservoir.

From a water quality perspective, the Klamath River is often described as an "upside down" system. Unlike every other major river system in California, water quality generally improves—significantly—as it moves downstream from Upper Klamath Lake to the estuary. The Project contributes to this process by slowing the transit time of water from Upper Klamath Lake to the lower river. Except during high winter flows, the transit time of water released from above the Project to the estuary is between 1 and 2 months.[1] This transit time allows for settling and processing of impaired water quality from Upper Klamath Lake and other upstream sources as it moves through the Project. But for the Project, this settling and processing would otherwise occur in the lower river and estuary.

Because of the unique and complex nature of the Klamath River environment and the Project's place and function within the system, determining the Project's effects on water quality conditions is difficult. In processing this application for water quality certification, the key issue is the Project's contribution to water quality conditions, and the controllable water quality factors reasonably available to address the Project's contribution to compliance with water quality objectives and protection of beneficial uses.

With respect to most water quality parameters and beneficial uses within and below the Project, the Project is neutral or has a beneficial effect. As described above and in Section 4.2 of this application, the Project allows settling and processing of substantial amounts of the large nutrient and organic load from Upper Klamath Lake. The effects of nutrients and organic matter in the Lower Klamath River on the Klamath River fishery are not well understood.

As a natural consequence of reservoir processes, however, the Project can affect temperature and dissolved oxygen conditions below the Project during some periods of the year. Most dissolved oxygen concerns in the Klamath River within and immediately below the Project are the result of large organic loads from upstream of the Project, natural barometric pressure, and temperature conditions in the Project area. During many times of the year, these conditions create saturation levels that make attainment of existing water quality objectives impossible. Although the Project does not contribute to these natural conditions, the conditions in Project reservoirs can at times affect dissolved oxygen discharges from Iron

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[1] In the absence of the Project facilities, the transit time of water through the system would be approximately 1 week during the summer.

Gate reservoir. As described in this application, PacifiCorp proposes to implement oxygenation systems at Copco and Iron Gate reservoirs to enhance dissolved oxygen in the reservoirs and increase dissolved oxygen levels below Iron Gate dam.

During the fall months, the Project can contribute to elevated temperature conditions below Iron Gate dam. The mass of water at Iron Gate reservoir naturally causes a thermal "lag" as water passes through the reservoir, increasing the temperature of reservoir releases as compared to without-dam conditions. This thermal lag does not appear to affect beneficial uses, however, as water temperatures tend to be decreasing during this period to levels that are suitable for anadromous fish and other beneficial uses. PacifiCorp is nevertheless committed to working with the State Water Resources Control Board and fisheries agencies to explore opportunities for using the limited cool water storage in Iron Gate reservoir to protect and enhance beneficial uses downstream of Iron Gate dam. Of course, such uses must be balanced against, and reconciled with, existing cool water needs at the Iron Gate fish hatchery.

It is important to recognize that this water quality certification will not, and cannot, address all of the water quality and fisheries issues in the Klamath Basin. Many of these broader issues must be addressed in other forums and processes, such as the existing Total Maximum Daily Load process. This certification cannot address nutrient and organic loading upstream of the Project, and will not address anadromous fishery reintroduction issues. Those issues would logically be addressed in tandem with solutions to water quality impairment upstream of the Project from Upper Klamath Lake and other sources, and would involve a much broader set of objectives than the scope of this particular water quality certification.[2] Likewise, this water quality certification should not address activities and facilities affecting water quality in Oregon, even if those activities or facilities affect water quality in California.

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[2] In this water quality certification, the State Water Resources Control Board is asked to address discharges that originate in California (33 U.S.C. § 1341(a)(1)). The state of Oregon, acting through its Department of Environmental Quality (ODEQ), will be issuing a water quality certification to PacifiCorp for discharges originating in the Oregon sections of the Klamath River. Concerns about water quality resulting from discharges in Oregon should be addressed to ODEQ, the U.S. Environmental Protection Agency, and FERC pursuant to the provisions of Section 401(a)(2) of the Clean Water Act (see 33 U.S.C. § 1341(a)(2)).

1.0 INTRODUCTION

This document contains PacifiCorp's application to the State Water Resources Control Board (State Water Board) for certification of the Klamath Hydroelectric Project (Project) pursuant to Section 401 of the federal Clean Water Act (CWA), 33 USC § 1341, and is submitted in compliance with the requirements of 23 CCR § 3856. This request supersedes PacifiCorp's March 29, 2006 and February 28, 2007 certification requests to the State Water Board. Because Section 401 provides that a state waives its certification authority if it does not act on a certification request within one year, PacifiCorp is withdrawing and resubmitting its request to allow the State Water Board additional time to consider it. This new request, however, includes revised Project proposals and additional water quality and other information.

The Project is owned and operated by PacifiCorp and is located along the Upper Klamath River in Klamath County, south-central Oregon, and Siskiyou County, northern California. The Project currently consists of seven hydroelectric generating facilities on the Klamath River and Fall Creek, as well as associated transmission lines. The Project was constructed between 1902 and 1967 and has a total rated capacity of 161 megawatts (MW).

The Federal Energy Regulatory Commission (FERC) licenses the Project under the Federal Power Act (Project No. 2082). Because the current license for the Project expires in March 2006, PacifiCorp applied to FERC in February 2004 for a new license. The application is pending. Under federal law, PacifiCorp will continue to operate the Project under the terms of the previous license until FERC takes final action on the pending license application.

Under CWA Section 401, the applicant for a federal license for an activity that may result in a discharge to "waters of the United States" must provide the licensing agency with a certification from the state in which the discharge originates that the discharge will comply with CWA Sections 301, 302, 303, 306, and 307. These sections include state water quality standards approved by the U.S. Environmental Protection Agency (EPA).

In California, the agency authorized to issue Section 401 certifications for hydroelectric projects is the State Water Board (Water Code § 13160). PacifiCorp submits this certification application to the State Water Board for the California portions of the Project. PacifiCorp is simultaneously submitting a Section 401 certification application to the Oregon Department of Environmental Quality (ODEQ) for the Oregon portions of the Project.

This document is organized as follows:

- Section 2.0 provides general information concerning the application and the Project.
- Section 3.0 describes the Project facilities and operations, and PacifiCorp's proposed measures and modifications to the Project.
- Section 4.0 provides an overview of the Klamath River in and around the Project area, including a summary of historical water quality conditions in the basin, current conditions and processes affecting water quality, a summary of the effects of basin water quality on Klamath River fisheries, and a summary of the Project's influence on the Klamath River environment.
- Section 5.0 provides a detailed discussion of the Project's effects on water quality and the measures proposed to enhance water quality and designated beneficial uses.
- Section 6.0 provides a bibliographic listing of literature cited in the application.

2.0 GENERAL PROJECT INFORMATION

This section provides general information about the Project and the certification application as required under 23 CCR § 3856.

2.1 PROJECT OWNER AND AUTHORIZED AGENT

The name, address, and telephone number of the Project applicant is:

PacifiCorp
825 N.E. Multnomah Street, Suite 2000
Portland, OR 97232
(503) 813-6011

Applicant Agent

Mr. Cory Scott
Project Manager, Hydro Licensing
PacifiCorp
825 N.E. Multnomah Street, Suite 1500
Portland, OR 97232
(503) 813-6011

2.2 PROJECT DESCRIPTION AND PURPOSE

This section describes (1) the Project location, (2) Project facilities located in California, and (3) the purpose and final goal of the Project.

2.2.1 Project Location

The Project area consists of the Upper Klamath River in Klamath County (south-central Oregon) and Siskiyou County (northern California). This area includes hydroelectric generation facilities on Fall Creek, tributary to the Klamath River in Siskiyou County, California, and a diversion facility on Spring Creek, tributary to Jenny Creek (hence the Klamath River) in Jackson County, Oregon.

Figure 2.2-1 is a map of the Project area. Detailed maps of Project facilities are contained in Exhibit G of PacifiCorp's 2004 FERC application (PacifiCorp, 2004d). These maps also delineate the proposed Project boundary.

2.2.2 Description of Current and Proposed Project Facilities in California

Copco No. 1 Development at RM 198.6. The Copco No. 1 Development consists of a reservoir, dam, spillway, intake, and outlet works and powerhouse located on the Klamath River between approximately RM 204 and RM 198 near the Oregon-California border. Copco No. 1 is downstream of the J.C. Boyle dam and upstream of Copco No. 2 dam. The powerhouse has a turbine with a nameplate generating capacity of 20 MW.

Copco No. 2 Development at RM 196.8. The Copco No. 2 Development consists of a diversion dam, small impoundment, water conveyance system, and powerhouse. The dam is located approximately

¼ mile downstream of Copco No. 1 dam. The powerhouse has a turbine with a nameplate generating capacity of 27 MW.

Iron Gate Development at RM 190. The Iron Gate Development consists of a reservoir, an earth embankment dam, an ungated side-channel spillway, intakes for the diversion tunnel and penstock, a steel penstock from the dam to the powerhouse, and the powerhouse. The powerhouse has a turbine with a nameplate generating capacity of 18 MW. It is located approximately 20 miles northeast of Yreka, California, and is the farthest downstream hydroelectric facility of the Project.

Fall Creek Development. The Fall Creek Development is located on Fall Creek, a tributary to the Iron Gate reservoir, approximately 0.4 mile south of the Oregon-California border. Additional diversion facilities are located on Spring Creek in Oregon. The facilities on Fall Creek consist of a concrete and timber flashboard spillway structure, an earth- and-rock-filled diversion dam, 4,560 feet of earthen and rock-cut power canal, 2,834 feet of steel penstock, and a powerhouse.

Additional Project facilities located in Oregon are as follows:

- The Spring Creek diversion, on Spring Creek in Jackson County Oregon. Spring Creek is a tributary to Jenny Creek. Both Jenny and Fall creeks flow into California, where they enter the Klamath River. Water diverted to Fall Creek from Spring Creek flows down Fall Creek to a point in California, where PacifiCorp diverts a portion of Fall Creek to the Fall Creek powerhouse, which is also located in California.

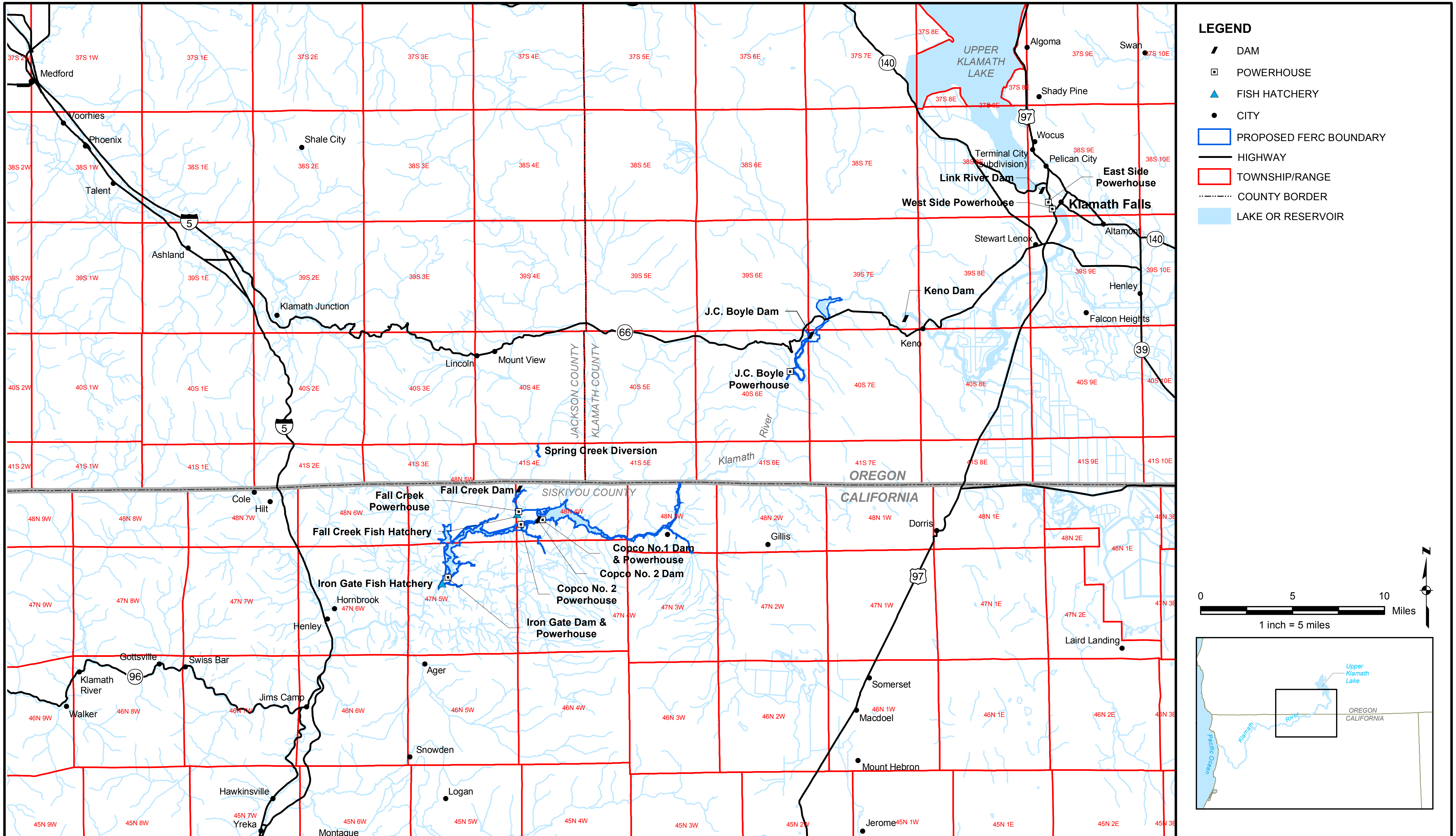
- J.C. Boyle powerhouse is at RM 220.4 and J.C. Boyle dam is several miles upstream at RM 224.7. The powerhouse contains two generating turbines with a nameplate generating capacity of 50.35 MW at unit 1 and 40 MW at unit 2.

- Keno dam (RM 233) is a regulating facility with no generation capability. PacifiCorp proposes to exclude Keno dam from the FERC-licensed Project because no power generation is associated with the dam, and therefore the dam is not within FERC's regulatory jurisdiction.

- The East Side (3.2 MW) and West Side (0.6 MW) powerhouses are associated with the U.S. Bureau of Reclamation (USBR) Link River dam. The developments are located near RM 254 within the city limits of Klamath Falls, Oregon. PacifiCorp proposes to decommission the East Side and West Side developments and to remove them from the FERC-licensed Project.

2.2.3 Project Purpose and Final Goal

In February 2004, PacifiCorp submitted the final application to FERC for a new project license (PacifiCorp 2004a, 2004b, 2004c, 2004d). The newly proposed project would remove from service the East Side and West Side Developments and FERC boundaries associated with these developments. It would also remove the Keno Development and associated FERC boundary because this facility does not have installed generation and does not substantially benefit generation at PacifiCorp's downstream hydroelectric developments. The existing Spring Creek diversion is proposed for inclusion with the Fall Creek Development. In some areas, Project FERC boundaries have been expanded to incorporate additional recreation areas and recreational access and terrestrial areas.



Klamath Hydroelectric Project

Figure 2.2-1
Klamath Hydroelectric Project Location

2.3 WATERS AFFECTED BY OR POTENTIALLY AFFECTED BY THE PROJECT

The California waters affected or potentially affected by the current Project are the Klamath River from the Oregon border (at approximately RM 209) to the Pacific Ocean. In addition, the Project includes a hydroelectric generation facility on Fall Creek, tributary to the Klamath River and Iron Gate reservoir. Project facilities and reaches in California (from upstream to downstream) are as follows:

- Klamath River from the Oregon-California border at RM 209.2 (below the J.C. Boyle powerhouse in Oregon at RM 220) to the head-end of Copco reservoir at RM 203.2. This portion of the river comprises the lowermost 6 miles of the reach referred to as the “J.C. Boyle peaking reach.”

- Copco reservoir on the Klamath River from RM 198.6 to RM 203.2. Copco reservoir is about 4.6 miles long, with a surface area of 1,000 acres and a maximum depth of about 115 feet.

- Copco No. 1 dam and powerhouse at RM 198.6. Copco No. 1 dam is 126 feet high and 415 feet long, and the powerhouse has a hydraulic capacity of 3,200 cfs.

- Copco No. 2 dam at RM 198.3 and re-regulating impoundment from RM 198.3 to RM 198.6. Copco No. 2 dam is 33 feet high and 278 feet long, and the impoundment is about 0.3 mile long with a maximum depth of about 28 feet.

- Copco No. 2 bypass reach on the Klamath River from RM 196.8 to RM 198.3.

- Copco No. 2 powerhouse on the Klamath River at RM 196.8. This powerhouse has a hydraulic capacity of 3,200 cfs.

- Iron Gate reservoir on the Klamath River from RM 190.5 to 196.7. Iron Gate reservoir is about 6.2 miles long, with a surface area of 944 acres and a maximum depth of about 162 feet.

- Iron Gate dam and powerhouse (downstream-most facility) on the Klamath River at RM 190.5. Iron Gate dam is 173 feet high and 740 feet long, and the powerhouse has a hydraulic capacity of 1,735 cfs.

- The Fall Creek Development on Fall Creek, a tributary to Iron Gate reservoir. The Fall Creek Development consists of two small diversion dams, an earthen ditch, a penstock, and a powerhouse. The uppermost diversion is located on Spring Creek, which when in use diverts water to Fall Creek. The lowermost diversion on Fall Creek then diverts water into the earthen ditch that supplies the powerhouse.

The Project’s transmission lines cross several small drainages and tributaries of the Klamath River, as well as the river itself. The stream crossings are identified in Exhibit G of PacifiCorp’s 2004 FERC application (PacifiCorp, 2004d). The transmission lines do not adversely affect water quality. Although each transmission line corridor is generally 100 feet wide (and corridors are sometimes parallel and adjacent to each other), no transmission facilities are physically located within a water body, and riparian vegetation is retained at stream crossings wherever possible.

2.4 FERC LICENSE FOR THE PROPOSED PROJECT

2.4.1 FERC License

FERC licenses the Project under the Federal Power Act (Project No. 2082). The current license for the Project expired in March 2006, and PacifiCorp applied to FERC in February 2004 for a new license. The Final License Application filed with FERC in February 2004 is available on FERC's website at www.ferc.gov, under docket number P-2082, and is incorporated into this application by reference. Final action by FERC on the license application is pending. Under federal law, PacifiCorp will continue to operate the Project under the terms of the current license until FERC takes final action on the pending license application.

2.4.2 FERC Notices

To date, FERC's public notices concerning PacifiCorp's application for a new license for the Project have been procedural notices. These have included, for example:

- "Notice of Intent to File Application for a New License" (February 7, 2001)
- "Notice of Application Filed with the Commission" (February 26, 2004)
- "Notice of Intent to Prepare an Environmental Impact Statement (EIS), Conduct Public Scoping Meetings and a Site Visit" (April 16, 2004)
- "Notice of Application Ready for Environmental Analysis and Soliciting Comments, Recommendations, Terms and Conditions, and Prescriptions" (December 28, 2005)
- "Notice of Authorization for Continued Project Operation" (March 9, 2006)
- "Notice of Availability of the Draft Environmental Impact Statement for the Klamath Hydroelectric Project and Intention to Hold Public Meetings" (September 25, 2006)
- "Notice of Intention to Hold Public Meetings for Discussion of the Draft Environmental Impact Statement for the Klamath Hydroelectric Project" (October 5, 2006)
- "Notice of Intent to Hold an Additional Public Meeting for Discussion of the Draft Environmental Impact Statement for the Klamath Hydroelectric Project and Extending Comment Deadline" (November 2, 2006)
- "Notice of Intent to Hold an Additional Public Meeting for Discussion of the Draft Environmental Impact Statement for the Klamath Hydroelectric Project" (November 9, 2006)
- "Notice of Availability of the Final Environmental Impact Statement for the Klamath Hydroelectric Project" (November 16, 2007)

These FERC notices and supporting information are part of the public FERC docket for the license application, and PacifiCorp understands that the State Water Board has copies of the notices and supporting information. The notices are also available on FERC's website at www.ferc.gov, under docket number P-2082, and are hereby incorporated by reference.

2.4.3 Documents Filed in Connection with the 401 Application

Table 2.4-1 lists documents that were previously submitted by PacifiCorp to the State Water Board or which PacifiCorp believes are already in the State Water Board's possession. These documents are incorporated by reference in this 401 application.

Table 2.4-1. List of Documents Filed in Connection with the 401 Application

FERC FLA Document	Date	Description
Volume I (Exhibits A, B, C, D, and H)	February 2004	Exhibit A—Project Description Exhibit B—Project Operation and Resource Utilization Exhibit C—Construction History and Proposed Construction Exhibit D—Statement of Costs and Financing Exhibit H—Plans and Ability of Applicant to Operate Project Efficiently for Relicense
Volume II (Exhibit E)		Exhibit E—Environmental Report
Volume III (Exhibit E)		Exhibit E—Environmental Report Appendices
Volume IV (Exhibit F)		Exhibit F—Design Drawings
Volume V (Exhibit G)		Exhibit G—Maps
FTR Documents	**Date**	**Description**
Fish Resources	February 2004	Fisheries Analysis of Project
Land Use, Visual, and Aesthetic Resources & Socioeconomic Resources		Land Use, Visual, Aesthetic, and Socioeconomic Analysis of Project
Recreation Resources		Recreational Analysis of Project
Terrestrial Resources		Terrestrial Analysis of Project
Water Resources		Water Resources Analysis of Project
Cultural Resources		Cultural Resources Analysis of Project
Additional Information Requests	**Date**	**Description**
Dissolved Oxygen Enhancement at Iron Gate	May 16, 2005	Documents the advantages and disadvantages of the two alternative systems that were proposed to alleviate the dissolved oxygen issues downstream of the Iron Gate Development
Reservoir Sediment Characterization	May 16, 2005	Provides additional information on the quantity and grain size of the material within project reservoirs that could be subject to resuspension from altered project features or operations
Input and Output Data Files for Water Quality Modeling	April 1, 2005 Additional submission December 12, 2005	Includes electronic input and output files of all water quality modeling runs that have been presented to the Commission and stakeholders
Hourly and Daily Hydrologic Data	Parts b and c (daily and basis) submitted April 1, 2005; Part a (hourly) filed May 3, 2005	Includes hourly and hydrologic data to facilitate analysis of the existing flow regime in the river, spillage, and through the turbines as well as the reservoir elevations

Table 2.4-1. List of Documents Filed in Connection with the 401 Application

Geomorphology Information	Submitted September 16, 2005	Includes available empirical data documenting channel conditions downstream of Iron Gate dam, all available aerial photographs, and various revisions of the sediment budgets
Additional Information Request AR-1(a)	September 2005	Includes revisions to schedule in order to fully evaluate the potential costs and benefits of installing temperature control structures at the Copco and Iron Gate reservoirs
Instream Flow Studies and Analysis of Effects on Aquatic Habitat and Other Flow-Dependent Resources	Submitted July 2005	Instream flow addendum report in response to FERC AIR AR-5
Evaluation of Effects of Flow Fluctuation on Aquatic Resources within the J.C. Boyle Peaking Reach	Submitted August 2005	Analysis of effects of peaking on aquatic resources within the J.C. Boyle peaking reach. Part of PacifiCorp's response to FERC AIR GN-2
Other Submittals to State Water Board	**Date**	**Description**
PacifiCorp 2007 Water Quality Study Plan	Submitted May 11, 2007	Study plan describing water quality studies by PacifiCorp within the Project area and the Klamath River during 2007. Submitted via letter to Marianna Aue (State Water Board) from Robert Donlan (Ellison, Schneider & Harris, L.L.P.).
PacifiCorp Response to State Water Board's Comments on PacifiCorp 2007 Water Quality Study Plan	Submitted August 7, 2007	Includes detailed technical responses to State Water Board's comments on PacifiCorp's 2007 Water Quality Study Plan. Submitted via letter to Les Grober (State Water Board) from Cory Scott (PacifiCorp).
Other Pertinent Documents	**Date**	**Description**
Causes and Effects of Nutrient Conditions in the Upper Klamath River (PacifiCorp 2006)	Submitted in November 2006 in conjunction with PacifiCorp comments on the FERC DEIS	This report assesses the causes and effects of nutrient conditions in the upper Klamath River in the vicinity of PacifiCorp's Project.

2.4.4 FERC's Draft Environmental Impact Statement

In September 2006, FERC issued a Draft Environmental Impact Statement (DEIS) for the Project (FERC 2006) to fulfill the requirements of the National Environmental Policy Act (NEPA). The purpose of an environmental impact statement is to inform FERC, the public, and the various federal and state agencies, tribes, and non-governmental organizations about the potential adverse and beneficial environmental effects of the proposed Project and reasonable alternatives. As described below in Section 2.4.6, FERC issued the Final Environmental Impact Statement for the Project in November 2007. For context, this section describes the DEIS.

The principal issues addressed by FERC in the DEIS include the influence of Project operations on water quality, including downstream of Iron Gate dam; approaches to facilitate the restoration of native anadromous fish within and upstream of the Project; the influence of peaking operations at the J.C. Boyle Development on downstream biota and whitewater boating opportunities; the effect of Project operations on archaeological and historic sites and resources of concern to various tribes; the effects of decommissioning East Side and West Side Developments and removing Keno Development from the proposed Project; and decommissioning other Project developments.

The FERC DEIS evaluates PacifiCorp's proposed Project, along with the terms and conditions, prescriptions, and recommendations from resource agencies, tribes, and other interested parties. Based on this evaluation, FERC staff compiled a set of proposed environmental measures to address the various resource issues, and called the collection of these measures the "Staff Alternative" (described in detail in Section 2.3.2 of the DEIS). The Staff Alternative incorporates most of PacifiCorp's proposed environmental measures, but in some instances with modifications.

The FERC DEIS is part of the public FERC docket for the license application, and PacifiCorp understands that the State Water Board has copies of the DEIS. The DEIS also is available on FERC's website at www.ferc.gov, under docket number P-2082.

2.4.5 FERC's Section 10(j) Determinations

Under Section 10(j) of the Federal Power Act (FPA), the license issued by FERC for the Project will include conditions based on recommendations provided by federal and state fish and wildlife agencies for the protection, mitigation, or enhancement of fish and wildlife resources. In response to FERC's Ready for Environmental Analysis (REA) notice of December 2005, Section 10(j) recommendations were submitted for the Project in March 2006 by Oregon Department of Fish and Wildlife (ODFW), California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS). Section 10(j) states that whenever FERC believes that any of the agency recommendations are inconsistent with the purposes and requirements of the FPA or other applicable law, FERC and the agency shall attempt to resolve any such inconsistency, giving due weight to the recommendations, expertise, and statutory responsibilities of the agency.

In the DEIS and follow-up letters to the agencies in October 2006, FERC issued its preliminary determinations regarding the measures recommended by the agencies. FERC found that several of the recommended measures were not within the scope of Section 10(j). For the 77 recommendations that FERC considered to be within the scope of Section 10(j), FERC did not accept 35 on technical grounds, but adopted the other 42 recommendations into the Staff Alternative as explained and summarized in the FERC DEIS (see Table 5-2 in the DEIS).

2.4.6 FERC's Final Environmental Impact Statement

In November 2007, FERC issued the Final Environmental Impact Statement (FEIS) for the Project (FERC 2007) to fulfill the requirements of the National Environmental Policy Act (NEPA). The principal issues addressed by FERC in the FEIS were similar to those addressed in the DEIS (described above in Section 2.4.4), including the influence of project operations on water quality; approaches to facilitate the restoration of native anadromous fish within and upstream of the Project; the influence of peaking operations at J.C. Boyle Development on downstream biota and whitewater boating opportunities; the effect of Project operations on archaeological and historic sites and resources of concern to various tribes; and the effects of decommissioning the East Side and West Side Developments and removing Keno Development from the Project. As in the DEIS, the FEIS evaluates PacifiCorp's proposed Project, along with the terms and conditions, prescriptions, and recommendations from resource agencies, tribes, and other interested parties.

Based on this evaluation, FERC staff compiled a set of environmental measures to address the various resource issues; the collection of these measures is called the "Staff Alternative" (described in detail in Section 2.3.2 of the FEIS). The Staff Alternative incorporates most of PacifiCorp's proposed environmental measures, but in some instances with modifications. With regard to the portion of the Project in California, these modifications include: implementation of turbine venting at Iron Gate dam as a dissolved oxygen enhancement measure; implementation of an adaptive sediment augmentation program downstream of Iron Gate dam; increasing the minimum flow in the Copco No. 2 bypassed reach to 70 cfs; increased funding responsibilities for the Iron Gate Hatchery; and implementation of a hatchery and genetics management plan. These modifications also contain an integrated fish passage and disease management program, including the following five components: (1) modifying adult collection facilities at Iron Gate dam to facilitate trapping and hauling of adult anadromous fish, (2) evaluation of survival of outmigrating wild smolts at Project reservoirs, spillways, and powerhouses, (3) an experimental drawdown of Copco and Iron Gate reservoirs to assess effects on smolt outmigration and water quality, (4) water quality monitoring in the Project reservoirs and to the mouth of the Klamath River, including major tributaries, to assess Project contributions to factors that may cause fish diseases in the lower river, and (5) evaluation of the most feasible and effective means to pass fish to and from project waters and minimize the risks associated with fish diseases that are Project-related. The Staff Alternative measures and key modifications from PacifiCorp's proposed environmental measures are pointed out and described in the relevant sections of this revised application for 401 certification.

The FEIS evaluates the differences between five alternatives: (1) PacifiCorp's Project proposal, (2) the FERC Staff Alternative, (3) the Staff Alternative with Mandatory Conditions, (4) Retirement of Copco No. 1 and Iron Gate Developments, and (5) Retirement of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Developments. Based on a detailed analysis, the FEIS concludes that the best alternative for the Project would be to issue a new license consistent with the environmental measures specified in the Staff Alternative.

The FEIS is part of the public FERC docket for the license application, and PacifiCorp understands that the State Water Board has copies of the FEIS. The FEIS also is available on FERC's website at www.ferc.gov, under docket number P-2082.

3.0 EXISTING AND PROPOSED PROJECT FACILITIES AND OPERATIONS

This section describes PacifiCorp's existing Klamath Hydroelectric Project facilities and operations in California, including the Copco No. 1, Copco No. 2, Iron Gate, and Fall Creek facilities. Project facilities and operations are described in greater detail in Exhibit A, Project Description and Exhibit B, Project Operation and Resource Utilization (PacifiCorp, 2004a) of the FERC Final License Application, respectively. A detailed description of aquatic habitat in the Project vicinity is presented in PacifiCorp's Exhibit E, Environmental Report, Section E.3 (PacifiCorp, 2004b). In addition, this section describes the proposed changes to the existing Project facilities.

3.1 EXISTING PROJECT FACILITIES AND OPERATIONS

The current Project consists of several facilities on the Klamath River between river mile (RM) 190.5 and RM 254. Facilities in California are described in detail below. Facilities in Oregon include the East Side and West Side generating facilities, Keno dam and reservoir, and the J.C. Boyle dam, reservoir, and powerhouse. The East Side and West Side generating facilities (at RM 253.7 and RM 253.3, respectively) receive flow diverted at the USBR-owned Link dam at RM 254 at the outlet of Upper Klamath Lake (UKL). Keno dam (at RM 233) has no generation facilities. Keno reservoir (from RM 233 to 252.7) is about 19.7 miles long, has a surface area of 2,475 acres, and a maximum depth of about 20 feet. J.C. Boyle dam (RM 224.3) and powerhouse (RM 220) is a generating facility that is typically operated in a load-following or "peaking" mode. J.C. Boyle reservoir (from RM 224.3 to 227.9) is about 3.6 miles long, has a surface area of 420 acres, and a maximum depth of about 42 feet.

The facilities in California (Copco No. 1, Copco No. 2, Iron Gate, and Fall Creek) are discussed in the following sections.

3.1.1 Copco No. 1 Development

3.1.1.1 Existing Project Facilities

The Copco No. 1 Development consists of a reservoir, dam, and powerhouse located on the Klamath River between approximately RM 198.6 and RM 203.2 just south of the Oregon-California border. Copco No. 1 dam is a concrete arch dam 126 feet high, with 13 radial gates. The impoundment formed upstream of the dam is approximately 1,000 acres in extent with approximately 46,900 acre-feet of total storage capacity and 6,235 acre-feet of active storage capacity. The Copco No. 1 powerhouse is located immediately below the Copco No. 1 dam. Water diverted for power use flows through several trash racks into three short penstocks that supply the two turbines, each 10 MW in size. Combined hydraulic capacity of the turbines is 3,200 cubic feet per second (cfs). Copco No. 1 powerhouse flow is directed to the Copco No. 2 powerhouse intake through the small, 0.3-mile-long Copco No. 2 reservoir. Key information about the Copco No. 1 Development is summarized in Table 3.1-1.

3.1.1.2 Existing Project Operations

Copco dam is operated for power generation, some very minor flood control and control of the Copco reservoir water surface elevation. The Copco No. 1 powerhouse is usually operated to generate during the day when energy demands are highest, and to store water during the non-peak times (weeknights and weekends). When river flows are near or in excess of turbine hydraulic capacity, the powerhouse generates continuously and excess water is spilled through the spill gates. Copco reservoir can fluctuate 5.0 feet between normal minimum and full pool elevations, but the average daily fluctuation is approximately 0.5 feet.

Table 3.1-1. Key Data Regarding the Existing Klamath Hydroelectric Project Developments in California

Item	Copco No. 1 Development	Copco No. 2 Development	Iron Gate Development	Fall Creek Development
General Information				
Owner of the Dam	PacifiCorp	PacifiCorp	PacifiCorp	PacifiCorp
Purpose	Hydropower	Hydropower	Hydropower	Hydropower
Completion Date	1918	1925	1962	Fall Creek: 1903
Dam Location (river mile)	198.6	198.3	190.5	Not applicable
Powerhouse Location (river mile)	198.5	196.8	190.4	Not applicable
Structural Features of the Dam				
Dam Type	Concrete	Concrete	Earthfill	Earthfill
Dam Height (ft)	126	33	173	7
Dam Length (ft)	415	278	740	95
Spillway Length (ft)	182	130	685	32” dia. pipe
Number of Spill Gates	13	5	0	1
Spill Gate Type	Tainter	Tainter	Ungated	Vertical Lift
Spillway Crest (ft msl)	2593.5	2454.0	2328.0	3253.4
Spillway Apron (ft msl)	2483.0	2452.0	2164.0	3249.5
Gross Head (ft) at Spillway	111	21	164	3.9
Spillway Energy Dissipaters	Yes	No	Yes	No
Reservoir Information				
Reservoir Common Name	Copco Reservoir	Copco No. 2 Reservoir	Iron Gate Reservoir	No reservoir
Distance to Upstream Dam (miles)	25.7	0.3	7.8	Not applicable
Reservoir Length (miles)	4.6	0.3	6.2	Run of river
Approximate Maximum Surface Area (acres)	1,000	40	944	Run of river
Normal Maximum Depth (ft) from Normal Maximum Surface Elevation	115.5	28	162.6	Unknown
Maximum Depth Elevations (ft msl) from 2001-2002 Study[a]	2,492.0	---	2,165.4	No reservoir
Normal Maximum Operating Surface Elevation (ft msl)	2,607.5	2,483.0	2,328.0	3,250.5 (local datum)
Normal Minimum Operating Surface Elevation (ft msl)	2601.0	Data not available	2,324.0	3250.5 (local datum)
Normal Annual Operating Fluctuation (ft)	6.5	Data not available	4.0	0
Total Storage Capacity (ac-ft)[b]	46,867	73	58,794	No reservoir
Current (2001-2002) Estimate of Gross Storage Capacity[a]	33,724	NA	50,941	No reservoir
Active Storage Capacity (ac-ft)	6,235	Negligible	3,790	0

Table 3.1-1. Key Data Regarding the Existing Klamath Hydroelectric Project Developments in California

Item	Copco No. 1 Development	Copco No. 2 Development	Iron Gate Development	Fall Creek Development
Average Flow (cfs)[c]	1,885	1,885	1,852	40
Retention Time (days)				
At Average Flow	12	0.020	16	<1 hour
At 710 cfs	32	0.052	42	<1 hour
At 1,500 cfs	15	0.025	20	<1 hour
At 3,000 cfs	8	0.012	10	<1 hour
At 10,000 cfs (extreme event)	2	0.004	3	<1 hour
Power Generation Features				
Trash Racks	Two 44 x 12.5 ft with 3-inch bar spacing	36.5 x 48 ft with 2-inch bar spacing	At penstock entrance, 17.5 x 45 ft with 4-inch bar spacing	At entrance to penstock, 17.5 x 10.7 ft with 3-inch bar spacing/none
Diversion to Powerhouse	Three penstocks at the dam	Wood-stave flow line and rock tunnel to two steel penstocks	Gated intake tower to penstock at dam	4,560-ft waterway to 42-inch (reducing to 30-inch) diameter penstock/6,850-ft waterway to Fall Creek
Number of Turbines	2	2	1	3
Turbine Type	Horizontal Francis	Vertical Francis	Vertical Francis	Pelton
Turbine Generator Nameplate Capacity (MW)	Unit 1: 10 Unit 2: 10	Unit 1: 13.5 Unit 2: 13.5	18	Unit 1: 0.5 Unit 2: 0.45 Unit 3: 1.25
Total Nameplate Generating Capacity (MW)	20	27	18	2.2
Gross Head (ft) at Powerhouse	123	152	158	730
Total Turbine Hydraulic Capacity (cfs)	Rated: 3,200 Max: 3,560 Min: Unit 1: 241 Unit 2: 467	Rated: 3,200 Max: 3,250 Min: 258	Rated: 1,550 Max: 1,735 Min: 296	Rated: 60 Max: 30 Min: 2
Powerhouse Construction	Reinforced concrete substructure with a concrete and steel superstructure	Reinforced concrete structure	Reinforced concrete structure	Reinforced concrete substructure with steel superstructure enclosed by metal siding
Transmission Lines				
Line Designation	15, 26-1, 26-2	None	62	3 (two sections)
Length (mi)	1.23, 0.7, 0.7	None	6.55	1.65 total
Voltage (kV)	69, 69, 69	None	69	Both 69

Table 3.1-1. Key Data Regarding the Existing Klamath Hydroelectric Project Developments in California

Item	Copco No. 1 Development	Copco No. 2 Development	Iron Gate Development	Fall Creek Development
Interconnections	Line 15 from Copco No. 1 switchyard to Copco No. 2 plant, line 26-1 from Copco No. 1 plant to switchyard, line 26-1 from Copco No. 1 plant to switchyard	None	Plant to Copco No. 2	Plant to tap point on line 18 (very short), Plant to Copco No. 1 switchyard

[a] Data from the Draft Bathymetry and Sediment Classification of the Klamath Hydropower Project Impoundments, J.M. Eilers and C.P. Gubala of JC Headwaters, Inc., prepared for PacifiCorp, March 2003.

[b] Total storage capacity is measured at normal full pool.

[c] Data for Keno are from USGS Gauge 11509500. All other data are average daily turbine flows plus spill flows for 1994 through 1997 provided by PacifiCorp.

Copco No. 1 and No. 2 operate together. Because flows through the system must be closely coordinated owing to lack of significant storage and mandatory downstream flow requirements, flow through the Copco plants typically mimics flow through J.C. Boyle on a daily average basis (with a time lag). Copco No. 2 has virtually no storage reservoir and operates in conjunction with Copco No. 1. That is, Copco No. 2 generation and hydraulic discharge follow Copco No. 1 generation and hydraulic discharge.

Copco No. 1 Development has no bypass reach. The powerhouse is located immediately below the dam. The Copco No. 1 powerhouse tailwater is the small Copco No. 2 reservoir. There are no minimum instream flow or ramp rate requirements for the Copco No. 1 Development.

The spill gates at Copco No. 1 dam may be opened if an unscheduled turbine shutdown results in a lengthy outage that adversely affects downstream water flow requirements.

The Copco No. 1 Development has been automated for remote control of unit start, stop, and loading. Copco No. 1 generation is scheduled to meet the power demands of the system while passing required flows. The development operation is monitored and controlled 24 hours per day, 7 days per week. Upon unit startup, generation loads are set and the unit will automatically reach and hold that requirement until reset or the unit shuts down. Project operators can control the operation manually from the powerhouse.

3.1.2 Copco No. 2 Development

3.1.2.1 Existing Project Facilities

The Copco No. 2 Development consists of a diversion dam, a small impoundment, and powerhouse located just downstream of Copco No. 1 dam between approximately RM 196.8 and RM 198.3. The reservoir created by the 38-foot-high dam has minimal storage capacity (73 acre-feet). Copco No. 2 is entirely dependent on Copco No. 1 releases for water and operates in conjunction with Copco No. 1.

Copco No. 2 dam has five spill gates and a manual gate valve that can divert a small amount of water into the bypass reach. The flowline to the powerhouse consists of portions of wood-stave pipe, rock tunnel, and steel penstock. At the entrance to the flowline is a 36.5-foot by 48-foot trash rack. There are two 13.5-MW units with a combined hydraulic capacity of 3,200 cfs in the powerhouse. Key information about the Copco No. 2 Development is summarized in Table 3.1-1.

3.1.2.2 Existing Project Operations

Copco No. 2 reservoir has virtually no active storage, and relies on Copco No. 1 releases for operating flows. Copco No. 2 generation and hydraulic discharge follow Copco No. 1 generation and hydraulic discharge. With this type of operation, water surface elevations of the Copco No. 2 reservoir rarely fluctuate more than several inches.

Because the Copco No. 2 Development is located immediately downstream of Copco No. 1 powerhouse, the Copco No. 2 generation is scheduled simultaneously with the generation at Copco No. 1. The Copco No. 2 units are automated. The daily generation schedule is established to meet the power demands of the system while passing required flows through the various Project facilities. The operation is monitored and controlled 24 hours per day, 7 days per week. Upon unit startup, generation loads are set and the unit will automatically reach and hold that requirement until reset or the unit shuts down.

3.1.2.3 Existing Instream Flow Releases and Ramping Rates

There are no ramp rate requirements for the 1.5 mile-long bypass reach between Copco No. 2 dam and Copco No. 2 powerhouse, but PacifiCorp currently releases a minimum flow of 5 to 10 cfs as standard operation practice (Table 3.1-2). No natural springs are known to contribute flow to this reach.

Table 3.1-2. Copco No. 2 Minimum Instream Flow and Ramp Rate Directives

River Reach	Length of Reach (River Miles)	Instream Flow	Ramp Rate
Copco No. 2 Bypass (dam to powerhouse)	1.5	5-10 cfs (nonregulatory release; PacifiCorp standard practice)	None
Klamath River (Copco No. 2 tailrace to Iron Gate reservoir)	0	None	None

In the event of an unscheduled shutdown at the Copco No. 2 powerhouse, the Copco No. 1 powerhouse is shut down. If flow in the Copco No. 2 waterway is at full capacity at time of shutdown, some water may be spilled into the lower Copco No. 2 bypass reach via an overflow waterway at the surge tank. If flows are near the capacity of a single unit (approximately 1,600 cfs), a surge chamber in the tunnel can accommodate the excess water. If the outage at Copco No. 2 powerhouse will be lengthy, Copco No. 1 powerhouse may be operated and water spilled at Copco No. 2 dam.

3.1.3 Iron Gate Development

3.1.3.1 Existing Project Facilities

The Iron Gate Development consists of a reservoir, dam, and powerhouse located on the Klamath River between approximately RM 190.5 and RM 196.8, which is approximately 20 miles northeast of Yreka, California. It is the most downstream hydroelectric facility of the Project, as well as the most downstream dam on the Klamath River. The rock fill Iron Gate dam is 173 feet high. The impoundment formed upstream of the dam is approximately 944 surface acres and contains approximately 58,794 acre-feet of total storage capacity and 3,790 acre-feet of active storage capacity. An ungated spillway 730 feet long leads to a large spill canal, allowing transport of high flows past the structure. The powerhouse is located at the base of the dam. Trash is prevented from entering the penstock by a 17.5-foot by 45-foot trash rack.

In 2003, modifications were made to Iron Gate dam to raise the dam crest elevation from El. 2343 feet msl to El. 2348 feet msl. The modifications included construction of a steel wall extension along the dam crest, anchored into the existing dam structure. Additional riprap materials were placed on the upstream face of the dam to protect those areas inundated by the higher reservoir elevations. This work included shotcrete protection at the top of the spillway and spillway chute. The crest elevation of the spillway was not changed.

The Iron Gate powerhouse consists of a single 18-MW unit with a hydraulic capacity of 1,735 cfs. In the event of a turbine shutdown, a synchronized bypass valve located immediately upstream of the turbine diverts water around the turbine to maintain flows downstream of the dam.

The original construction diversion tunnel is still in place. Operation of the gate controlling the flow through the tunnel is limited to emergency use during high flow events. If needed for such purposes, the tunnel can pass up to approximately 5,000 cfs. Key information about the Iron Gate Development is summarized in Table 3.1-1.

3.1.3.2 Existing Project Operations

The Iron Gate powerhouse is located at the base of the dam and has no bypass reach. The facility operates as a regulating dam to dampen the effects of fluctuating river levels from the Copco Nos. 1 and 2 peaking operations. Releases through the turbine can be as much as 1,735 cfs. When flows are higher, or higher flows are needed to meet regulatory conditions downstream, additional water is passed over the ungated spillway. The amount of spill is controlled to the extent possible through Copco Nos. 1 and 2 operations. If a consistent spill is needed at Iron Gate dam, Copco Nos. 1 and 2 cannot operate in a peaking operation, but must provide a constant flow to maintain Iron Gate reservoir elevations.

The Iron Gate Development is primarily operated manually with minor control provided remotely to serve as the Project's regulating facility. Generation schedules reflect instream flow requirements and ramp rates. (See Section 3.1.3.3.) Exceptions may occur seasonally when high river flows result in spills. The single Iron Gate unit is scheduled to maintain those regulated flows as well as provide minimal adjustments for seasonal peaks within its range limits. This schedule is given daily. Monitoring and control is provided 24 hours per day, 7 days per week. Local operators can start and stop the unit, but unit control generally is done automatically on a defined (preprogrammed) ramp rate. The unit can be tripped remotely.

3.1.3.3 Existing Instream Flow Releases and Ramping Rates

The current FERC license stipulated minimum flow requirements below Iron Gate dam are 1,300 cfs from September through April, 1,000 cfs in May and August, and 710 cfs in June and July. However, since 1997, PacifiCorp has operated to provide instream flow releases dictated by USBR's annual Operations Plans for the Klamath Irrigation Project (KIP). The KIP's 2007 Operations Plan (USBR 2007) is the plan currently in effect. The 2007 Operations Plan describes expected operations from April 2007 through March 2008 based upon current and expected hydrologic conditions and consistent with the 2002 Biological Opinion (NMFS 2002, USFWS 2002). The Plan is initially derived from the April 1, 2007 Natural Resource Conservation Service (NRCS) inflow forecast. USBR developed the Plan to serve as a planning aid for agricultural water users, Klamath Basin Tribes, national wildlife refuges and other interested parties.

PacifiCorp coordinates with USBR to provide flows below Iron Gate dam as stated in the current Operations Plan rather than those cited as the FERC minimum. The current Operations Plan flows that USBR is required to meet or exceed at Iron Gate dam are listed in Table 3.1-3. The flows are established by water year types based on UKL net inflow (during April – September) that are initially derived from Natural Resource Conservation Service (NRCS) inflow forecast on April 1 and then subsequently adjusted based on actual hydrologic conditions after April 1 (USBR 2007).

Table 3.1-3. Instream Flow Releases as Measured at Iron Gate Dam in the USBR's Klamath Project Operations 2002 Biological Assessment (USBR 2007).

Time Step	**Flows (cfs) at Iron Gate Dam (Average Daily Flow) by Water Year Type***				
	Wet	**Above Average**	**Average**	**Below Average**	**Dry**
April	2050	2700	2850	1575	1500
May	2600	3025	3025	1400	1500
June	2900	3000	1500	1525	1400
July	1000	1000	1000	1000	1000
August	1000	1000	1000	1000	1000
September	1000	1000	1000	1000	1000
October	1300	1300	1300	1300	1300
November	1300	1300	1300	1300	1300
December	1300	1300	1300	1300	1300
January	1300	1300	1300	1300	1300
February	1300	1300	1300	1300	1300
March	2300	2525	2750	1725	1450

*Water Year Type is based on Upper Klamath Lake Net Inflow (during April – September) as follows:

Wet	Above 785,200 acre-feet
Above Average	568,600 to 785,200 acre-feet
Average	458,400 to 568,500 acre-feet
Below Average	286,800 to 458,300 acre-feet
Dry	Below 286,800 acre-feet

In addition, to protect coho salmon, USBR is required to operate the KIP to provide water and coordinate with PacifiCorp to achieve the rates for ramping down of flows between monthly or biweekly timesteps below Iron Gate dam as listed in Table 3.1-4. The 2002 Biological Opinion issued by NMFS for USBR specified a ramp rate of 50 cfs per 2-hour period at the Iron Gate powerhouse at those times when flows are within the hydraulic capacity of the plant (Table 3.1-4). The 2002 Biological Opinion also set a limit for flow reduction to 150 cfs per day (NMFS, 2002). This limit is five times more restrictive than the current FERC license ramp rate of 250 cfs per hour. PacifiCorp has found that the equipment in the powerhouse can achieve this lower ramp rate. However, coordination between USBR and PacifiCorp is necessary to make sure enough water is available for release over the long ramp-down periods. This operational change relies on semi-automated control. PacifiCorp has committed to implement these ramp rates to the extent possible based on the physical limitations of the hydroelectric Project facilities**.** These limitations include the absence of spill gates at Iron Gate dam.

Flow below Iron Gate dam is measured every 15 minutes at a USGS gauging station (No. 11516530) located approximately 0.6 mile downstream. The gauge is also downstream of Bogus Creek, a tributary to the Klamath River; hence, instream flow at the gauge is a measure of flow from the powerhouse, Iron Gate fish hatchery return water, and the ungauged Bogus Creek.

Table 3.1-4. Iron Gate Dam (IGD) Minimum Instream Flow and Ramp Rate Directives.

River Reach	Length of Reach (River Miles)	Minimum Instream Flow	Ramp Rate
Iron Gate Dam	Not Applicable	Minimum instream flows are specified in PacifiCorp's existing FERC license (FPC, 1956). However, instream flows are released per USBR's 2007 Operations Plan in accordance with the 2002 Biological Opinion (NMFS 2002)	Ramp rates of 250 cfs or 3 inches per hour, whichever is less, are specified in PacifiCorp's existing FERC license (FPC, 1956). However, PacifiCorp is using ramp rates as specified per USBR's 2007 Operations Plan in accordance with the 2002 Biological Opinion (NMFS 2002): 1. When IGD flows exceed 1,750 cfs, decreases in flow are limited to 300 cfs or less per 24-hour period, and no more than 125 cfs per 4-hour period; 2. When IGD flows are 1,750 cfs, or less, decreases in flow are limited to 150 cfs or less per 24-hour period, and no more than 50 cfs per 2-hour period.

3.1.4 Fall Creek Development

3.1.4.1 Existing Project Facilities

The Fall Creek Development is a run-of-river facility located on Fall Creek, which is a tributary of the Iron Gate reservoir. The Fall Creek Development consists of two small diversion dams, an earthen ditch, a penstock, and a powerhouse. The upper-most diversion is located on Spring Creek in Oregon. Spring Creek is a tributary to Jenny Creek that in turn flows into the Iron Gate reservoir. Spring Creek water can be diverted out of the Jenny Creek basin, in Jackson County, Oregon, and into the Fall Creek basin for use at the Fall Creek powerhouse.

When in use, it diverts up to 16.5 cfs of water to Fall Creek. The diversion dam on Fall Creek then diverts up to 50 cfs into the power canal and penstock that supplies the powerhouse.

The diversion dam on Fall Creek is an earth- and rock-filled berm. The spillway structure is constructed of timber flashboards and concrete. The length of the power canal from the dam to the penstock intake is approximately 4,560 feet. At the entrance to the penstock is a trash rack. The penstock drops over the hillside, providing a 730-foot head to the three Pelton turbines in the powerhouse. Generation capacity is 0.5 MW for unit 1, 0.45 MW for unit 2, and 1.25 MW for unit 3. The total hydraulic capacity of the turbines is 50 cfs. Key information about the Fall Creek Development is summarized in Table 3.1-1.

3.1.4.2 Existing Project Operations

The water supply for the Fall Creek powerhouse is predominantly spring fed and is fairly consistent. As a result, the facility was designed without a storage reservoir and is operated as a run-of-the-river facility under all river flows and water year types. Generation is dependent on flow.

The Fall Creek Development is operated manually, owing primarily to its run of river operation, smaller generation potential, and the consistency of the stream flow at the diversion point. The facility is operated at a constant discharge equal to the diversion dam inflow minus the 0.5 cfs instream release. The flashboards at the diversion dam are maintained at a constant elevation, and during periods of higher flow, the water in excess of the diversion capacity (50 cfs) passes over the diversion dam. The three units are manually operated as flows become available or diminish seasonally. After normal business hours, the units are monitored. The Fall Creek generation is monitored 24 hours per day, 7 days per week from a continuous total generation readout and through limited critical alarming. Should a critical alarm occur, the local operator is contacted to respond on site. Since the units are impulse runners, normal unit shut-downs will deflect flows from the runners and not change flow releases until the operator elects to do so.

3.1.4.3 Existing Instream Flow Releases and Ramping Rates

To provide the minimum instream flow, a notch in the lower stop logs at the Fall Creek diversion dam ensures that 0.5 cfs is continually released into the bypass reach. Continuous operation at the powerhouse (including turbine bypass) or flow through the bypass channel during maintenance ensures that the 15 cfs minimum instream flow downstream of the powerhouse is met (Table 3.1-5). A gauge (USGS No. 11512000) was previously operated downstream of the powerhouse, and has recently been reactivated (spring 2003). It is unknown how long this gauge will be in operation. Flow released at the powerhouse can be estimated through a flow-generation relationship.

Table 3.1-5. Fall Creek Minimum Instream Flow and Ramp Rate Directives.

River Reach	Length of Reach (River Miles)	Minimum Instream Flow	Ramp Rate
Fall Creek Bypass	1.2	0.5 cfs into bypass plus a 15 cfs continuous flow downstream of the powerhouse tailrace (FPC 1956)	None

3.2 PROPOSED PROJECT

This section describes the proposed Project facilities in California, as submitted to FERC for relicensing by PacifiCorp. In the California portion of the Project, the primary generation facilities and operation will be unchanged. However, PacifiCorp's proposed Project includes numerous measures to enhance water quality and beneficial uses. This section introduces and describes these proposed measures. The basis for those measures related to water quality are assessed and discussed in subsequent sections of this document.

3.2.1 J.C. Boyle Powerhouse Bypass Valve

Under existing conditions, the J.C. Boyle powerhouse does not have the means to maintain downstream river levels in the event of either or both generating units are tripped off line (unscheduled outage). Upon a plant trip, the river stage drops according to plant discharge. Flow capacity through each unit is roughly 1,425 cfs. In the case of a unit trip when both units are operating, the river drops 1.3 feet. If both units are operating and they both trip, the river will drop approximately 3 feet. If either event was to occur, river stage is not corrected until the generating unit is back in service, water is released at the canal spillway, or water is released at the dam. Also, in the event both units trip, the canal cannot contain enough of the backed-up water and the canal spillway gate is opened. Spill amount and duration at this location is dependent on amount of flow in the canal at time of unit trip and the time it takes to close the canal headgate.

To reduce the potential for river stage changes in response to unit trips at the J.C. Boyle powerhouse, PacifiCorp is proposing to install synchronized bypass valves on each of the two units. The intent of the valves is to maintain the river level even if a unit trips off-line. The two bypass valves should also eliminate use of the canal spillway, as water would not be backed up in the event of a unit trip. Further details on the synchronized bypass valves are provided in PacifiCorp (2004a).

The installation of the proposed synchronous bypass valves at the powerhouse will eliminate this fish stranding potential, due to unscheduled unit trips. Another anticipated benefit of the installation of the bypass valves is the elimination of the use of the canal spillway. Past use of the spillway has resulted in erosion of the hillside leading down to the bypass reach and subsequent increases in turbidity in this otherwise clear water segment of river.

3.2.2 Instream Flows and Ramping Rates

A summary of the proposed instream flows and ramping rate measures for each of the future Project reaches in California is provided in Table 3.1-6. (PacifiCorp is not proposing any modifications to its operation that would affect the Project's ability to meet USBR's flow requirements downstream of Iron Gate dam.) For more information about proposed instream flows and ramping rates, refer to PacifiCorp (2004c), Exhibit E-Environmental Report, Section E.4.

Table 3.1-6. Proposed Instream Flow and Ramp Rate Measures for River Reaches Affected by the Klamath Hydroelectric Project.

River Reach	Instream Flow	Ramp Rate
Copco No. 2 Bypass (dam to powerhouse)	A minimum instream flow of 10 cubic feet per second (cfs) from the dam. Release facility will be constructed to monitor flow releases.	125 cfs per hour (downramp rate) with the exception of conditions beyond the Project's reasonable control. To extent practical, flow changes will be limited to a total magnitude change of 1,600 cfs in a daily period. This rate is primarily applicable to planned maintenance events.
Klamath River (Copco No. 2 tailrace to Iron Gate reservoir)	None	None
Iron Gate dam	The instream flow schedule below Iron Gate dam will be maintained according to USBR's 2007 Operations Plans (USBR 2007) consistent with the 2002 Biological Opinion issued by NMFS (2002).	Current ramp rates below Iron Gate will be maintained according to USBR's 2007 Operations Plans (USBR 2007) consistent with the 2002 Biological Opinion issued by NMFS (2002).
Fall Creek Bypass	A minimum of 5 cfs into the bypass plus a 15 cfs continuous flow downstream of the bypass confluence. Release structure will be constructed to maintain continuous release at the dam.	Not applicable

3.2.3 Reservoir Management Plan for Copco and Iron Gate Reservoirs

PacifiCorp is implementing a reservoir management plan (RMP) to improve water quality in Copco and Iron Gate reservoirs and below the Project. The RMP is attached as Appendix B, and is a revised version of a similar plan developed in March 2006 (PacifiCorp 2007a). This revised version of the RMP contains updated information on the process PacifiCorp is following for identifying, testing, implementing, and monitoring several technologies and measures for enhancing water quality conditions in Copco and Iron Gate reservoirs and below the Project. The technologies and measures considered in this RMP consist of proven techniques for lake and reservoir water quality management, as described by Cooke and Kennedy (1989), Cooke et al. (2005), Holdren et al. (2001), Thornton et al. (1990), and UNEP (2004). Based on the approach outlined in the RMP, decisions regarding selection and implementation of specific technologies and measures will be made by PacifiCorp in consultation with the State Water Board.

Copco and Iron Gate reservoirs are nutrient-enriched (eutrophic) as a result of large inflowing loads of nutrients and organic matter from upstream sources in the upper basin, particularly UKL (PacifiCorp 2006). Management of these upstream sources is unaffected by and beyond the control of PacifiCorp's Project operations. As such, this plan does not (and cannot) address the upstream loads of nutrients and organic matter. Control of the large inflow loads of nutrients and organic matter from upstream sources is most appropriately addressed through implementation of the Total Maximum Daily Loads (TMDLs) that are currently being developed by the state of California's North Coast Regional Water Quality Control Board (NCRWQCB) and ODEQ. However, actions implemented in this plan are aimed at improving reservoir water quality conditions related to algae, dissolved oxygen, and pH that are largely driven by the upstream loads of nutrients and organic matter. Therefore, this reservoir management program is an important adjunct to the TMDLs, and provides a proactive response by PacifiCorp to implementation of the anticipated TMDLs, particularly as they may pertain to Copco and Iron Gate reservoirs.

During 2008, PacifiCorp plans to proceed with implementation and/or testing of certain technologies and measures for reservoir water quality management and enhancement. PacifiCorp plans to assess the potential effectiveness and feasibility of constructing wetlands upstream and/or along the reservoirs as a means of capturing and removing particulates and nutrients in upstream river inflow to the reservoirs. PacifiCorp also plans to proceed with turbine venting tests at the Iron Gate powerhouse and a develop a design and implementation plan for an oxygen diffuser system in Iron Gate reservoir. These two technologies are expected to yield substantial improvements in dissolved oxygen conditions in releases from Iron Gate dam to the river below. PacifiCorp plans additional pilot-scale testing of solar-powered epilimnetic circulators in 2008 to gain better reliability and effectiveness information prior to potential scale-up to more extensive implementation in the reservoirs. PacifiCorp plans to proceed with effectiveness testing of sodium carbonate peroxyhydrate (PAK™27) applications in the reservoirs based on test applications to confined areas of the reservoirs or suitable separate enclosures using water taken from the reservoirs. Sodium carbonate peroxyhydrate (PAK™27) is approved by the EPA and the California Department of Pesticide Regulation (DPR) for aquatic application as an algaecide to control blue-green algae. Further details on planned RMP activities, including those planned to occur in 2008, are provided in Appendix B.

3.2.4 Selective Withdrawal for Temperature Management

Water temperature in the Klamath River below Iron Gate dam is warmer in the late summer and fall than it would be in the absence of the Project, and is colder in the winter and spring. This "thermal lag" is a consequence of the presence of Iron Gate reservoir (i.e., the mass of the reservoir that is available to store thermal energy), ambient temperature, the reservoir's normal temperature stratification, and the location of the generator penstock intake. Because the reservoir does stratify, some cool wintertime water is retained in the hypolimnion throughout the summer.

In the FLA (PacifiCorp 2004b), PacifiCorp describes a potential measure to implement a low-level release of cooler hypolimnetic water from Iron Gate reservoir during summer to provide some cooling of the Klamath River downstream of the Project. However, although hypolimnetic cool water storage is available in Iron Gate reservoir, the volume of this cool water is limited, and potential downstream effects would be of short duration and would not affect the entire length of river below Iron Gate dam to the ocean. In addition, the sole water supply for Iron Gate Hatchery withdraws cold water from the deeper water of Iron Gate reservoir, and depleting or exhausting this cold water pool during the summer would likely seriously impair hatchery operations during any year that such hypolimnetic releases occur.

PacifiCorp analyzed the hypothetical release of hypolimnetic water from both Copco and Iron Gate reservoirs using comprehensive water quality modeling (PacifiCorp 2004h, 2005a, 2005b, 2005c, 2005d). PacifiCorp estimates the maximum useable cold water volume in Copco reservoir in summer to be about

3,100 acre-feet and 4,800 acre-feet at less than 14°C and 16°C, respectively. The modeling results show that the duration of hypolimnetic releases from this cold water storage in Copco reservoir would last about 1.8 days at 1,000 cfs. The maximum volume of cold water (8°C or less) at Iron Gate reservoir during the summer is about 8,000 to 10,000 acre-feet. The modeling results show that the duration of hypolimnetic releases from this Iron Gate cold water storage would last about 5 days at 1,000 cfs.

PacifiCorp's modeling results indicate that it may be possible to extend these release durations by a small amount by reducing the release volume to less than 1,000 cfs. For example, if releases from Iron Gate dam are managed to sustain decreased temperatures for the longest duration, hourly temperatures would be reduced by about 1.1°C on average, with a maximum decrease of 1.8°C, for a period of up to 1½ months in late summer and early fall. Alternatively, if releases from Iron Gate dam are managed to maximize the decrease in downstream water temperature, a maximum reduction of 10°C is possible, but would last only for about a day until the cold water pool is depleted. Modeling scenarios designed to enhance potential temperature benefits by incorporating Copco reservoir into a coordinated effort to lower water temperature downstream of Iron Gate dam showed negligible benefits.

Any cooling benefits obtained from selective withdrawals from Iron Gate would diminish with distance below Iron Gate dam. PacifiCorp's modeling results indicate that cooling benefits are substantially reduced at Seiad Valley (about 60 miles below Iron Gate), with almost no benefit below Clear Creek (about 90 miles below Iron Gate). The lower 100 miles of river generally are unaffected. As the distance downstream from Iron Gate dam increases, observed and modeled temperatures show greater variability as the river becomes more responsive to changes in meteorological and tributary inflow conditions.

In the FEIS for the Project (FERC 2007), FERC staff independently reviewed PacifiCorp's area-capacity curves and vertical temperature profiles for Copco and Iron Gate reservoirs, and concur with PacifiCorp's assessment of the limited coldwater release capabilities at Copco No. 1 and Iron Gate dams. FERC staff recommend development of a temperature management plan that would include: (1) a feasibility study to assess modifications of existing structures at Iron Gate dam to enable release of the maximum volume of cool, hypolimnetic water during "emergency circumstances" to be completed within 1 year of license issuance; (2) an assessment of methods to increase the dissolved oxygen of waters that may be released on an emergency basis; and (3) development of protocols that would be implemented to trigger the release of hypolimnetic water by using existing, unmodified structures at Iron Gate or, if determined to be feasible, modified structures, within 2 years of license issuance. FERC staff indicate that "emergency circumstances" would be if and when temperature conditions for downstream juvenile anadromous fish survival approach critical levels. In addition, FERC staff suggest that the feasibility study would assess alternative or supplemental Iron Gate Hatchery water supply options that could provide temporary cool water supplies to the hatchery during any use of hypolimnetic water under emergency circumstances.

In consultation with the State Water Board, PacifiCorp will evaluate the effectiveness and feasibility of the implementation of a low-level release of cooler hypolimnetic water from Iron Gate reservoir during summer to provide some targeted cooling of the Klamath River below the Project area, consistent with the cold water needs of the Iron Gate fish hatchery. The low-level release would likely require retrofitting an existing low-level outlet at Iron Gate dam to permit controlled release of water from the bottom of Iron Gate reservoir and to release that water in a manner that would provide the greatest benefit to temperature conditions in the Klamath River.

3.2.5 Fish Passage Facilities

Canal screens and fish ladders are proposed for the Fall Creek diversion. The canal screens will be diagonal-type screens meeting NMFS Southwest Region criteria for salmonid fry and trout. Further discussion of the design and a general arrangement drawing of the facilities are included in PacifiCorp (2004c).

The Fall Creek fish ladder will be a pool- and weir-type ladder consisting of six pools. The pools will be constructed from rock and include a 0.5-foot vertical jump for each pool. Further discussion of the design is available in PacifiCorp (2004c).

Section 18 of the FPA states that FERC is to require construction, maintenance, and operation by a licensee of such fishways as the Secretaries of Commerce and Interior may prescribe. In March 2006, NMFS and USFWS provided preliminary fishway prescriptions for anadromous and resident fish passage for Project facilities. In January 2007, NMFS and USFWS filed modified prescriptions and alternatives analyses for fishways at Project facilities. The NMFS and USFWS prescriptions take the approach of requiring volitional upstream and downstream passage facilities at each Project development and tailrace barriers at each of the Project powerhouses. These prescriptions include fish ladders and screens at J.C. Boyle dam and Keno dam[3] in Oregon, and Copco No. 1, Copco No. 2, and Iron Gate[4] dams in California, but also include provisions for collecting smolts at Link River dam and adult fish at Keno dam to transport fish past Keno reservoir when water quality conditions are adverse.

In August 2006, PacifiCorp reached a stipulated agreement with the Departments of Commerce and Interior on spillway modifications and tailrace barriers in preparation for the 2006 EPAct trial-type proceeding. The stipulated agreement specifies that PacifiCorp would be allowed to conduct site-specific studies on the need for and design of spillway modifications and tailrace barriers, and consult with NMFS and USFWS to determine on whether spillway modifications or tailrace barriers are unnecessary based on PacifiCorp's studies.

PacifiCorp filed alternatives to the NMFS and USFWS preliminary prescriptions in April 2006 and December 2006. These alternatives were offered by PacifiCorp only for consideration by NMFS and USFWS in developing modified prescriptions. These alternatives do not constitute a modification or adjustment in the proposed Project as described in PacifiCorp's Final License Application to FERC (PacifiCorp 2004a) or as presented in this 401 Application.

In the alternative to the NMFS and USFWS preliminary prescriptions filed in April 2006, PacifiCorp recommended that NMFS and USFWS consider different prescriptions that involve initiating feasibility studies to be followed by a trap and haul approach to provide passage between Iron Gate dam and J.C. Boyle reservoir, if studies indicate that establishing self-sustaining runs of anadromous fish is possible. In the alternative filed in December 2006, PacifiCorp recommended that NMFS and USFWS consider implementing an adult trap and haul program, initially using the existing collection facilities at Iron Gate dam, and constructing a second adult trap below Copco No. 2 dam in year 4 following issuance of the FERC license. PacifiCorp recommended that NMFS and USFWS consider that any construction of downstream passage facilities would be deferred for 4 years, during which time PacifiCorp would conduct juvenile and spill survival studies, and recommend modifications to downstream fishway prescriptions based on study results.

In the FEIS for the Project (FERC 2007), FERC staff assessed the potential risks and benefits of various approaches for restoring anadromous fish to the Klamath River upstream of Iron Gate dam. FERC staff concludes that critical uncertainties (e.g., disease, predation, water quality) should be addressed before making a substantial investment in volitional fishways at the various Project facilities—a concern that is consistent with that expressed by PacifiCorp. In response to numerous comments from stakeholders, FERC (2007) recommends an approach which would proceed with the immediate reintroduction of anadromous fish species upstream of Iron Gate dam, while implementing an integrated program to

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[3] PacifiCorp notes that Section 18 fishway prescriptions related to Keno dam will not be applicable if the new FERC license for the Project excludes the Keno dam.

[4] The Iron Gate fishway prescription calls for PacifiCorp to modify and use the existing adult trapping facility at the base of Iron Gate dam as an interim measure before completion of a ladder over the dam five years after license issuance.

identify the most effective methods for addressing critical uncertainties related to fish passage, predation, fish disease, and water quality.

FERC (2007) refers to this integrated approach to anadromous fish restoration as an "integrated fish passage and disease management program". The integrated fish passage and disease management program would include several components:

- Installation of a downstream passage and fish collection facility at J.C. Boyle dam
- Modifying adult collection facilities at Iron Gate dam to facilitate trapping and hauling of adult anadromous fish to upstream reaches of the Klamath River within and above the Project area (to be specifically determined based on adaptive management)
- Evaluation of survival of outmigrating wild smolts at Project reservoirs, spillways, and powerhouses (to better determine the most appropriate approach to juvenile bypass facilities)
- An experimental drawdown of Copco and Iron Gate reservoirs to assess effects on smolt outmigration and water quality
- Water quality monitoring in Project reservoirs and to the mouth of the Klamath River, including major tributaries, to assess factors that may contribute to fish diseases in the lower river
- Evaluation of the most feasible and effective means to pass fish to and from project waters and minimize the risks associated with fish diseases.

Notwithstanding the Section 18 fishway prescriptions by the Secretaries of Commerce and Interior, PacifiCorp's proposed project has not changed since the filing of the FLA (PacifiCorp 2004a, 2004b, 2004c, 2004d, 2004e) and the March 2006 application for water quality certification (PacifiCorp 2006a). As such, and because the Section 18 fishway prescriptions do not become effective unless and until PacifiCorp accepts a final license that includes such conditions, it would be inappropriate to modify the Project description in this revised and resubmitted application for water quality certification. PacifiCorp nevertheless recognizes that the Section 18 prescriptions likely will become Project conditions and, as such, it may be appropriate for the State Water Board to consider such prescriptions in the California Environmental Quality Act (CEQA) review, to the extent the prescriptions are not already addressed in FERC's FEIS for the Project (FERC 2007).

3.2.6 Gravel Augmentation

PacifiCorp proposes gravel augmentation measures to enhance spawning gravels below Iron Gate dam. The gravel augmentation proposal is designed to be an adaptive mitigation measure with an initial augmentation followed by recurring augmentation based on detailed monitoring of the added material over the life of the new FERC license. The specific methods of augmenting gravel will depend on the logistics of the selected augmentation sites, as well as other considerations regarding water quality and aquatic and riparian habitat. It would be preferable to create a gravel stockpile along the bank of the river that would erode during high flows, or to add gravel directly during high flows, to reduce turbidity issues.

It is proposed that 1,755 to 3,510 cubic yards of spawnable gravel be placed in the reach just downstream of Iron Gate dam. (See additional discussion at Section 5.1.12.) The results of PacifiCorp's geomorphology study (PacifiCorp, 2004h) indicate that Project impacts on sediment transport and fluvial geomorphology are overwhelmed by other processes downstream of the Shasta River. Accordingly, gravel augmentation is proposed only for the reach between Iron Gate dam and the Shasta River confluence. Approximately 75 percent of this total volume (1,316 to 2,632 cubic yards) would be placed just downstream of Iron Gate dam where access is easy and significant bed coarsening is documented.

The remaining volume would be split into three similar sized placements (146 to 293 cubic yards each) to be distributed at several sites between Bogus Creek and the Shasta River confluence. The volumes and frequencies of recurring gravel augmentation in this reach would be based on monitoring of the initial gravel placements.

In the FEIS for the Project (FERC 2007), FERC staff recommends implementation of an adaptive sediment augmentation program in the J.C. Boyle bypass reach and in the Klamath River from Iron Gate dam to the confluence of the Shasta River. FERC staff conclude that the sediment augmentation program would provide substantial benefits to spawning fish. The FERC staff's recommended program would begin with developing a resource management plan; mapping existing spawning gravel deposits and alluvial surfaces suitable for riparian recruitment; and, based on the results of that mapping, developing sediment augmentation volumes, locations, and sizes that meet plan goals. FERC staff recommends that augmentation would include a range of sediment sizes to support channel complexity and recruitment of riparian vegetation. FERC staff further indicate that during some years it may not be necessary to provide any augmentation if previous sediment has remained at locations that would provide appropriate spawning habitat (e.g., during relatively dry years).

To estimate the cost and benefits of implementing the program, FERC assumed 3,500 cubic yards of sediment (likely to be primarily gravel) would be placed downstream of Iron Gate dam at 3-year intervals (actual amounts would depend on gravel mapping and assessment prior to augmentation). FERC staff estimated that this amount of sediment would provide sufficient spawning habitat to support about 4,300 fall Chinook salmon redds downstream of Iron Gate dam, and would provide substantial benefits to populations of fall Chinook salmon, and PacifiCorp includes the measure in the Staff Alternative. FERC staff further recommend that, if future restoration of anadromous fish into the Copco No. 2 bypass reach occurs, additional augmentation of spawning gravel and monitoring of the condition of spawning gravel in the Copco would likely be implemented.

3.2.7 Maintenance Practices and Scheduling

PacifiCorp will conduct maintenance on the Copco and Iron Gate facilities in the spring (March –May) to minimize the release of warmer, surface water when the powerhouses are shut down.

3.2.8 Roads Management

A road inventory study (PacifiCorp, 2004b Section E.3) identified 253 miles (407 kilometers [km]) of road systems within the road inventory study area (both California and Oregon), and approximately 20 percent (95 km) are on PacifiCorp property. The existing FERC Project boundary contains 48 miles (77 km) of roadway, of which only 55 percent (42.5 km) is on PacifiCorp land.

PacifiCorp will continue to use best management practices for the maintenance of these roads and culverts, reducing the potential for impacts to water quality and beneficial uses. Refinement of these best management practices, including site-specific planning, is ongoing.

3.2.9 Riparian Enhancements

To enhance vegetation resources, PacifiCorp will develop a Vegetation Resources Management Plan (VRMP) to guide land management practices on PacifiCorp-owned land within the FERC boundary.

For further discussion of the VRMP, refer to PacifiCorp (2004b), Section E.5.

4.0 OVERVIEW OF KEY WATER QUALITY CONDITIONS AND PROCESSES IN AND AROUND THE PROJECT AREA

This section describes historical and current water quality conditions in the Klamath River in the vicinity of the Project.

4.1 AN OVERVIEW OF HISTORICAL WATER QUALITY CONDITIONS IN THE BASIN

Upper Klamath Lake (UKL) has been the subject of intensive scientific investigation dating back to the 1950s. Despite these investigations, no viable solutions have been implemented to remedy the lake's hypereutrophic condition. Unless and until these problems are resolved, the impaired quality of the water flowing from UKL will remain a background condition for the Klamath River, constraining efforts to improve water quality.

Concerns over the quality of water in the UKL date back to the earliest known contacts with that body of water. Bortleson and Fretwell (1993) suggest that the lake has probably been naturally eutrophic since before settlement of the basin by non-Native Americans. During the 20th Century, UKL has become hypereutrophic.

In 1953, a study was conducted by the state of Oregon et al. (1955) to explain the problems associated with the *Aphanizomenon* algae at UKL. The study concluded that the shallow configuration of UKL provides for rapid decomposition of dead organic material and maintains the lake in almost constant nutrient circulation. Recirculation of the nutrients released through decomposition occurs rapidly, and this constant release means the nutrients are regularly available to organisms at both the surface and bottom of the lake.

In August 1957, Oregon and California entered into the Klamath River Basin Compact. The Klamath River Basin Commission funded several water quality studies over the following decades. In 1962, the Commission convened a panel of experts to review the Klamath Basin problems and identify possible solutions. According to the experts' findings, chemical treatment of algae, control of algae through biological means or harvesting, control of the algae through the elimination of the nutrients, or control of algal populations through artificial reduction of light penetration in the lake were all infeasible.

In 1964, the Oregon State Sanitary Authority (OSSA), after gathering baseline data in efforts to control basin pollution, issued a report stating, "all of the man-made BOD [biochemical oxygen demand] loadings in the [Klamath] Basin are quite insignificant when compared to the BOD of naturally occurring organic materials emitting from the upper Klamath Lake." After studying the UKL algal blooms around 1967, Dr. A.F. Bartsch, the director of the Federal Water Pollution Control Administration's Eutrophication Research Branch, concluded (Klamath County Historical Society, 1967):

> It is possible that bottom sediments could supply nutrients in such quantity that the nuisance algal growths would continue as a major problem in the lake even if all other nutrient sources were controlled to the maximum practicable degree.

The U.S. Environmental Protection Agency also conducted studies regarding UKL. In the early 1970s, the agency announced that UKL would be one of seven Oregon lakes studied as part of a national survey in regard to eutrophication. The EPA planned to include approximately 1,200 lakes across the continental United States in this survey, which sought to "identify and evaluate water bodies…which have actual or potential eutrophication problems…." The survey emphasized the role of phosphates in algal growth, and aimed at assisting state and local governments in determining whether the reduction of excess phosphates through additional municipal waste treatment facilities was a viable option in attempting to reduce algal populations. This "National Eutrophication Survey" sampled 49 lakes in July 1971. UKL was "ranked third in algal productivity and was one of the six lakes characterized as highly productive."[5]

Congress authorized the Army Corps of Engineers (Corps) to investigate potential methods of revitalizing the UKL area in 1977. Two years later, the Corps recommended more research be conducted (Corps, 1979). While the Corps considered various alternatives, the lake's characteristics made it unclear whether any alternative could be implemented without adverse consequences: "The lake is hyper-eutrophic…High nutrient loadings and associated sedimentation of organic matter have produced an ideal habitat for the abundant growth of algae, benthic animals, and macrophytes." In 1982, the Corps issued a second report (Corps, 1982), which concluded:

> …a full scale reversal of the lake's long-term natural, and ultimately irresistible eutrophication is simply not feasible given the present limits of applied limnology, economic means and project priority.

In 1993, U.S. Geological Survey (USGS) scientists produced a report suggesting several explanations for UKL's excessive nutrient enrichment (Bortleson and Fretwell, 1993). Among the more likely explanations, the report suggested, were human activities such as agricultural activities. Natural causes were deemed less likely to be the source of the trouble, for two reasons: (1) the lake's water levels had remained stable over the last 70 years; and, (2) the evidence that human activities produced the excessive nutrient enrichment was more compelling. Whether natural or human in origin, the impacts to UKL have been studied for decades without leading to a viable solution to the problem.

In May of 2002, ODEQ established TMDLs for the UKL drainage. The UKL TMDL for nutrient-related pollution identified controlling total phosphorous loading as the "primary and most practical mechanism to reduce algal biomass and attain water quality standards for pH and dissolved oxygen." To alleviate the lake's pollution, a reduction by 40 percent of total phosphorous loading was called for, and the UKL TMDL stated that this reduction could be achieved by restoring wetlands, changing hydrology along the watercourses flowing into the lake, and reducing phosphorous discharge levels.

4.2 CURRENT CONDITIONS AND PROCESSES AFFECTING WATER QUALITY

Flow and water quality conditions in the Klamath River basin vary dramatically along the approximately 250 river miles from UKL to the estuary at the Pacific Ocean. A wide range of natural and anthropogenic influences affect water quality throughout the system. Inflows to the system at Link dam originate in hypereutrophic UKL. Two of the four major reservoirs on the mainstem Klamath River operate as hydropower peaking facilities. Diversions and return flows for agriculture, as well as municipal and industrial use, occur in the reach between Link dam and Keno dam. The river receives considerable inflow from major and minor tributaries between Iron Gate dam and the estuary.

Not only is the Klamath River system complex, it is also unique because water quality generally improves as water flows from headwaters towards the estuary. In most river systems, water quality is highest at the source and degrades as water flows downstream. The water quality of UKL often is profoundly impaired and has deteriorated at an accelerated rate over the last century as a result of anthropogenic activities.

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[5] "Three Local Lakes Included in EPA Study," Herald and News, June 4, 1972; J.W. Mullins, R.N. Snelling, D.D. Moden, and R.G. Seals, "National Eutrophication Survey: Data Acquisition and Laboratory Analysis System for Lake Samples," EPA-600/4-75-015, U.S. EPA, Office of Research and Development, Environmental Monitoring and Support Laboratory, November 1975, 1; Peter D. Dileanis, Steven E. Schwarzbach, Jewel Bennett and others, *Detailed Study of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Klamath Basin, California and Oregon, 1990-92*, U.S. Geological Survey Water-Resources Investigations Report 95-4232 (Sacramento, CA, 1996), 7.

UKL is now hypereutrophic. A critical feature of hypereutrophic systems is that the eutrophication processes are typically irreversible. The result is that the quality of the water flowing from UKL is the "driver" that dictates water quality throughout the system. The influence of UKL's highly variable and seasonal discharges of large quantities of algae, nutrients, and organic matter on downstream river reaches can be dramatic, especially related to algal production and associated effects on dissolved oxygen, pH, and alkalinity.

It is well documented that nutrient enrichment is a key precursor to algae bloom formation, and algae blooms are common in waters that receive high loads of nutrients. Paerl (1988) reports that inorganic and organic nutrient enrichment is integral to stimulating and supporting algae bloom formation, and that research and management efforts have focused on nutrient loading as the key to bloom formation. Kennedy and Walker (1990) report that reservoir water quality and algal productivity are controlled to a large extent by external nutrient loadings, and that the nature of these nutrient inputs reflect watershed characteristics, especially land use activities. Welch (1992) reports that blue-green algae require high supply rates of nutrients in order to produce a high biomass. Holdren et al. (2001) report that elevated nutrients are the key to excessive algae production in reservoirs, and that management for nutrient input reduction (potentially involving a variety of watershed or basin management activities) is an essential component of algal control, particularly when inflow nutrient loading is dominated by external (input) sources. Cooke et al. (2005) report that the principal cause of increased algal biomass is excessive loading of nutrients and organic matter from external (input) sources, and that the first and most obvious step towards improving reservoir water quality is to limit, divert, or treat excessive external nutrient loading.

The following six dams are on the Klamath River: Link, Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate. The dams directly affect how long it takes for water to travel from UKL to the estuary (except for Copco No. 2 dam, which is a small dam and does not appreciably affect water travel time). The transit time of waters released from UKL to the estuary (as well as water released from the USBR reclamation project to the river between UKL and Keno dam) is about 1 to 2 months or more, except during high winter flow conditions when the transit time may be reduced to as little as 2 weeks. If no dams were in place, transit time from UKL (Link dam) to the estuary would be about a week during summer periods and less during winter high flow events. The dams basically slow the travel time in the upper 65 miles, which allows settlement and processing of impaired quality water from UKL.

UKL is a critical feature for water quality throughout downstream river reaches. Consequently, the following sections provide a detailed conceptual framework of current water quality conditions of the Klamath River in Oregon as well as California. The conceptual framework for Klamath River water quality includes an assessment of available field data, literature, and working knowledge of the basin. Monitoring data from 2000 to 2004 form the basis for much of the conceptual framework. These publicly available data are derived from monitoring programs carried out by the USBR, USFWS (Arcata), USGS, NCRWQCB, PacifiCorp, Klamath Tribes, and other sampling programs. References to flow and water quality conditions in this document generally refer to this body of literature. The intent of the conceptual framework is not to assess each short-term deviation or near-field variability, but to provide a comprehensive conceptual model of the basin.

The following sections are organized by discrete reaches that are defined by existing facilities (e.g., reservoirs, river reaches) and physical conditions.

4.2.1 Upper Klamath Lake

Although UKL is upstream of the Project and is not affected by the Project's operations, and PacifiCorp does not have control over the level of UKL under the contract with USBR, the lake's water quality is discussed here because of its importance as inflow or “boundary” conditions to water quality within and downstream of the Project.

UKL is a large (121 mi^2), shallow (mean depth about 7.8 feet) lake that is geologically old and classified as hypereutrophic (highly enriched with nutrients and supporting high abundance of suspended algae) (Johnson et al. 1985). The lake is subject to wind mixing, and physical or chemical stratification is not evident. A paleolimnological study by Eilers et al. (2001) revealed that UKL has been a very productive lake, with high nutrient concentrations and blue-green algae, for at least the period of record represented by the study (about 1,000 years). However, recent lake sediments showed that the water quality of UKL has apparently changed substantially over the past several decades. Mobilization of phosphorus from agriculture and other nonpoint sources (Walker, 2001) appears to have pushed the lake into its current hypereutrophic state, which includes algal blooms reaching or approaching theoretical maximum abundance. In addition, algal populations now are strongly dominated by the single blue-green algal species Aphanizomenon flos-aquae (cyanobacteria) rather than taxa that apparently dominated blooms before increased nutrient enrichment (Kann, 1998; Eilers et al. 2001).

Low dissolved oxygen and high pH values have been linked to high algal productivity in UKL (Kann and Walker, 2001; Walker, 2001). Chlorophyll *a* concentrations exceeding 200 µL are frequently observed in the summer months (Kann and Smith, 1993). Algal blooms are accompanied by violations of Oregon’s water quality standards for dissolved oxygen, pH, and free ammonia. Such water quality violations led to 303(d) listing of UKL in 1998 by ODEQ. ODEQ subsequently established TMDLs for UKL in May 2002 (ODEQ, 2002).

4.2.2 Link River

The Link River reach is approximately 1.2 miles in length. The upstream boundary of this reach is Link River dam (RM 254.6), which regulates the level of UKL. Link River dam releases water to the Link River, as well as to the East Side and West Side powerhouses and the USBR reclamation project**.** There are no known significant outflows or inflows in this reach. The reach extends to the headwaters of Keno reservoir (Lake Ewauna).

4.2.2.1 Hydrology

Link River is very short and water travels through this reach in a short time—about 1 hour. There are no major tributaries or withdrawals from the reach proper. The East Side powerhouse returns water on the river’s left bank about halfway down the reach, and the West Side powerhouse return is just above the confluence with Lake Ewauna on the right bank. Because of these diversions, releases from Link dam to the river channel proper may sometimes fall to the required minimum flows of 90 cfs or 250 cfs (as listed in Table 3.2-2) upstream of the East Side powerhouse. Both powerhouses are run-of-the-river hydroelectric facilities (versus peaking facilities), and operations at Link River dam are by and large governed by downstream demands and return flows (e.g., USBR, private agriculture, and wildlife refuges) and flow requirements below Iron Gate dam.

4.2.2.2 Water Temperature

The quality of water of the Link River reach is dominated by UKL, and thus water temperature conditions in Link River are similar to those in UKL. Over the course of a year, releases at Link dam range in temperature from near zero degrees Celsius in winter periods to over 25°C in summer periods. Because Klamath Lake is shallow, the release temperatures generally reflect variations in local meteorological conditions. Water temperatures in Link River upstream of the East Side powerhouse may experience some slight heating or cooling at low flows relative to UKL temperatures.

4.2.2.3 Nutrients and Algal Production

Levels of nitrogen and phosphorous vary considerably throughout the year in the UKL outflow at Link River dam, as well as over short periods, primarily in response to primary production. During the late fall through early spring, short days, limited light, and cold water temperatures result in low levels of primary production. Although nutrients are available, demand is low. During the warmer periods of the year, nutrient availability largely varies with the standing crop of phytoplankton in UKL. During bloom conditions, inorganic nutrient concentrations (e.g., NH_4^+, NO_3^-, PO_4^{3-}) may be low, while post-bloom conditions may result in higher inorganic nutrient concentrations. The organic matter (both living (e.g., algae) and dead) represents a considerable nutrient pool. Overall, the nutrient load from UKL is largely unchanged in the short Link River reach.

Phytoplankton that wash out of UKL pass through this reach in a short time. Benthic forms are limited to filamentous forms on the channel margins or shallow areas. Light penetration and the variable flow regime play a potentially critical role in benthic algae production. Seasonally, the appreciable phytoplankton counts and other particulate matter play a role in light extinction; however, throughout the year, the color of the water ranges in tint from a light to a strong tea. Light extinction measurements in the growth season suggest light limitation probably plays a key role in benthic algae production. The variable flow regime associated with operations of downstream water resource activities also presents a variable wetted channel that may limit algae growth.

4.2.2.4 Dissolved Gases

Dissolved oxygen conditions in the UKL outflow at Link River dam vary throughout the year. During winter months when temperatures and primary production are low, the dissolved oxygen levels remain close to saturation.[6] During the warmer period of the year, when primary production plays a role, the diurnal range and short-term variation can be considerable. Dissolved oxygen concentrations range from less than 2 milligrams per liter (mg/L) to more than 14 mg/L. Because the Link River includes several riffles, there is the opportunity for natural physical reaeration (mechanical reaeration) to occur within this reach. The role of algae in this short reach is not well understood. Field data suggest that conditions may be sufficient for phytoplankton to continue to photosynthesize and respire in portions of this reach, as is suggested by the larger daily diurnal range at the bottom of the reach than at the top.

4.2.2.5 Alkalinity and pH

Generally, the alkalinity of UKL at Link Dam is between 40 and 60 mg/L. This level of alkalinity represents a weakly buffered system (EPA, 1987). A weakly buffered system is predisposed to fluctuations in pH if sufficient primary production occurs (Horne and Goldman, 1994). Elevated pH can lead to increased toxicity of certain constituents (e.g., ammonia) (Colt et al. 1979; EPA, 1984). Changes in pH can lead to increased toxicity of certain constituents (e.g., ammonia). pH values range from 7.0 to 8.0 at Link River dam during winter periods, while during periods when significant primary production occurs pH values typically range from 8.0 to 10.0. Values above 8.5 to 9.0 can lead to ammonia toxicity. Alkalinity and pH are generally unchanged from the upstream end to the downstream end of this reach.

4.2.2.6 Summary and Relationship of Link River to System Water Quality

Link River is very short and water travels through the reach in a short time. The reach passes material from UKL to Keno reservoir with little or no change.

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[6] Saturation dissolved oxygen concentration is the theoretical value where concentration of dissolved oxygen in the water column is in equilibrium with the partial pressure of oxygen in the atmosphere. It is temperature and elevation dependent (Bowie et al. 1985).

4.2.3 Keno Reservoir

Keno reservoir extends from the headwaters of Lake Ewauna (RM 253.4) to Keno dam (RM 233.3). The impoundment is generally a broad, shallow body of water. The width of the reach ranges from several hundred to over 1,000 feet, with maximum depths along its length ranging from less than 6 feet to approximately 20 feet (Eilers, 2005). Municipal, industrial, and agricultural activities are located along this reach (ODEQ, 1995; USBR, 1992).

Currently, Keno reservoir experiences severe water quality impairment. These impairments include persistent summer anoxia for several miles of the river. This impairment, although variable, can extend from the bed to just a few inches below the water surface and from just downstream of Link River to Keno dam. Although the impacts of anthropogenic inputs are notable, and legacy impacts are present, the primary source of loadings to this system is UKL.

4.2.3.1 Hydrology

Under the direction of USBR, PacifiCorp maintains Keno reservoir at a near constant elevation during the irrigation season to facilitate diversions from the river to agricultural uses, and to meet Klamath wildlife refuge demands. Maintaining a near constant elevation can lead to variable flow conditions in the Klamath River below Keno dam. Facilities operated by USBR include the Lost River Diversion Channel (LRDC), North Canal, ADY Canal, and Klamath Straits Drain (KSD). The LRDC has a 3,000-cfs discharge (to the river) and 600-cfs diversion (from the river) capacity. The North Canal and ADY Canals have capacities of approximately 200 cfs and 400 cfs, respectively. The KSD is the primary drain for the Reclamation project and has a capacity of 600 cfs, but typically discharges from 50 to 200 cfs. Winter discharges from USBR operations typically are small (USBR, 1992).

One of the critical features of this reach is the impoundment of the Klamath River to form Keno reservoir. The result is a wide, relatively shallow reservoir with a residence time of approximately a week under typical spring through fall flow rates. A small, but noticeable velocity is generally apparent in the thalweg of the reservoir (i.e., an unanchored boat will drift downstream), leading to a condition that is similar to a slow, deep river.

Because water surface elevation of Keno reservoir is kept relatively constant most of the, inflows must be matched by the outflows. It follows that flows through Keno dam largely mimic those into Keno reservoir, namely releases from UKL plus the net USBR canal flows into Keno reservoir. A result of such operations is that the river below Keno may fluctuate to keep Keno reservoir elevation constant.

4.2.3.2 Water Temperature

Keno reservoir does not experience seasonal thermal stratification, but exhibits weak, intermittent temperature gradients during summer periods. Annual water temperatures range from near zero degrees Celsius to more than 25°C and are at or near equilibrium temperatures,[7] reflecting local meteorological conditions and the fact that UKL is generally at or near equilibrium. The inputs to the reservoir are usually small compared to the overall volume (although agricultural return flows can, at times, form a large percentage of the in-river flows), and are of similar temperature so as to not affect conditions appreciably. The reservoir freezes in some winters. Water temperatures of reservoir inflows are similar to water temperatures of reservoir outflows.

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[7] Equilibrium water temperature is the water temperature for a given set of meteorological conditions (Martin and McCutcheon, 1999). It is somewhat of a theoretical concept because of constantly changing meteorological conditions, but is nonetheless useful when considering water temperature conditions on a conceptual basis.

4.2.3.3 Nutrients and Algal Production

Nutrient conditions vary throughout the year in response to inputs from UKL and the role of primary production. Organic matter is a primary product from UKL to the downstream river reaches. This material may exist as living material (algae) or dead and decomposing material. Owing to the hypereutrophic nature of the lake, large quantities of material can be passed downstream—the highest BOD value recorded at Link Dam is over 50 mg/L. This problem is not recent, as noted by the state of Oregon et al. (1955), where it is stated that the large nutrient load and oxygen demand cause severe downstream impacts that are "equivalent to the raw sewage from a population of more than 240,000 persons" but that "94 percent of BOD is derived from natural causes." Beyond oxygen demand, organic matter, which may take on one of several forms (labile, refractory, particulate, and/or dissolved) (Wetzel, 2001), also contains organic forms of nutrients (N and P). These nutrients are transported downstream and upon breakdown of the organic matter are released and available for uptake by phytoplankton and benthic algae in downstream reaches (Elwood et al., 1983). One of the most notable aspects of the reach is the large amount of inorganic nutrients present during periods of anoxia (e.g., total inorganic nitrogen [nitrate and ammonia] is in excess of 1 mg/L, and orthophosphate values are in excess of 0.5 mg/L).

The agricultural return flows from the KIP typically have elevated nutrient levels, total dissolved solids, and BOD. Other agricultural diversions (private) have not been quantified, but the quality is presumably similar to the KIP return flows. Although the municipal and industrial inputs are small in quantity, they contribute waters that generally have elevated nutrient, total suspended solids, and BOD loads.

Under anoxic conditions, internal nutrient cycling from the sediments has been identified (Eilers and Raymond, 2003 and Raymond and Eilers, 2004). Of critical importance in this reach is that when the entire water column experiences anoxia, processes typically restricted to the bed (such as release of phosphorous and ammonia bound to organic or inorganic particles) can occur throughout the water column.

During winter, primary production in Keno reservoir is limited. During spring, when water temperatures are still cool, diatoms are present. As waters warm and day length increases, Keno reservoir often experiences an extensive algal standing crop. This standing crop is apparently the result of in-reservoir internal production, as well as wash-in of algae from UKL. Maximum concentrations of chlorophyll *a* at Link River are in excess of 250 µg/L, while concentrations in the Klamath River below Keno dam are generally well under 100 µg/L. However, at times of severe anoxia the reservoir has limited primary production, apparently as a result of the lack of available oxygen to meet algal respiratory demands.

Macrophytes grow seasonally in the shallow areas and margins in some reaches of Keno reservoir, and wetland plants such as cattails and bulrush occupy the shoreline margins throughout much of the reservoir. The total areal extent of macrophytes, with the exception of marsh areas, is relatively minor compared to open water areas of the reservoir.

To estimate nutrient retention (reduction) in Keno reservoir, PacifiCorp completed mass balance estimates on reach inflows and outflows for total nutrients. These analyses are not comprehensive mass balances accounting for all inflow and outflow within the reach. Rather, these results indicate loads at the top of the reach and at the bottom of the reach, and internal processes are implicitly included. Figure 4.2-1 shows the differences in total mass of nutrients (nitrogen and phosphorus) at the upstream and downstream end of Keno reservoir, and indicates that Keno reservoir is a net sink of total nitrogen and total phosphorous.

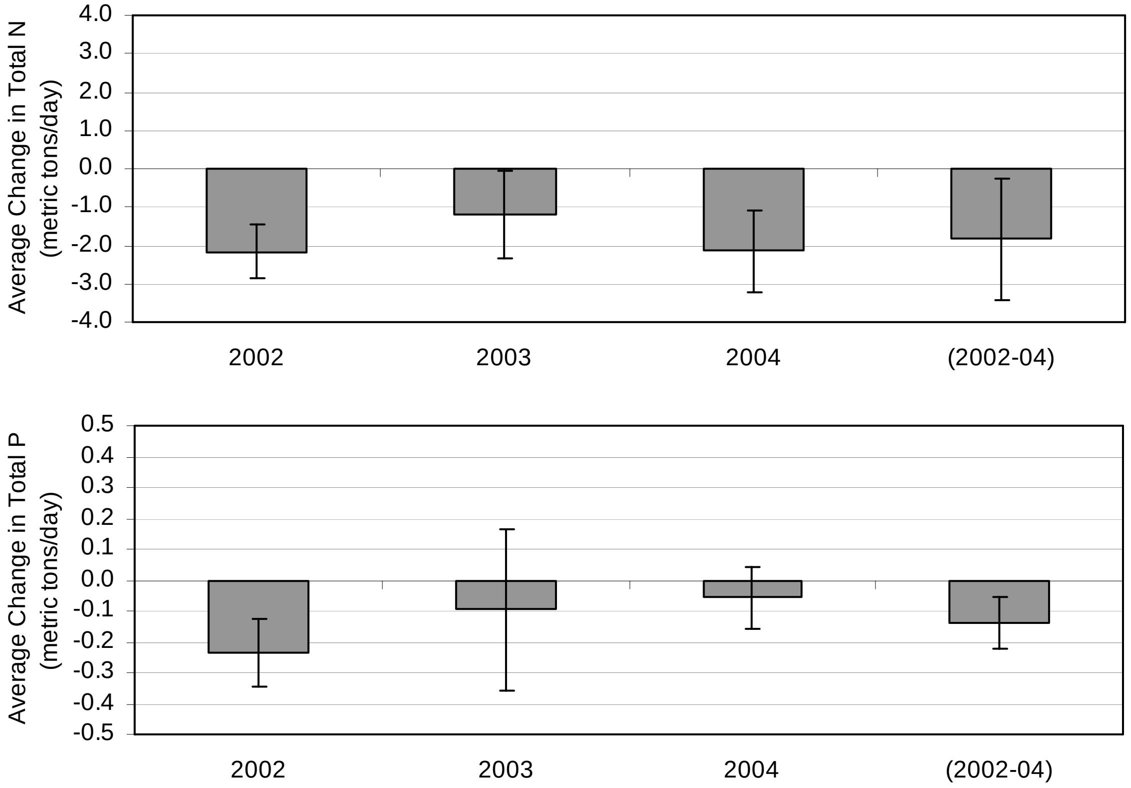

Figure 4.2-1. Annual change in total nitrogen (top plot) and total phosphorous (bottom plot), in metric tons/day, between Link River above Lake Ewauna and Klamath River below Keno Dam, 2002, 2003, 2004, and 2004-2004 (positive represents increase, negative represents decrease). The 90 percent confidence intervals are represented by error bars.

Additional information on nutrient conditions in the vicinity of the Project, including in Keno reservoir, are provided in documents filed in connection with the 401 Application, including the FERC Final License Application (FLA), Volume 2, Exhibit E—Environmental Report (PacifiCorp 2004b), the Water Resources Final Technical Report (PacifiCorp 2004e), and the report titled “Causes and Effects of Nutrient Conditions in the Upper Klamath River” (PacifiCorp 2006). As identified more than 50 years ago, Upper Klamath Lake provides a tremendous source of nutrients and organic matter to Keno reservoir that dramatically impact water quality conditions, particularly dissolved oxygen (Oregon State Sanitary Authority et al. 1955).

4.2.3.4 Dissolved Gases

Dissolved oxygen conditions vary seasonally in Keno reservoir. Winter conditions result in near saturation values for dissolved oxygen, while summer and fall values can remain well under saturation and may be near zero in some reaches for weeks. These conditions consistently occur, to one degree or another, each year. The source of the depressed dissolved oxygen is largely organic matter influx from UKL. Review of detailed vertical profiles at multiple sites along the longitudinal axis of the reservoir suggests that Keno reservoir experiences something akin to an oxygen sag (Tchobanoglous and Schroeder. 1985) in the vicinity of Miller Island.

One method of conceptualizing this process is to consider organic matter from UKL as a source of oxygen demand. Considering the reduced width of the Keno reservoir reach compared to UKL, a large portion of living algae is restricted to regions below the photic zone. The outcome is reduced vigor. Coupled with the weak stratification that can occur daily, and the current in Keno reservoir, the influent algal population from UKL suffers increased mortality. This creates substantial oxygen demand, which combines with other sources of oxygen demand (in-reservoir phytoplankton mortality; influent from municipal, industrial, and agricultural sources; nitrogenous biochemical processes; and organic matter in reservoir sediments) to produce persistent sub-saturation conditions for much of the reservoir during summer and into fall.

At times of severe anoxia, Keno reservoir is limited in primary production, apparently as a result of the lack of available oxygen to meet algal respiratory demands, consistent with Peterson (1996). Low dissolved oxygen concentrations persist well into October and may extend into November. Figure 4.2-2 shows dissolved oxygen isopleths in Keno reservoir for example dates in May, July, and October 2005, which depict the timing and magnitude of the reservoir's low dissolved oxygen conditions.

It is common to see some recovery in dissolved oxygen conditions by the time waters reach Keno dam. This may be due to residence time (e.g., processing time and settling), physical reaeration aided by windy conditions in the Keno area, primary production, or other factors. Conditions below Keno dam are generally improved due to reaeration during releases from the dam, where the configuration of radial gates can act to reaerate releases to some degree, and from natural mechanical aeration in the riverine environment downstream of the dam. Overall, dissolved oxygen concentrations are highly variable due to the variability of local conditions (e.g., phytoplankton blooms, meteorological conditions) in and around UKL.

4.2.3.5 Alkalinity and pH

Alkalinity increases seasonally in this reach in response to anthropogenic inputs. Values range from 50 to over 100 mg/L. However, at these levels, the system is still considered weakly buffered (EPA, 1987). The result is that pH values in the reservoir are similar to those at the Link River dam, with values ranging from 7.0 to 8.0 in winter and between 8.0 and 10.0 in summer. One deviation from this pattern is that during severe anoxia, pH values may fall to under 7.0 during summer and early fall periods where regions of low dissolved oxygen persist.

4.2.3.6 Summary and Relationship to System Water Quality

The net effect of Keno reservoir on water temperature is minimal, with inflow temperatures similar to outflow temperatures. Although dissolved oxygen conditions may be notably depressed within the impoundment, particularly during summer, conditions at the downstream end of the reservoir are generally similar to the upstream end. However, in the fall there are periods when dissolved oxygen conditions immediately below Keno dam are notably lower than in Link River. The overall effect on BOD and total suspended solids is reduced concentrations below Keno dam as compared to Link River. Specific conductance and alkalinity both show notable increases in this reach, presumably from the KIP agricultural return flows. pH is generally similar or higher at Link dam than at Keno dam.

This reservoir reach experiences highly variable, complex water quality conditions in response to hydrology (including water resources development), meteorology, and impaired water quality from UKL. The result of extensive temporal and spatial impairment, particularly with regard to low dissolved oxygen conditions, is a reduced ability to process organic matter and retain nutrients. Further, this impairment commonly leads to extensive fish die-offs as in 2005 (R. Piaskowski, USBR fish biologist, pers. comm.). Overall, these findings suggest that this reach is doing little to reduce total nutrient levels in the river under typical conditions.

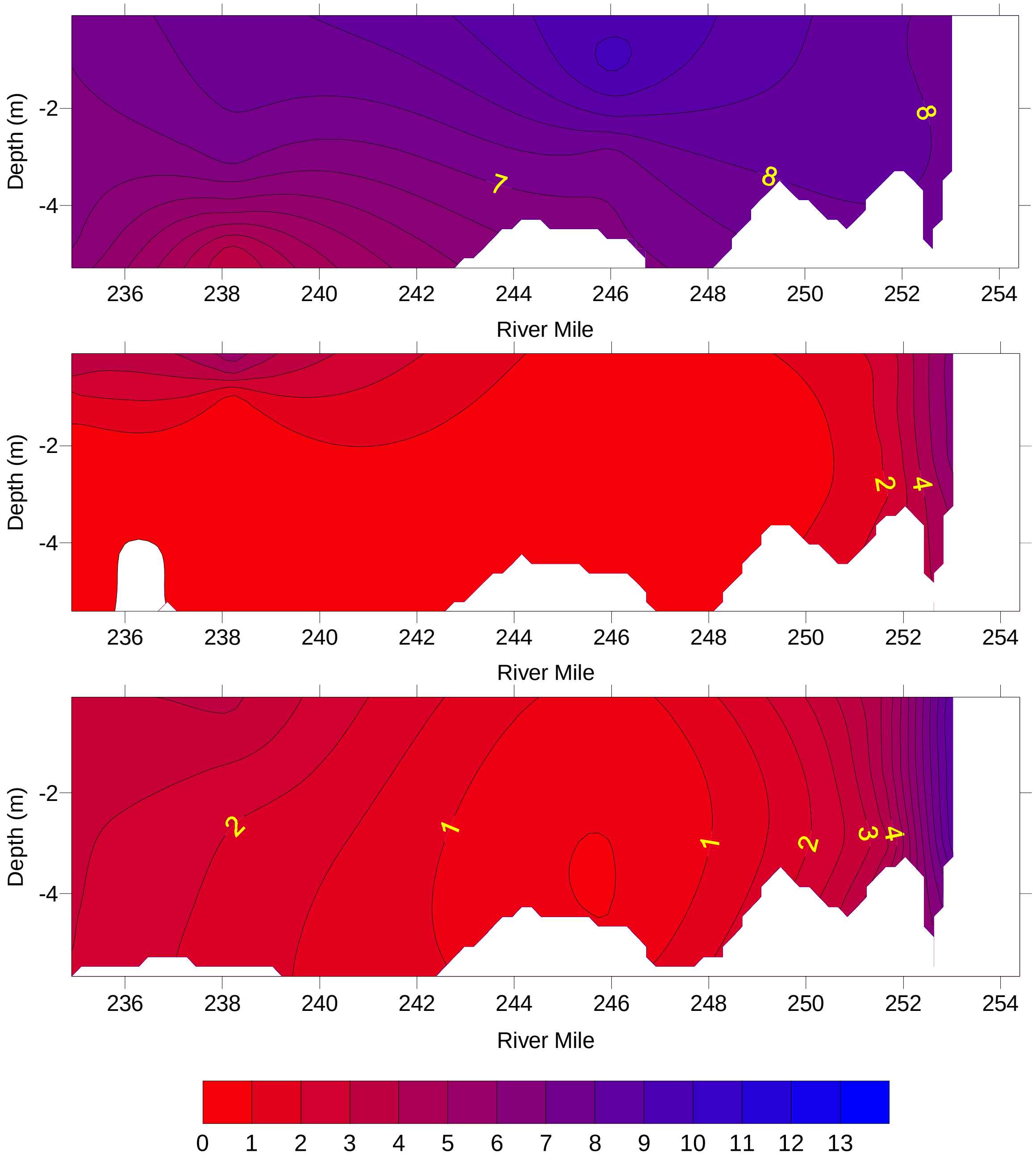

Figure 4.2-2. Dissolved oxygen isopleths (in mg/L) in Keno reservoir on May 3, 2005 (top plot), July 26, 2005 (middle plot), and October 18, 2005 (bottom plot). Data obtained from U.S. Bureau of Reclamation.

4.2.4 Keno Reach—Keno Dam to J.C. Boyle Reservoir

The Keno reach of the Klamath River extends from Keno dam (RM 233.3) to the headwaters of J.C. Boyle reservoir (RM 228.2).

4.2.4.1 Hydrology

There are no facilities in this reach and there are no appreciable tributaries, diversions, returns, or springs. A steep bedrock channel dominates the reach as the Klamath River traverses the Cascade Range. During the summer, operations associated with the maintenance of a constant water elevation in Keno reservoir result in variable flows in the reach. Flows can vary by several hundred cubic feet per second over a period of days or weeks. The residence time varies with flow, but is approximately 5 hours under summer flow conditions. Mean annual flow below Keno Dam is on the order of 1.12 MAF.

4.2.4.2 Water Temperature

Water temperatures in this reach vary along its length only modestly. The exception is that releases from Keno dam may experience only a modest diurnal range during warmer periods of the year due to the depth and volume of water upstream of the dam. However, by the time flows reach the headwaters of J.C. Boyle reservoir there is a notable diurnal cycle—in response to heat transfer across the air-water interface. As with other reaches, the thermal conditions of this reach are generally at or near equilibrium temperature.

4.2.4.3 Nutrients and Algal Production

Examination of field data at Keno dam and just above J.C. Boyle reservoir suggests that a portion of available ammonia converts to nitrate in route to J.C. Boyle reservoir, and that total inorganic nitrogen increases. This increase may be due to organic matter from Keno reservoir converting to inorganic nitrogen in this reach, resulting in a net increase. However, overall total nitrogen is almost unchanged in the reach. As with total inorganic nitrogen, inorganic phosphorous, as represented by orthophosphate, is slightly higher at the downstream end of the reach. Total phosphorous is similar at the top and bottom of this reach. Total organic carbon was also examined, and conditions at the top and bottom of this reach were nearly identical. Figure 4.2-3 shows the differences in total mass of nutrients (nitrogen and phosphorus) at the upstream and downstream end of Keno reach, and indicates that this reach is doing little to reduce total nutrient levels in the river under typical conditions.

Diurnal variations in dissolved oxygen concentrations above J.C. Boyle reservoir, as well as periphyton sampling, suggest that there is some level of primary production occurring in this reach (i.e., producing diurnal variations in excess of those associated with diurnal temperature fluctuations). However, the high velocities and variable flows, coupled with relatively high light extinction characteristic, probably limit attached algae production. Maximum chlorophyll *a* concentrations in the river above J.C. Boyle reservoir were approximately two to four times smaller than concentrations at Keno dam.

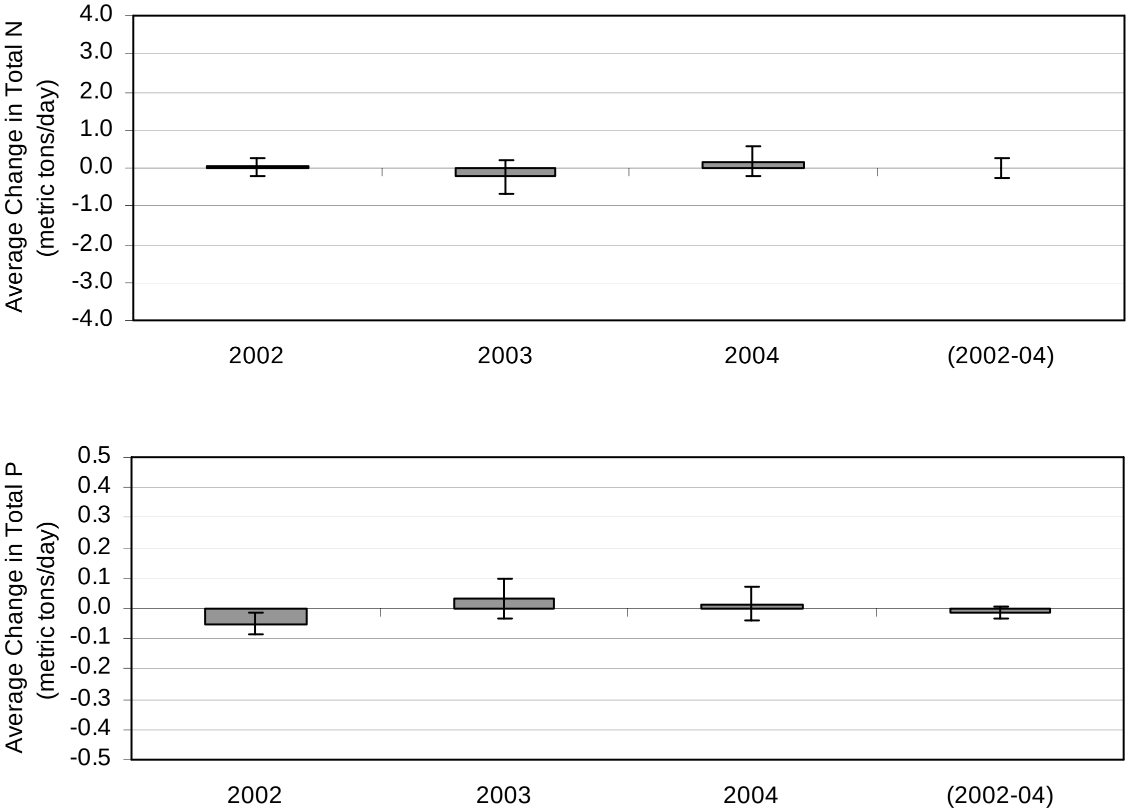

Figure 4.2-3. Annual change in total nitrogen (top plot) and total phosphorous (bottom plot), in metric tons/day, in the Keno reach of the Klamath River between Keno dam and J.C. Boyle reservoir, 2002, 2003, 2004, and 2004-2004 (positive represents increase, negative represents decrease). The 90 percent confidence intervals are represented by error bars.

4.2.4.4 Dissolved Gasses

Due to the steepness of this reach and the associated natural physical aeration, dissolved oxygen concentrations generally improve in this reach, approaching equilibrium conditions with the atmosphere. However, dissolved oxygen concentrations in the river are generally not completely (100 percent) saturated during the summer period, with values around 7 mg/L. This sub-saturation condition may be associated with the large organic load from upstream sources in UKL and Keno reservoir. Modest diurnal variations in dissolved oxygen concentrations above J.C. Boyle reservoir (that are in excess of that associated with diurnal temperature variations) suggest that there is some primary production occurring in this reach.

4.2.4.5 Alkalinity and pH

Alkalinity does not appreciably change in this relatively short reach. pH generally shows a seasonal reduction, with values at the lower end of the reach often less than at Keno dam during the summer. These lesser values are expected given the high levels of primary production in Keno reservoir inflows to the reach and the potential for entraining carbon dioxide via natural physical aeration in the reach.

4.2.4.6 Summary and Relationship to System Water Quality

The available data for the Keno dam to J.C. Boyle reach suggests that many water quality characteristics do not change appreciably: temperature, total nitrogen, total phosphorus, total organic carbon, alkalinity, pH, and specific conductance. There are exceptions. Notable changes occur in the inorganic forms of nitrogen, namely the nitrification of ammonia to nitrate, as well as the reduction in BOD—both of which would be expected in this relatively steep, free-flowing river reach with minimal inflows or outflows. The reduction in chlorophyll *a* is also expected, as viable phytoplankton (principally *Aphanizomenon*, but other species as well) washing out of Keno reservoir die or are reduced in vigor in the riverine environment. Water color and light extinction, coupled with variable flow regime, substrate, and high velocities also play important roles in this reach, further limiting benthic algae production (Hill, 1996; Stevenson, 1996; Peterson, 1996; Kirk, 1994).

The ability of river reaches to process organic matter and nutrients is a function of many factors, including flow volume, flow velocity and travel time, reach morphology, light extinction characteristics, and water quality of reach inflows (upstream and tributaries) (Kalff, 2002; Wetzel, 2001; Horne and Goldman, 1994). These factors vary in space and time. Examination of the Keno dam to J.C. Boyle reservoir reach sheds light on the broader issue concerning the potential for Klamath River reaches to process organic matter and nutrients. Overall, the reach appears to be providing conditions for oxidation of organic matter and ammonia (potentially other constituents as well); however, nutrient concentrations are unchanged or increase within the reach.

4.2.5 J.C. Boyle Reservoir

J.C. Boyle reservoir primarily serves to provide peaking flows for the J.C. Boyle powerhouse (RM 220.4). This reach extends from the headwaters of the reservoir (the end of the Keno reach at RM 228.2) to J.C. Boyle dam (RM 224.6). This reservoir has a total storage capacity of approximately 3,500 acre-feet, and the maximum depth is about 40 feet (Eilers, 2005). Spencer Creek is a minor tributary in this reach, entering near the headwaters of the reservoir.

4.2.5.1 Hydrology

Reservoir residence time ranges from less than half a day to over 2 days, depending on flows through the reservoir. The annual flow is increased slightly due to watershed contributions, predominately from Spencer Creek. Due to peaking operations, the water level in J.C. Boyle reservoir is prone to surface fluctuations of up to 2 feet per day and accumulated fluctuations of up to approximately 6 feet may occur over the course of several days. Releases to the river from J.C. Boyle dam downstream of the dam are set at 100 cfs, except during occasional periods in winter or spring when flows in the river are high enough (greater than about 3,000 cfs) that the reservoir is spilling.

4.2.5.2 Water Temperature

The short residence time, hydropower peaking operations, and modest depth (maximum depth is approximately 40 feet) of J.C. Boyle reservoir prevent the development of thermal stratification driven by solar heating of the reservoir. However, a slight temperature gradient is maintained in the reservoir as a result of the diurnal variation in the temperature of the influent river. Cooler water entering the reservoir at night tends to flow under the warmer water at the surface of the reservoir, while warmer water flowing in during the day tends to remain close to the surface. Average inflow temperatures are similar to average outflow temperatures because the inflow temperatures are at or near equilibrium temperature. The short residence time also contributes to this condition. As with Keno reservoir, the outflow temperatures exhibit a reduced diurnal variation due to the deep profile of the reservoir compared to shallow depths in typical river reaches. This reduced diurnal variation results in a maximum daily temperature that is lower in the reservoir's outflow than inflow.

4.2.5.3 Nutrients and Algal Production

The total nutrient concentrations in the reservoir's outflowing waters are often similar to those in inflowing waters. However, data indicate a consistent increase in ammonia in reservoir releases compared to inflows, particularly in the warmer months of the year. Nitrate concentrations are generally lower in release waters than reservoir inflows. The result is that inflow and outflow concentrations for total inorganic nitrogen are often unchanged. Total nitrogen is likewise similar among inflow and outflow, but there are times when inflow is higher than outflow and vice versa.

Orthophosphate values are quite similar between reservoir inflows and outflows. Total phosphorous is likewise similar, but there are times when inflow is higher than outflow and vice versa. Total organic carbon observations, although limited to 2004, suggest that values are equal to or lower in reservoir releases than in inflows. Figure 4.2-4 shows the differences in total mass of nutrients (nitrogen and phosphorus) at the upstream and downstream end of J.C. Boyle reservoir, and indicates that J.C. Boyle is not appreciably retaining (reducing) nutrient levels under typical conditions. This is in contrast to the larger downstream Copco and Iron Gate reservoirs, which retain (reduce) significant amounts of the annual load of nutrients that flow into those reservoirs. The lesser retention of nutrients in J.C. Boyle reservoir in comparison to Copco and Iron Gate reservoirs is attributed to the much shorter hydraulic retention or residence time in J.C. Boyle reservoir (e.g., on the order of 2 days in J.C. Boyle reservoir during average summer flow conditions, compared to 32 and 42 days, respectively, in Copco and Iron Gate reservoirs). Additional information on nutrient conditions in the Project reservoirs, is provided in documents filed in connection with the 401 Application, including the FERC Final License Application (FLA), Volume 2, Exhibit E—Environmental Report (PacifiCorp 2004b), the Water Resources Final Technical Report (PacifiCorp 2004e), and the report titled "Causes and Effects of Nutrient Conditions in the Upper Klamath River" (PacifiCorp 2006).

Algal species in mainstem reservoirs show a general succession typical of temperate regions (Kalff, 2002; Wetzel, 2002; Horn and Goldman, 1994). There is typically a large spring bloom of diatoms and chrysophytes when water temperatures are cooler (March and April). Dinoflagellates may reach appreciable numbers in May. Green algae increase to a peak in July, and Cyanophytes and cryptophytes typically reach their annual maxima in August. Average phytoplankton biovolume and chlorophyll *a* concentrations in J.C. Boyle reservoir are consistent with this pattern. Values are typically high in March, decrease in April into June, and increase to a peak in August. Biovolume and chlorophyll *a* values typically decrease considerably in September but might show a modest rebound in October and then decrease with the onset of cold temperatures and decreased light. These patterns and levels of primary production vary from year to year, with meteorological conditions, hydrology, and upstream water quality conditions playing important roles in the species timing, magnitude, and persistence, and in the duration of standing crop.

The short residence time produces a noticeable current in the reservoir, which is not generally conducive to phytoplankton populations. However, the reservoir morphology and setting allows primary production to generally persist from spring through fall. Specifically, there are large shallow areas that do not mix readily with the center of the reservoir or that create a broad enough cross section to slow velocities sufficiently to be conducive to algal growth. Generally, algal concentrations as represented by chlorophyll *a* are similar to or lower below J.C. Boyle reservoir than upstream of the reservoir, suggesting that although primary production is present, it is not of the same magnitude as in upstream areas such as UKL and Keno reservoir.

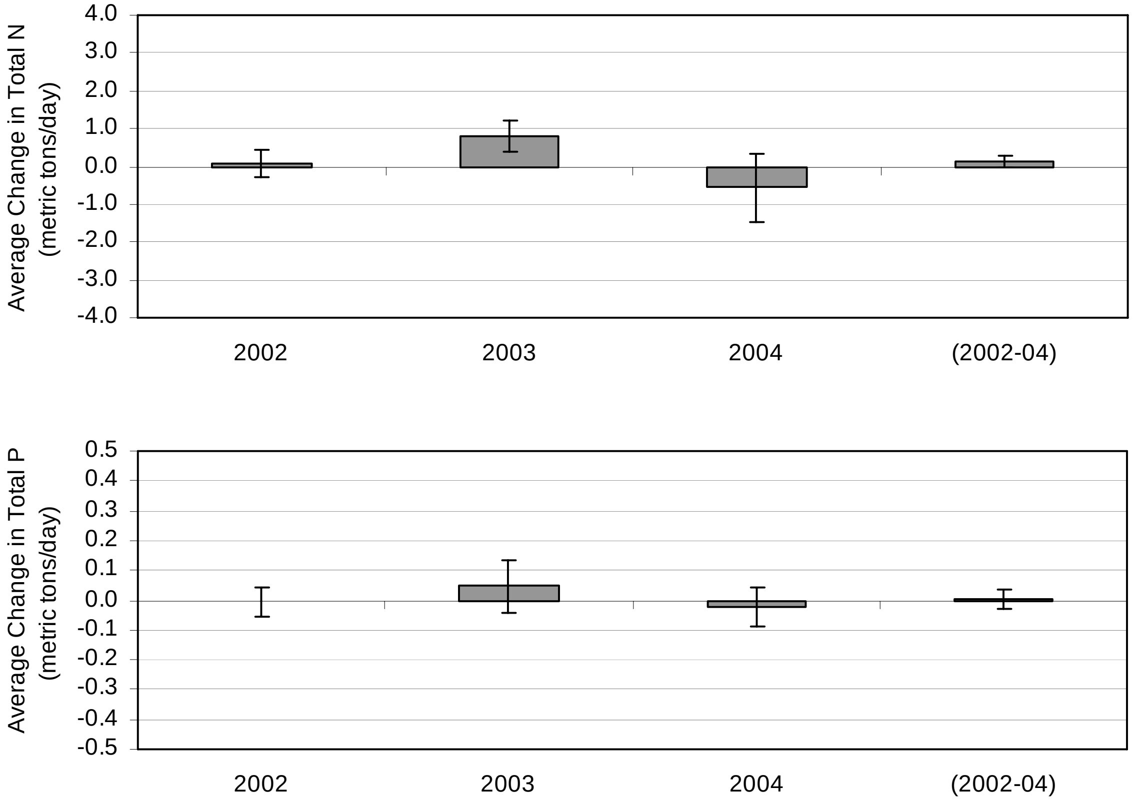

Figure 4.2-4. Annual change in total nitrogen (top plot) and total phosphorous (bottom plot), in metric tons/day, in the inflow versus outflow of J.C. Boyle reservoir, 2002, 2003, 2004, and 2004-2004 (positive represents increase, negative represents decrease). The 90 percent confidence intervals are represented by error bars.

4.2.5.4 Dissolved Gases

J.C. Boyle reservoir experiences dissolved oxygen concentrations that deviate from saturation—falling to about 3 mg/L at certain times of the year. The lowest dissolved oxygen levels are restricted to a relatively small volume of water in the deeper portions of the reservoir. Although primary production occurs in the reservoir surface waters, the organic matter input from upstream sources appears to be the primary source of low dissolved oxygen. Dissolved oxygen concentrations in water released from the reservoir are often similar to inflow concentrations, but there are periods when the released waters have lower concentrations than reservoir inflows as a result of interflow of cooler water with low dissolved oxygen that enters the reservoir at night.

4.2.5.5 Alkalinity and pH

These parameters do not appreciably change in this relatively short reservoir reach. pH values are generally equal to or lower below J.C. Boyle dam than upstream of the reservoir. An exception is that during summer periods, pH is occasionally higher below J.C. Boyle dam than above J.C. Boyle reservoir. These occasional high pH levels are expected given that primary production (phytoplankton) in J.C. Boyle reservoir can occur during these periods.

4.2.5.6 Summary and Relationship to System Water Quality

J.C. Boyle reservoir is eutrophic because of the large nutrient load from upstream sources and seasonally warm water temperatures. Inflowing waters are distributed throughout the depth of the reservoir as a result of the diurnal temperature change in the inflow. This distributes nutrients and organic matter vertically in the reservoir. Because the reservoir's hydraulic residence time is short and the photic zone is restricted to the near-surface waters, a potentially significant portion of the nutrients that flow into the reservoir pass through the reservoir. There is probably some settling of organic matter, but it is likely limited by the reservoir's short hydraulic residence time. This organic material is primarily from upstream sources (UKL, Keno reservoir). In general, the reservoir is not producing marked reductions or increases in nutrients or organic matter.

4.2.6 Bypass Reach—J.C. Boyle Dam to J.C. Boyle Powerhouse

The J.C. Boyle bypass reach extends from J.C. Boyle dam (RM 224.6) to J.C. Boyle powerhouse (RM 220.4)—a distance of approximately 4 miles. There is a minimum 100 cfs required release from J.C. Boyle dam to meet instream flow and fish ladder requirements. Large inflows enter the bypass reach through a series of springs that are distributed over approximately 1 to 2 miles of river.

4.2.6.1 Hydrology

Starting approximately a half-mile downstream of the dam, the first of several large springs enters the river. Within the next 1½ miles or so, the river gains some 220 to 250 cfs of spring input—resulting in a reach base flow of approximately 320 to 350 cfs. The residence time of this steep reach under non-spill conditions at J.C. Boyle reservoir is on the order of hours but can be considerably less under large spill events.

4.2.6.2 Water Temperature

The river immediately downstream of J.C. Boyle dam is similar in quality to the waters of J.C. Boyle reservoir. However, the springs that enter in this reach have a notable impact on conditions within this reach down to the J.C. Boyle powerhouse. The springs discharge water at a roughly constant 11°C temperature year round within much of the bypass reach. As a result of the spring inflows, the river temperature deviates substantially from equilibrium in summer and winter. During the winter, the springs provide warmer water to a river that otherwise may be less than 2°C, and in summer they provide cool water to a river that may exceed 25°C. Flows out of the bypass reach range in temperature from less than 10°C in winter to greater than 15°C in summer. There are periods in the spring and fall when the springs have little impact on water temperature due to the similarity of river and spring temperatures.

PacifiCorp notes that the existing instream flow release of 100 cfs from J.C. Boyle dam (which is also the proposed flow release in PacifiCorp's FLA) provides the best balance of preferred water temperature conditions and available physical habitat for redband/rainbow trout (*Oncorhynchus mykiss*) in the reach (PacifiCorp 2004b, 2004e, 2005a, 2005e). In comments to PacifiCorp's FLA, ODFW, NMFS, and CDFG recommended that PacifiCorp release a minimum flow of 640 cfs or 40 percent of inflow, whichever is more, from the dam into the J.C. Boyle bypass reach. BLM specified a similar flow, except that the minimum flow threshold would be 470 cfs rather than 640 cfs. The Hoopa Valley Tribe recommended that PacifiCorp discharge a continuous minimum flow of 500 cfs or 70 percent of inflow to the project, whichever is greater. Each of these recommendations included a provision for minimum flows to be reduced to inflows to J.C. Boyle reservoir when inflows drop below the recommended minimum flows. Technical analyses indicate that these higher instream flows would substantially impair water quality in the J.C. Boyle bypass reach by degrading the beneficial cooling effects of the 250 cfs of springs that discharge into the reach. Modeling by PacifiCorp demonstrates that as bypass release flows are incrementally increased above 100 cfs, water temperatures in the bypass reach are incrementally warmed to unsuitable levels (> 21°C), particularly at flow releases of 400 cfs or greater.

Independent water temperature predictions by Bartholow and Heasley (2005) for the J.C. Boyle bypass reach are similar to those of PacifiCorp as described above—that is, as bypass release flows are incrementally increased above 100 cfs, water temperatures in the bypass reach are incrementally warmed as the cooling benefits of the significant groundwater accretions in this reach are progressively diminished. Bartholow and Heasley's (2005) estimates suggest that a release from J.C. Boyle dam of 100 cfs retains a much more expansive region of high quality water temperature conditions throughout the J.C. Boyle bypass reach. In their discussion, Bartholow and Heasley (2005) state that:

> "These results should be useful in determining when release temperatures "drown" the thermal benefit of the cold water springs located in this segment and either lead to a thermal barrier at the downstream end of the bypass segment or not offer suitable cold water refuge throughout the segment."

4.2.6.3 Nutrients and Algal Production

Nutrient concentrations are generally reduced within this reach by dilution from spring inflows. The ratio of release from J.C. Boyle dam to spring inflows is approximately 1:2. Comparisons of total nitrogen, total phosphorous, and total organic carbon concentrations at the top and bottom of the reach indicate that in almost all instances concentrations are reduced consistently with this ratio, i.e., they are reduced by approximately two-thirds. There are periods when inorganic forms of nitrogen and phosphorous are equal or even greater at the bottom of the reach than at the top (particularly nitrate and orthophosphate). This may result from the conversion of organic matter to inorganic forms and the conversion of ammonia to nitrate via nitrification.

Estimating concentrations of the spring inflow with a simple mass balance using available field data suggests that a modest amount of background nutrients occur in the springs (e.g., approximately 0.15 mg/L of PO_4^{-3} and NO_3^-), with only small or zero concentrations of organic forms.

Based on chlorophyll *a* concentrations at the top and bottom of the reach, it is apparent that release waters from J.C. Boyle reservoir introduce phytoplankton into the downstream river reach. The general physical aspects of this reach are not conducive to phytoplankton growth and limit attached algae forms (Wetzel, 2001; Borchardt, 1996; Reynolds and Descy, 1996; Reynolds, 1994). These features include bedrock or large substrate channel forms; steep, high velocity reaches; and topographic shading. Typical forms of algae include periphyton and limited filamentous species in the low gradient upper portion of the reach and on channel margins (Reynolds and Descy, 1996; Reynolds, 1994). The limited range present in the dissolved oxygen field observations may or may not be indicative of photosynthetic and respiratory activity associated with primary production. Field monitoring in this reach has suggested that steep, extensive rapids often result in maintaining the river at or near saturation through natural mechanical reaeration. However, at times pH at the bottom of this reach is higher than at the top, suggesting that there is sufficient algal photosynthesis in this weakly buffered system to affect pH.

4.2.6.4 Dissolved Gases

Dissolved oxygen conditions of the spring inputs are apparently at or near saturation. Direct field measurements are not available because the springs emanate from beneath extensive talus slopes. Large volume springs with high elevation source water, such as the springs located in the bypass reach, tend to have relatively rapid transit times (in relation to typical groundwater movement) from source to discharge location. Because the source water is at or near saturation and there is little organic matter in the source water or rock matrix, the spring inputs are presumed to have oxygen levels at or near saturation. There is a modest diurnal variation in observed dissolved oxygen concentrations above the powerhouse in the summer. A portion of this may be due to diurnal temperature differences, with the balance the result of modest levels of primary production.

4.2.6.5 Alkalinity and pH

The spring inflows apparently have a lower alkalinity than the river water—at least seasonally—and downstream concentrations are generally lower than those below J.C. Boyle dam, i.e., weakly buffered. pH values are generally similar at the top and bottom of the reach, although the values tend to be somewhat higher at the bottom than at the top.

4.2.6.6 Summary and Relationship to System Water Quality

This short residence time reach is largely dominated by the spring inflow, with the exception of occasional periods in winter or spring when river flows are high enough (greater than about 3,000 cfs) that J.C. Boyle reservoir is spilling. If the spills are sufficiently large (on the order of 600 to 800 cfs), the river dominates the spring inputs. The total nitrogen, phosphorous, and organic carbon data suggests that the principal “process” in this reach is dilution. The physical constraints of high velocity, substrate, and possibly light (topographic shading and/or color in the upper reaches) limit the ability to support a large standing crop of attached algae. Other processes in this reach include natural physical reaeration, which creates sufficient conditions to support oxidation of organic and inorganic nutrient forms (Chapra, 1997). Thermal conditions within the reach during the summer are well below equilibrium conditions in response to the large, cold spring inflows.

4.2.7 Peaking Reach—J.C. Boyle Powerhouse to Copco Reservoir

The J.C. Boyle peaking reach extends from J.C. Boyle powerhouse (RM 220.4) to the California border at RM 209 and beyond to the headwaters of Copco reservoir (RM 203.1). Noteworthy features of the reach include the powerhouse penstock return and the influence of the bypass reach flows. There are few small streams entering the reach, the most significant being Shovel Creek, which enters the California portion of the reach at RM 206.4. Water quality conditions vary considerably from low flow conditions that are dominated by spring accretions flowing out of the bypass reach, to high flow conditions where powerhouse releases (equivalent to J.C. Boyle reservoir release water quality) dominate the downstream water quality.

4.2.7.1 Hydrology

The peaking operations at J.C. Boyle produce a daily flow fluctuation in the reach as flows range from the baseflow out of the bypass reach (300 to 350 cfs) to about 1,500 cfs (with one-unit peaking) or about 3,000 cfs (with two-unit peaking) during generation. Under low flow conditions (powerplant off-line), the reach is dominated by Bypass reach waters. This low flow condition generally occurs during the late evening hours to the mid-to late-morning, as well as other periods when the powerhouse is off-line. Peaking operations generally take place from mid- to late-morning to late afternoon and into the evening.

The mean annual flow for the Klamath River below the J.C. Boyle powerhouse (USGS 11510700) is 1.295 MAF (million acre-feet) per year, which is approximately 115 percent of the mean annual flow at Keno. Residence time through the reach varies depending on flow conditions. During peaking operations transit time may range from 8 to 10 hours, while under low flow conditions the transit time may be twice as long.

4.2.7.2 Water Temperature

Inflow temperatures from the bypass reach and the powerhouse can differ considerably during the summer and winter periods due to the groundwater inputs from springs in the bypass reach. The two flows are generally well mixed within a short distance downstream due to the configuration of the powerhouse discharge and downstream river reach, and the large flow rates associated with peaking power production. During winter months, the combined flow below the powerhouse is often above equilibrium temperature due to bypass reach contributions, and waters may cool in the downstream direction. During summer periods the combined flow is often less than equilibrium and waters may warm en route to Copco reservoir. During low flow conditions, the water may heat or cool faster because of the shallow depths, smaller flow volume and increased transit times, i.e., the river approaches or reaches equilibrium more quickly for smaller flows than for larger flows.

During the warmer periods of the year, the river heats in the downstream direction, with a diurnal range of over 5°C at times. Water temperatures at the lower end of this reach may be 1°C to 4°C cooler than releases from J.C. Boyle dam during June through September, indicating not only the impact of the cool spring inflow on mainstem temperatures, but also the impact of operations and flow timing on the thermal regime. The peaking operations, combined with constant temperature spring inputs in the bypass reach, may also impose unique temperature signals on the river above Copco reservoir.

Additional information on water temperature conditions in the J.C. Boyle peaking reach is provided in Section 5.2.3.

4.2.7.3 Nutrients and Algal Production

Nutrient conditions also respond to variations due to peaking operations. Nitrate concentrations in the Klamath River above Copco reservoir can increase 30 percent between non-peak and peaking periods. Ammonia and phosphate also respond to the flow regime, but not as dramatically. Total nitrogen, phosphorous, and organic carbon are generally lower at the bottom of the J.C. Boyle peaking reach than at the top. It appears that only modest changes in nutrients occur within the relatively short residence time, with the exception of reduction via dilution. Phytoplankton generally perform poorly in river conditions, and increased depths, high velocities, significant light extinction, and boulder/bedrock substrate limit benthic algae, thus limiting the ability of nutrients to be acquired by aquatic plants.

Conditions within the peaking reach probably lead to only a limited capacity for algal biomass to utilize available nutrients due to scour, light limitations due to colored water and suspended matter, the inability of phytoplankton to persist in the riverine environment, and short residence time (Reynolds, 1994; Stevenson, 1996). Field observations indicate that the standing crop of attached algae is modest, with some filamentous algae on the channel margins and among partially submerged boulders, and limited periphyton growth.

Additional information on nutrient and production conditions in the J.C. Boyle peaking reach is provided in Section 5.2.11.

4.2.7.4 Dissolved Gases

Dissolved oxygen conditions in the peaking reach are variable due to the flow regime (low and high flow conditions). In the upper portion of this reach, the river is steep and punctuated by several large rapids. In the vicinity of the California border, the slope of the river lessens but is still steep. Natural physical reaeration in the larger, more extensive rapids results in dissolved oxygen conditions at or near saturation (Chapra, 1997; Thomann and Mueller, 1987). However, primary production also plays a role in dissolved oxygen during the growing season (Wetzel, 2001). Primary production occurs in this reach, but is modest for the reasons described above. The diurnal range in dissolved oxygen at the California border is close to 2 mg/L, while above Copco reservoir it can exceed 2 mg/L. These levels, over a daily average, suggest the system is running under 100 percent saturation during the summer months. This condition may be associated with the appreciable organic load imparted on the reach from upstream sources.

Additional information on dissolved oxygen conditions in the J.C. Boyle peaking reach is provided in Section 5.2.1.

4.2.7.5 Alkalinity and pH

Alkalinity concentration does not change dramatically within this reach. The system remains well under 100 mg/L, indicating the system is still weakly buffered (EPA, 1987). Even with modest primary production the pH in the reach downstream of the powerhouse can range from approximately 8.0 to over 8.7 during the summer. During the late fall through early spring, the pH is generally at or under 8.0.

Additional information on pH conditions in the J.C. Boyle peaking reach is provided in Section 5.2.1.

4.2.7.6 Summary and Relationship to System Water Quality

The J.C. Boyle peaking reach is a highly dynamic reach. Inflows from the bypass reach provide dilution and reduce overall nutrient concentrations accordingly. Physical reaeration may create an oxidative environment that allows decay of organic matter and nitrification to proceed. Field data suggest that the river dissolved oxygen concentrations generally are under saturation during summer periods, a condition that is presumed to be associated with the organic load from upstream sources. The impact of upstream agricultural operations can occasionally be observed in the specific conductance above Copco reservoir, indicating a direct connection between the upper basin and the bottom portion of the peaking reach.

Upstream of Copco reservoir, water temperature and dissolved oxygen are close to equilibrium and 100 percent saturation, respectively. Algae, as represented by chlorophyll *a* (APHA, 1995), steadily drops with distance from Keno dam. From spring through summer, on average, total nitrogen concentrations are some 30 percent lower, total phosphorous drops to a lesser degree, and total organic carbon concentrations are reduced approximately 30 to 40 percent. These values are close to the dilution ratio of the springs to total mainstem flows during the summer period.

4.2.8 Copco Reservoir Complex

The Copco reservoir complex includes Copco reservoir and both Copco No. 1 and Copco No. 2 developments. Because the reach below Copco No. 2 dam is relatively short and transit time is likewise short, discussion will focus on Copco reservoir. Copco reservoir extends 4.6 miles from Copco dam at RM 198.6 to the reservoir headwaters at RM 203.2. There are no major tributaries in this reach. The reservoir has a storage capacity of approximately 40,000 acre-feet and is its maximum depth is approximately 115 feet (Eilers, 2005).

4.2.8.1 Hydrology

Copco reservoir's hydraulic residence times range from a few days under winter high flow events to approximately 2 to 3 weeks under typical summer conditions. Because the reservoir stratifies during the warmer periods of the year, the deeper waters of the reservoir have a longer residence time than the intermediate surface waters. Reservoir profiles suggest density dependent interflow or intrusion occurs within the reservoir, affecting residence time estimations (Fischer et al. 1979; Ford, 1990). Because of these density driven flow conditions, the surface waters may have a residence time that is longer than 2 to 3 weeks. These conditions play an important role in water quality response of the reservoir to upstream fluxes.

4.2.8.2 Water Temperature

The onset of seasonal stratification typically occurs in mid to late March, and the breakdown of stratification in October. Fall cooling (e.g., cold fronts) acts to cool river flows, which can subsequently "plunge" to deeper levels in the reservoir and contribute to destratification. The minimum temperatures at the bottom of this reservoir during mid-summer and early fall are typically in the range of 12°C to 14°C. This cool pool of water is relatively small (approximate annual minimum is less than 2,000 AF).

During the spring months, the reservoir tends to minimize deviations from seasonal mean temperatures, i.e., the relatively deep water release moderates short term response in water temperature to deviations in meteorological conditions ("hot" or "cold" spells). During late spring and mid-summer, the reservoir releases are generally below equilibrium. In the fall, reservoir release temperatures tend to be above equilibrium temperatures of the Klamath River upstream and downstream due to the seasonal loading (summer) and large thermal mass of the reservoir. This thermal lag is perceptible in late August and persists through the fall period, with the maximum deviation from equilibrium of approximately 5°C in fall. Fall turnover does not immediately ameliorate this condition; rather continued cooling in response to meteorological conditions and river inflows results in an isothermal condition that is near equilibrium. Throughout the year, diurnal range of release temperatures is moderated by the volume of the reservoir. Due to these dynamics of the reservoir and upstream river, release waters are sometimes warmer and sometimes cooler than the inflowing river.

Additional information on water temperature conditions in Copco reservoir is provided in Section 5.2.3.

4.2.8.3 Nutrients and Algal Production

Copco reservoir acts as an annual net sink for both total nitrogen and total phosphorous (Kann and Asarian, 2005). Reservoirs can act as traps, reducing organic matter, nutrient, and particulate matter (Thornton, 1990; Ward and Stanford, 1983). There are periods during the growth season when the reservoir may act as a source of nutrients; however, careful consideration of upstream fluxes and residence time are critical. Transit time from UKL at Link dam to Copco reservoir is approximately 10 days and on the order of 2 to 3 days from Keno dam under typical summer flows. Thus, upstream (UKL and Keno reservoir) algal blooms and die-offs, fish die-offs, severe anoxia and the associated water quality conditions may reach Copco reservoir in a matter of days. At times, these upstream conditions produce large quantities of organic matter and can increase the nutrient fluxes into the reservoir substantially. However, the subsequent impact on Copco reservoir water quality does not occur instantly, but rather over several days or weeks because of both the duration of the upstream conditions and the residence time of the reservoir. As a result of this time lag, it is expected that the reservoir will occasionally experience nutrient fluxes in release waters greater than that in inflowing waters. For example, following a bloom event in the upper system (UKL, Keno), poor water quality conditions abate and the level of impairment diminishes, and inflowing waters to Copco begin to improve. Simultaneously, however, Copco reservoir will still be responding to previous inputs of nutrients and organic matter from upstream sources.

Algal species in mainstem reservoirs like Copco reservoir show a general succession typical of temperate regions (Kalff, 2002; Wetzel, 2001; Horn and Goldman, 1994). Typically, a large spring bloom of diatoms and chrysophytes occurs when water temperatures are cooler (March and April). Dinoflagellates may reach appreciable numbers in May. Green algae increase to a peak in July, and Cyanophytes (blue-green algae) and cryptophyes typically reach their annual maxima in August.

Average phytoplankton biovolume and chlorophyll concentrations in Copco reservoir are consistent with this pattern. Values are typically high in March, decrease in April into June, and increase to a peak in August. Biovolume and chlorophyll *a* values typically decrease considerably in September, but might show a modest rebound in October and then decrease after the end of the growing season with the onset of cold temperatures and decreased light. These patterns and levels of primary production are not consistent from year to year, with meteorological conditions, hydrology, and upstream water quality conditions playing important roles in the species timing, and magnitude, persistence, and duration of standing crop.

Under normal conditions, there is an appreciable load of nutrients and organic matter flowing into the reservoir from the substantial upstream sources of UKL. Under certain conditions, the loads of nutrients and/or organic matter entering the reservoir from these upstream sources is so high that Copco reservoir can be overwhelmed—somewhat similar to how UKL discharge conditions overwhelm Keno reservoir during summer periods. Under such conditions, Copco reservoir can assume characteristics more consistent with a hypereutrophic system, experiencing large, persistent algae blooms and subsequent die-offs. These conditions can persist for weeks during the warmer part of the year and contribute to nuisance algae being present in large numbers.

Nuisance bloom-forming blue-green algae, such as *Aphanizomenon* and *Microcystis,* have been observed to form large blooms in the reservoir during summer. This succession is consistent with other systems where these species are prevalent, with controlling factors potentially linked to macronutrient (e.g., nitrogen) and micronutirent (i.e., iron) limitation. *Aphanizomenon* is usually the dominant bloom-forming species, although large blooms of *Microcystis* have been observed recently, particularly in late summer. Certain conditions favor *Microcystis* over *Aphanizomenon*. For example, an abundance of ammonia gives a competitive edge to *Microcystis*. Large populations of *Microcystis* cannot be created nor sustained by recycling the relatively small pool of nutrients in the photic zone—a bloom of *Microcystis* must be supplied partially by ammonia from another source. This source may be derived from anoxic sediments, recycling of organic and inorganic material through bacterial processes, or inflow (Horne and Goldman, 1994). Sustained *Microcystis* blooms in Copco reservoirs are consistent with the potentially elevated levels of inorganic nitrogen (ammonia) and organic matter in influent waters, particularly if iron is limiting *Aphanizomenon* during some summer periods.

Overall, the nutrient processes at work in Copco Reservoir are complex. The fate of inflowing nutrients (organic and inorganic), subsequent decay of organic forms to inorganic forms, uptake of inorganic nutrients by algae, the role of nutrient release from sediments (under anoxic conditions), and other processes may play a role in reservoir processes (Horne and Goldman, 1994, Kalff, 2002; Wetzel, 2001). Nonetheless, field observations suggest that Copco reservoir water quality responds strongly to variations in the quantity and quality of the inflow from upstream sources, i.e., UKL.

Additional information on nutrient and production conditions in Copco reservoir is provided in Section 5.2.11.

4.2.8.4 Dissolved Gases

Dissolved oxygen conditions in Copco reservoir vary seasonally as a result of thermal stratification, seasonal water temperature variations in inflowing waters, and seasonal nutrient loading and organic matter from upstream sources. Under purely isothermal conditions, dissolved oxygen concentrations are generally at or near equilibrium (Wetzel, 2001); however, even small temperature differences can impede mixing that can lead to localized anoxia, e.g., in bottom waters (Cole and Hannan, 1990). Under stratified conditions, seasonal anoxia of bottom waters occurs. The onset of anoxic conditions occurs initially in bottom waters (typically commencing in May through June), reaching a maximum in July when roughly the bottom 60 feet of the reservoir can have dissolved oxygen concentrations less than 1.0 mg/L.

The reservoir is productive, leading to dissolved oxygen concentrations in surface waters during the growth season at, or even above, saturation. Copco reservoir releases from mid-summer through mid-fall are typically below saturation, with minimum values in late September to early October reflecting the subsaturated conditions within deeper portions of the reservoir.

Additional information on dissolved oxygen conditions in Copco reservoir is provided in Section 5.2.1.

4.2.8.5 Alkalinity and pH

Alkalinity and pH conditions in Copco reservoir vary seasonally and with depth. Generally, during winter isothermal conditions the pH ranges from below 7 to about 8. With the onset of thermal stratification, pH in surface waters can reach levels above 9 units due in large part to primary production in these weakly buffered waters that are typical of UKL and the Klamath River. When anoxia is present in the lower portions of the reservoir, it is not uncommon for pH values to fall below 6, even during summer periods.

Alkalinity concentrations generally show a seasonal trend with lower values (e.g., less than 60 mg/L) in winter periods and slightly higher values (e.g., 70 to 80 mg/L) during summer. The change is presumed to be partly associated with irrigation water returns to the river from agricultural activities in the upper basin (the alkalinity of return flows in the upper basin might be on the order of 250 mg/L); however, vertical variations also occur. These variations may be due to stratification that “traps” lower alkalinity water below the thermocline.

Additional information on pH conditions in Copco reservoir is provided in Section 5.2.2.

4.2.8.6 Suspended Sediments and Turbidity

Total suspended solids are generally lower below Copco dam than upstream of the reservoir. Owing to the relatively long residence time of the reservoir, this result is not unexpected.

Additional information on suspended sediments and turbidity conditions in Copco reservoir is provided in sections 5.2.5 and 5.2.9.

4.2.8.7 Summary and Relationship to System Water Quality

Copco reservoir is the first relatively large, deep reservoir on the Klamath River mainstem below UKL. As such, it bears the burden of accepting and processing the water quality that is ultimately borne out of UKL and any agricultural and municipal/industrial return flows. The result of these substantial upstream loads is a eutrophic reservoir.

Copco reservoir is generally productive during summer months, but can produce large nuisance algal blooms if the influx of nutrients via the inflow increases in response to upstream conditions (e.g., large algal blooms, severely impaired water quality conditions from upstream). In general, field data suggest that Copco Reservoir acts as a net sink for both total nitrogen and phosphorous. The transit time from the upper basin, the reservoir residence (or transit) time, and stratification in Copco reservoir each play important roles in this regard. Such basin-scale processes are important to understanding the character of water quality in Copco reservoir and downstream reaches.

4.2.9 Iron Gate Reservoir

Iron Gate reservoir reach extends from Iron Gate dam at RM 190.5 to the reservoir's headwaters at RM 196.7. Three tributaries enter Iron Gate reservoir: Camp Creek, Jenny Creek, and Fall Creek. Camp Creek is a small seasonal creek. Jenny Creek occupies a large watershed and historically had appreciable flows, but to a large extent has been diverted into the Rogue River basin. Fall Creek is a small, but persistent spring creek, with a portion of the water diverted as a water supply for the city of Yreka. The reservoir has a storage capacity of approximately 50,000 acre-feet, and a maximum depth of 162 feet (Eilers, 2005).

Iron Gate reservoir is located approximately 1.5 miles below Copco reservoir, and the two reservoirs essentially act in series because the Copco No. 2 powerhouse discharges waters directly into Iron Gate reservoir headwaters. In many ways, Iron Gate reservoir is similar to Copco reservoir in thermal stratification, dissolved oxygen conditions, and water quality response. However, the implications of receiving discharge from an upstream reservoir versus a river reach play an important role in this eutrophic reservoir, as do processes within the reservoir.

4.2.9.1 Hydrology

Iron Gate reservoir's hydraulic residence times range from a few days under winter high flow events to approximately 3 to 4 weeks under typical summer conditions. Because the reservoir stratifies during the warmer periods of the year, the deeper waters of the reservoir have a longer residence time than the intermediate surface waters. Reservoir profiles suggest density dependent interflow or intrusion occurs within the reservoir, affecting residence time estimations (Fischer, 1979). Because of these density-driven flow conditions, the surface waters may have a residence time that is longer than 3 to 4 weeks. These conditions play an important role in water quality response of the reservoir to upstream fluxes.

The mean annual flow below Iron Gate dam (USGS 11516530) is 1.5 MAF, which is approximately 133 percent of the mean annual flow approximately 43 miles upstream at Keno in Oregon.

4.2.9.2 Water Temperature

The onset of seasonal stratification in Iron Gate reservoir typically occurs in mid to late March, and the breakdown of stratification in November. Iron Gate reservoir thermal profiles indicate a strong seasonal thermal stratification. Copco reservoir provides fairly constant temperature inflows to Iron Gate reservoir, usually representing a general seasonal response but with little or no short term (e.g., daily) temperature variation. Thus, unlike Copco reservoir that experiences a large range of inflow temperatures in the fall from the river upstream, Iron Gate reservoir generally experiences fall turnover approximately 3 to 4 weeks after Copco reservoir. This delay in destratification is in response to a fairly stable inflow temperature from Copco reservoir. The associated contribution of variable temperature inflows to destratification is thus reduced, and the role of convective cooling plays a more prominent role in fall destratification of Iron Gate reservoir (Fischer, 1979).

The minimum temperatures at the bottom of Iron Gate reservoir during mid-summer and early fall are typically in the range of 7°C to 8°C. The bottom waters of Iron Gate reservoir are appreciably cooler than Copco reservoir owing to the larger size of Iron Gate and the generally stable (short-term) inflow temperatures from Copco No. 2 powerhouse releases to Iron Gate reservoir. These conditions create a fairly isolated hypolimnion (approximate annual minimum 5,000 AF) and minimize mixing into the deeper portions of Iron Gate reservoir. The Iron Gate fish hatchery also draws on this cold water volume.

During the spring months, Iron Gate reservoir tends to minimize deviations from seasonal mean temperatures, i.e., the relatively deep water release moderates short term response in water temperature to deviations in meteorological conditions (“hot” or “cold” spells). During late spring and mid-summer, the reservoir releases are generally below equilibrium. In the fall, reservoir release temperatures tend to be above equilibrium temperatures of the downstream Klamath River because of the large mass of the reservoir (compared to the river). This thermal lag is perceptible in late August and persists through the fall period.

Fall turnover does not immediately ameliorate this condition. Rather, continued cooling in response to meteorological conditions and river inflows results in an isothermal condition that is near equilibrium. Throughout the year, the diurnal range of release temperatures from Iron Gate reservoir is moderated by the volume of the reservoir. Owing to the mass of Iron Gate and Copco reservoirs (and the resulting thermal lag effect), release waters from Iron Gate dam are sometimes warmer and sometimes cooler than the inflows from the Copco No. 2 powerhouse. However, temperatures below Iron Gate dam are mostly cooler than the inflows from the Copco No. 2 powerhouse because of contributions from deeper cooler waters in Iron Gate reservoir.

Additional information on water temperature conditions in Iron Gate reservoir is provided in Section 5.2.3.

4.2.9.3 Nutrients and Algal Production

Iron Gate reservoir is eutrophic largely due to nutrient inputs (organic and inorganic) from upstream sources; tributary inputs are insignificant in comparison to Klamath River inflows. Iron Gate reservoir acts as an annual net sink for both total nitrogen and total phosphorous (Kann and Asarian, 2005). Reservoirs can act as traps, reducing organic matter, nutrient, and particulate matter (Thornton, 1990; Ward and Stanford, 1983). There are periods during the year when the reservoir may act as a source of nutrients. However, as with Copco reservoir, careful consideration of upstream fluxes and residence time are critical. At times, these upstream conditions may produce large quantities of organic matter and can increase the nutrient fluxes into Iron Gate reservoir substantially. However, the subsequent impact on Iron Gate reservoir water quality does not occur instantly, but rather over several days or weeks due to both the duration of the upstream conditions and the residence time of the reservoir. Because of this time lag, it is expected that the reservoir will occasionally experience nutrient fluxes in release waters greater than that in inflowing waters.

Overall, the nutrient processes at work in Iron Gate reservoir are complex. The fate of inflowing nutrients (organic and inorganic), subsequent decay of organic forms to inorganic forms, uptake of inorganic nutrients by algae, the role of nutrient release from sediments (under anoxic conditions), and other processes play a role. Field observations suggest that Iron Gate reservoir water quality responds strongly to inflow quantity and quality of the inflow. The annual contribution to the reservoir’s nutrient loading from internal reservoir nutrient cycling is probably not significant, due to the comparatively large hydraulic and nutrient loads from the river, the complete replacement of reservoir volume during winter periods, and the reservoir’s persistent stratification during the algae growth season.

Algal species in mainstem reservoirs show a general succession typical of temperate regions (Kalff, 2002; Wetzel, 2001; Horn and Goldman, 1994). There is typically a large spring bloom of diatoms and chrysophytes in the when water temperatures are cooler (March and April). Dinoflagellates may reach appreciable numbers in May. Green algae increase to a peak in July, and Cyanophytes (blue-green algae) and cryptophytes typically reach their annual maxima in August. Field data suggest that there are differences in succession of algal species between Copco and Iron Gate reservoirs. These differences have not been fully explored: the lag time of nutrients from upstream sources (e.g., UKL), through Copco reservoir, and into Iron Gate reservoir may contribute to the differences.

Average phytoplankton biovolume and chlorophyll concentrations in Iron Gate reservoir are consistent with this pattern. Values are typically high in March, decrease in April into June and increase to a peak in August. Biovolume and chlorophyll *a* values typically decrease considerably in September, but might show a modest rebound in October and then decrease after the end of the growing season with the onset of cold temperatures and decreased light. These patterns and levels of primary production are not consistent from year to year, with meteorological conditions, hydrology, and upstream water quality conditions playing important roles in the species timing, and magnitude, persistence, and duration of standing crop.

Under normal conditions there is an appreciable load of nutrients and organic matter flowing into Iron Gate reservoir. As with Copco reservoir, under certain conditions, the loads of nutrients and/or organic matter entering the reservoir from these upstream sources is so high that Iron Gate reservoir can be overwhelmed—somewhat similar to how UKL discharge conditions overwhelm Keno reservoir during summer periods. Under such conditions, Iron Gate reservoir can assume characteristics more consistent with a hypereutrophic system, experiencing large, persistent algae blooms and subsequent die-offs.

Additional information on nutrient and production conditions in Iron Gate reservoir is provided in Section 5.2.11.

4.2.9.4 Dissolved Gases

Dissolved oxygen conditions in Iron Gate reservoir vary seasonally due to thermal stratification, seasonal water temperature variations in inflowing waters, and seasonal nutrient loading and organic matter from upstream sources. Under purely isothermal conditions, dissolved oxygen concentrations are generally at or near equilibrium (Wetzel, 2001); however, even small temperature differences can impede mixing that can lead to local anoxia (Cole and Hannan, 1990). Under stratified conditions, seasonal anoxia of bottom waters occurs. The onset of anoxic conditions occurs initially in bottom waters (typically commencing in May through June), and reaching a maximum in September wherein roughly the bottom 100 feet of the reservoir can experience dissolved oxygen concentrations less than 1.0 mg/L.

The reservoir is productive, leading to dissolved oxygen concentrations in surface waters during the growth season at, or even above, saturation. Iron Gate reservoir releases from mid-summer through mid-fall are typically below saturation, with minimum values in late September to early October reflecting the subsaturated conditions within deeper portions of the reservoir.

Additional information on dissolved oxygen conditions in Iron Gate reservoir is provided in Section 5.2.1.

4.2.9.5 Alkalinity and pH

Alkalinity and pH conditions in Iron Gate reservoir vary seasonally and with depth. Generally during winter isothermal conditions, the pH ranges from below 7 to approximately 8. With the onset of thermal stratification, pH in surface waters can reach levels above 9 units due in large part to primary production in these weakly buffered waters that are typical of UKL and the Klamath River. When anoxia is present in the lower portions of Iron Gate reservoir, it is not uncommon for pH values to fall to 6, even during summer periods. pH below Iron Gate dam may be elevated during periods of high primary production in the reservoir.

Alkalinity concentrations generally show a seasonal trend with lower values (e.g., less than 60 mg/L) in winter periods and slightly higher values (e.g., 70 to 80 mg/L) during summer. The change is presumed to be partly associated with irrigation flow returns from upstream agricultural activities (the alkalinity of return flows in the upper basin might be on the order of 250 mg/L); however, vertical variations also occur. These variations may be due to stratification that "traps" lower alkalinity water below the thermocline.

Additional information on pH conditions in Iron Gate reservoir is provided in Section 5.2.2.

4.2.9.6 Suspended Sediments and Turbidity

Total suspended solids and turbidity are generally lower below Iron Gate dam than upstream of the reservoir. Due to the relatively long residence time of the reservoir this is not unexpected. BOD is also generally equal to or lower below the dam than the upstream concentrations, but there are exceptions. Total organic carbon is generally lower below Iron Gate dam than the inflows to the reservoir below Copco No. 2 powerhouse.

Additional information on suspended sediments and turbidity conditions in Iron Gate reservoir is provided in sections 5.2.5 and 5.2.9.

4.2.9.7 Summary and Relationship to System Water Quality

Iron Gate reservoir is the second relatively large mainstem reservoir on the Klamath River below UKL. Iron Gate reservoir receives large hydraulic and nutrient loads from the inflowing Klamath River. The result of these substantial upstream loads is a eutrophic reservoir.

Iron Gate reservoir is generally productive during summer months, but can produce nuisance algal blooms if the influx of nutrients increases in response to upstream conditions (e.g., large UKL algal blooms, severely impaired water quality conditions in Keno reservoir). The transit time from the upper basin (including Copco reservoir), the reservoir residence (or transit) time, and stratification in Iron Gate reservoir each play important roles in this regard. Such basin-scale processes are important to understanding the character of water quality in Iron Gate reservoir and downstream reaches.

4.2.10 Klamath River from Iron Gate Dam to Turwar

The Iron Gate dam to Turwar reach extends from Iron Gate dam (RM 190.5) to the USGS gauge at Turwar (RM 5.3) near the mouth of the Klamath River. There are several main tributaries flowing into the reach—Shasta River (RM 177.3), Scott River (RM 143.6), Salmon River (RM 66.4), and Trinity River (RM 43.3)—as well as many minor tributaries. The flow in the river increases significantly in the downstream direction due to major and minor tributary contributions. There are no major diversions in this reach and the river largely flows through forested, mountainous terrain.

The Klamath River downstream of Iron Gate dam can be described as a eutrophic stream. It is a complex system where riverine forces play a predominant role in water quality response. Interactions of flow, geomorphology (geology), meteorological conditions, tributaries, upstream conditions, regulation, and other factors influence water quality in this reach.

4.2.10.1 Hydrology

Flow conditions vary considerably downstream of Iron Gate dam. Mean annual flow for the four mainstem Klamath River gauges, from upstream to downstream, are presented in Table 4.2-1. Flow approximately doubles between each gauge, indicating the considerable tributary accretion (major tributary flows are shown in Table 4.2-2). The percentage of flow in the lower basin compared to the upper basin is also considerable: flows at Iron Gate dam are about 30 percent greater than flows at Keno dam, but increase dramatically downstream with flows at the mouth greater by an order of magnitude than flows at Iron Gate dam. Seasonally, summer period flow increases are not as dramatic, but nonetheless flows are notably larger in the lower river below Iron Gate dam.

Table 4.2-1. Klamath River Mainstem Mean Annual Flow and Percentage of Flow Based on the Klamath River at Keno (USGS 11509500).

Location	USGS Gauge	Mean Annual Flow (million acre feet)	Percentage of Flow at Keno
Klamath River bel Iron Gate Dam (RM 190.1)	11516530	1.50	133%
Klamath River nr Seiad Valley (RM 129.0)	11520500	2.70	240%
Klamath River at Orleans (RM 57.6)	11523000	6.18	549%
Klamath River at Klamath (RM 7)	11530500	12.58	1118%

Table 4.2-2. Klamath River Major Tributary Mean Annual Flow and Percentage of Flow Based on the Klamath River at Iron Gate Dam (USGS 11506530).

Location	USGS Gauge	Mean Annual Flow (million acre feet)	Percentage of Flow Below Iron Gate
Shasta River nr Yreka	11517500	0.136	9%
Scott River nr Ft. Jones	11519500	0.457*	30%
Salmon River at Somes Bar	11522500	1.33	89%
Trinity River at Hoopa	11530000	3.49	233%

* The USGS gauge for Scott River at Ft. Jones is located approximately 24 miles upstream from the confluence with the Klamath River.

An additional flow-related aspect of this long river reach is that the mainstem Klamath River channel is relatively “stable” between Iron Gate dam and the Scott River. Releases from Iron Gate dam have not exceeded 25,000 cfs since 1960 and only exceeded 10,000 cfs in about 20 percent of the years. Further, inflows are modest from the Shasta River and other minor tributaries above the Scott River. Maximum flow at Seiad Valley was 115,000 cfs, and flows over 40,000 cfs occur in about 20 percent of the years. The increased flow below the Scott River, coupled with coarse sediment inputs from minor and major tributaries, results in an active alluvial system where coarse sediment transport occurs with regularity.

Travel time through the reach under typical summer flows is on the order of 4 days. Under extreme low flow conditions (e.g., drought) this may be slightly longer, and under winter flood conditions travel time would be somewhat less.

4.2.10.2 Water Temperature

Water temperatures in this reach are generally at or near equilibrium with the exception of immediately below Iron Gate dam and in the vicinity of certain tributaries. As previously described, Iron Gate reservoir releases are generally moderated owing to the relatively large reservoir volume and a penstock release elevation that is about 30 feet deep. These attributes lead to water temperatures that may be at or slightly below equilibrium temperature of the river downstream of the dam in the spring (the river is considerably smaller in terms of volume per unit length, and thus cools and heats more quickly than the reservoir in response the ambient meteorological conditions).

During the fall period, release water temperatures from Iron Gate dam are higher than equilibrium temperature of the river due to the thermal lag caused by the reservoir's mass. This lag is largest at the dam and diminishes relatively quickly in the downstream direction as the river comes into equilibrium with the local meteorological conditions. By the time flows reach the Shasta River, the impact of the lag is diminished by approximately 50 percent, and continues to diminish in the downstream direction. Regulation of the river at Iron Gate dam also produces a thermal signal downstream of the reservoir spaced at intervals of 24 hour travel time. These nodes of minimum diurnal variation are documented in USFWS (1999).

Water temperatures are generally at or near equilibrium once below the Shasta River. Exceptions may include periods during spring snowmelt runoff or rain on snow events when tributary contributions yield cold runoff to the main stem Klamath River. In addition, during warmer periods of the year there are isolated regions at the confluence of many tributaries where water temperatures are markedly colder than the main stem. These areas, termed thermal refugia, may range from a few square yards to several hundred square yards in size depending on the flow and temperature in the tributary, flow conditions in the main stem Klamath River, and local geomorphology. These thermal refugia have been the subject of an ongoing study sponsored by the USBR (Sutton et al., 2002).

Field observations indicate that the warmest reach of the Klamath River under existing conditions is the reach between approximately Seiad Valley (RM 129) and Clear Creek (RM 98.8). Maximum daily temperatures can approach 30°C and daily minimum temperatures in the 20° to 24°C range are common in this reach during summer. Downstream of this reach, the river experiences considerable accretion and the aspect ratio of the channel changes from a broad shallow stream to a deeper river. The diurnal range in temperature is moderated in the lower river as well. Temperatures in the lower river experience lower river temperatures overall during summer periods, with highs generally in the vicinity of 25°C; however, daytime lows remain in the 20° to 24°C range. As the river approaches the coast, marine influences can moderate river temperatures, but when clear warm conditions prevail, water temperatures respond accordingly. During winter, the lower river locations may be warmer than the locations closer to Iron Gate dam due to more mild meteorological conditions at lower elevations.

Additional information on water temperature conditions in the Klamath River downstream of Iron Gate dam is provided in Section 5.2.3.

4.2.10.3 Nutrients and Algal Production

Waters flowing downstream carry a variety of particles and nutrients from the headwaters to the terminus of the river system. However, nutrients (herein including particulate and dissolved organic matter) are not simply traveling downstream without interaction with the surrounding aquatic environment. Instead, nutrients in river systems cycle through the ecosystem in a manner similar to the cycling processes in lakes and reservoirs: organic matter breaks down into its components as it moves downstream; aquatic plant life extracts nitrogen and phosphorus from the water; aquatic flora and fauna excrete nutrient rich waste or through mortality produce organic matter and the cycle begins anew—albeit at a location downstream (Elwood et al., 1983).

This concept is useful when considering the Klamath River reach below Iron Gate dam. As noted previously, reservoirs can act as traps, reducing organic matter, nutrient and particulate matter. However, reservoirs can also transform incoming nutrients (e.g., as organic and inorganic particulate and dissolved matter) into dissolved organic and ammonia forms (Ward and Stanford, 1983). The result can support primary production within the reservoir as well as downstream of the reservoir.

Field observations support these concepts. The concentrations of nitrate and phosphorous are steadily reduced with distance from Iron Gate dam. This condition is partly due to dilution, but also in response to uptake from seasonal periphyton growth in the river. The rate of nutrient reduction in the downstream direction tends to diminish in the vicinity of Salmon and Trinity Rivers. The reduction in rate may be due to the large alluvial channel and the inability of perilithic films to effectively uptake nutrients due to an ever deepening water column, some light limitation with increasing river depth, and dilution. Nutrient concentrations also indicate seasonal variations with lower concentrations in early spring, increasing through summer and fall. This condition is probably due to both dilution from tributaries during the wetter months as well as seasonal fluxes from upstream. Total organic carbon tends to decrease in the downstream direction similar to nitrate and orthophosphate. However, field data suggest that during some periods there may be higher levels of organic matter in the Klamath River above the Shasta River than below Iron Gate dam. This would be consistent with increased algal densities in the intermediate reach and associated respiration, excretion, and mortality (see below).

During summer and fall periods there is a considerable amount of particulate matter readily observable in the Klamath River in this reach. The proportion of this particulate matter that is derived from Iron Gate reservoir and upstream sources compared to that generated within the river downstream of Iron Gate dam is unknown at this time. Regardless, the eutrophic nature of the Klamath River downstream of Iron Gate dam is largely due to upstream sources of nutrients. This particulate matter (and presumably dissolved matter as well) is readily advected downstream and a portion ultimately settles in the Klamath River Estuary.

Benthic algae play an important role in the water quality conditions in the Klamath River below Iron Gate dam, with the majority of the rooted aquatic vegetation occurring above the Scott River. Examination of field data indicates there are sufficient nutrients to support a significant benthic algal community below Iron Gate dam, with very high concentrations between the dam and the Shasta River.

As noted above, active alluvial channel processes downstream of the Scott River appears to limit rooted aquatic vegetation. Longitudinal surveys of the benthic algal community indicate that although there is appreciable (and sometimes significant) rooted aquatic vegetation above the Scott River, the occurrence of such species below the Scott are limited to backwater areas and in the lower river are largely absent altogether. However, surveys completed in 2003 and 2004 suggest that multiple below-normal runoff years may allow these rooted aquatic species to expand, sometimes dramatically, in downstream reaches. Downstream of the Scott River the benthic algae community is dominated by periphyton, typically eutrophic diatoms.

The relatively broad shallow nature (and relatively stable bed) of the reach from Iron Gate dam to the Scott River provides a suitable environment for extensive periphyton and rooted aquatic vegetation growth during late spring through early fall. During winter periods (low temperature and low light), benthic algal populations are largely reduced or absent. The large standing crop tends to produce diurnal variations identified above. Downstream of the Scott River, the standing crop is reduced because the benthic algal community is limited to periphyton. The result is a diminished diurnal variation in dissolved oxygen in the lower river, typically on the order of 1 to 2 mg/L.

Additional information on nutrient and production conditions in the Klamath River downstream of Iron Gate dam is provided in Section 5.2.11.

4.2.10.4 Dissolved Oxygen

Daily mean dissolved oxygen conditions are at or near saturation throughout the entire reach due to the many cascades, rapids, and riffles in this steep reach of river that provide mechanical reaeration. An exception is the reach immediately below Iron Gate dam during late summer and fall periods, where relatively deep releases from Iron Gate reservoir entrain water with low dissolved oxygen concentration, resulting in discharges from the dam of water that is below 100 percent saturation.

Although daily mean dissolved oxygen concentrations are at or near saturation, there are reaches where dissolved oxygen concentrations deviate considerably from saturation in response to primary production. The reach from approximately Iron Gate dam to approximately Seiad Valley can experience diurnal range in dissolved oxygen of 3 to 4 mg/L in response to the benthic algal community (epiphyton and attached algae/macrophytes). During the day, supersaturation may occur, while nighttime respiration results in subsaturated conditions.

Further, it is not uncommon to find the Klamath River at several locations experiencing “chronic” mild subsaturation during the warmer periods of the year. These are conditions when the average dissolved oxygen concentration over a period of time (days or weeks) is below saturation, and dissolved oxygen never rises above saturation. It is postulated that this mild, persistent subsaturation is related to the appreciable organic load being carried by the river. During winter, conditions are typically at or near saturation throughout the reach.

Additional information on dissolved oxygen conditions in the Klamath River downstream of Iron Gate dam is provided in Section 5.2.1.

4.2.10.5 Alkalinity and pH

Alkalinity is generally under 100 mg/L throughout the reach. Unlike the water from UKL, water from the Shasta River is well buffered with 200 to 300 mg/L of alkalinity. The Scott River inputs are on the order of 100 mg/L, while the Salmon and Trinity Rivers are well under 100 mg/L. While the Shasta River contributes appreciable alkalinity, its overall contribution is small and the Klamath River retains a weakly buffered status. Thus the river is prone to pH changes in response to primary production, where sufficient algal growth is present.

A byproduct of this level of primary production in a weakly buffered system is a notable diurnal variation in pH (Wetzel, 2001). It is not uncommon to observe pH values in excess of 9.0 in the early afternoon during late spring and summer periods in the reach between Iron Gate dam and Seiad Valley. One concern with pH levels in this range includes the potential for chronic or acute ammonia toxicity (USEPA, 1984). Thus the potential for multiple stressors—elevated temperature and ammonia toxicity—may play a role in aquatic ecosystem function (Chapra, 1997). Such elevated pH conditions are less frequent in the lower river (below approximately Clear Creek), reducing the risk of stress from unionized ammonia.

Additional information on pH conditions in the Klamath River downstream of Iron Gate dam is provided in Section 5.2.2.

4.2.10.6 Other-Tributaries

The characteristics and role of tributary contributions are critical to the water quality conditions in the Klamath River downstream of Iron Gate dam (Figure 4.2-1). The major tributaries—Shasta, Scott, Salmon, and Trinity Rivers—have different characteristics. The Shasta and Scott River watersheds have extensive agriculture development and associated water quality issues, as well as depleted summer flows. The Salmon River has almost no development, but extensive logging has occurred in the basin. The Trinity River has been developed for water resources (most notably the Trinity reservoir with a capacity of 2.4 MAF) and an out-of basin diversion to the Sacramento River system. The minor tributaries are generally high quality waters and several of these creeks provide a consistent base flow throughout the summer and fall. Overall, these contributions, with the exception of the Shasta River and perhaps the Scott River, provide direct dilution and improve water quality from upstream to downstream.

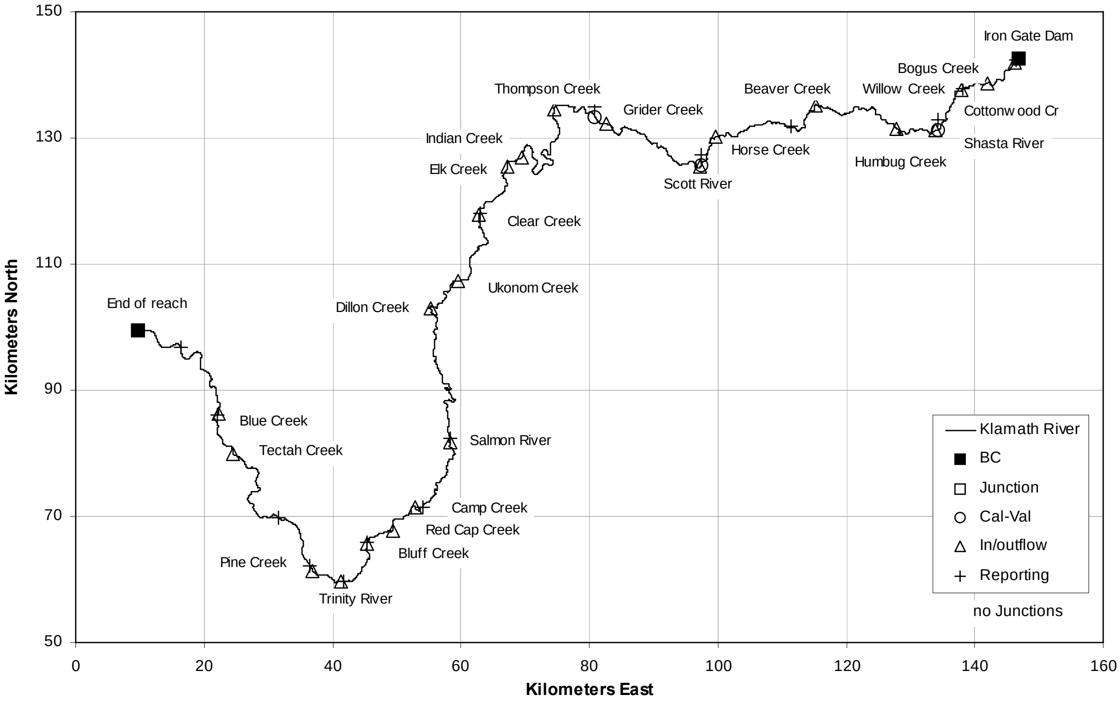

Figure 4.2-1. Iron Gate Dam to Turwar Reach Representation Showing Selected Tributaries.

4.2.10.7 Summary and Relationship to System Water Quality

The Klamath River downstream of Iron Gate dam can be described as a eutrophic stream. Winter conditions are generally benign from a water quality perspective with cool to moderate water temperatures and dissolved oxygen conditions at or near saturation. Although there may be nutrients sufficient for primary production, low water temperatures and short day length preclude a large algal standing crop. Conditions change markedly with the onset of warmer weather. Water temperatures rise and primary production (benthic algae) can lead to deviations in dissolved oxygen (above and below saturation), but these effects are spatially variable. Primary production is driven in large part by nutrients from upstream sources, with tributaries generally providing waters low in nutrient and organic matter. The impact of upstream reaches diminishes with distance downstream of Iron Gate dam, but even with 190 miles of free flowing river and multiple tributaries, the large loads of nutrients and organic matter out of UKL and the upper basin play a role in the water quality of the Klamath River downstream to the Pacific Ocean.

4.2.11 Klamath River Estuary

The Klamath River estuary forms approximately the lower 5 or 6 miles of the river that are tidally influenced between the free flowing river and the Pacific Ocean. This area has not been intensively studied in the past, but more recent efforts are beginning to shed light on this feature of the Klamath River.

Water quality of the estuary is potentially an important component of the overall water quality picture, because anadromous fishes utilize the region as a migratory pathway, and the estuary plays a role in juvenile rearing for certain species (Moyle, 2002; Biggs and Cronin, 1981). As an area of ongoing study, water quality aspects are only briefly presented herein.

4.2.11.1 Hydrology

The flow in the Estuary is not readily measured at the outfall to the ocean due to a large, permeable bar consisting of sand and gravel. The mean annual flow at Klamath is 12.6 MAF (USGS 11530500). During the winter when large flows occur, and peak annual flows over 50,000 cfs are the rule rather than the exception at this location, the estuary is overwhelmed by river outflow and is largely freshwater. During summer, flows are on the order of 3000 cfs, and in drier periods the mouth may close for relatively short periods of time. Because storage on the mainstem Klamath River is limited, operations of mainstem reservoirs for flow management of the estuary are likewise limited. However, Trinity reservoir, located approximately 115 miles upstream on the Trinity River, has 2.4 million acre-feet of storage, and operations on the Trinity River could possibly provide some level of management. This aspect of flow and water quality management has not been fully explored at this time.

4.2.11.2 Water Temperature

River inflows to the estuary may cool slightly as they approach the Pacific Ocean during summer in response to marine influences (e.g., fog); however, such influences may or may not be persistent through time and may vary spatially up river. There are few upstream operations that affect temperature at this location, with the possible exception of Trinity reservoir operations. However, the lowermost estuary can stratify during summer months, with cooler, brackish or saline water near the bottom and warmer freshwater on top (Biggs and Cronin, 1981). Stratification appears to be intermittent based on river flows, influences of the Pacific Ocean, and perhaps other factors. During winter, when flows are high, the estuary is dominated by river conditions and stratification is absent.

4.2.11.3 Nutrients and Algal Production

The nutrient inputs and outputs, as well as storage in the estuary are not completely characterized at this time. Nutrient levels generally are at their lowest concentrations at the downstream most portion of the Iron Gate dam to Turwar reach. Although ammonia levels are typically low, nitrate and orthophosphate levels are at sufficient levels for primary production to occur. Seasonal variation in nutrient levels occurs, although not as marked as in upstream reaches. The estuary provides another opportunity for phytoplankton growth, probably supporting a diverse assemblage of species adapted to fresh, brackish and/or marine conditions. Levels of production are not well understood spatially or temporally. Inflowing river waters are weakly buffered but brackish waters may not be.

4.2.11.4 Dissolved Oxygen

Dissolved oxygen conditions in the estuary are generally at or near equilibrium. Because velocities are greatly reduced in the broad, relatively shallow estuary, particulate matter borne out of the Klamath River tends to settle. There are instances where near bottom waters or deeper waters under stratified conditions indicate dissolved oxygen conditions well under saturation (DFG, 1998). The impact of organic matter loading on the estuary has not been thoroughly studied to date.

Primary production in the estuary also occurs, but the dynamics are not completely understood at this time.

4.2.11.5 Summary and Relationship to System Water Quality

The Klamath River estuary is an important reach in the Klamath River system, providing a vital transition between the freshwater environment of the Klamath River and the marine environment of the Pacific Ocean. It is a dynamic system that is highly dependent on hydrologic (freshwater and marine), water quality (freshwater and marine), and meteorological conditions. Stratification may play a critical role in water quality conditions in the estuary, with cool brackish waters underlying warm freshwaters. During summer and fall months when river flows are at their annual minimums, water quality of inflowing river waters can impact the estuary as evidenced by occasional subsaturated dissolved oxygen conditions in bottom waters. This sub-saturation condition suggests that eutrophic conditions from far up river can affect estuarine water quality.

4.2.12 Summary of Current Water Quality Conditions

Below is a summary of the principal factors driving current water quality condition in the Klamath River in the vicinity of the Project. While the representation on a reach basis is important to characterize and identify key system processes, the reader is encouraged to consider the water quality conditions at the basin scale for assessing water quality response through the seasons.

Water Temperature

The system is essentially at equilibrium at UKL. Deviations from equilibrium occur in three primary areas:

- Spring inflows: in summer they may be cooler (below equilibrium); in the winter they may be warmer (above equilibrium)
- Below dams: typically below equilibrium in summer and above in fall (thermal lag).
- Tributaries: tributary water can be warmer or colder than the mainstem. Tributaries and their effects are very small above Iron Gate dam. Below Iron Gate dam, there are several larger tributaries that form refugial areas, as well as add volume to the main stem Klamath River.

Hypereutrophic Headwater Condition at UKL

It is rare to have a hypereutrophic headwater condition for a river of this size. The condition results in large fluxes of organic matter and nutrients, and impacts water quality throughout the entire downstream system. Organic matter can be living (algae) or dead (dead algae and other respiratory or flora/fauna byproducts). Coupled with inorganic nutrient forms, these processes represent a complex set of transport mechanisms for downstream nutrient passage. Particulate forms can travel farther prior to “releasing” their nutrient load and oxygen demand on the system. Because the system is in a warm sunny climate, there is the potential for the system to become very productive at certain times of the year.

Light Limitation

Even above UKL, the Sprague and Williamson Rivers have a notable “color.” Color is largely conservative (the end product of organic decay—refractory substances). This color, coupled with particulate matter, plays a large role in limiting algae growth in Keno reservoir and in the river reaches.

Color is diminished, however, by dilution and the continued processing of organic matter (there is still decay among refractory compounds, but at a slower rate). Also, the aspect ratio of Keno dam to the J.C. Boyle bypass and peaking reaches down to approximately the California border is generally narrow, steep, and deep, with high velocities. These conditions limit algal growth in these reaches. When the river widens above Copco, and becomes shallower, there is more opportunity for light to become less limiting. Another important observation is that light extinction is not constant through the year—blooms and upstream conditions lead to increases and decreases in light extinction. This condition may lead to die back of periphyton or other attached algae in certain reaches if light extinction increases due to upstream changes in water quality.

Settling in Reservoirs

All reservoirs trap material and increase residence time (process time). Studies by Kann and Asarian (2005) indicate that Copco and Iron Gate reservoirs act as a significant annual net sink of nutrients. The reservoirs differ markedly from the river reaches in their water quality character, mainly because of the longer hydraulic residence time in the reservoirs. These reservoirs are more effective than the river in retaining organic matter, especially particulate forms, and nutrients delivered from UKL and the upper basin. Retention of organic matter and nutrients in the reservoirs results in periodic seasonal blooms of planktonic algae and can contribute to low dissolved oxygen below the thermocline. However, these processes also result in a net decrease in organic matter and nutrients that would otherwise continue downstream and contribute to increased algae growth in the Lower Klamath River.

4.3 PROJECT CONTRIBUTIONS TO WATER QUALITY

During the new license period, PacifiCorp will continue to operate its currently licensed facilities, except for the East Side and West Site Developments at Link River, which will be decommissioned, and Keno dam, which will not be part of the Project. Operations will continue at the J.C. Boyle Development, including load following (peaking) operations. Diversion of flows up to approximately 3,000 cfs from the J.C. Boyle bypass reach (except for a minimum instream flow release of 100 cfs from J.C. Boyle dam) will continue to allow 225 cfs of high-quality spring inflow to dominate and enhance water quality conditions in the reach. Peaking operations at the J.C. Boyle powerhouse will continue to occur when flows are less than approximately 3,000 cfs, causing daily flow fluctuations in the peaking reach. These flow fluctuations will continue to cause the presence of the relatively less productive varial zone along the margin of the Klamath River's channel, and cause a larger daily range of water temperatures than would occur without the Project. However, implementation of instream flow and ramping rate enhancement measures as proposed will reduce the magnitude of these flow fluctuations (PacifiCorp, 2006).

Operations will continue at the Copco Nos. 1 and 2 Developments, including load following (peaking) operations. Diversion of flows up to 3,200 cfs from the Copco No. 2 bypass reach will continue (except for a minimum instream flow release of 10 cfs from Copco No. 2 dam). The bypass reach is relatively short (1.4 miles) and consists of a relatively high gradient, confined channel. Transit time of water through the reach is short. As a result, little change is expected to occur in water quality in the reach below Copco reservoir.

The existing Project reservoirs included in this new Project license application—J.C. Boyle, Copco, and Iron Gate—will have continuing effects on water quality. These reservoirs differ markedly from the river reaches in their water quality character, mainly because of the longer hydraulic residence time in the reservoirs. These reservoirs are more effective than the river in retaining organic matter, especially particulate forms, and nutrients delivered from UKL. Retention of organic matter and nutrients in the reservoirs results in periodic seasonal blooms of planktonic algae and can contribute to low dissolved oxygen below the thermocline. This results in a net decrease in organic matter and nutrients that would otherwise continue downstream and contribute to increased algae growth in the Lower Klamath River. PacifiCorp proposes to implement a reservoir management plan (Appendix B) for improving water quality in Copco and Iron Gate reservoirs. Actions implemented through the RMP are aimed at improving reservoir water quality conditions (such as algae, dissolved oxygen, and pH) related to primary production from organic and nutrient loads contributed from sources upstream of the Project.

J.C. Boyle reservoir is relatively small, with short residence time and limited, weak thermal stratification. Copco and Iron Gate reservoirs are larger, deeper reservoirs with water quality characteristics that include stable seasonal thermal stratification. As a consequence of thermal stratification in Iron Gate reservoir and the biological processes occurring in the reservoir, the hypolimnetic water is deficient in oxygen by early summer. PacifiCorp proposes to conduct turbine venting tests at the Iron Gate powerhouse. Turbine venting, if successful, will help to prevent any adverse effects that might occur as a result of the oxygen-deficient condition of the released water. Another potential measures being considered by PacifiCorp are: 1) installation of an oxygenation system in Iron Gate reservoir; and 2) implementation of a low-level release of cooler hypolimnetic water from Iron Gate reservoir during summer to provide some cooling of the Klamath River below Iron Gate dam (described in Section E3.8 of PacifiCorp 2004b). However, the volume of this cool water is limited and this water is also used by the hatchery. Therefore, the potential benefit from releases of this cool water for downstream temperature reduction is likewise limited.

Iron Gate dam will continue to be operated in a modified run-of-river generation mode under the schedule for instream flow releases and ramping rates at Iron Gate dam dictated by USBR’s Klamath Project Operations Plans (consistent with biological opinions issued by USFWS and NMFS). Any increase in discharge from Iron Gate dam would require additional flow from upstream of the Project. This instream flow schedule, along with potential water temperature management and hypolimnetic oxygenation measures (described in Section E3.8 of PacifiCorp 2004b), will help to maintain and improve current water quality conditions in the Klamath River below Iron Gate dam.

The Fall Creek Development will continue to operate in run-of-river generation mode. Under current Project operations, water quality in Fall Creek is spring-flow dominated and considered excellent. Proposed higher minimum instream flows (as described in Section E3.8 of PacifiCorp 2004b) will protect this water quality.

Additional details on Project contributions to water quality are discussed in Chapter 5.0 of this document.

5.0 WATER QUALITY STANDARDS EVALUATION

5.1 APPLICABLE DESIGNATED USES

The Water Quality Control Plan for the North Coast Region (Basin Plan) designates numerous beneficial uses of the waters of the Klamath River within and below the Klamath Hydroelectric Project. These specific beneficial uses are defined in Section 2 of the Basin Plan. Table 2-1 of the Basin Plan lists the particular uses of water by hydrologic unit (HU), hydrologic area (HA), hydrologic subarea (HSA), and water body. The Basin Plan specifically designates the existing ("E") and potential ("P") beneficial uses within each HU, HA, or HSA. Under the Clean Water Act, protection is afforded to present and potential beneficial uses of water, as designated in Table 2-1. Protections are extended to the water bodies specifically identified in the Basin Plan, and generally to the tributaries to those water bodies.

The California portion of the Project is located entirely within the Iron Gate HSA (CALWATER No. 105.37) and the Copco Lake HSA (CALWATER No. 105.38). The Iron Gate HSA extends from the Klamath River at its confluence with Dry Creek near Klamathon, upstream to and including Iron Gate reservoir. The Iron Gate HSA includes the Fall Creek Development, upstream of Iron Gate reservoir. The Copco Lake HSA extends from the upper end of Iron Gate reservoir where it is fed by the Klamath River, upstream to the California-Oregon state line. The Copco Lake HSA includes the Copco No. 1 and Copco No. 2 Developments. In addition, the Project potentially affects other waters in the Klamath River HU (CALWATER No. 105.00) downstream of the Project, including the waters of the Middle Klamath HA (CALWATER No. 105.30) and the Lower Klamath River HA (CALWATER No. 105.10).

The list of beneficial uses in the Basin Plan is based on those uses that have been attained in a particular water body, or that could be attained with the implementation of technologies to achieve the effluent limitations in Section 306 of the Clean Water Act and with cost-effective and reasonable Best Management Practices. (Basin Plan, p. 2-13.00.) Existing beneficial uses are based on biological data, human use statistics, and/or professional experience. (*Id.*) "Existing uses are those uses, which were attained in a water body on or after November 28, 1975 [the date of the first Water Quality Standards Regulation published by USEPA, at 40 CFR 131.3(e)]." (*Id.*) Potential beneficial uses may have been established for any of the following reasons:

(1) The uses existed prior to November 28, 1975, but is not currently being attained

(2) Plans exist to put the water to that use

(3) Conditions make such future use likely

(4) The water has been identified as a potential source of drinking water

(5) Existing water quality does not support the uses, but remedial measures may lead to attainment in the future

(6) There is insufficient information to support the use as existing, but the potential for the use exists and the use may be re-designated (*Id.*)

These definitions aid in the determination of resources to be protected in and below the Project area.

This section discusses: the applicable designated uses within the Project area and, where appropriate, below the Project area; the resources that constitute these designated uses within the specific HAs and

HSAs; the Project's effects on particular uses (if any); measures proposed by PacifiCorp to address effects or potential effects; and the effectiveness of these measures in protecting or enhancing beneficial uses.

5.1.1 Municipal and Domestic Supply (MUN)

Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. North Coast Basin Plan, 2-1.00.

The Basin Plan designates Municipal and Domestic Supply (MUN) as a potential ("P") beneficial use in the Iron Gate HSA, and as an existing ("E") use in the Copco Lake HSA, the Middle Klamath River HA, and the Lower Klamath River HA. The only known MUN uses within the Project area are the City of Yreka's Fall Creek diversion, and small domestic uses made by PacifiCorp employees and personnel who reside within the Project area. No known MUN uses of water from the Klamath River are known to occur downstream of the Project area. As discussed below, the Project does not adversely affect MUN uses within or below the Project. Therefore, no measures are proposed in this application to specifically protect or enhance MUN uses.

5.1.1.1 City of Yreka Municipal Water Supply

The City of Yreka has a California water right permit (with a 1966 priority date) to divert up to 15 cfs from Fall Creek, tributary to Iron Gate reservoir, for municipal water supply. The City maintains and operates two diversions on Fall Creek; the A-dam is the City's primary diversion structure, and the B-dam is the secondary diversion structure. The A-dam is located upstream from the California Department of Fish and Game (CDFG) Fall Creek hatchery intake and downstream from the Fall Creek powerhouse. The B-dam is located upstream of the powerhouse tailrace in the natural channel below a waterfall. If the Fall Creek powerhouse trips offline, flow to the A-dam is reduced and eventually ceases. During these periods, the City exercises the B-dam point of diversion to ensure a continuous supply. The two points of diversion thus provide flexibility to ensure adequate flow to the City's municipal water supply system.

Both diversions are concrete structures with stop logs spanning the width of the creek. Screened pumps are used at both locations. According to the City, year 2000 was a fairly typical year relative to the amount of water diverted to the City. Approximately 820 million gallons per year (2,519 acre-feet per year) of water was diverted from Fall Creek with the largest diversions occurring during the late summer. Monthly average diversion rates did not exceed 10 cfs.

5.1.1.2 Domestic Water Use by Project Personnel Within Project Area

PacifiCorp Project staff, their families, and the maintenance crews (less than 50 people) rely on water in the Project area. The Project operators' residences, the lodging complexes, and the workshops and control center obtain water for domestic and other non-power uses primarily through springs and wells. A tap in the penstock at Fall Creek supplies water to a single residence. If maintenance is required on the Fall Creek penstock, the resident temporarily moves to the bunkhouse at Copco No. 2 Development.

5.1.1.3 No Effect of Project on MUN Uses

The Project does not adversely affect MUN uses by the City of Yreka, or PacifiCorp domestic water systems within the Project area. Moreover, PacifiCorp is not aware of the Project affecting or any other public or private domestic water supplier within or below the Project area. Diversion and use of water by the Project is predominantly non-consumptive, and therefore does not generally affect the availability of water to MUN uses below the Project. Consumptive uses made by PacifiCorp personnel within the

Project are insignificant. There is no evidence or information to indicate that the Project adversely affects MUN uses.

5.1.2 Agricultural Supply (AGR)

Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing. North Coast Basin Plan, 2-1.00.

The Basin Plan designates Agricultural Supply (AGR) as a potential (“P”) beneficial use in the Iron Gate HSA, and as an existing (“E”) use in the Copco Lake HSA, the Middle Klamath River HA, and the Lower Klamath River HA. Small agricultural and stock water uses may occur adjacent to the Klamath River, or on tributaries such as Shovel Creek, but the Project is not expected to adversely affect these uses. Therefore, no measures are proposed in this application to specifically protect or enhance AGR uses.

5.1.3 Industrial Service Supply (IND)

Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization. North Coast Basin Plan, 2-1.00.

The Basin Plan designates Industrial Service Supply (IND) as a potential (“P”) beneficial use in the Iron Gate HSA and the Klamath Glen HSA (downstream in Lower Klamath HA), and as an existing (“E”) use in the Copco Lake HSA and all other areas of the Middle Klamath River HA and the Lower Klamath River HA. There are no known IND uses within or downstream of the Project area. The Project is not expected to adversely effect IND uses within or below the Project. Therefore, no measures are proposed in this application to specifically enhance IND uses.

5.1.4 Industrial Process Supply (PRO)

Uses of water for industrial activities that depend primarily on water quality. North Coast Basin Plan, 2-1.00.

The Basin Plan designates Industrial Process Supply (PRO) as a potential (“P”) beneficial use in the Iron Gate HSA, the Copco Lake HSA, and the Lower Klamath HA, and as an existing (“E”) use in the all areas of the Middle Klamath River HA other than the Iron Gate and Copco Lake HSAs. There are no known PRO uses within or downstream of the Project area in California. The Project is not expected to adversely affect uses of water for industrial activities within or below the Project that depend primarily on water quality. Therefore, no measures are proposed in this application to specifically enhance PRO uses.

5.1.5 Groundwater Recharge (GWR)

Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Groundwater Recharge (GWR) as an existing (“E”) use in all areas of the Lower Klamath HA and Middle Klamath River HA other than the Iron Gate and Copco Lake HSAs. GWR is not a designated beneficial use within the Project area. The Project does not use or affect groundwater and groundwater recharge within the Project area in California, nor is the Project known to affect uses of water for natural or artificial recharge of groundwater in other areas of the Middle Klamath

River HA below the Project. Therefore, no measures are proposed in this application to specifically enhance GWR uses.

5.1.5.1 Freshwater Replenishment (FRSH)]

Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity). North Coast Basin Plan, 2-2.00

The Basin Plan designates Freshwater Replenishment (FRSH) as an existing (“E”) beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As a predominantly non-consumptive use of water, the Project does not adversely affect the use of water for natural or artificial maintenance of surface water quality. In fact, the existence of the Project reservoirs serve to enhance FRSH uses within the Klamath River, by providing conditions and time to process the significant nutrient load from UKL (see Section 4.0). Because the project does not adversely affect FRSH uses, no measures are proposed in this application to enhance this use.

5.1.6 Navigation (NAV)

Uses of water for shipping, travel, or other transportation by private, military or commercial vessels. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Navigation (NAV) as an existing (“E”) beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. The Project does not adversely affect uses of water for shipping, travel, or other transportation by private, military or commercial vessels. Project operations support NAV uses by maintaining flows that support commercial and private whitewater boating opportunities in the J.C. Boyle peaking reach, and by maintaining recreational boat launching facilities in Copco and Iron Gate reservoirs. PacifiCorp proposes to maintain these measures, and therefore will continue to support NAV uses.

5.1.7 Hydroelectric Power (POW)

Uses of water for hydropower generation. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Hydroelectric Power (POW) as an existing (“E”) beneficial use in the Iron Gate HSA and the Copco Lake HSA, and as a potential (“P”) use in the all areas of the Lower Klamath HA and Middle Klamath River HA, other than the Iron Gate and Copco Lake HSAs. The Project generates hydroelectric power, and therefore POW uses are being achieved in the Project area. Relicensing the Project will ensure that these uses are maintained and protected. The quality of water flowing into and through the Project area is adequate for the Project’s hydroelectric generating facilities.

5.1.8 Water Contact Recreation (REC-1)

Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white-water activities, fishing, or use of natural hot springs. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Water Contact Recreation (REC-1) as an existing (“E”) beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As described below, the Project protects REC-1 uses by providing an important regional recreation resource for several water-related recreation activities, in both the riverine and reservoir reaches of the

Project. PacifiCorp proposes to maintain and improve recreational facilities associated with the Project, and therefore will continue to protect REC-1 uses.

The Project's recreation facilities and resources offer opportunities that include flatwater reservoir activities (such as boating, water skiing, and swimming) and whitewater river water-based activities (such as whitewater boating and fishing); as well as land-based activities associated with and enhanced by the presence of water (such as shoreline camping, picnicking, wildlife viewing, hiking, sightseeing, and resting/relaxing). Recreation opportunities are provided at developed sites, such as campgrounds and day use areas, and undeveloped use areas, such as dispersed shoreline sites with no developed infrastructure. In addition to PacifiCorp, recreation resources in the existing Project area and its surroundings also are managed by a variety of public agencies including the BLM, ODFW, California Department of Fish and Game (CDFG), and City of Klamath Falls.

Project operations have minimal effects on reservoir-related recreation opportunities in the proposed Project area as a result of reservoir level fluctuations (e.g., reservoir levels occasionally affect boating and boating-related facilities along the shoreline during significant reservoir drawdowns). However, results from recreation visitor surveys indicate that reservoir pool level do not negatively affect enjoyment or safety for a majority of visitors (89 percent of survey respondents) to the Project area (PacifiCorp, 2004f).

Although river-related recreation activities (e.g., whitewater boating and fishing) in certain reaches can be affected at times by Project operations, such temporal effects tend to be offset by enhanced recreational uses at different times and locations (see below). The Recreation Flow Analysis (PacifiCorp, 2004b) identifies the potential effects from Project operations, which are summarized as follows:

- J.C. Boyle peaking reach (Hell's Corner reach)—Flows in this reach are influenced by daily peaking operations. J.C. Boyle peaking operations have minimal effects on many recreational opportunities in the Project vicinity, but such operations affect the frequency and quality of whitewater boating and fishing within the peaking reach. Peaking flows (which range from approximately 1,500 cfs to 1,700 cfs) provide high-quality whitewater boating opportunities, but limit fishing opportunities. During off-peak base flow periods, in contrast, the peaking reach provides high quality fishing opportunities but less whitewater opportunity.
- Copco No. 2 bypass reach—Recreational opportunities in this reach are limited by lack of easy access (there are no well marked trails at the lower end and the road to the upper end of this reach is through private residences).
- Below Iron Gate dam reach—Recreational opportunities in this reach are dictated by flows from Iron Gate dam. These flows are controlled by the USBR and the resource agency, and are largely dictated by fishery requirements. PacifiCorp coordinates with USBR on moving the flows through the Project to meet USBR's flow obligations. In general, however, flow regimes below Iron Gate dam have not adversely affected whitewater boating opportunities during wet periods or in most high-flow periods during average years. Similarly, flows from Iron Gate dam generally provide excellent fishing opportunities in the Middle and Lower Klamath HAs.

PacifiCorp's proposed recreation measures focus on improving existing recreation resources and providing new and enhanced recreation opportunities in suitable areas when the need is demonstrated through a monitoring program. A key recreation proposal is to continue to provide whitewater boating and fishing opportunities in the Upper Klamath River/Hell's Corner reach. These proposed measures are further detailed and addressed in PacifiCorp (2004a).

As described in sections 4.2.8 and 4.2.9, blue-green algae have been observed to form large blooms in the Copco and Iron Gate reservoirs during summer. Blue-green algal blooms are common during summer not only in these reservoirs, but also in UKL, and a number of other lakes and reservoirs in the region and in California. The occurrences of these blooms are largely driven by elevated levels of nutrients in waters entering the reservoirs from upstream sources, i.e., Upper Klamath Lake, and ambient conditions. There is no evidence or information to suggest that the presence of these conditions substantially diminishes the level of Project area recreational use; recreation uses in the Project area remain high during summer. Current recreational use of Copco and Iron Gate reservoirs during the peak season (May 24-September 2) is about 6,000 and 24,000 recreation user-days (RD)[8], respectively. Recreational users interviewed at Iron Gate reservoir considered it one of their top recreation destinations in the region (PacifiCorp, 2004f). Recreational use in the area is projected to increase 47 percent by the year 2040 (PacifiCorp, 2004f).

An important concern regarding blue-green algae blooms in the Klamath Basin, including the Project reservoirs, is the occurrence of potentially toxigenic blue-green species, like *Microcystis aeruginosa* (MSAE). As described in sections 4.2.8 and 4.2.9, MSAE has become more prevalent in the Project reservoirs since 2004. PacifiCorp is funding and conducting research and studies related to the occurrence and causes of MSAE in the Project area reservoirs and elsewhere in the Basin (upstream and downstream of the Project area). PacifiCorp also has proposed and is implementing reservoir management plans (RMP) for the Copco and Iron Gate reservoirs (Appendix B) and J.C. Boyle reservoir in Oregon (PacifiCorp 2008). The RMPs will evaluate various technologies and management actions to address algal blooms and their potential effects in Project reservoirs and downstream of the Project. PacifiCorp plans ongoing consultation with the State Water Board on the RMPs.

As occurs in other regional lakes and reservoirs that experience potentially harmful blue-green algae blooms (such as MSAE), health advisories are established and posted by the County Health Department, if conditions warrant, to caution recreational users. Advisory postings are a practical and prudent course of action in such circumstances, and have been used in numerous recreational lakes and reservoirs across the region and the country. PacifiCorp has, and will continue to cooperate with the County Health Department and other appropriate agencies in these circumstances.

It is important to note that very large loads of nutrient and organic matter from upstream sources, notably hypereutrophic Upper Klamath Lake, is the principal driver of algal blooms and associated water quality conditions in the Project reservoirs. PacifiCorp has no control of these large upstream loads of nutrients and organic matter, and any such control will need to occur from implementing TMDLs that are currently being developed in the Upper Klamath Basin. The Klamath River TMDLs are being implemented by the Regional Board, in conjunction with ODEQ and EPA. PacifiCorp is hopeful that a comprehensive TMDL for the entire Klamath River system will result in measures to bring about meaningful reductions in nutrient and organic matter from upstream sources and real improvements in water quality flowing into the Project area. The TMDL is a critical process to address this primary cause of blue-green algal blooms within the Project reservoirs.

5.1.9 Non-Contact Water Recreation (REC-2)

Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. North Coast Basin Plan, 2-2.00.

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[8] A recreation user-day (RD) is defined as a visit by a person to an area for recreation purposes during any portion of a 24-hour period.

The Basin Plan designates Non-Contact Water Recreation (REC-2) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. For similar reasons as described above for REC-1, the Project protects or enhances REC-2 uses by providing an important regional recreation resource for several noncontact water-related recreation activities. PacifiCorp proposes to maintain and enhance recreational facilities associated with the Project, and therefore will continue to benefit REC-2 uses.

5.1.10 Commercial and Sport Fishing (COMM)

Uses of water for commercial, recreational (sport) collection of fish, shellfish, or other aquatic organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Commercial and Sport Fishing (COMM) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As described below, the Project supports COMM uses by providing sport fishing opportunities within and below the Project area, and through funding of the Iron Gate Hatchery. PacifiCorp will continue such support with the Project, and therefore will continue to protect COMM uses. In addition, the proposed Project includes several measures (Section 3.2) that will improve and enhance habitat conditions for fish in the project area. These measures will further benefit COMM uses.

5.1.10.1 Rainbow/Redband Trout Sport Fishery

The rainbow/redband trout population in the J.C. Boyle peaking reach of the Klamath River supports a high quality recreational fishery. Annual angler catch rates in the California portion of the peaking reach averaged 0.59 rainbow trout per hour during 1974 to 1977, 1981, and 1982. CDFG (2000) reported that the Upper Klamath River wild trout area (WTA) had the highest overall catch rate among the wild trout rivers it monitors in California. Annual angler catch rates in the Oregon portion of the peaking reach from 1979 to 1984 averaged 0.77 rainbow/redband trout per hour. These catch rates are comparable to or exceed those of other high quality trout streams in the vicinity, including the Deschutes and Metolius rivers (City of Klamath Falls, 1986).

5.1.10.2 Reservoir Sport Fishery

Both Copco and Iron Gate reservoirs support popular sport fisheries for primarily warm water species, particularly for yellow perch and largemouth bass. Both reservoirs host largemouth bass fishing tournaments during the summer.

5.1.10.3 Iron Gate Hatchery Contribution to Commercial and Sport Fishery

Iron Gate dam was built in 1961 by Pacific Power and Light Company (now PacifiCorp). PacifiCorp was required by FERC to build and fund the Iron Gate salmon and steelhead hatchery. The adult salmon ladder, trap and spawning facility was built at the base of the dam and was put into operation in February 1962.

Iron Gate fish hatchery is operated by CDFG. The program is funded both by CDFG and PacifiCorp. By agreement, PacifiCorp funds 80 percent of the total operating costs of the hatchery for fall Chinook fingerlings, coho yearlings, and steelhead yearlings. Since 1979, CDFG has funded portions of the fall Chinook fingerling production that are reared to the yearling stage for release in November.

Adult fall Chinook, coho salmon and steelhead trout, which are produced from smolt releases at the Iron Gate fish hatchery, contribute significantly to the ocean and in-river commercial and sport fisheries. Based on smolt-to-adult survival studies conducted on Iron Gate fall Chinook salmon, the hatchery production contributes about 50,000 adult fish annually to these fisheries plus escapement back to the hatchery. Maintaining the current production at the hatchery will continue to provide these benefits.

PacifiCorp will continue funding 80 percent of the production and operation costs of the Iron Gate Hatchery to meet current production goals. PacifiCorp also will purchase and construct facilities and provide the necessary equipment to expand the marking and tagging of fall Chinook salmon smolts produced at the Iron Gate Hatchery from the current 5 percent rate to 25 percent. The commitment to increase the tagging rate is based on CDFG's desire to increase the percentage of Chinook tagging at IGH to match the percent done at the Trinity River Hatchery so as to achieve a "constant fractional marking" (CFM) rate in the Klamath-Trinity River Basin.

Increased tagging of fall Chinook salmon at the Iron Gate Hatchery will have positive benefits to fisheries management in the Klamath River Basin. Having a higher and constant fractional marking rate allows fisheries managers to calculate management metrics with greater precision thus potentially allowing better and more timely management decisions. Relative and absolute hatchery contribution and straying rates are important management metrics that would benefit from increased CFM rates within the Klamath-Trinity Basin.

5.1.10.4 Fish Disease Management

In the FEIS for the Project (FERC 2007), FERC staff concludes that if disease issues in the Klamath Basin are not addressed effectively within the next several years, there is a risk that the fall Chinook fishery could suffer a further dramatic decline and that increased prevalence of disease pathogens (like *Ceratomyxa shasta*) may affect other salmonid species including the ESA-listed coho salmon. This assessment is in contrast to the stated positions of the fisheries agencies, particularly during the EPAct trial-type proceeding, that minimize and downplay the disease risks. Because of this uncertainty and agency difference of opinion, PacifiCorp supports the FERC FEIS recommendation for the development of a disease monitoring and management plan that involves a collaborative effort between federal and state agencies, and other stakeholders to identify and implement measures and identify areas where additional studies are needed to develop solutions. PacifiCorp has already committed to be an active participant in such a planning process.

While supporting development of a disease monitoring and management plan, PacifiCorp disagrees that Project operations are contributing to pathogen densities and the transmission of disease. The FERC FEIS listed three factors on how the Project operations may contribute to fish disease losses in the lower Klamath River: (1) increasing the density of fall Chinook spawning below Iron Gate dam; (2) promoting the development of the attached periphyton algae *Cladophora*; and (3) contributing to the water quality conditions that increase the stress level of juvenile and adult migrants and increase their susceptibility to disease. FERC Staff's assessment of these three factors on fish disease is incorrect for four reasons.

First, as the FEIS points out, the number of fall Chinook that spawn in the mainstem Klamath River is a relatively small proportion of the total basin-wide escapement. The density of fall Chinook spawning below Iron Gate dam is not high in comparison to other similarly-sized rivers. In any event, Project operations are not the cause of increased density in fall Chinook spawning below Iron Gate dam since most of the fall Chinook spawning production below Iron Gate dam occurs in Bogus Creek, a tributary to the Klamath River below Iron Gate dam that is not associated with the Project. In addition, if there is a relationship between the number of spawning fish and the rate of disease infectivity as FERC suggests, one would expect a decrease in *Ceratomyxa shasta* if the number of fish spawning declined. However, there does not appear to be a relationship between density of spawning fish and *Ceratomyxa shasta*. Mainstem redd counts have been declining since 2002 yet *Ceratomyxa shasta* prevalence has been increasing. The relationship of the spawning density to disease infection prevalence is a hypothesis that has not yet been tested, and if any relationship does exist, it does not appear to be linear.

Second, the Project reservoirs do not cause nutrient enrichment that contributes to increased *Cladophora* growth that in turn provides habitat for the *C. shasta* polychaete host *Manayunkia speciosa*. In fact, the Project reservoirs, particularly Iron Gate and Copco reservoirs, retain significant portions of the very large loads of nutrients and organic matter from upstream sources, notably Upper Klamath Lake (reservoir nutrient retention is discussed in further detail in Section 5.2.11 of this document). The abundance and distribution of *Cladophora* in the Project area would likely be more extensive in the absence of the Project reservoirs because the nutrient-enriched waters from upstream sources would travel much faster and further through the river system in the absence of reservoirs. Key factors controlling the distribution of *Cladophora* (and other attached and rooted plants) are the hydrology and geomorphology of the river. Relatively modest flow contributions from the upper basin and tributary inputs lead to stable flow and bed conditions in the Klamath River above the Scott River. (The Scott River provides nearly 50 percent of the annual inflow between the Iron Gate dam and Seiad Valley USGS flow gages, and downstream of the Scott River alluvial transport is active in all but the driest years.) The lack of alluvial transport allows extensive *Cladophora* (and other attached and rooted plants) to persist, in some cases year-round, between Iron Gate dam and the Scott River. If Project reservoirs were absent, little would change regarding the hydrology and geomorphology, but nutrients originating from upstream sources would be increased below the Project area. Therefore, if Project reservoirs were absent, a probable outcome would be considerably more *Cladophora* (and other attached and rooted plants) in the river where the reservoirs are now located and between Iron Gate dam and the Scott River.

Third, recent research by Stocking (2006) indicates that, instead of contributing to increases in disease incidence, the Project reservoirs may be beneficial in reducing the effects of *C. shasta* infection. Stocking's data indicates that mortality due to *C. shasta* infection was both greatly reduced and delayed in rainbow trout groups exposed in the upper Klamath River (from Link to Iron Gate dam) when compared to groups exposed in the lower Klamath River (downstream of Iron Gate dam). In general, mortality was reduced and delayed in the reservoir groups when compared to groups exposed in stretches of the river. Stocking (2006) indicates that the infectious stage (actinospore) of *C. shasta* is viable for less than 10 days, and concludes that the Project reservoirs may serve to reduce incoming spore densities by delaying passage of the actinospore and by means of spore sedimentation, due to the reservoirs' longer retention time relative to the faster-flowing river stretches.

Fourth, the Project is not causing water quality conditions that increase the stress level of juvenile and adult migrants and increase their susceptibility to disease. As discussed in further detail in Section 5.2.3 of this document, Project operations and the presence of Project reservoirs do not affect temperature in the Klamath River to an extent that causes significant adverse effects to anadromous fish that use the reach below Iron Gate dam at the time of migration, spawning, and egg incubation. Copco and Iron Gate reservoirs create a thermal lag that causes Iron Gate dam release temperature to be slightly cooler in the spring and slightly warmer during the fall than would theoretically occur in the absence of the reservoirs. However, the thermal lag effect is not detrimental, and may be beneficial, to certain life stages of Chinook, coho, and steelhead that use the river below Iron Gate dam. In addition, as a result of basin climatological conditions and tributary inflows in the lower basin, Project operations have no effect on water temperature conditions for Chinook, coho, and steelhead within the lower reaches of the Klamath River.

PacifiCorp's conclusions in this regard are supported by other recent independent analyses. In the recent EPAct trial-type proceeding, the presiding administrative judge (ALJ) ruled, based on the testimony of agency fisheries experts, that existing temperatures conditions will not preclude the various life stages of anadromous fish from successfully utilizing habitat either below or above Iron Gate dam. Also, in an analysis of the effects on fall Chinook of hypothetical temperature conditions with and without Project dams and reservoirs, Bartholow et al. (2005) concluded that water temperature conditions for juvenile rearing life stages are better with Project dams and reservoirs than without, especially immediately below Iron Gate dam.

In a subsequent analysis of factors limiting fall Chinook production potential, Bartholow and Henriksen (2006) concluded that water temperature during spawning and egg incubation is not a significant factor affecting fall Chinook freshwater production in the Klamath River. Likewise, the ALJ (McKenna 2007) ruled, based on the testimony of agency fisheries experts, that existing temperatures conditions will not preclude successful fall Chinook spawning and egg incubation. The ALJ concluded that the fall Chinook spawning period (early September through late October) coincides with declining river temperatures in the suitable range, which by early November are within the optimal range for the developing embryos (i.e., 4-12^{o}C) (see Findings of Fact 2A-27 and 2A.6 in McKenna 2007).

Lastly, in a similar situation to the Klamath River, Geist et al. (2006) conducted research on fall Chinook salmon spawning in the Snake River downstream of Hells Canyon dam at temperatures greater than 13^{o}C, which exceeds the established water quality standards in Oregon and Idaho for salmonid spawning. The key objective of the research by Geist et al. (2006) was to determine whether various temperature exposures from 13^{o}C to 17^{o}C during the first 40 days of spawning egg incubation followed by declining temperature of approximately 0.28^{o}C per day (to mimic the thermal regime of the Snake River) affected survival, development, and growth of fall Chinook salmon embryos, alevins, and fry. Geist et al. (2006) determined that there were no significant differences in embryo survival at initial temperature exposures up to 16.5^{o}C. Geist et al. (2006) further determined that there were no significant differences in alevin and fry size at hatch and emergence across the range of initial temperature exposures. On the basis of their research, Geist et al. (2006) concluded that an exemption to the state water quality standards for temperature was warranted for the portions of the Snake River where fall Chinook salmon spawning occurs.

5.1.11 Warm Freshwater Habitat (WARM)

Uses of water that support warm water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Warm Freshwater Habitat (WARM) as an existing (“E”) beneficial use in all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As described below, the Project does not adversely affect WARM uses with or below the Project. In fact, Copco and Iron Gate reservoirs provide habitats that support an important fishery for warm-water species such as largemouth bass, crappie, and yellow perch. No additional measures are proposed in this application to specifically benefit WARM uses.

5.1.11.1 Copco Reservoir Warm Freshwater Fish Community

Copco reservoir contains a diverse fishery, including both warm and cold water species, although warm water fish are the most abundant. Electrofishing by CDFG (unpublished file data) in 1987 through 1989 captured 17 species in Copco Lake, with yellow perch the most common (62 percent) followed by golden shiner (15 percent) and largemouth bass (14 percent). Non-native species comprised 97 percent of the total catch.

Approximately 45,000 fish representing 22 taxonomic categories were collected in Copco reservoir by Desjardins and Markle (2000). Nearly 8,000 fish representing 18 taxa and more than 37,000 fish representing 19 taxa were collected in 1998 and 1999, respectively. The five most abundant taxa collected overall in 1998 were yellow perch (5,990 individuals), golden shiner (596), chub spp. (229), sucker spp. (213), and bullhead spp. (202). Largemouth bass (160) was the sixth most abundant species collected. These taxa collectively accounted for 94 percent of the total catch in 1998. Yellow perch alone accounted for 76 percent of the total catch.

PacifiCorp conducted hydroacoustic-based fisheries sampling in Copco reservoir in August and October 2003, and in April 2004 (PacifiCorp, 2004e). The August 2003 results indicate that the majority of fish were observed above the thermocline in the impoundment. Fish abundance along the survey paths were similar between day and night sampling runs. Fish netting conducted in the pelagic zone concurrently with the hydroacoustic activities showed that most of the fish targets were yellow perch.

Most of the fish targets observed in Copco reservoir were generally towards the middle and eastern end of the lake. There were relatively few differences in spatial distribution of the targets in Copco reservoir between the day and night run. Most of the fish in Copco reservoir were distributed at a depth between 3 and 11 m during the day, but the fish were typically deeper at night, with an average depth of 11 m.

The results for the fish netting show that all of the fish caught were yellow perch within the size range of 130 to 285 mm. The median size of fish netted in Copco reservoir was 193 mm (CV 9.2). The only non-perch fish caught were two black crappie.

5.1.11.2 Iron Gate Reservoir Warm Freshwater Fish Community

The fishery in Iron Gate reservoir is similar to Copco reservoir. There are few trout and large numbers of non-native fish, mostly yellow perch and crappie, along with bullheads. Electrofishing by CDFG (unpublished file data) in 1988 found a similar fish community as that in Copco reservoir, with the catch dominated by yellow perch followed by sunfishes (22 percent) and largemouth bass (13 percent). Non-native species comprised 96 percent of the total catch.

Approximately 25,000 fish representing 21 taxonomic categories were collected in Iron Gate reservoir by Desjardins and Markle (2000). More than 5,000 fish representing 18 taxa and nearly 20,000 fish representing 21 taxa were collected in 1998 and 1999, respectively. The five most abundant taxa collected overall in 1998 were tui chub (3,128), chub spp. (1,314), largemouth bass (336), crappie spp. (168), and golden shiner and yellow perch (133 each). All but tui chub and chub spp. were introduced species. Rainbow trout are present but not commonly collected in Iron Gate reservoir (Desjardins and Markle, 2000).

The results from PacifiCorp's (2004b) August 2003 hydroacoustic survey indicate that the majority of fish were observed above the thermoclines in the impoundment. Fish abundance along the survey paths were similar between day and night sampling runs. Fish netting conducted in the pelagic zone concurrently with the hydroacoustic activities showed that most of the fish targets were yellow perch.

The distribution of fish in Iron Gate reservoir showed few fish present in the open-water area. Most fish were observed adjacent to the shorelines, especially the eastern shore, and in the inlet arm. During the night run, a large number of fish were congregated in the thalweg, 2 km west of the inlet. The fish were generally observed at depths from 3 to 13 m, with a considerable aggregation near the bottom end of this range.

The results for the fish netting show that most of the fish caught were yellow perch within the size range of 130 to 285 mm. The median size of fish netted in Iron Gate reservoir was 200 mm (CV 10.3).

5.1.12 Cold Freshwater Habitat (COLD)

Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement or aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Cold Freshwater Habitat (COLD) as an existing ("E") beneficial use in all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As described in this section, the Project supports COLD uses within or below the Project. Water quality conditions are generally sufficient to support a cold water ecosystem. However, there are times of the year, particularly during summer, when natural or ambient water quality conditions can affect COLD uses. A significant driver of water quality during these periods is loading of organic matter and nutrients from UKL upstream of the Project area. It is assumed that control of the large upstream loads of nutrients and organic matter from upstream sources will occur from implementing TMDLs that are currently being developed in the Upper Klamath Basin, and that this is the most appropriate means to address water quality issues caused by these loads. However, in addition, PacifiCorp proposes to implement several measures (such as a reservoir management plan for Copco and Iron Gate reservoirs and potential selective withdrawal for temperature management) that will improve and enhance habitat conditions for fish in and below the Project area. These measures will further benefit COLD uses (as described in Section 5.1.12.3 below).

5.1.12.1 Macroinvertebrate Community

PacifiCorp conducted a bioassessment of macroinvertebrates in the Project area during fall 2002 and spring 2003. The bioassessment was used in part to assess the potential relationship of macroinvertebrate community composition to water quality conditions. The following section briefly summarizes the purpose, methods, and results of the fall 2002 and spring 2003 studies**.** Details on purpose, methods, and results of these studies are contained in PacifiCorp 2004f, Section 8.0 (fall 2002) and Section 12.0 (spring 2003).

PacifiCorp used the California Stream Bioassessment Procedure (CSBP) and the California Lentic Bioassessment Procedure (CLBP) protocols adapted from the EPA's Rapid Bioassessment Protocols (CDFG 1999a and 1999b). The CSBP and CLBP data analysis procedures are based on a multimetric approach to bioassessment data analysis. The taxonomic list and numbers of organisms reported for each sample was used to generate a table of sample values and means for several biological metrics in four categories: richness measures, composition measures, tolerance/intolerance measures, and functional feeding groups.

Fall 2002 sampling occurred during September 6-14, 2002. During the fall 2002 study, macroinvertebrate samples were collected in 21 lotic riverine reaches along the Klamath River from Link River dam (RM 254.3) to the mouth of the Shasta River (RM 176.7). Six additional stream reaches were sampled in Fall Creek. Spring 2003 sampling occurred during May 19 to 23, 2003. During the spring 2003 study, the collection of macroinvertebrate samples occurred in 17 of the same lotic riverine reaches that were sampled in fall 2002. These included the lotic areas of (1) Keno dam to J.C. Boyle reservoir (Keno reach), (2) J.C. Boyle dam to J.C. Boyle powerhouse (J.C. Boyle bypass reach), (3) J.C. Boyle powerhouse to Copco No. 1 reservoir (J.C. Boyle peaking reach), and (4) Iron Gate dam to the confluence with the Shasta River.

The results of the bioassessments indicate a healthy and diverse macroinvertebrate community that are comparable in overall taxa richness and abundance to those of other similar-sized river systems in the region (PacifiCorp, 2004f). The macroinvertebrate communities of the riverine reaches revealed some differences among sites (Figure 5.1-1), most of which are attributable to expected differences associated with geographic variation and the longitudinal or elevation changes in riverine communities. The physical habitats along the river were variable in predictable ways, with fast water and boulder substrates predominating in the steep, J.C. Boyle peaking reach and a wider, even-flowing, cobble-bottomed river in the lower reaches below Iron Gate reservoir. For example, the metric taxa richness (number of species present) indicates relatively consistent taxa richness levels in the J.C. Boyle peaking reach and in the river below Iron Gate reservoir (Figure 5.1-1).

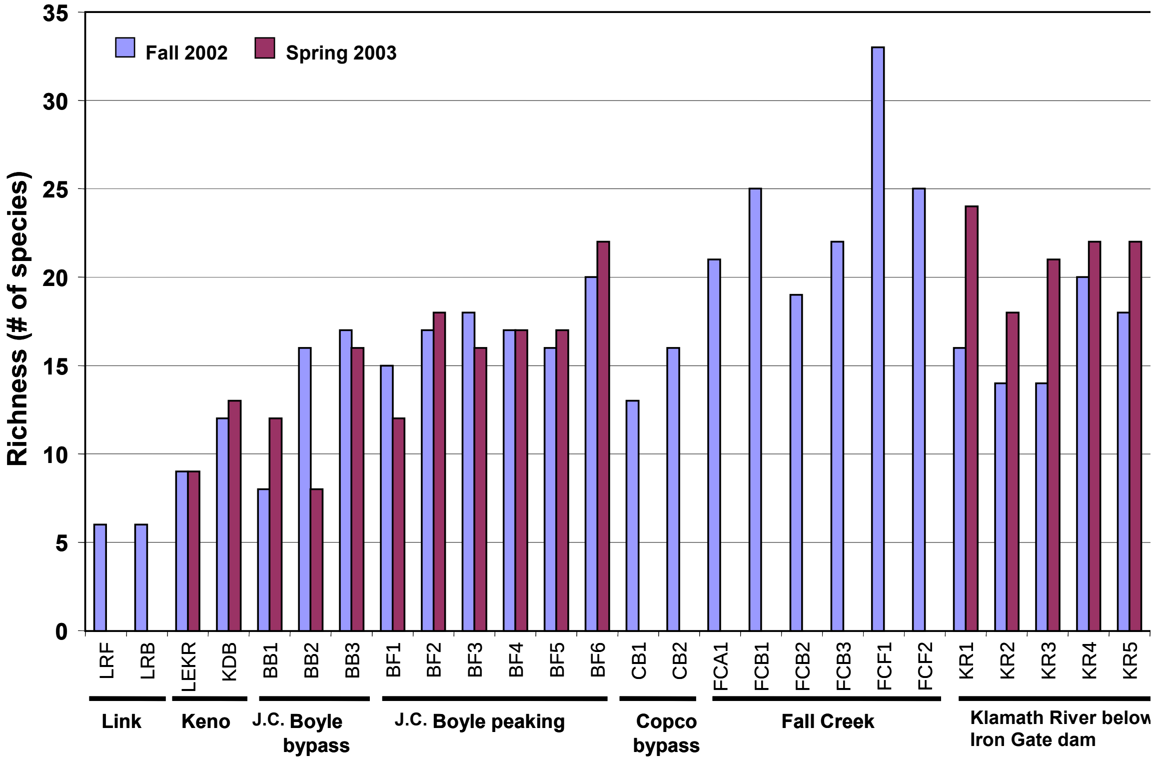

Figure 5.1-1. Taxa Richness (number of species) Observed During Fall 2002 and Spring 2003 Sampling of Macroinvertebrates at Several Location in Reaches in the Vicinity of the Klamath Hydroelectric Project.

For purposes of the macroinvertebrate studies conducted in the Project area, PacifiCorp assumed that, in general, the Fall (September) sampling coincided with the annual peak in macroinvertebrate abundance and diversity (see PacifiCorp 2004e, page 8-5). It was also assumed that, in general, the Spring (April-May) sampling coincides with the annual low in macroinvertebrate abundance and diversity because of declines through the winter, followed by emergence of many taxa in the spring coincident with the annual runoff flow peak. Abundance then increases through the summer with recruitment to the autumn peak during a period of lower, stable flows and suitable water temperatures. Given these assumptions, it is estimated that macroinvertebrate abundance and diversity during summer would be intermediate between the Fall and Spring macroinvertebrate conditions reported by PacifiCorp.

Documents filed in connection with the 401 Application include the Water Resources Final Technical Report (PacifiCorp, 2004e) and the FERC Final License Application, Volume 2, Exhibit E—Environmental Report (PacifiCorp, 2004b). Section 8 of the Water Resources FTR provides an analysis of the Fall 2002 macroinvertebrate sampling, and Section 12 of the Water Resources FTR provides an analysis of the Spring 2003 macroinvertebrate sampling. An analysis of the Fall 2002 and Spring 2003 macroinvertebrate data is also presented in Section E3.3.6 on pages 3-115 to 4-127 of the Exhibit E document (PacifiCorp, 2004b).

Macroinvertebrate Drift Sampling

Samples of macroinvertebrate drift were collected in late June/early July and early September 2004 as part of a bioenergetics study of trout feeding and growth in the J.C. Boyle peaking reach (Addley et al. 2005). Sample results indicate that the late June/early July drift density was relatively high (e.g., 0.183 prey/ft^3 in the J.C. Boyle peaking reach). Even the later September samples show good drift densities, albeit much smaller than the earlier samples (e.g., 0.025 prey/ft^3 in the J.C. Boyle peaking reach).

The drift densities in the Project reaches easily fall within this literature-reported range (Addley et al. 2005), and are similar to densities reported below Iron Gate dam by Hardy and Addley (2002). Drift densities in the literature span a very wide range depending on the river (physical and chemical characteristics), season, and sampling methods (e.g., net size). Drift densities are the highest in the summer and decrease into winter. Excluding some of the very high drift densities, most of the reported densities are between about 0.005 and 0.3 per ft^3.

5.1.12.2 Cold Water Freshwater Fish Community

Fish in the J.C. Boyle Peaking Reach

The J.C. Boyle peaking reach of the Klamath River is 17.3 miles long. It extends from the J.C. Boyle powerhouse discharge at RM 220.4 to the upper end of Copco No. 1 reservoir at RM 203.1. The Oregon/ California state line is at RM 209.3. The upstream 11.1 miles of this river reach are in Oregon and have been federally designated as a Wild and Scenic River.

As described above under the Commercial and Sport Fishery (COMM) use, the California portion of the peaking reach is managed as a wild trout fishery. The reach was designated a wild trout area (WTA) in 1974 and has since been managed under California's Wild Trout Program (WTP), which was established in 1971. The objective of the WTP is to maintain natural, productive trout fisheries, with major emphasis on the perpetuation of wild strains of trout. The rainbow/redband trout population in this river reach has been described as highly productive and self sustaining (National Park Service, 1994). CDFG (2000) reported that the Upper Klamath River WTA had the highest overall catch rate among the wild trout rivers it monitors in California.

PacifiCorp sampled the J.C. Boyle peaking reach using backpack electrofishing and angling during fall 2001 and spring, summer, and fall 2002. Boat electrofishing was conducted during fall 2002. Minnow traps and snorkeling were used to gather additional information during summer and fall 2002. Fry distribution and relative abundance studies were also conducted in the peaking reach in 2003. A technical report was completed that documents the methods and findings of these studies and is included in PacifiCorp (2004a) and discussed in Section 5.1.17, Spawning, Reproduction, and/or Early Development (SPWN).

Fish in the Copco No. 2 Bypass Reach

The Copco No. 2 bypass reach of the Klamath River is 1.4 miles long. It extends from the 38-foot-high Copco No. 2 dam at RM 198.3 to the 27-MW Copco No. 2 powerhouse at RM 196.9. The powerhouse discharges directly into Iron Gate reservoir. The Copco No. 2 bypass reach is in a deep, narrow canyon with a steep gradient similar to that of upstream Klamath River reaches. The channel consists of bedrock, boulders, large rocks, and occasionally pool habitat. The riparian zone is well developed, but has been influenced by the altered flow regime. PacifiCorp currently releases 5 to 10 cfs from Copco No. 2 dam to the bypass reach during summer.

PacifiCorp conducted fish sampling in the Copco No. 2 bypass reach using backpack electrofishing during fall 2001 and spring, summer, and fall 2002. Angling was also conducted in the reach during spring and fall 2002. Collectively, sampling captured eight different fish species, five of which were native (Table 5.1-1), including rainbow trout.

Table 5.1-1. Fish Species Collected, All Methods All Seasons: Copco No. 2 Bypass Reach, 2001-2002.

Fish Species Common Name
Rainbow trout*
Blue chub*
Tui chub*
Speckled dace*
Sculpin spp.*
Largemouth bass
Crappie spp.
Yellow perch

*Native species

During fall 2001, only three species were captured (tui chub, speckled dace, and sculpin spp.) by backpack electrofishing. Of these, speckled dace and sculpin were the most abundant. During spring 2002, again only three species were captured (sculpin spp., speckled dace, and yellow perch). Speckled dace was the most abundant species collected. In the summer, five species were caught, which included those captured in the spring plus rainbow trout and blue chub. Speckled dace and sculpin again were the most abundant species collected. During fall 2002, five species also were captured and consisted of speckled dace, sculpin, rainbow trout, black crappie, and largemouth bass, in order of relative abundance.

Angling yielded few fish in the Copco No. 2 bypass reach. Only three fish were captured during spring 2002, one each of largemouth bass, yellow perch, and speckled dace. During fall 2002, three rainbow trout were captured.

Fish in Fall Creek

Fall Creek is a tributary to the Iron Gate reservoir. It enters at RM 196.3, approximately 0.6 mile downstream of the Copco No. 2 powerhouse discharge. The 2.2-MW Fall Creek Hydroelectric facility is operated by PacifiCorp in a run-of-river (ROR) mode. There have been no investigations on Fall Creek, but it is likely that some of the native, riverine species of fish discussed previously for the Klamath River, including rainbow trout, use portions of Fall Creek. This predominantly spring-fed tributary may provide refugia for rainbow trout from Iron Gate reservoir during summer when water quality conditions decline.

PacifiCorp conducted backpack electrofishing and angling (fly fishing) methods to sample fish in the bypass reach of Fall Creek. Electrofishing was conducted during fall 2001 and spring, summer, and fall

2002, and summer 2005. Angling was conducted only during summer 2002. The only species captured using both methods was rainbow trout. A total of 89 trout were captured by electrofishing for all seasons combined, and eight trout were captured by angling during summer.

In addition to the above efforts, sampling was done in Fall Creek upstream of the diversion structure and in the diversion canal during fall 2002 and summer 2005 by backpack electrofishing. Again, the only species captured was rainbow trout. For both seasons, a total of 16 trout were caught upstream of the diversion, and 67 trout were caught in the canal. It should be noted, that while the number of fish in the canal is greater than that upstream of the diversion, it may simply be a function of the canal being easier to sample. There is little structure in the canal, except for a few boulders, that fish could use to actively or passively avoid capture. In addition, the canal is very narrow with little riparian vegetation, which allowed easy sampling access (i.e., line-of-sight and netting).

Fish in the Klamath River Below Iron Gate Dam

Iron Gate dam, located at RM 190.1, is the downstream-most hydroelectric facility of the Project and the downstream-most dam on the Klamath River. The Klamath River downstream of Iron Gate dam to the mouth is designated under state and federal Wild and Scenic River Acts. There are no upstream fish passage facilities past Iron Gate dam. Current distributions of anadromous species in the Lower Klamath River system include the mainstem Klamath River; major tributaries such as the Shasta, Scott, Salmon, and Trinity rivers; and many smaller tributaries in the lower basin. Anadromous salmonids currently using the Lower Klamath River basin downstream of Iron Gate dam include spring/summer-, fall-, and winter-run steelhead, spring- and summer/fall-run Chinook salmon, and coho salmon. Hardy and Addley (2001) also reported that chum and pink salmon still are captured infrequently in the Lower Klamath River.

Hardy and Addley (2001) summarized population trend data, as well as returns to Iron Gate fish hatchery, for steelhead, fall-run Chinook salmon, and coho salmon in the Klamath River basin and in the Mid-Klamath subbasin (from Iron Gate dam downriver to Weitchpec). Spring-run Chinook salmon also are present in this subbasin of the Klamath River, but they generally do not occur far upstream past the confluence with the Salmon River. Hardy and Addley (2001) reported that miles of suitable habitat available to these three species in the Mid-Klamath subbasin total approximately 168 miles for fall- and spring-run Chinook salmon, 250 miles for steelhead, and 190 miles for coho salmon. CH2M HILL (1985) reported that the most important fall-run Chinook spawning areas in the Mid-Klamath subbasin are in the mainstem Klamath River between Iron Gate dam and the mouth of the Shasta River, a 13.5-mile-long river reach, and in Bogus Creek downstream of Iron Gate dam. Hardy and Addley (2001) reported that about 50 percent of the fall-run Chinook salmon spawning that occurs in the mainstem Klamath River occurs in this 13.5-mile reach.

Steelhead. Hardy and Addley (2001) reported that in the 1980s, the hatchery-influenced summer/fall-run of steelhead throughout the Klamath and Trinity rivers consisted of approximately 10,000 fish, while the winter-run steelhead component was estimated at approximately 20,000 fish. Numbers of adult summer steelhead in the Klamath River basin in the 1990s have been estimated to vary between about 1,000 and 1,500 fish (National Research Council, 2003). Numbers of adult steelhead in the Trinity River basin are reported to be relatively stable, varying between approximately 1,300 and 2,800 fish per year, although about 50 to 90 percent of these fish are hatchery fish (NMFS, 1998).

A production goal of the Iron Gate fish hatchery is to produce and release 200,000 winter-run steelhead smolts to the Klamath River each year (National Research Council, 2003). Steelhead smolts are released in late March and most reach the estuary in late April along with wild steelhead smolts (National Research Council, 2003). Adult steelhead returns to Iron Gate fish hatchery, which consist of fall/winter-run fish (KRBFTF 1991), have varied widely since counts began in the mid-1960s. Annual hatchery returns averaged 1,935 fish through 1990, 166 fish from 1991 through 1995, and declined to only 11 fish in 1996 (Hardy and Addley, 2001). Recent counts (1997 through 2001) have increased slightly and averaged 265 fish per year. A total of 532 steelhead returned to Iron Gate fish hatchery in 2001, the largest number since 1989, when a total of 759 fish returned.

Chinook Salmon. Spring-run Chinook, which were considered to be more abundant than summer/fall-run fish prior to 1900, today consist of only remnant numbers (Hardy and Addley, 2001). Over the last 25 years, numbers of adult fall-run Chinook in the Klamath River basin have varied between approximately 27,000 and 218,000 fish, with natural spawners representing about 20,000 to 40,000 of these totals (Andersson, 2003). In 2002, the Chinook salmon total in-river fall run in the Klamath River basin was estimated to be 162,297 fish with natural spawners comprising approximately 42 percent (68,165 fish) of this total. The Klamath River basin Chinook salmon spring run, which utilizes the Salmon and Trinity River subbasins, has varied between approximately 200 and 1,500 adults per year over the last 25 years, and in 2002 was estimated to consist of just over 1,000 fish (Andersson, 2003).

Iron Gate fish hatchery produces and releases approximately 5 to 8 million Chinook salmon smolts (all fall-run fish) to the Klamath River each year (National Research Council 2003). Smolts are typically released in late May or early June, and most reach the estuary 1 to 2 months later. Numbers of fall-run Chinook adults returning to Iron Gate fish hatchery have ranged from 365 fish in 1966 (CH2M HILL, 1985) to a combined total for 2001 and 2002 of 111,042 Chinook. KRBFTF (1991) reported that fall-run Chinook salmon arrive at Iron Gate fish hatchery from approximately mid-September through mid-November, peaking in abundance about mid-October.

Coho Salmon. Surveys in 2001 indicated that 17 of 25 streams in the Klamath River basin known to historically support coho salmon currently support small numbers of juvenile coho. In the early 1990s, estimated coho salmon spawning escapement for the entire Klamath-Trinity river system was 1,860 native and naturalized fish. Some tributary streams in the Middle and Upper Klamath basin still support coho populations that may be native, while native coho runs are diminished in Lower Klamath River tributaries (Brown et al. 1994). Of the larger tributaries, the Scott River probably holds the largest number of native coho, while the Salmon River probably has few, if any, native coho.

Iron Gate fish hatchery currently releases an average of about 71,000 coho smolts to the Klamath River each year (National Research Council, 2003). Coho smolts are released between about mid-March and early May and reach the estuary at the same time as wild smolts, peaking in late May and early June. Annual returns of coho salmon to Iron Gate fish hatchery have been highly variable, ranging from 2 fish in 1966 during the first year of hatchery operation to 4,097 fish in 1997.

Additional discussion of Project support of coho salmon is provided in Section 5.1.14 regarding the Rare, Threatened, and Endangered Species (RARE) use.

Other Species of Importance. Two other important anadromous species, Pacific lamprey and green sturgeon, also use or could potentially use the Mid-Klamath subbasin for spawning and rearing. Pacific lamprey is a federal species of concern downstream of Iron Gate dam (PacifiCorp, 2004a), and NMFS is reviewing the status of Pacific lamprey to determine whether federal listing is warranted. Both Pacific lamprey and green sturgeon have been observed as far upstream as Iron Gate dam (KRBFTF, 1991; Hardy and Addley, 2001). Hardy and Addley (2001) reported that no quantitative data are available for the Mid-Klamath subbasin on the status of Pacific lamprey, although their distribution is believed to be generally similar to that of steelhead.

There also are no quantitative data on populations of green sturgeon in the Mid-Klamath subbasin. CH2M HILL (1985) reported that while green sturgeon have access upriver as far as Iron Gate dam, most adults do not migrate above Ishi Pishi Falls (RM 66.1) during their spawning migrations from the ocean. The National Research Council (2003) reported there is some evidence that populations of green sturgeon are in decline, but that reduced commercial harvest may have addressed this decline somewhat. NMFS rejected a petition in 2003 to have green sturgeon listed as a threatened species under the ESA (National Research Council, 2003).

The federally and state-designated endangered shortnose sucker also is reported to occur in the Klamath River downstream of Iron Gate dam. The presence of this lake-dwelling species may reflect the downstream emigration of juveniles and adults from upstream basin habitat, a behavior suggested for this species when present elsewhere in the Klamath River downstream of Project dams (Henriksen et al. 2002). Additional discussion of Project support of listed sucker species is provided in Section 5.1.14 regarding the Rare, Threatened, and Endangered Species (RARE) use.

Major Tributaries. Major tributaries entering the Klamath River downstream of Iron Gate dam are the Shasta River at RM 176.6, the Scott River at RM 143.0, the Salmon River at RM 66.0, and the Trinity River at approximately RM 40. All of these tributaries enter the Klamath River in what the KRBFTF (1991) defined as the Mid-Klamath subbasin. Anadromous fish production in each tributary subbasin is generally reduced compared to estimated historical levels (CH2M HILL, 1985; KRBFTF, 1991; Hardy and Addley, 2001; National Research Council, 2003).

The National Research Council (2003) reviewed factors in the Klamath River basin that likely are most limiting to anadromous fish species. Emphasis was placed on coho salmon, spring-run Chinook salmon, and summer-run steelhead because of the magnitude of risk these populations currently face. However, all anadromous species would benefit from improved tributary conditions, particularly in major drainages including the Shasta, Scott, Salmon, and Trinity rivers and their tributaries because of their importance to salmonid spawning and rearing. It was concluded that for most tributaries, improving summer temperatures is probably the most critical factor (and action) that would benefit all salmonids, especially those salmonids at greatest risk. Other important factors (and actions) include removing fish passage barriers, improving physical habitat for spawning and rearing, and increasing minimum stream flows (National Research Council, 2003). These actions would be expected to benefit anadromous life stages in the Klamath River system as a whole.

5.1.12.3 Proposals for Cold Water Freshwater Fish

Fish Proposals in the J.C. Boyle Peaking Reach

Minimum Flows. An increased minimum flow level and adjustments in peaking operations are proposed in the J.C. Boyle peaking reach to enhance usable fish habitat and decrease the reach's unproductive varial zone, while preserving existing water quality, recreational boating and angling conditions.

A minimum release of 200 cfs plus J.C. Boyle bypass accretion will be provided at the USGS gauge downstream of the J.C. Boyle powerhouse (USGS gauge No. 11510700). This flow release will provide approximately 425 cfs into the J.C. Boyle peaking reach. The minimum flow will be met through an additional release of 100 cfs (200 cfs total) at the powerhouse (plus 100 cfs from J.C. Boyle dam).

Combined with the spring water accretion flow (about 220 to 250 cfs) that occurs in the bypass reach, a minimum flow of about 425 cfs would be maintained in the 17-mile peaking reach. This is an increase of about 100 cfs compared to current minimum flow conditions. Based on the results of the instream flow study analysis for rainbow/redband trout, the new base flow of 425 cfs would increase the instream habitat (Weighted Usable Area [WUA]) for adult and juvenile trout to near maximum (i.e., 99 percent) available levels. The increased minimum flow would provide 62 percent of maximum habitat conditions for rainbow trout fry—a 5 percent increase over levels at the current minimum flow.

The habitat response to the increased minimum flow for suckers would be similar to that described for trout based on the preliminary WUA results. Habitat for adult suckers would increase slightly, while habitat for juvenile suckers would decrease slightly.

The proposed increase in the minimum flow for the peaking reach would also increase the area of the streambed that is continually wetted (typically defined as the wetted perimeter across a given cross-section of stream). The amount of the streambed that would be subjected to watering-dewatering events (the varial zone) would be reduced during periods of flow fluctuations.

For the total streambed area (all habitat types), the increase in minimum flow from the current 325 cfs to the proposed 425 cfs would increase the wetted perimeter of the river, on average, by 6.5 feet or about 5.3 percent (Table 5.1-2). In riffle areas, the average increase in wetted perimeter would be about 11.3 feet (8.0 percent). This increase in wetted perimeter is expected to increase the biomass of aquatic macroinvertebrates. An increase in macroinvertebrate biomass is expected to positively affect the growth and condition of fish in this reach.

Table 5.1-2. Difference in Wetted Perimeter of the J.C. Boyle Peaking Reach Under Current and Proposed Minimum Flows.

Minimum Flow (cfs)	**Wetted Perimeter (all habitat types)**	**Wetted Perimeter (riffle habitat)**
325 cfs (current minimum flow)	122.8 ft	141.3 ft
425 cfs (proposed minimum flow)	129.3 ft	152.6 ft
Difference in wetted perimeter	+ 6.5 ft	+11.3 ft
Percent difference	+ 5.3%	+ 8.0%

In the FEIS for the Project (FERC 2007), FERC staff conclude that “available information indicates that the rainbow trout population in this river reach is highly productive, and we expect that this fishery would be sustained and improved under PacifiCorp’s proposed flow regime, which would increase base flows and reduce the total flow change that would occur under peaking operations”. FERC staff also performed an independent analysis of the effect of alternative flow regimes on angling opportunities in the J.C. Boyle peaking reach, and conclude that “under PacifiCorp’s proposed flow regime, the total number of days with flows that create acceptable angling opportunities would be comparable to those that would be available under run-of-river operations, recommended by NMFS and Cal Fish & Game”. In addition, FERC staff also concluded that “PacifiCorp’s Proposal would provide from 20 to 31 days of optimal angling flows during nearly all months from June through October for all water year types analyzed, and operating in a run-of-river mode would not provide any days with optimal angling flows during the same time frame”.

Ramping Rates. As measured at USGS gauge No. 11510700 downstream of the J.C. Boyle powerhouse, flow upramp rates will not exceed 9 inches (in water level) per hour. Flow downramp rates will not exceed 9 inches per hour for flows above 1,000 cfs, and will not exceed 4 inches per hour for flows less than 1,000 cfs. In addition, PacifiCorp proposes that Project-controlled downramping will not exceed 2 inches per hour during the first down ramp event following a prolonged period (10 days or more) of continuous stable flow conditions in the reach.

In the FEIS for the Project (FERC 2007), FERC staff recommend a downramping rate that is consistent with the rate proposed by PacifiCorp except to specify that, when peaking operation of the J.C. Boyle powerhouse commences in the spring, or after 7 or more days of non-peaking operation (as defined by the consistent operation of only 0, 1, or 2 units), downramping would be limited to a maximum rate of 2 inches per hour in the first 24 hours, 4 inches per hour in the second 24 hours, 6 inches per hour in the third 24 hours, and 9 inches per hour thereafter. During the periods when 6- or 9-inch downramping rates are in effect, downramping would also be limited to 4 inches per hour whenever flows are 1,000 cfs or less.

Peaking operations will continue at the powerhouse. However, the daily Project-controlled flow change (or flow magnitude change, that is, the difference between lowest and highest flow in a 24-hour period) during peaking operations will not exceed 1,400 cfs (as measured at USGS gauge No. 11510700 downstream of the J.C. Boyle powerhouse). This limit of flow change to 1,400 cfs per 24-period will preclude no load to full two-unit peaking events (420 cfs to 3,420 cfs at gauge). Two-unit operation will occur if inflows are high enough to run both units, or run one unit in continuous operation and the second one operated in peaking fashion. Peaking of the second unit will only occur while the first unit is in operation.

This limit on powerhouse operations will provide greater flow stability for aquatic resources and continue to provide a balance of whitewater boating and angling opportunities (periods of optimal wading-based fishing and standard whitewater boating flows), as one unit can provide raftable flows. Low flow periods (that is, flows of 700 cfs or lower at Iron Gate dam) will have limited one-unit peaking time "windows" for standard whitewater boating (which relies on flows of 1,500 to 1,800 cfs). Anglers will conversely have larger time "windows" for angling opportunities.

The proposed down ramp rate of 4 inch/hr when flows at the gauge are <1,000 cfs will reduce the potential for small fish to become stranded because the stream bank gradients and corresponding water-edge receedance rate (which most relates to stranding potential) is greater at flows <1,000 cfs compared to higher flows. In most areas of the J.C. Boyle peaking reach, the toe-of-bank, which defines the edge of the predominant active stream bed, occurs at the waters edge at flows of approximate 1,000 cfs. Therefore, reducing down ramp rates when the water level is below this point would be most effective at reducing the risk of fish stranding. The 4 inch/hr rate will attenuate to about 3 inch/hr at Frain Ranch (RM 214.3) and to about 2 inch/hr near Shovel Creek (RM 201.5) (see Section E42.2.1). Although studies conducted in the J.C. Boyle peaking reach did not indicate that much fish stranding was occurring at the current rate of 9 inch/hr, there were limited numbers of trout fry observed in the study area. The other abundant riverine species, such as speckled dace and marbeled sculpin, did not appear to be prone to stranding at the current ramp rate. Nevertheless, more restrictive downramping would provide additional enhancements in light of potential increases in the recruitment of trout fry into this reach that may result from other enhancement measures, such as gravel augmentation in the upstream bypass reach and improvements to the Copco Ranch irrigation diversions.

Restricting powerhouse operations to one turbine (of two) ramping at a time will limit the amplitude of flow change and the associated streambed reductions that occur during each peaking cycle. The proposed increase in minimum base flow from 325 cfs to 425 cfs will also contribute to a reduction of the flow-change amplitude (see discussion above). Studies conducted in 2003 indicate that adult trout as well as trout fry moved very little during a one-unit peaking cycle.

<u>J.C. Boyle Powerhouse Bypass Valve</u>. Under existing conditions, the J.C. Boyle powerhouse does not have the means to maintain downstream river levels in the event of either or both generating units are tripped off line (unscheduled outage). Upon a plant trip, the river stage drops according to plant discharge. Flow capacity through each unit is roughly 1,425 cfs. In the case of a unit trip when both units are operating, the river drops 1.3 feet. If both units are operating and they both trip, the river will drop approximately 3 feet. If either event was to occur, river stage is not corrected until the generating unit is back in service, water is released at the canal spillway, or water is released at the dam. Also, in the event both units trip, the canal cannot contain enough of the backed-up water and the canal spillway gate is opened. Spill amount and duration at this location is dependent on amount of flow in the canal at time of unit trip and the time it takes to close the canal headgate.

To reduce the potential for river stage changes in response to unit trips at the J.C. Boyle powerhouse, PacifiCorp is proposing to install synchronized bypass valves at the J.C. Boyle powerhouse once a new license is issued and accepted. After the bypass valves are installed, the canal spillgate will no longer be used during a unit trip or maintenance, and flows will remain stable in the J.C. Boyle bypass reach during unit trips and maintenance events. A general arrangement drawing of the proposed modification is presented in Exhibit F to the FERC license (PacifiCorp, 2004c). This bypass facility may need to be modified when the new instream flow requirements are adopted downstream of the J.C. Boyle powerhouse. For example, a 100-cfs flow release at the powerhouse during non-peaking operations could be accomplished with a small hydro turbine or modifications to the proposed synchronous bypass valves.

The installation of the proposed synchronous bypass valves at the powerhouse will eliminate this fish stranding potential, due to unscheduled unit trips. Another anticipated benefit of the installation of the bypass valves is the elimination of the use of the canal spillway. Past use of the spillway has resulted in erosion of the hillside leading down to the bypass reach and subsequent increases in turbidity in this otherwise clear water segment of river.

Fish Proposals in the Copco No. 2 Bypass Reach

Down-Ramping. PacifiCorp proposed that flow downramp rates in the Copco No. 2 bypass reach will not exceed 125 cfs per hour, except for flow conditions beyond the Project's control (e.g., inflows to the J.C. Boyle reservoir that change at rates greater than above ramp rate). This rate is primarily applicable to planned maintenance events. To the extent possible, flow changes will occur during the night to reduce the risk of potential fish stranding associated with river spill events.

Down ramping in this reach is rare and occurs primarily when Copco No. 1 is coming off of a spill event or during scheduled maintenance shut-down of the Copco No. 2 powerhouse. Although fish use of the Copco No. 2 bypass reach is limited, such events may strand some fish. Ramping of flows through the Copco No. 2 bypass will be accomplished at the Copco No. 1 Development. For flows less than 3,200 cfs control will be through the Copco No. 2 dam. The proposed ramp rate of 125 cfs per hour is equivalent to less than 2 inches per hour in most of the expected flow ranges.

Minimum Flow. A minimum flow of 10 cfs will be released from Copco No. 2 dam at all times. The 10 cfs will be regulated through an automated gate that allows for changes in water surface elevation in the forebay of the dam.

Fish Proposals at Copco and Iron Gate Reservoirs

PacifiCorp proposes to implement several water quality measures that will improve water quality in Copco and Iron Gate reservoirs and in releases from Copco and Iron Gate dams to downstream reaches. The resulting improvement in water quality will benefit habitat conditions for fish in these areas. Specifically, these include a reservoir management plan for Copco and Iron Gate reservoirs (Appendix B), and potential selective withdrawal for temperature management at Iron Gate dam. These measures are described in Section 3.2.

Fish Proposals on Fall Creek

Minimum Flow. A minimum flow of 5 cfs will be released into the Fall Creek bypass reach, and a minimum flow of 15 cfs minimum flow will be maintained downstream of the bypass confluence with powerhouse tailrace. Flow release control structures associated with the proposed fish passage facilities at the dam will be constructed to maintain the continuous 5 cfs release at the dam. Of the 5 cfs minimum flow, approximately half will consist of the fish ladder flow and the other half will be the fish screen bypass flow.

The Fall Creek bypass supports a population of rainbow trout, nearly all of which are smaller than 150 mm. Results of the instream flow analysis indicate that the proposed 5 cfs minimum flow will nearly maximize the available habitat for juvenile sized (<150 mm) trout in the bypass reach. This will result in an increase of juvenile trout habitat of about 45 percent.

The proposed 15 cfs minimum flow for the stream reach downstream of the tailrace confluence with the bypass channel is the same minimum flow as stipulated in the current FERC license. The flow requirement is largely moot because of the powerhouse flow continuation valves, which maintains flow in lower Fall Creek even if the powerhouse is not operating. The flow would only pertain to those rare occasions when the powerhouse or diversion canal is in the process of being shut down and flow is being returned to the bypass channel. This process must be done slowly enough to allow the required 15 cfs to reach the lower creek before the canal diversion is completely shut off.

Fish Proposals Downstream of Iron Gate Dam

Instream Flows and Ramp Rates. The instream flow schedule and ramp rates below Iron Gate dam will be maintained according to USBR’s KIP 2007 Operations Plans (USBR 2007) consistent with the 2002 Biological Opinions issued by USFWS (2002) and NMFS (2002). Detailed description of these instream flows and ramp rates are provided in Section 3.1.3.3 of this document.

Gravel Augmentation. Gravel augmentation mitigation and enhancement measures are proposed to address the effects that Project reservoirs have had on spawning gravel. A detailed description of proposed gravel augmentation is provided in Section 3.2.6 of this document. In general, the gravel augmentation proposal is designed to be an adaptive mitigation measure with an initial augmentation followed by recurring augmentation based on detailed monitoring of the added material over the life of the new license. Monitoring will document the movement of gravels from the augmentation sites, accumulation of gravels in formerly gravel-starved sites downstream of the augmentation sites, and use of the augmented gravels by spawning fish.

The potential benefits to fisheries below Iron Gate dam from gravel augmentation is simply to restore a more “natural” substrate composition in the River, especially in the areas immediately below the dam, which have been most affected by blocked gravel recruitment. The segment of river from Iron Gate dam to the confluence with the Shasta River currently supports the majority of fall Chinook spawning in the mainstem of the Klamath River, which indicates that this segment of river provides suitable water quality, temperature, and channel morphology for successful spawning. Therefore, the proposed gravel augmentation in this river segment is expected to enhance spawning success for fall Chinook salmon and potentially for other fish such as steelhead trout.

Iron Gate Fish Hatchery. As part of the mitigation for development of Iron Gate dam, Pacific Power and Light Company (now PacifiCorp Energy) was required to build and fund the Iron Gate salmon and steelhead hatchery. The adult salmon ladder, trap and spawning facility was built at the base of the dam and was put into operation in February 1962. The hatchery complex, including egg incubation, rearing, maintenance, and administration facilities, as well as staff residences, was constructed about 400 yards downstream of the dam with a completion date of March 1966. The largest feature of the hatchery complex comprises the 32 rearing ponds, each measuring 10 by 100 feet. The facilities have operated every year since construction with little modification.

Iron Gate fish hatchery is operated by CDFG. The program is funded both by CDFG and PacifiCorp. By agreement, PacifiCorp funds 80 percent of the total operating costs of the hatchery to satisfy its annual mitigation goals for fall Chinook fingerlings, coho yearlings, and steelhead yearlings. Since 1979, CDFG has funded portions of the fall Chinook fingerling production that are reared to the yearling stage for release in November.

PacifiCorp will continue funding 80 percent of the production and operation costs of the Iron Gate Hatchery to meet current production goals. The hatchery has been successful at meeting production goals in nearly all years, with a significant number of adult returns to the Klamath River. The facility has been largely free of disease outbreaks and other major sources of mortality. Broodstock selection has, and will continue to be based on procedures used by CDFG to minimize adverse genetic consequences to the hatchery stock and naturally spawning fish in the Klamath River. PacifiCorp will continue to work with CDFG in their efforts to improve production efficiency and effectiveness and to minimize conflicts between hatchery-reared and naturally-produced salmon and steelhead trout. This may result in shifts in production goals requiring operational changes or new facilities.

Adult fall Chinook and coho salmon and steelhead trout, which originate from smolt releases at the Iron Gate fish hatchery, have contributed significantly to the ocean and in-river commercial and sport fisheries since the late 1960s. Based on smolt-to-adult survival studies conducted on Iron Gate fall Chinook salmon, the hatchery production contributes about 50,000 fish annually to these fisheries plus escapement back to the hatchery. Maintaining the current production at the hatchery will continue to provide these benefits.

PacifiCorp proposes to purchase and construct facilities and provide the necessary equipment to expand the marking and tagging of fall Chinook salmon smolts produced at the Iron Gate Hatchery from the current 5 percent rate to 25 percent. The proposal includes the purchase of a mass-marking system for use at the hatchery. The system uses automated fish-marking equipment that reduces handling stress on the fish compared to manual methods. The system also will meet the need to mark the required numbers of fish in the available 6-week timing window.

The purpose of the mass-marking trailer is to increase the number of fall Chinook salmon smolts that are marked at the hatchery prior to release. Currently, about 5 percent of the Iron Gate Hatchery Chinook are tagged with coded wire tags (CWT) and marked with an adipose fin clip. The increased percentage of Chinook tagged at IGH will match the percent done at the Trinity River Hatchery so as to achieve a “constant fractional marking” (CFM) rate in the Klamath-Trinity River Basin.

Increased tagging of fall Chinook salmon at the Iron Gate Hatchery will have positive benefits to fisheries management in the Klamath River Basin. Having a higher and constant fractional marking rate allows fisheries managers to calculate management metrics with greater precision thus potentially allowing better and more timely management decisions. Relative and absolute hatchery contribution and straying rates would be important management metrics benefiting from increased CFM rates within the Klamath-Trinity Basin.

5.1.13 Wildlife Habitat (WILD)

Uses of water that support terrestrial ecosystems, including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates) or wildlife water and food sources. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Wildlife Habitat (WILD) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As described below, the Project supports WILD uses within or below the Project. PacifiCorp has proposed several measures in this application to specifically benefit WILD uses.

The Project area supports a wide variety of wildlife species, including deer and elk, a several species of smaller mammals, birds, amphibians, and reptiles. From a regional perspective, the canyon and mid-elevation hillsides and plateaus between the J.C. Boyle powerhouse and Iron Gate dam are considered critical deer winter range. Within the study area, south-facing lower canyon walls and hillsides are some of the most critical habitat for the wintering migratory Pokegama black-tailed deer (*Odocoileus hemionus*) herd and resident deer. The South Cascades deer study (Jackson and Kilbane, 1996) documented movement from the wintering range on the Horseshoe Ranch to the Cascade Mountains north and south of the Project. This study showed at least some movement across the Klamath River either across or near Iron Gate reservoir. Elk telemetry data from the CDFG showed a single individual with a long-range migration pattern between the Shasta Valley in California and the forests to the west of UKL in Oregon. Another telemetry study showed that elk used summer ranges in the upper portions of the Long Prairie Creek and Jenny Creek areas as well as several areas at higher elevations north of the Klamath River (BLM, 1996).

Of the 20 habitats where wildlife observations were recorded in the study area, riparian/wetland shrub and riparian/wetland forests supported the most wildlife species, with 87 and 106 species, respectively. Project reservoirs also provide habitat for many species; lacustrine habitat was found to support 62 species, with each reservoir having a slightly different assemblage of species.

A combination of existing databases and literature and surveys of potential pond-breeding, stream, and terrestrial habitats conducted in 2002, along with spotted frog (*Rana pretiosa*) and foothill yellow-legged frog (*Rana boylii*) surveys conducted in 2003, documented five species of amphibians and 16 species of reptiles in the study area. Pond-breeding amphibians in the study area include long-toed salamander (*Ambystoma macrodactylum*), Pacific treefrog (*Hyla regilla*), western toad, and bullfrog (*Rana catesbeiana*). The only riverine amphibian species found was the Pacific giant salamander (*Dicamptodon tenebrosus*).

There is no evidence or information to suggest that the Project adversely affects wildlife, either directly or indirectly through effects on prey species. Entrainment data collected at Fall Creek and J.C. Boyle canal trash racks indicate that medium-sized and large mammals are not entrained in any Project canals with regularity. The Fall Creek canal does not appear to represent significant entrapment hazards to big game or most other wildlife because its water velocity is low and the canal banks are earthen construction that allows animals to escape.

PacifiCorp proposes to implement a vegetation resource management plan and a wildlife resource management plan. Collectively, these two plans will include the following enhancement measures: (1) roadside and powerline right-of-way (ROW) management activities, (2) noxious weed control, (3) restoration of Project-disturbed sites, (4) protection of TES plant populations, (5) riparian habitat restoration, (6) installation of wildlife crossing structures on the J.C. Boyle canal, (7) deer winter range management, (8) monitoring powerlines and retrofitting poles to decrease electrocution risk,

(9) development of amphibian breeding habitat along Iron Gate reservoir, (10) support of aerial bald eagle surveys and protection of bald eagle and osprey (*Pandion haliaetus*) habitat, (11) selective road closures, (12) installation of turtle basking structures, (13) installation of bat roosting structures, (14) surveys for TES species in areas to be affected by new recreation development, and (15) long-term monitoring of PM&E measures.

In addition to the above measures, the proposed changes in instream flow and ramping rates will improve conditions for wetland and riparian vegetation in the J.C. Boyle peaking reach.

5.1.14 Rare, Threatened, or Endangered Species (RARE)

Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal laws as rare, threatened or endangered. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Rare, Threatened, or Endangered Species (RARE) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. As described below, the Project supports RARE uses within or below the Project. Several measures are proposed in this application to specifically benefit RARE uses.

5.1.14.1 Federal and State Listed Fish Species

Three fish species in the Project area are listed under the ESA and are under the protection of the State of California:

- Coho salmon
- Lost River sucker
- Shortnose sucker

Coho Salmon

The coho salmon is a native anadromous salmonid fish to the Klamath River system. The specific coho salmon stock in the Klamath River system belongs to the southern Oregon/northern California (SONC) ESU as defined by NMFS. The SONC coho salmon was listed as threatened species under the ESA in June 1997 (62 FR 24588). The coho salmon was designated as a candidate species under CESA in 2001. In 2003, the California Fish and Game Commission found that the coho salmon warranted designation as a threatened species under CESA. In November, 2003, the CDFG released its Draft Recovery Strategy for the Coho Salmon, including the Klamath River system.

Prior to the federal listing in 1997, and in subsequent documentation regarding the listing of this stock of coho, much was written regarding the life history and factors affecting the populations. The following description of general information, life history, and limiting factors of the SONC stock of coho salmon has been taken directly from the more recent USBR's Biological Opinion (NMFS, 2002).

All SONC coho salmon populations within the ESU are depressed relative to their past abundance, based on the limited data available (July 25, 1995, 60 FR 19 38011; May 6, 1997, 62 FR 24588). The Klamath River population is heavily influenced by hatchery production, and a large component of the population is of hatchery origin, apparently with limited natural production. The apparent declines in production suggest that the natural population may not be self-sustaining (May 6, 1997, 62 FR 24588). These declines in natural production are related, at least in part, to degraded conditions of the essential features of spawning and rearing habitat in many areas of the SONC coho salmon ESU.

Iron Gate fish hatchery currently releases an average of about 71,000 coho smolts to the Klamath River each year (National Research Council, 2003). Coho smolts are released between about mid-March and early May and reach the estuary at the same time as wild smolts, peaking in late May and early June. Annual returns of coho salmon to Iron Gate fish hatchery have been highly variable, ranging from 2 fish in 1966 during the first year of hatchery operation to 4,097 fish in 1997.

The major activities identified as responsible for the decline of coho salmon in Oregon and California include logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, water withdrawals, and unscreened diversions for irrigation (May 6, 1997; 62 FR 24588). Coho salmon harvested by California Native American tribes in the northern California portion of the SONC ESU are primarily incidental to larger Chinook salmon subsistence fisheries in the Klamath and Trinity rivers; in neither basin is tribal harvest considered to be a major factor for the decline of coho salmon.

Coho salmon occur in the mainstem Klamath River year round, and coho also inhabit several Klamath River tributaries (Henriksen 1995; INSE 1999; Yurok Tribe 2001; CDFG 2002). Between Iron Gate dam and Seiad Valley, coho salmon populations are known to occur in Bogus Creek, Little Bogus Creek, Shasta River, Humbug Creek, Little Humbug Creek, Empire Creek, Beaver Creek, Horse Creek, and Scott River.

Limited information exists regarding coho salmon abundance in the Klamath River basin. Surveys in 2001 indicated that 17 of 25 streams in the Klamath River basin known to historically support coho salmon currently support small numbers of juvenile coho. Wild coho stocks in the Trinity River subbasin have declined by about 96 percent from historical levels (National Research Council, 2003). In the early 1990s, estimated coho salmon spawning escapement for the entire Klamath-Trinity river system was only 1,860 native and naturalized fish. Some tributary streams in the Middle and Upper Klamath basin still support coho populations that may be native, while native coho runs are greatly diminished in Lower Klamath River tributaries (Brown et al. 1994). Of the larger tributaries, the Scott River probably holds the largest number of native coho, while the Salmon River probably has few, if any, native coho.

As described in this application for water quality certification, PacifiCorp proposes a number of measures that will specifically benefit coho salmon. These include: (1) maintaining instream flows and ramp rates below Iron Gate dam according to USBR's KIP 2007 Operations Plan (USBR 2007) consistent with the 2002 Biological Opinions issued by NMFS (2002) and USFWS (2002); (2) augmentation of spawning gravel in the Klamath River below Iron Gate dam; (3) continued funding of operations at the Iron Gate hatchery; and (4) implementation of reservoir management plan (RMP) actions, which will enhance water quality conditions in the reservoirs and the Klamath River below Iron Gate dam that are currently affected by substantial upstream nutrient loading.

Lost River Sucker

The Lost River sucker is an endemic species to the Upper Klamath River basin and has limited distribution. The Lost River sucker was first listed as a state endangered species in 1974 by the State of California, and also is included on California's Fully Protected Species list. In 1988, it was listed as a federally endangered species (53 FR 137). In 2002, a petition was presented to the USFWS to delist the Lost River sucker (67 FR 93). The USFWS concluded that there was not sufficient scientific or commercial information to warrant the delisting of Lost River sucker from the federal list of endangered species.

At the time of the federal listing of the Lost River sucker (and shortnose sucker), the recognized threats to the species were stated as (67 FR 93):

- Drastically reduced adult populations and lack of significant recruitment
- Over-harvesting by sport and commercial fishing
- Potential competition with introduced exotic species
- Lack of regulatory protection (since rectified with the listing)
- Hybridization with other sucker species
- Large summer die-offs caused by declines in water quality in UKL

In addition to these, there is also the recognized issue of entrainment of suckers from UKL into the USBR KIP's A-Canal where they were essentially lost to the system. Also there is a recognized concern over the entrainment of suckers from UKL into the downstream river where habitat may or may not be suitable for a sustainable population, and entrainment into PacifiCorp's East Side and West Side hydroelectric facilities.

The Lost River sucker is native to UKL (Williams et al. 1985) and most of its tributaries, which include the Williamson, Sprague, and Wood rivers; and Crooked, Seven Mile, Four Mile, Odessa, and Crystal creeks (Stine, 1982). It is also native to the Lost River system, Lower Klamath Lake, Sheepy Lake (Williams et al. 1985), and Tule Lake (Stine, 1982).

The Lost River sucker's present distribution is not well known, but it still occurs in UKL and its tributaries (Buettner and Scoppettone, 1990), Clear Lake reservoir and its tributaries (Buettner pers. comm.), and the Upper Klamath River including Copco reservoir. Juvenile suckers are suspected to have been observed in the Wood River and Crooked Creek (Markle, OSU, pers. comm.).

Lost River suckers are a long-lived species, with the oldest individual recorded as 43 years old when taken from UKL (Scoppettone, 1988). Lost River suckers are one of the largest sucker species and may obtain a length of up to 1 meter (Moyle, 1976). Sexual maturity for suckers sampled in UKL occurs between the ages of 6 to 14 years, with most maturing at age 9 (Buettner and Scoppettone 1990).

Spawning for Lost River suckers has been observed by various researchers to occur between March and May (Moyle 1976). Observations of Lost River suckers spawning in the tributaries of UKL found that most spawned at depths between 21 to 70 cm and in water velocities ranging from 31 to 90 cm/sec (Buettner and Scoppettone 1990). The best substrate for Lost River sucker spawning is believed to be those areas that are dominated by gravel with little sand (Klamath Tribe 1987).

Shortnose Sucker

The shortnose sucker is an endemic species to the Upper Klamath River basin (including UKL and some of its tributaries) and is limited in its distribution within the region. The shortnose sucker was first listed as a California state endangered species in 1974, the same year as the Lost River sucker. Like the Lost River sucker, the shortnose sucker also is included on California's Fully Protected Species list. In 1988, it was listed as a federally endangered species (53 FR 137). In 2002, a petition was presented to the USFWS to delist the shortnose sucker (67 FR 93). The USFWS concluded that there was not sufficient scientific or commercial information to warrant the delisting of the shortnose sucker from the federal list of endangered species. As stated above, the limiting factors that potentially affect the shortnose sucker are those that were stated for the Lost River sucker.

The only known native historical distribution of the shortnose sucker is in UKL and its tributaries (Miller and Smith 1981; Williams et al. 1985). Shortnose sucker have been collected from numerous other areas in the Klamath River basin, such as the Lost River, Clear Lake reservoir, and Tule Lake, but it is hypothesized that they gained access to the Lost River, and subsequently the other areas, by way of the A-canal of the Klamath Irrigation District (Williams et al. 1985). Shortnose sucker have also been observed in Copco reservoir on the Upper Klamath River, but it presumed that they are not native to this area. The Copco reservoir population of shortnose sucker is presumed to have come from UKL (Dennis Maria, CDFG, Yreka 1991).

As with Lost River sucker, shortnose sucker are a long-lived species. Scoppettone (1988) found that the oldest shortnose sucker he examined in the basin was 33 years old when taken from Copco reservoir. Sexual maturity for shortnose sucker appears to occur between the ages of 5 and 8 years with most maturing at the age of 6 or 7 years (Buettner and Scoppettone 1990). Buettner and Scoppettone (1990) found that for female shortnose sucker sampled from UKL, most growth occurred in the first 6 to 8 years of life. After that, the growth rates decreased and it was felt that this was related to the fish reaching sexual maturity.

Moyle (1976) reports that researchers have observed shortnose sucker spawning in April and May in the waters of the Klamath River basin. Shortnose suckers have been observed in their spawning migrations up streams when water temperatures were between 5.5 and 17°C (Andreasen 1975; Buettner and Scoppettone 1990). Most shortnose suckers spawning in the tributaries of UKL have been observed in water depths ranging from 21 to 60 cm and in water velocities of 41 to 110 cm/sec (Buettner and Scoppettone 1990). The spawning behavior for shortnose suckers is similar to what was described for Lost River suckers (Buettner and Scoppettone 1990). After migrating from the shortnose sucker spawning tributaries, juveniles are thought to inhabit near-shore areas similar to that of Lost River suckers (Buettner and Scoppettone 1990).

5.1.14.2 ESA-Listed Nonfish Species

The northern spotted owl is the only federally listed species documented in the Project vicinity. The other three federally listed species—western snowy plover, Canada lynx, and gray wolf—were not observed during field surveys in 2002 or 2003 and have not been reported from any other known sources as occurring in the Project vicinity.

PacifiCorp notes that the bald eagle was discussed in this section in the previous application for water quality certification (PacifiCorp 2007b). However, as of August 8, 2007, the bald eagle is no longer listed under the ESA.

Northern Spotted Owl

During 2002 and 2003, spotted owl protocol surveys were conducted in suitable habitat within 1.2 or 1.3 miles of Project facilities and recreation sites that are adjacent to the Project reservoirs (includes Project- and non-Project recreation sites) (PacifiCorp, 2004g). During spotted owl surveys in 2002, one male detected along the J.C. Boyle peaking reach in June, and a pair detected along the J.C. Boyle peaking reach in the same general area on two separate days in July. None of these detections were within 5 miles (8 km) of any Project facilities. During surveys in 2003, a pair of owls was detected southwest of the Beswick Ranch in the J.C. Boyle peaking reach. A lone female owl was detected earlier in the season approximately 0.5 mile (0.8 km) from the pair. There are no effects to spotted owls resulting from the Project (PacifiCorp, 2004g).

5.1.14.3 ESA-Listed Plant Species

Two plant species—Applegate's milkvetch (*Astragalus applegatei*) and slender orcutt grass (*Orcuttia tenuis*)—are federally listed as endangered and threatened, respectively, in the vicinity of the Project. However, neither species has been documented in the Project area (PacifiCorp 2004g). Only Applegate's milkvetch has been documented in the Project area in Oregon—reported by the ONHP to occur near Keno reservoir. There are no effects to these plant species resulting from the Project (PacifiCorp 2004g).

5.1.14.4 State-Listed Wildlife Species

Eight wildlife species known to occur in the Project vicinity that are not federally listed are listed as endangered or threatened by the State of California. These species are: Swainson’s hawk (*Buteo swainsoni*), peregrine falcon (*Falco peregrinus anatum*), greater sandhill crane (*Grus canadensis tabida*), yellow-billed cuckoo (*Coccyzus americanus occidentalis*), great gray owl (*Strix nebulosa*), willow flycatcher (*Empidonax trailii adastus*), bank swallow (*Riparia riparia*), and Sierra Nevada red fox (*Vulpes vulpes necator*). However, of these species, only great gray owl and willow flycatcher have been observed in the Project area in California.

Great Gray Owl

Two great gray owl detections, likely separate vocalizations by the same individual bird, were recorded during spotted owl protocol surveys conducted in 2002; no detections of this species occurred during 2003 protocol great gray owl or northern spotted owl surveys (PacifiCorp, 2004g). The two detections were approximately 1 mile (1.6 km) from Fall Creek.

Willow Flycatcher

Thirteen willow flycatcher detections were recorded in riparian or wetland habitat located peripheral to a reservoir or river reach during May and June 2002 (PacifiCorp, 2004g). Willow flycatchers were most abundant around Iron Gate reservoir and the Iron Gate-Shasta section. It is unknown if the detections were of breeding individuals or birds migrating through the area. If breeding is occurring, it is patchy and restricted to dense riparian shrub habitat, specifically, dense willow thickets (PacifiCorp, 2004g).The distribution of riparian shrub and forest habitat for this species is addressed in PacifiCorp (2004g). The Project affects the overall distribution of willow-dominated riparian and wetland habitat.

5.1.14.5 Enhancement Proposals

PacifiCorp proposes a number of measures to benefit RARE resources. These measures are described above under the Cold Freshwater Habitat (COLD) use discussion, and in descriptions of measures for protection of water quality objectives in Section 5.2.

There is no evidence or information to suggest that the Project adversely affects wildlife resources within or below the Project. However, PacifiCorp proposes to implement a vegetation resource management plan and a wildlife resource management plan. Among the measures included in these two plans are several that will benefit TES species, including: (1) protection of TES plant populations, (2) riparian habitat restoration, (3) development of amphibian breeding habitat along Iron Gate reservoir, (4) support of aerial bald eagle surveys and protection of bald eagle and osprey (Pandion haliaetus) habitat, (5) installation of turtle basking structures, (6) surveys for TES species in areas to be affected by new recreation development, and (7) long-term monitoring of these measures. In addition to the above measures, the proposed changes in instream flow and ramping rates will improve conditions for wetland and riparian vegetation in the J.C. Boyle peaking reach.

5.1.14.6 Biological Opinions

NMFS Biological Opinion

In December 2007, NMFS issued a Biological Opinion (BiOp) for the Project (NMFS 2007) to fulfill the requirements of the Endangered Species Act (ESA) Section 7 Consultation on the Project. The NMFS (2007) BiOp addresses the effects of the Project on the Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*) and its designated critical habitat. The NMFS (2007) BiOp concludes that the license for the Project is not likely to jeopardize the continued existence of SONCC coho salmon, and is not likely to result in the destruction or adverse modification of SONCC coho salmon critical habitat. The NMFS (2007) BiOp determined that the Project would result in the incidental taking of SONCC coho salmon, and therefore provided an incidental take statement, containing reasonable and prudent measures, and terms and conditions to monitor and minimize the impact of incidental take.

The NMFS (2007) BiOp assumes that coho salmon fish passage is provided above Iron Gate dam and into the Project reaches, even though such passage is not a component of PacifiCorp's proposed Project as described in the FLA (PacifiCorp 2004a, 2004b, 2004c, 2004d) or as presented in this 401 Application. PacifiCorp notes that, in January 2007, NMFS and USFWS issued Section 18 fishway prescriptions for the Project requiring volitional upstream and downstream passage facilities at each Project development. PacifiCorp recognizes that the Section 18 prescriptions likely will become Project conditions. As such, it may be appropriate for the State Water Board to consider the fishery prescriptions as part of its CEQA review, to the extent the measures are not addressed in FERC's FEIS for the Project.

The NMFS (2007) BiOp estimates that incidental taking of SONCC coho salmon would occur as a result of the effects of implementing fish passage measures including adult delays at fish ladders, adult spillway mortalities, adult delays or injuries at powerhouses, juvenile spillway mortalities, juvenile fish screen losses, and juvenile predation in reservoirs. The NMFS (2007) BiOp estimates that incidental taking of SONCC coho salmon would also occur as a result of water quality effects (specifically related to dissolved oxygen and water temperature) downstream of Iron Gate dam, and effects of flow fluctuations from Project peaking operations upstream in the J.C. Boyle peaking reach.

The NMFS (2007) BiOp further acknowledges that certain proposed Project activities are likely to improve baseline habitat conditions of SONCC coho salmon above and below Iron Gate Dam (e.g., gravel augmentation, water quality enhancements, reduced peaking operations. The NMFS (2007) BiOp concludes that spawning gravel augmentation will improve coho salmon spawning success within the Klamath River below Iron Gate dam, resulting in greater population abundance and productivity. The NMFS (2007) BiOp concludes that improved dissolved oxygen conditions resulting from turbine venting should afford rearing coho salmon greater access into foraging habitat adjacent to cold-water refugial areas. The NMFS (2007) BiOp concludes that the proposed flow regime below Iron Gate dam (i.e., Phase III flows) provides the depth and velocity of river flow necessary to protect coho salmon migration through the mainstem Klamath River. Finally, the NMFS (2007) BiOp concludes that the viability of the Upper Klamath Historical Population of coho salmon would benefit from passage above Iron Gate dam and into the Project reaches.

PacifiCorp provided detailed comments on a draft version of the NMFS (2007) BiOp (PacifiCorp 2007c). Aside from effects that the NMFS (2007) BiOp attributes to the implementation and presence of volitional anadromous fish passage facilities (which are not included in PacifiCorp's proposed Project as described in the FLA or as presented in this 401 Application), PacifiCorp does not agree with the NMFS (2007) BiOp regarding potential effects downstream of Iron Gate dam related to water quality, specifically related to water temperature and dissolved oxygen. As described in Section 5.2.3 of this document, water temperature conditions downstream of Iron Gate dam under the proposed Project will be suitable for coho salmon. The NMFS (2007) BiOp acknowledges that the "thermal lag" caused by the presence of the Copco and Iron Gate reservoirs "does not appear to appreciably affect coho salmon within the Upper Klamath Population Unit". As described in Section 5.2.1 of this document, dissolved oxygen conditions downstream of Iron Gate dam under the proposed Project will be suitable for coho salmon. The NMFS (2007) BiOp acknowledges that Project measures (i.e., turbine venting) aimed at enhancing dissolved oxygen conditions downstream of Iron Gate dam would increase over-summer survival of juvenile coho salmon. The NMFS (2007) BiOp also concludes that dissolved oxygen conditions attributed to Project operations are restricted to the area immediately below Iron Gate Dam, and thus, would not affect the Lower and Middle Klamath Population Units of coho salmon.

USFWS Biological Opinion

In December 2007, USFWS issued a Biological Opinion (BiOp) for the Project (USFWS 2007) to fulfill the requirements of the Endangered Species Act (ESA) Section 7 Consultation on the Project. The USFWS (2007) BiOp addresses the effects of the Project on the federally-listed endangered Lost River sucker (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes brevirostris*), threatened bull trout (*Salvelinus confluentus*), threatened slender Orcutt grass (*Orcuttia tenuis*), endangered Applegate's milk-vetch (*Astragalus applegatei*), endangered Gentner's fritillary (*Fritillaria gentneri*), threatened northern spotted owl (*Strix occidentalis caurina*), threatened California redlegged frog (*Rana aurora draytonii*), threatened western snowy plover (*Charadrinus alexandinus nivosis*), threatened Canada lynx (*Lynx canadensis*), and threatened gray wolf (*Canis lupus*). The USFWS (2007) BiOp also addresses the effects of the Project on the designated critical habitat for the northern spotted owl and bull trout, and the proposed critical habitat for the listed sucker species.

The USFWS (2007) BiOp concludes that the license for the Project is not likely to jeopardize the continued existence of Lost River sucker, shortnose sucker, and bull trout, and is not likely to result in the destruction or adverse modification of designated or proposed critical habitat. The USFWS (2007) BiOp determined that the Project would result in the incidental taking of Lost River sucker, shortnose sucker, and bull trout, and therefore provided an incidental take statement, containing reasonable and prudent measures, and terms and conditions to monitor and minimize the impact of incidental take.

The USFWS (2007) BiOp estimates that incidental taking of Lost River sucker and shortnose sucker would occur as a result of the potential for entrainment or impingement of young at Project powerhouse intakes and spillways, false attraction at downstream tailrace barriers, restricted passage at Project dams, water quality effects related to Project operations, and predation and competition with non-native fishes in Project reservoirs. The USFWS (2007) BiOp estimates that incidental taking of bull trout would occur because provision of fish passage will allow anadromous fish to re-occupy habitats where bull trout currently exist, and adverse interactions between the species, such as predation or competition, may result.

The USFWS (2007) BiOp concludes that the license for the Project will have no effect on the California red-legged frog, western snowy plover, Canada lynx, and gray wolf. The USFWS (2007) BiOp concludes that the license for the Project is not likely to adversely affect the slender Orcutt grass, Gentner's fritillary, Applegate's milk vetch, and the northern spotted owl or its critical habitat.

PacifiCorp provided detailed comments on a draft version of the USFWS (2007) BiOp (PacifiCorp 2007d, 2007e). Aside from effects that the USFWS (2007) BiOp attributes to the implementation and presence of volitional anadromous fish passage facilities (which are not included in PacifiCorp's proposed Project as described in the FLA or as presented in this 401 Application), PacifiCorp does not agree with the USFWS (2007) BiOp estimates of potential effects on Lost River sucker and shortnose sucker related to water quality, entrainment or impingement, and Project reservoirs. PacifiCorp notes that the potential water quality effects on Lost River sucker and shortnose sucker discussed in the USFWS (2007) BiOp are attributed primarily to conditions in Keno reservoir in Oregon. However, Keno reservoir is not part of PacifiCorp's proposed Project for relicensing. Regarding entrainment or impingement, PacifiCorp concludes that the USFWS (2007) BiOp estimates are grossly in error, mainly in overestimating the abundance and distribution of Lost River sucker and shortnose sucker in the Project area. Small numbers of adult Lost River sucker and shortnose sucker, and few if any juveniles of these listed sucker species, occur in Copco and Iron Gate reservoirs. Regarding the Project reservoirs, the USFWS (2007) BiOp acknowledges that the Project reservoirs do not have a high priority for sucker 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." The USFWS (2007) BiOp USFWS also acknowledges that the range of the listed sucker species has actually been expanded by the construction and presence of the Project reservoirs, and goes on to conclude that the listed sucker species that reside in the Project reservoirs provide a long-term storage of a small number of adult suckers that serves as insurance against potential loss of the other viable populations in the upper basin.

5.1.15 Marine Habitat (MAR)

Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds). North Coast Basin Plan, 2-2.00.

The Basin Plan designates Marine Habitat (MAR) as an existing ("E") beneficial use in the Klamath Glen SA of the Lower Klamath HA. The Project does not adversely affect MAR uses. Under existing conditions, most effects of the Project on water quality dissipate within several miles of Iron Gate dam, far upriver from the estuary and marine environments at the mouth of the Klamath River. One exception is organic materials. Analyses by PacifiCorp (2006), PacifiCorp (2004h), Kann and Asarian (2005), and Kann and Asarian (2007) indicate that the Project reservoirs provide an annual net reduction in the large loads of organic matter and nutrients to the river in the Project area from upstream sources, particularly UKL. The reduction in organic matter and nutrients provided by the Project reservoirs likely decreases the risk of enrichment-related water quality problems in the estuary that might otherwise occur in the absence of the Project reservoirs. No measures are proposed in this application to enhance MAR uses.

5.1.16 Migration of Aquatic Organisms (MIGR)

Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Migration of Aquatic Organisms (MIGR) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. The Project supports MIGR uses within and below the Project, and generally does not impede migration of resources protected under the Basin Plan. PacifiCorp has proposed measures in this application to specifically benefit MIGR uses at the Fall Creek diversion dam.

5.1.16.1 Adult Trout Movement in the J.C. Boyle Peaking Reach

Movements of adult trout in response to peaking were assessed using observations of radio-tagged fish in the summer of 2003 (PacifiCorp, 2004e). Results of the study found that of 12 observations made during a peaking cycle only four movements were noted. These movements were generally not extensive (10 to 210 feet) and usually occurred either upstream or downstream within the same habitat unit. These results are consistent with the findings of other studies of trout movement in response to flow fluctuations from power peaking. Both Niemela (1989) and Pert and Erman (1994) found that trout tend to stay in the immediate area, usually in the same habitat unit, when exposed to wide flow fluctuations, but the movement response of each fish can be variable. Some fish remain in a single location while other fish tend to move to more energetically favorable sites for foraging or refuge. Studies by Pert and Erman (1994) and by Rincon and Lobon-Cervia (1993) observed that the trout that remained in one location often lowered their position in the water column closer to the substrate in response to increased water velocities. The studies conducted in the J.C. Boyle peaking reach in 2003 were not designed to detect changes in vertical position.

Another objective of the radio-telemetry study was to determine whether migrating adult trout respond to the differences in water quality and flow at the confluence of the bypass reach and powerhouse tailrace when the powerhouse is discharging. Study results found no conclusive evidence of delay or deterrence of fish at this location. In fact, most fish appeared to move past the powerhouse tailrace and into the bypass reach on their first attempt without delay.

Additional discussion of trout spawning and fry distribution in the J.C. Boyle peaking reach is described below under the Spawning, Reproduction, and/or Early Development (SPWN) use.

5.1.16.2 Fish Movement at Copco No. 1 and Copco No. 2 Dams

Neither Copco No. 1 nor No. 2 dams were constructed with fish passage facilities; therefore, upstream migration of fish species is not possible. However, there is no evidence that the species found in this reach are migratory and would not benefit from upstream fish passage facilities. Intake facilities are not screened. However, the results of hydroacoustic sampling in Copco reservoir 2003 and 2004 indicate that entrainment is relatively low and is not likely to cause significant adverse affects on resident fish populations in Copco reservoir (PacifiCorp, 2004e). Most fish targets in Copco reservoir were observed generally toward the middle and eastern end of the lake farthest away from the deeper water near the dam.

The fish species composition in Copco reservoir suggests that the species that are most likely to become entrained, consist of non-native fish species, including yellow perch, pumpkinseed, bluegill, crappie, other sunfish, and bullheads. The likely predominance of yellow perch entrainment is further supported by the results of vertical gill netting in Copco reservoir in August 2003, which was done in conjunction with the hydroacoustic surveys. Yellow perch accounted for 95 percent of the catch in Copco reservoir, with black crappie being the remaining 5 percent.

5.1.16.3 Fish Movement at Iron Gate Dam

Iron Gate dam was not constructed with upstream fish passage facilities; therefore, upstream migration of resident fish species is not possible. Iron Gate dam has blocked anadromous fish passage since 1962.[9] The Basin Plan does not contemplate anadromous fish passage at Iron Gate dam, and therefore no measures are proposed in this application to provide anadromous fish passage above Iron Gate dam.[10]

As discussed in Section 3.2.5, in January 2007, NMFS and USFWS filed Section 18 prescriptions for fishways at Project facilities. These prescriptions take the approach of requiring volitional upstream and downstream passage facilities at each Project development, including fish ladders and screens at J.C.

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[9] PacifiCorp (2004b) presents a detailed discussion of anadromous fish passage issues.

[10] Iron Gate dam has been a passage barrier into and above the Project since 1962, well before the first Water Quality Standards Regulation was adopted by the USEPA on November 28, 1975. According to the Basin Plan, “Existing uses are those uses which were attained in the water body on or after November 28, 1975.” (Basin Plan, p. 2-13.00). Consequently, the MIGR use and other beneficial use categories that sometimes apply to anadromous fish do not apply to anadromous fish resources above Iron Gate dam.

Boyle dam and Keno dam[11] in Oregon, and Copco No. 1, Copco No. 2, and Iron Gate[12] dams in California. Notwithstanding the Section 18 fishway prescriptions, PacifiCorp's proposed project has not changed since the filing of the FLA (PacifiCorp 2004a, 2004b, 2004c, 2004d, 2004e) and the March 2006 application for water quality certification (PacifiCorp 2006a). As such, and because the Section 18 fishway prescriptions do not become effective unless and until PacifiCorp accepts a final license that includes such conditions, it would be inappropriate to modify the Project description in this revised and resubmitted application for water quality certification. PacifiCorp nevertheless recognizes that the Section 18 prescriptions likely will become Project conditions and, as such, it may be appropriate for the State Water Board to consider such prescriptions in the CEQA review, to the extent the prescriptions are not already addressed in FERC's FEIS for the Project (FERC 2007).

Fish entrainment and associated turbine mortality are not likely to significantly adversely affect resident fish populations in Iron Gate reservoir. The results of hydroacoustic sampling in Iron Gate reservoir indicate that entrainment may be relatively low (PacifiCorp, 2004e). Although intake facilities to the Iron Gate powerhouse are not screened, the distribution of fish in Iron Gate reservoir showed few fish present in the deeper open-water areas and most fish adjacent to the shorelines, especially along the eastern shore and in the inlet arm.

The fish species composition in Iron Gate reservoir provides an indication that most entrainment, to the limited extent it occurs, likely consists of non-native fish species including yellow perch, pumpkinseed, bluegill, crappie, other sunfish, and bullheads. Only yellow perch were captured in the open water areas of Iron Gate reservoir during 2003 vertical gill net studies, suggesting that perch are not susceptible to entrainment.

The most abundant native species found in the Klamath reservoirs are chubs (tui and blue). These fish are generally bottom dwellers and, thus, are not as prone to entrainment despite their relative abundance in the reservoirs. Similarly, bullheads and suckers are bottom dwellers and are less prone to entrainment especially at Iron Gate reservoir, which has shallow intakes at the deep-water dam faces.

5.1.16.4 Fall Creek Diversion Dam Fish Passage Upgrades

The original construction of the Fall Creek Development did not include fish screens at the Fall Creek diversion. Fish ladders were not included over the dam. PacifiCorp proposes to install canal screens and a fish ladder at the Fall Creek diversion. The canal screens will be diagonal-type screens meeting NMFS SW Region criteria for salmonid fry. The Fall Creek fish ladder will be a pool- and weir-type ladder consisting of six pools. The pools will be constructed from rock and include a 0.5-foot vertical jump for each pool. The existing flashboards will be notched at the exit pool to permit a fishway flow of 2.5 cfs.

The fish species of primary concern at this site is resident trout. The fish ladder proposed will allow trout and other species to freely access upstream spawning and rearing habitat. The downstream screening facilities will prevent fish from becoming entrained into the canals and then through the Fall Creek powerhouse.

5.1.17 Spawning, Reproduction, and/or Early Development (SPWN)

Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. North Coast Basin Plan, 2-2.00 to 2-3.00.

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[11] PacifiCorp notes that Section 18 fishway prescriptions related to Keno dam will not be applicable if the new FERC license for the Project excludes the Keno dam.

[12] The Iron Gate fishway prescription calls for PacifiCorp to modify and use the existing adult trapping facility at the base of Iron Gate dam as an interim measure before completion of a ladder over the dam five years after license issuance.

The Basin Plan designates Spawning, Reproduction, and/or Early Development (SPWN) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, including the Iron Gate and Copco Lake HSAs. The Project supports SPWN uses within or below the Project. PacifiCorp therefore is not proposing additional measures to protect SPWN uses.

5.1.17.1 Trout Spawning Distribution in the J.C. Boyle Peaking Reach

There is very little spawning habitat for trout in the peaking reach (City of Klamath Falls, 1986; Henriksen et al. 2002) because gravel accumulation in this reach is limited. The extent to which spawning may occur in this reach is unknown (PacifiCorp, 2000), but the lack of suitable spawning substrate in the reach and the historical accounts of large trout spawning migrations into Shovel Creek suggest that trout did not likely spawn historically in the mainstem peaking reach.

Shovel Creek is a well established spawning area for trout in the California segment of the J.C. Boyle peaking reach. The spawning run was studied extensively by Beyer (1984). PacifiCorp's trout movement study (PacifiCorp, 2004e) found that nearly all (11 of 14) of the adult trout radio-tagged in the California segment of the peaking reach entered and presumably spawned in Shovel Creek. Also, two of the 14 fish radio-tagged in the upper Oregon segment of the peaking reach dropped downstream and entered Shovel Creek.

5.1.17.2 Redband/Rainbow Trout Fry Distribution and Movement

Past studies have documented trout spawning and fry rearing in the Project area tributaries, particularly Shovel Creek in California (Beyer, 1984) and Spencer Creek in Oregon (various ODFW reports). Most trout fry tend to remain in these tributaries through the summer, and through the winter in Spencer Creek, before migrating to the Klamath River. A fry distribution and relative abundance study was conducted from May through August 2003 (depending on the location).

During the biweekly sampling between late May and early September, a total of 1,212 fry were captured by single-pass electrofishing at 26 index locations (six in the bypass and 10 each in the Oregon and California peaking reaches). Two approaches were used to determined downstream movement. One approach was to examine changes in fry densities over time at each of the index areas to determine whether fry were dispersing downstream from the areas of initial highest density near known spawning areas (J.C. Boyle bypass reach and Shovel Creek). The other approach was to mark (fin clip) and recapture fry following at least one peaking cycle to determine whether they tended to remain near the area of original capture or move to downstream sampling areas.

Results of the trout fry movement studies indicated very little downstream dispersal of fry. In the Oregon portion of the J.C. Boyle peaking reach, fry were captured in the upper five index areas closest to the bypass reach where they most likely originated, but almost no fry were observed in the downstream index areas near Frain Ranch. In the California portion of the J.C. Boyle peaking reach, all fry were observed in the river downstream of the mouth of Shovel Creek; none were observed at the three locations upstream of Shovel Creek in California. Repeat sampling through the summer at these locations showed only a minor decrease in fry densities at all reaches, and the highest densities remained near the known spawning areas. Results of the mark-recapture studies indicated that all of the recaptured fry in the peaking reach were collected at the same location they were originally captured and marked.

Juvenile Fish Stranding Studies

Observations made for potential fish stranding in the J.C. Boyle peaking reach were conducted at three locations in California downstream of Shovel Creek (RM 206.3) and at two locations in Oregon at Frain

Ranch (RM 214.3) (see PacifiCorp, 2004e). These sites were selected for having high potential for fry stranding based on (1) large exposure area, (2) low beach gradient (less than 2 percent), (3) depressions and potholes, (4) presence of both aquatic vegetation and submerged grasses at the high-flow end of the ramping event, (5) top of islands, and (6) association with side channels. In total, the sites represent 75,500 square feet of area that is subject to river stage changes during a typical one-unit down-ramping cycle.

Observations were made on May 31, July 11, and August 8 to 9, 2002, and again on June 10 to 11, July 14, and August 19 to 20, 2003. These time periods were chosen to coincide with the period during which fry, especially trout fry, would most likely be present. Ramping on these dates (and throughout these periods) generally consisted of up-ramping in the morning (at the powerhouse) and down-ramping in late afternoon or evening through a flow range of approximately 1,500 (one turbine unit) to 350 cfs. The test conducted June 10 to 11, 2003, occurred following a down-ramp from 2,800 to 350 cfs (both turbine units). Ramping rates recorded at the USGS gauge just downstream of the powerhouse averaged about 0.7 ft/hr.

During the three tests conducted in 2002, no fish of any species or size were observed stranded. (Eight to 10 live trout fry were observed trapped in a pothole at the Foam Eddy bar (California) on July 11, 2002; the particular pothole was near shore and shaded, and was not at risk of drying up before the next flow cycle.) Trout fry were observed swimming along the margins of all California sites in 2002. Numerous small dace, often several hundred, were observed swimming along the margins at most sites, but none were seen stranded.

In the three tests conducted in 2003, only fish was observed stranded in California. Results of the stranding observation tests, while demonstrating very limited stranding of non-trout species, provided no indication that trout fry were being stranded by the current down-ramping in the peaking reach. Trout fry were observed during the fry distribution study downstream of the mouth of Shovel Creek (a known spawning tributary) where all of the California stranding test sites were located. Also, trout fry were observed at base flow along the margins of all three stranding test sites in California following the down-ramp tests. Thus, while trout fry generally may not be abundant in the peaking reach, the stranding observation sites in California corresponded to where most fry seem to be distributed in the reach.

Another factor that may have influenced the results of the fish stranding observations is the attenuation of the down-ramping rate, measured by stage change per hour, as the water travels downstream of the powerhouse. The down-ramp attenuation (and lag time) was evaluated at lower Frain Ranch (5.4 miles below the powerhouse) and at the mouth of Shovel Creek (13.4 miles below the powerhouse). At Frain Ranch, the powerhouse down-ramp rate of approximately 9 inches/hr became attenuated to about 5 inches/hr. This equates to a 44 percent reduction in the down-ramp rate. At the Shovel Creek site, a powerhouse down-ramp rate of about 8 inches/hr was attenuated to about 3 inches/hr. This equates to a 62 percent reduction in down-ramp rate. At both sites, the rate of attenuation was accompanied by a corresponding increase in the duration of the down-ramp event. For example, the 3-hour-duration down-ramp event at the powerhouse lasted 6 hours at the mouth of Shovel Creek. PacifiCorp's proposed downramping rate (as described in Section 3.2) would further reduce potential stranding risk.

PacifiCorp notes that Dunsmoor (2006) did observe stranding in the peaking reach on July 5, 2006. However, it is important to recognize that this observed stranding occurred under the atypical circumstances of that day and is not evidence of stranding under normal daily peaking operations. The first observation made by Dunsmoor (2006) occurred on July 5, 2006, when the J.C. Boyle powerhouse underwent the first down-ramp event of the year following several months of relatively stable flows (near 3,000 cfs). At a site near the lower end of the relatively-wide Frain Ranch part of the J.C. Boyle peaking reach, Dunsmoor observed considerable numbers of stranded fish (although no trout) as well as crayfish and macroinvertebrates. The next day, following the second two-unit down ramp, he observed no fish stranded at sites downstream below Shovel Creek in the California section of the J.C. Boyle peaking reach. On the third day, July 7, 2006, Dunsmoor returned to the Frain Ranch area and observed no fish stranded at the same site where stranding was observed just two days earlier following the first ramp event.

PacifiCorp interprets these 2006 observations to support our proposal to limit down ramping to a single unit and to down ramp more slowly at flows below 1,000 cfs. In addition, this information suggests a need to limit down ramping to a more conservative rate, such as two inches per hour, during the first down ramp event following a prolonged period (e.g., ten days) of stable flow. As a result, PacifiCorp has proposed to FERC to include such a down ramping limit following a prolonged period of stable flow. This limit will provide greater protection for aquatic resources under these occasional circumstances.

5.1.17.3 Anadromous Fish Movement and Spawning Downstream of Iron Gate Dam

As discussed in further detail in sections 5.1.10 and 5.2.3 of this document, Project operations and the presence of Project reservoirs do not affect temperature in the Klamath River to an extent that causes significant adverse effects to anadromous fish that use the reach below Iron Gate dam at the time of migration, spawning, and egg incubation. Copco and Iron Gate reservoirs create a thermal lag that causes Iron Gate dam release temperature to be slightly cooler in the spring and slightly warmer during the fall than would theoretically occur in the absence of the reservoirs. However, the thermal lag effect is not detrimental, and may be beneficial, to certain life stages of Chinook, coho, and steelhead that use the river below Iron Gate dam. In addition, as a result of basin climatological conditions and tributary inflows in the lower basin, Project operations have no effect on water temperature conditions for Chinook, coho, and steelhead within the lower reaches of the Klamath River.

As discussed in further detail in sections 5.2.1 of this document, PacifiCorp concludes that dissolved oxygen conditions downstream of Iron Gate dam under the proposed Project will be suitable for anadromous fish migration, spawning, and egg incubation. Dissolved oxygen in the Klamath River is at or near 100 percent saturation throughout the river downstream of Iron Gate dam with the exception of the segment just below the dam (see Section 5.2.1). As a result of natural conditions and large loads of nutrients and organic matter from upstream sources, dissolved oxygen below Iron Gate dam does not consistently meet the 9.0 mg/L objective that applies during the spawning period, which typically starts in October and extends into December. For the segment just below the dam, PacifiCorp is evaluating turbine venting and implementation of oxygenation systems within Copco and Iron Gate reservoirs to increase dissolved oxygen concentrations and enhance dissolved oxygen conditions downstream of the dams in compliance with water quality objectives.

5.1.18 Shellfish Harvesting (SHELL)

Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes. North Coast Basin Plan, 2-3.00.

The Basin Plan designates Shellfish Harvesting (SHELL) as an existing (“E”) beneficial use in the Iron Gate HSA. As described below, the Project supports SHELL uses within or below the Project. No measures are proposed in this application to specifically protect or enhance SHELL uses.

The Klamath River basin is a highly diverse region for freshwater mollusk species. Aquatic mollusks may be found in lotic and lentic habitats, with springs containing the most diversity and endemism of species. The Upper Klamath River drainage, not all of which is in the Project area, contains 73 mollusk species.

Much of this diversity can be attributed to the continuance of UKL as a Great Basin pluvial lake (Frest and Johannes, 1998; Frest and Johannes, 2002). To add to the evolutionary complexity of this ancient lake system, it is thought that a connection to the Columbia River basin, the Sacramento River system, and the Rogue/Umpqua basin existed sometime in the past (Frest and Johannes, 1998; Frest and Johannes, 2000). Aquatic mollusk species in the Klamath River basin are a mix of both coastal and Great Basin fauna (Frest and Johannes, 1998). The eruption of Mount Mazama and the corresponding ash falls reduced the area's diversity, although some mollusk fauna survived the incident (Frest and Johannes, 1998; Frest and Johannes, 2002).

PacifiCorp conducted a study of bivalves in the vicinity of the Project in 2003 (PacifiCorp, 2004h) focused on large (generally, 2 to 4 inches) bivalve species of the family Unionidae, which in California includes the genera *Anodonta*[13] (floaters), *Gonidea* (ridgemussel), and *Margaritifera* (pearlmussel)(PacifiCorp, 2000e). The goal of this study was to better understand the relative abundance, diversity, distribution, and population characteristics of bivalves in the vicinity of the Project. Sampling sites were established among several Project area reaches, including the reach between Iron Gate dam and the Shasta River in California. Information collected during this study complements a previous study that included the distribution of bivalves in the California section of the Klamath River (Taylor, 1981).

Sampled microhabitats within the Klamath River between Iron Gate dam and the Shasta River appear to support locally extensive populations of both *Anodonta oregonensis* and *Gonidea angulata*. Both species could be exceptionally dense where found. Low-energy areas where sediments accumulate and where hydrology is consistent were most suitable for *Anodonta oregonensis*. While these types of habitats also supported *Gonidea angulata*, this latter species appeared to prefer faster waters and, consequently, coarser substrates such as medium and coarse sands.

Commonly, *Gonidea* were found buried to depths of 6 inches, oftentimes atop one another. Perhaps intergravel flow in the faster-moving water areas provided enough oxygen to support animals that had no apparent connection to the water column. *Gonidea* were always buried at least 80 percent, with only the tops of shells evident. In contrast, *Anodonta* were sometimes found lying atop the bottom substrate. Others were buried slightly, but never to the extent that the *Gonidea* were buried.

Mussel predation was evident in the sampled reaches, with most middens containing *Anodonta*. It was assumed that predation on mussels in the Project area was primarily due to aquatic mammals—namely river otter and/or muskrat—but such predation was not observed directly.

5.1.19 Estuarine Habitat (EST)

Uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds). North Coast Basin Plan, 2-2.00.

The Basin Plan designates Estuarine Habitat (EST) as an existing ("E") beneficial use in the Klamath Glen SA of the Lower Klamath HA. The Project does not adversely affect EST uses. Under existing conditions, influences from the Project on most water quality parameters have largely dissipated far upriver from the estuary and marine environments at the mouth of the Klamath River. However, detailed modeling and analysis by PacifiCorp (2006) indicates that the Project reservoirs provide an annual net reduction in the large loads of organic matter and nutrients to the river in the Project area from UKL. The reduction in organic matter and nutrients provided by the Project reservoirs likely decreases the

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[13] *Gonidea angulata* is the only species within the genus *Gonidea* monospecific genus, and this species is therefore commonly referred to in this section by its generic name only. In contrast, several species of *Anodonta* exist in California, necessitating the use of the full genus-species nomenclature in this section. Where "*Anodonta*" appears without reference to a species, it should be interpreted as *A. oregonensis*.

enrichment-related water quality problems in the estuary that might otherwise occur in the absence of the Project reservoirs. No measures are proposed in this application to specifically enhance EST uses.

5.1.20 Aquaculture (AQUA)

Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes. North Coast Basin Plan, 2-2.00.

The Basin Plan designates Aquaculture (AQUA) as an existing ("E") beneficial use in the Iron Gate HSA and the Copco Lake HSA, and as a potential ("P") use in the all areas of the Lower Klamath HA and Middle Klamath River HA, other than the Iron Gate and Copco Lake HSAs. As described above under Commercial and Sport Fishing (COMM) uses, the Project supports AQUA through funding of the Iron Gate hatchery. The Iron Gate Hatchery also depends on cold water stored in the hypolimnion of Iron Gate reservoir for maintaining adequate temperature for aquaculture at the hatchery during summer. PacifiCorp will continue such support with the Project, and therefore will continue to enhance AQUA uses.

5.1.21 Native American Culture (CUL)

Uses of water that support the cultural and/or traditional rights of indigenous people such as subsistence fishing and shellfish gathering, basket weaving and jewelry material collection, navigation to traditional ceremonial locations, and ceremonial uses. North Coast Basin Plan, 2-3.00.

The Basin Plan designates Native American Culture (CUL) as an existing ("E") beneficial use in the all areas of the Lower Klamath HA and Middle Klamath River HA, other than the Iron Gate and Copco Lake HSAs, as well as the next downstream Hornbrook and Beaver Creek HSAs. CUL use is not designated within the Project area, and the Project is not known to adversely affect designated CUL use below the Project in the Lower and Middle Klamath River HAs. As described in more detail elsewhere in this application, the Project and Project operations may provide some benefits to downstream CUL uses. For example, the Project allows settling and processing of substantial amounts of the organic load from above the Project, particularly UKL. In addition, the Iron Gate fish hatchery, which is 80 percent funded by PacifiCorp and which relies on cold water from Iron Gate reservoir, is responsible for a substantial percentage of the anadromous fish population in the Lower Klamath River that contributes to subsistence fishing.

5.2 WATER QUALITY OBJECTIVES

The water quality objectives applicable to the Project are set forth in Section 3 of the Basin Plan. Under the Basin Plan, "*controllable water quality factors* shall conform to the water quality objectives" contained in Section 3. (Basin Plan, p. 3-1.00). Controllable factors may not further degrade water quality when other factors have degraded water quality beyond the limits established in the Basin Plan. *Controllable water quality factors* are "those actions, conditions, or circumstances resulting from man's activities that may influence the quality of the waters of the State and *that may be reasonably controlled*." (*Id.*). This definition is used in this application to assess the Project's contribution to water quality conditions in the Klamath River within and below the Project area, and as the basis for measures to address such contributions.

This section summarizes the applicable water quality objectives in Section 3 of the Basin Plan; discusses existing water quality conditions in the Klamath River within and below the Project area relative to the water quality objectives; assesses the effects of the Project relative to these water quality objectives; and proposes measures, where appropriate, to address the Project's contribution to water quality conditions where reasonably controlled water quality factors are present.

5.2.1 Dissolved Oxygen

5.2.1.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:

Dissolved oxygen concentrations shall conform to those limits listed in Table 3-1. For waters not listed in Table 3-1 and where dissolved oxygen objectives are not prescribed the dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time.

> *Waters designated WARM, MAR, or SAL...........5.0 mg/L*
> *Waters designated COLD..................................6.0 mg/L*
> *Waters designated SPWN..................................7.0 mg/L*
> *Waters designated SPWN during critical spawning and egg incubation periods........ 9.0 mg/L*

North Coast Basin Plan, Table 3.1, at 3-5.00 to 3-7.00 establishes the following specific dissolved oxygen objectives for segments of the Klamath River within and below the Project:

	Min	**90% Lower Limit** [14]	**50% Lower Limit** [15]
Middle Klamath HA			
Klamath River above Iron Gate Dam including Iron Gate and Copco Reservoirs	7.0		10.0
Klamath River below Iron Gate Dam	8.0		10.0
Lower Klamath HA			
Klamath River	8.0		10.0

5.2.1.2 Present Conditions

Present dissolved oxygen conditions in the Klamath River in California are largely a consequence of upstream water quality conditions in the Klamath River in Oregon as well as temperature and barometric pressure. A primary influence on dissolved oxygen in the Klamath River is the heavy load of organic material exported to the river from UKL and other discharges to Keno reservoir. This organic load imposes an oxygen demand throughout the river. In the free-flowing sections, turbulent mixing, shallow water, and short residence time combine to keep the water near 100 percent saturation much of the time; however, deviations can occur as a result of photosynthesis and respiration associated with primary production, and as a result of seasonally large organic load carried by the river. In segments of the river where the water deepens, turbulence decreases, and residence time increases, physical reaeration may be insufficient to meet the oxygen demand and dissolved oxygen concentration often falls below saturation.

Barometric pressure and natural ambient temperatures also significantly affect dissolved oxygen in the project area. The Basin Plan water quality objective does not account for elevation effects on barometric

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[14] "90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit." North Coast Basin Plan, at 3-7.00.

[15] "50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit." *Id*.

pressure or naturally occurring water temperatures found in many higher elevation regions of the Klamath Basin. For example, dissolved oxygen saturation at sea level is 10 mg/L at 15.5°C. However, barometric pressure decreases with elevation and at 2,750 ft msl (approximate elevation of the Oregon-California state line), barometric pressure is approximately 9 percent lower than at sea level. At Stateline, the temperature corresponding to a dissolved oxygen saturation of 10 mg/L is 11°C (based on Bowie et al. 1985). Because of naturally occurring meteorological conditions, plus the inflow of spring water upstream (at approximately 11°C), natural dissolved oxygen saturation concentration is somewhat lower than the established criteria.

Klamath River from Stateline to Copco Reservoir

This segment of the river is well oxygenated because of extensive large rapids just upstream. Dissolved oxygen data has been collected from the Klamath River at river mile (RM) 206, just upstream from the mouth of Shovel Creek, four miles upstream from Copco reservoir, at approximately monthly intervals between March and November from 2001 through 2005. Additional measurements were made approximately bi weekly in June through November 2007. Measurements were made mostly during the daytime. No value was recorded less than 7.0 mg/L and 51 percent of values were less than 10 mg/L. However, because of local conditions of barometric pressure (elevation), the achievable dissolved oxygen concentration at 100 percent saturation was less than 10 mg/L for all temperatures greater than approximately 11°C. Of the values that measured less than 10 mg/L, all but one were greater than 90 percent saturation. Dissolved oxygen data measured in the Klamath River above Copco reservoir (RM 206) are summarized in Table 5.2-1. The seasonal distribution of dissolved oxygen concentration is shown in Figure 5.2-1.

Table 5.2-1. Summary of Dissolved Oxygen Measurements Made in the Klamath River at River Mile 206 from 2000 through 2005 and in 2007.

	Concentration (mg/L)	**Saturation (Percent)**
No. of values	72	71
Minimum	7.2	86.4
1st Quartile	9.0	101.7
Median	9.9	104.3
3rd Quartile	11.0	111.3
Maximum	12.5	128.9
Mean	10.0	105.8

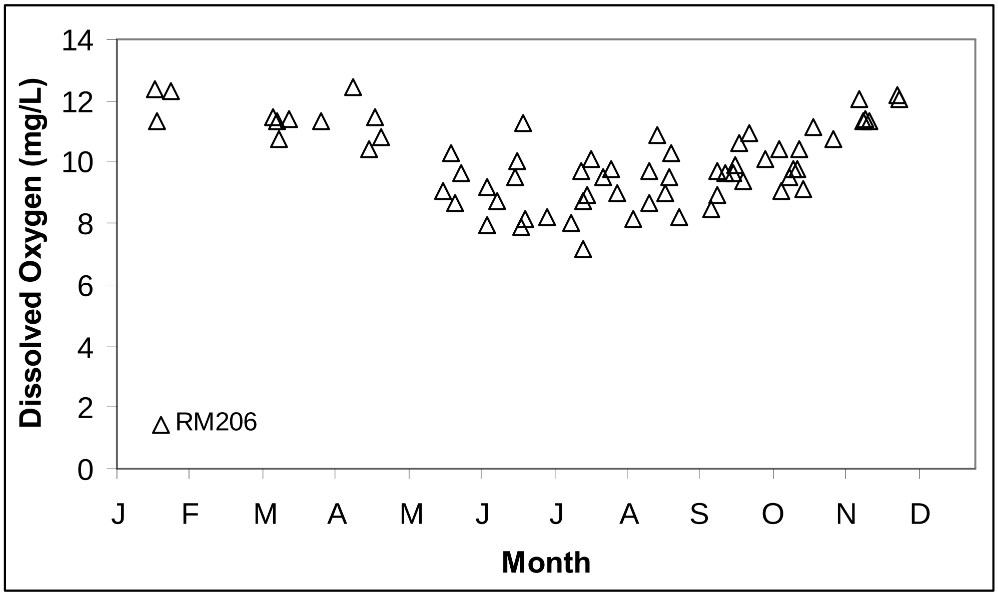

Figure 5.2-1 Values of dissolved oxygen measured in the Klamath near Shovel Creek (RM 206) at various times of the year in 2001 through 2007.

Copco Reservoir Hydrologic Subarea

Monthly vertical profiles of dissolved oxygen concentration have been sampled in Copco reservoir, generally between March and November, from 2000 through 2005 and June through November in 2007. Dissolved oxygen data for Copco reservoir are summarized in Table 5.2-2. A typical mid-summer profile of dissolved oxygen and temperature is shown in Figure 5.2-2. The distribution of measured dissolved oxygen by depth in Copco reservoir is shown in Figure 5.2-3. The distribution of dissolved oxygen values by depth with regard to the water quality objective is presented in Table 5.2-3.

Dissolved oxygen conditions in Copco reservoir vary seasonally because of thermal stratification. When the reservoir is not stratified (typically November through April), dissolved oxygen throughout the reservoir is generally at equilibrium conditions, i.e., near saturation concentration. Copco reservoir exhibits seasonal temperature stratification that impedes mixing of bottom waters with surface waters. As a consequence of being separated from contact with the atmosphere, decomposition of organic carried into the reservoir from the Klamath River, and settling from shallow depths from within the reservoir, results in depletion of dissolved oxygen in the hypolimnion. Depletion of dissolved oxygen in the hypolimnion during stratification is a common phenomenon in eutrophic reservoirs and lakes (Welch, 1992, Thornton et al. 1990; Wetzel, 1972). However, with the exception of two values in 2007, water in the epilminion of Copco reservoir has dissolved oxygen concentrations of 7.0 mg/L or more at all times (Figures 5.2-2 and 5.2-3). These dissolved oxygen levels provide suitable conditions for fish in the reservoir, since most fish occur in the epilimnion and above the thermocline (Section 5.1.11.1). Because the outlet structure is located at a depth of approximately 8 to 10 meters (depending on reservoir water level elevation), discharges from the reservoir reflect the oxygen content that occurs in the epilimnion and above the thermocline. Vertical profile data from 2000-2007 indicate that the lowest average dissolved oxygen concentration in the top 10 meters occurred in September at 8.3 mg/L. These averaged values represent the discharge concentration from Copco reservoir. In the fall, slow deepening of the epilimnion allows hypolimnetic waters to reoxygenate from gradual mixing with the much larger, well-oxygenated epilimnetic volume.

Table 5.2-2. Summary of Vertical Profile Dissolved Oxygen Measurements Taken in Copco Reservoir in 2000 Through 2007.

Dissolved Oxygen	Concentration (mg/L)	Percent Saturation
N	1203	1203
Mean	6.8	73.0
Minimum	0.0	0.1
1st Quartile	3.7	40.7
Median	8.0	85.1
3rd Quartile	9.7	98.6
Maximum	17.1	230.2

The frequency distribution for dissolved oxygen concentration in Copco reservoir shows that about 62 percent of measured values between 2000 and 2007 at all depths were greater than 7.0 mg/L, and about 16 percent of values were greater than 10 mg/L. Examination of the 50th percentile values of monthly means[16] shows that the 50th percentile average dissolved oxygen concentrations in the top 10 meters were 9.3 mg/L. It can be seen in Figure 5.2-3 that at all depths less than 7 m, the relevant water quality objective minimum of not less than 7.0 mg/L dissolved oxygen is met. At no depth are more than 50 percent of dissolved oxygen values greater than 10.0 mg/L. However, 79 percent of temperature values are greater than 11°C, above which the water quality objective of 10.0 mg/L cannot be met because 100 percent saturation is less than 10.0 mg/L. The seasonal distribution of dissolved oxygen values in the Klamath River below the Copco 2 powerhouse is shown in Figure 5.2-4.

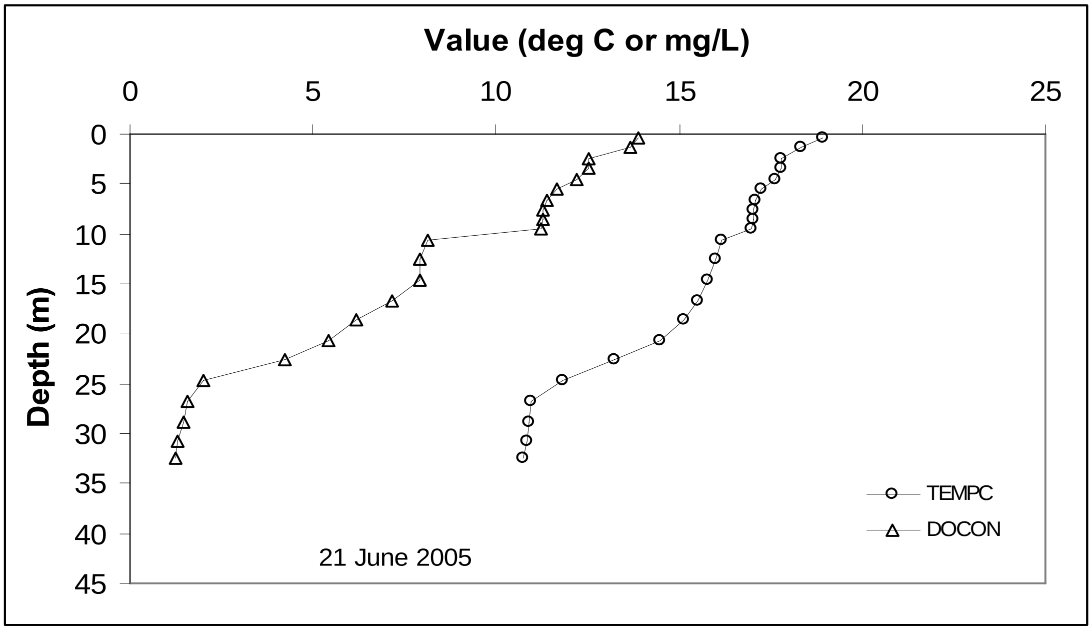

Figure 5.2-2. Vertical Profile of Temperature and Dissolved Oxygen from Copco Reservoir in June 21, 2005.

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[16] Because data were not available for most winter months, the entire period was examined (versus calendar years). The winter months would have provided colder water temperatures and higher dissolved oxygen concentrations, thus this approach is somewhat conservative.

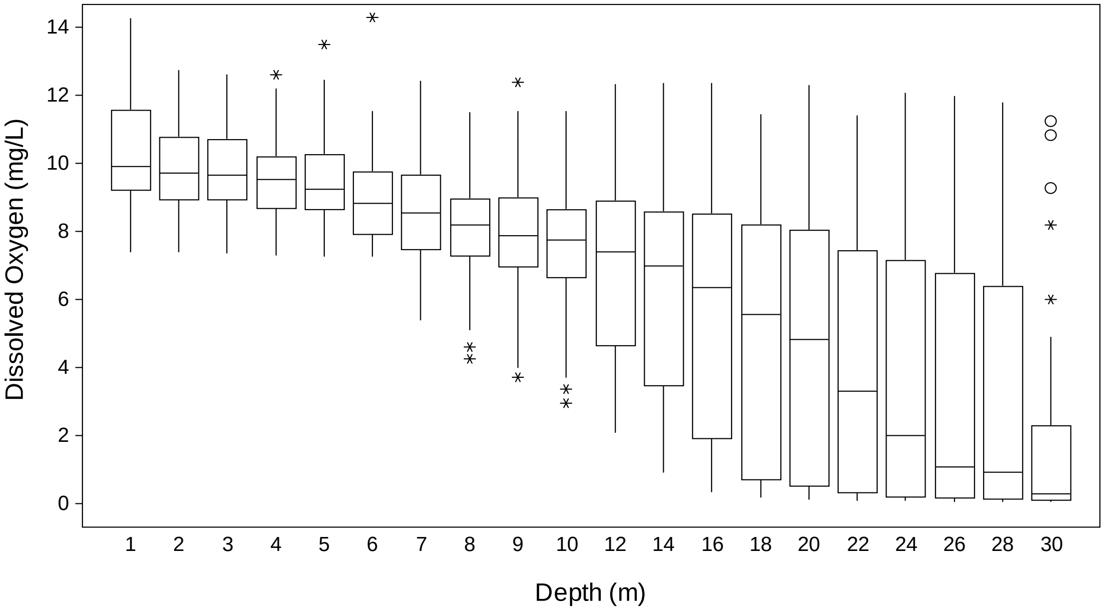

Figure 5.2-3. The Distribution of Dissolved Oxygen Values with Depth Measured in Copco Reservoir between March 2000 and November 2005.

Table 5.2-3. Distribution of Dissolved Oxygen Values by Depth Range in Copco Reservoir 2000 - 2007

Depth Range (meters)	**N**	**Percent < 7.0 mg/L**	**Percent < 10.0 mg/L**
1-6	397	1.3	60.7
6-12	280	32.1	86.8
12-18	188	60.6	91.5
18-24	175	70.9	94.3
24-30	155	77.4	94.2
30+	8	87.5	100

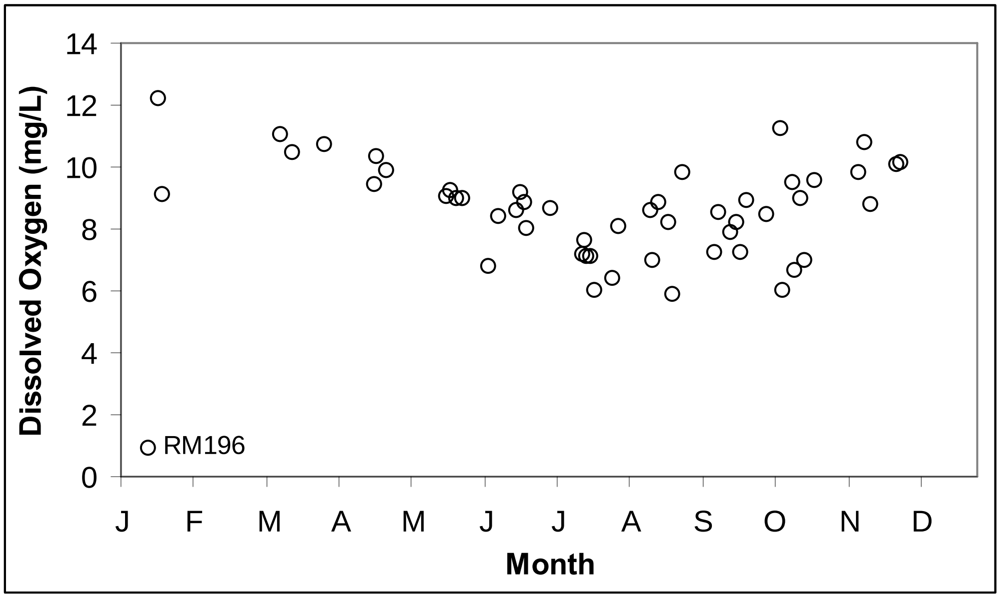

Figure 5.2-4. Values of dissolved oxygen measured in the Klamath below Copco 2 powerhouse (RM 196) at various times of the year in 2001 through 2007.

Iron Gate Hydrologic Subarea

Monthly vertical profiles of dissolved oxygen concentration have been sampled in Iron Gate reservoir, generally between March and November, from 2000 through 2005, and in June through November in 2007. Data from these profiles are summarized in Table 5.2-4. Profiles of dissolved oxygen during months when stratification occurs is shown in Figure 5.2-5. The distribution of measured dissolved oxygen values by depth range in Iron Gate reservoir is shown in Figure 5.2-6. The distribution of dissolved oxygen values by depth with regard to the water quality objective is presented in Table 5.2-5.

Dissolved oxygen values in Iron Gate reservoir vary seasonally similar to Copco reservoir. Iron Gate reservoir exhibits seasonal density stratification based on temperature similar to Copco reservoir, but stratification in Iron Gate reservoir persists longer in the fall as compared to Copco reservoir. For all dissolved oxygen values measured at all depths in Iron Gate reservoir, about 40 percent of values were greater than 7.0 mg/L, and 16 percent of values were greater than 10 mg/L. As can be seen in Figure 5.2-6, the relevant water quality objective minimum of not less than 7.0 mg/L dissolved oxygen is not met at some times and depths. At the peak of stratification in Iron Gate reservoir during mid-summer, waters below about 15 m depth can be devoid of oxygen. By contrast, the reservoir surface waters retain dissolved oxygen concentrations at or near saturation. Examination of the 50th percentile values of monthly means between 2000 and 2005 shows that the 50th percentile average dissolved oxygen concentrations in the top 10 meters was 8.4 mg/L. These dissolved oxygen levels provide suitable conditions for fish; hydroacoustic surveys in August 2005 found most fish at depths of 3 to 13 m in Iron Gate reservoir (Section 5.1.11.2). These values are below the 10 mg/L Basin Plan objective. However, given the naturally occurring water temperatures during the warmer periods of the year and elevation of the reservoir, the water quality objective of 10.0 mg/L cannot be met because 100 percent saturation is less than 10.0 mg/L.

Because of the temperature stratification and location of the discharge intake, withdrawal from Iron Gate reservoir during the stratification period is restricted to approximately the top 10 meters of the reservoir. Review of 2000-2005 vertical profile data indicates that the minimum average dissolved oxygen concentrations in the top 10 meters was 5.4 mg/L. The depth-averaged values in the top 10 meters approximate discharge concentrations from Iron Gate reservoir. In the fall, slow deepening of the epilimnion allows hypolimnetic waters to reoxygenate from gradual mixing with the much larger, well-oxygenated epilimnetic volume.

Table 5.2-4. Summary of Vertical Profile Dissolved Oxygen Measurements Taken in Iron Gate Reservoir in 2000 Through 2005.

Descriptive Statistics - Dissolved Oxygen	Concentration (mg/L)	Percent Saturation
N	1470	1468
Mean	5.9	60.1
Minimum	0.0	0.0
1st Quartile	2.7	26.6
Median	6.0	61.3
3rd Quartile	8.9	86.6
Maximum	18.3	241.0

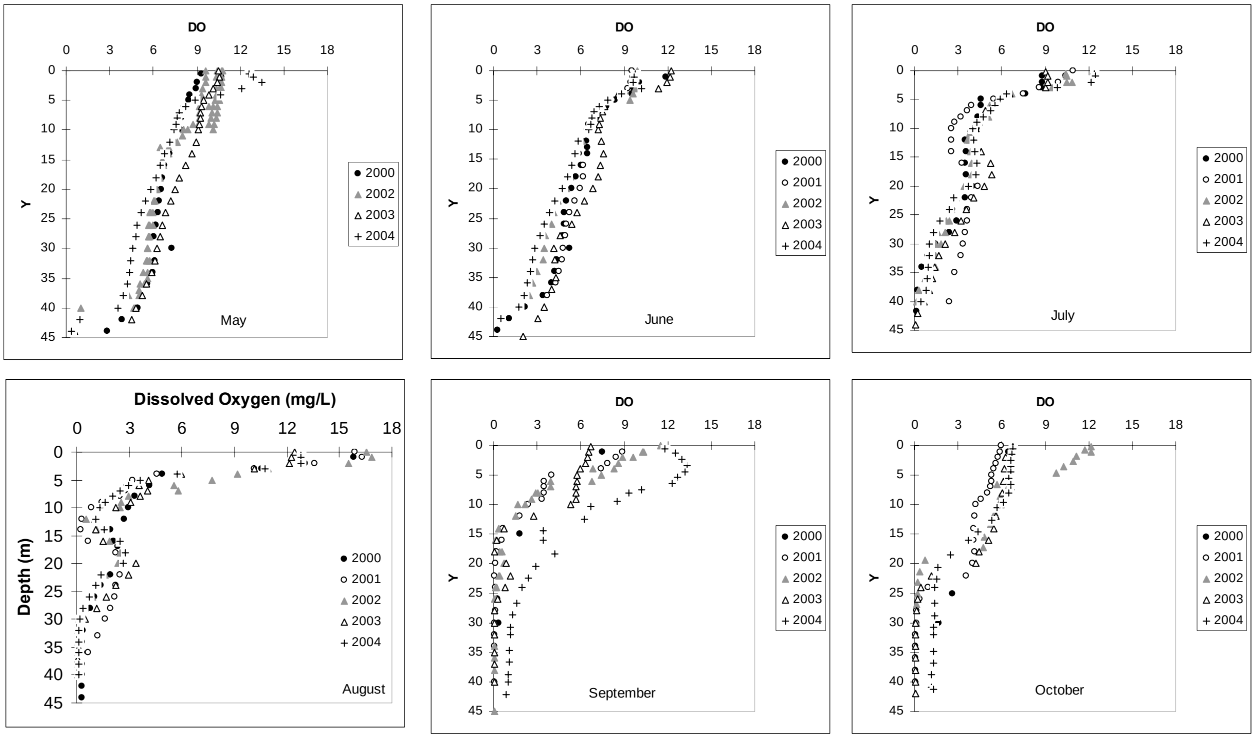

Figure 5-2-5. 2000-2004 Dissolved Oxygen Profiles for Iron Gate Reservoir during May-October.

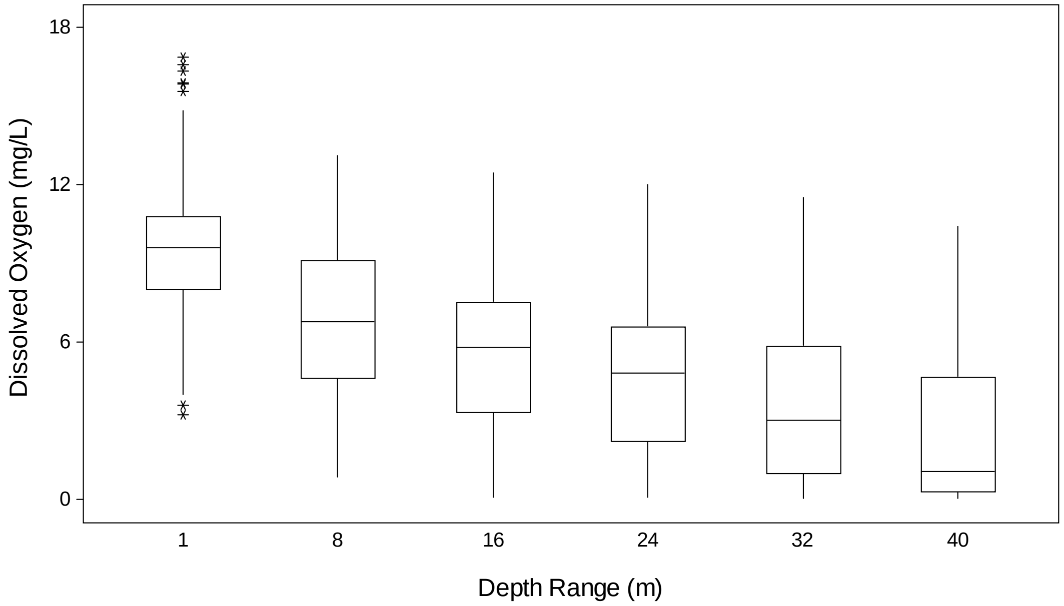

Figure 5.2-6. The Distribution of Dissolved Oxygen Values with Depth Measured in Iron Gate Reservoir Between March 2000 and November 2005. [Depth range 1 = 1-6m, 8 = 6-12 m, 16 = 12-20 m, 24 = 20-28 m, 32 = 28-34 m, 40 = 34-42 m].

Table 5.2-5. Distribution of Dissolved Oxygen Values by Depth Range in Iron Gate Reservoir 2000 – 2007.

Depth Range	N	Percent < 7.0 mg/L	Percent < 10.0 mg/L
1-6	392	23.0	62.2
6-12	276	58.3	85.9
12-18	180	73.3	91.1
18-24	171	80.1	93.0
24-30	156	80.8	93.6
30-36	145	82.1	95.2
36-42	123	87.8	98.4
42 +	27	92.6	100

Hornbrook Hydrologic Subarea

Dissolved oxygen data has been collected from the Klamath River at river mile (RM) 189, just below Iron Gate dam (KR19873), and at RM 176, the Collier Rest Area at I-5 (KR17600), at approximately monthly intervals between March and November from 2002, 2004 through 2005, and June through November 2007. Measurements were made mostly during the daytime. Those values are summarized in Table 5.2-6. Hourly measurements of dissolved oxygen were made at the corresponding locations by USFWS in 2001 through 2003. Those data are summarized in Table 5.2-7.

Table 5.2-6. Monthly Dissolved Oxygen Data Collected Below Iron Gate dam.

	KR18973 Below Iron Gate dam		**KR17600 At Highway I-5**	
	Concentration	**Saturation**	**Concentration**	**Saturation**
No. of values	71	71	30	30
Minimum	5.9	61.1	7.3	85.4
1st Quartile	7.8	87.9	8.6	93.8
Median	8.7	99.9	9.6	102.6
3rd Quartile	10.0	107.7	10.8	124.9
Maximum	13.1	130.0	13.6	137.6
Mean	9.0	97.3	9.9	107.7

Table 5.2-7. Summary of Hourly Dissolved Oxygen Data Collected by USFS 2001-2003.

	Below Iron Gate dam KR18973, RM 189		**Above Shasta River KR17300, RM 173**	
	DO	DO%	DO	DO%
N	19567	19567	13691	13691
Minimum	3.4	38.5	3.4	38.5
1st Quartile	6.5	76.5	6.4	74.4
Median	7.5	88.3	7.5	86.7
3rd Quartile	8.2	95.4	8.2	94.0
Maximum	11.8	137.6	10.7	124.4
Mean	7.4	85.3	7.3	83.4

As a result of natural conditions and nutrient concentrations from upstream sources, water quality below Iron Gate dam can not meet the water quality objectives year-round. In particular, water quality conditions below Iron Gate dam do not consistently meet the 9.0 mg/L objective that applies during the spawning period, which typically starts in October and extends into December.

At the elevation of discharge from Iron Gate reservoir (approximately 10 meters [33 feet], depending on reservoir elevations) local conditions of barometric pressure and temperature may limit the dissolved oxygen concentration at 100 percent saturation. Based on U.S. Fish and Wildlife Service measurements below Iron Gate reservoir, local conditions would prevent attainment of dissolved oxygen concentration greater than 11.0 mg/L 68 percent of the time, greater than 10.0 mg/L 44 percent of the time, and greater than 8.0 mg/L 14 percent of the time. Table 5.2-8 shows the 100 percent saturation values of dissolved oxygen concentration at Iron Gate and Copco reservoirs. Dissolved oxygen in the Klamath River is at or near saturation for the entire length of the river with the exception of the segment immediately below Iron Gate dam. Conditions of temperature and barometric pressure may prevent even highly oxygenated water from meeting the relevant water quality objective in the upstream portions of the segment.

Table 5.2-8. 100 Percent Saturation Dissolved Oxygen Values (based on Lewis 2006).

Temperature	Iron Gate	Copco
0	13.1	13.3
5	11.8	11.6
10	10.5	10.2
15	9.3	9.1
20	8.4	8.2
25	7.6	7.5

5.2.1.3 Project Contribution

Klamath River from Stateline to Copco Reservoir

Dissolved oxygen conditions in this river segment are a reflection of the natural conditions in the river. The turbulent nature of the river keeps it well aerated in the face of oxygen demand from the substantial load of organic material exported from upstream with origins in UKL.

Even though the river is well oxygenated, at times it may be constrained from meeting the water quality objectives because the combination of water temperature and barometric pressure that exist through much of the segment for much of the year preclude attaining of the objective (Table 5.2-1). During these periods, however, the Project does not contribute to depressed dissolved oxygen levels. The seasonal distribution of dissolved oxygen values in the Klamath River below Iron Gate dam is shown in Figure 5.2-7.

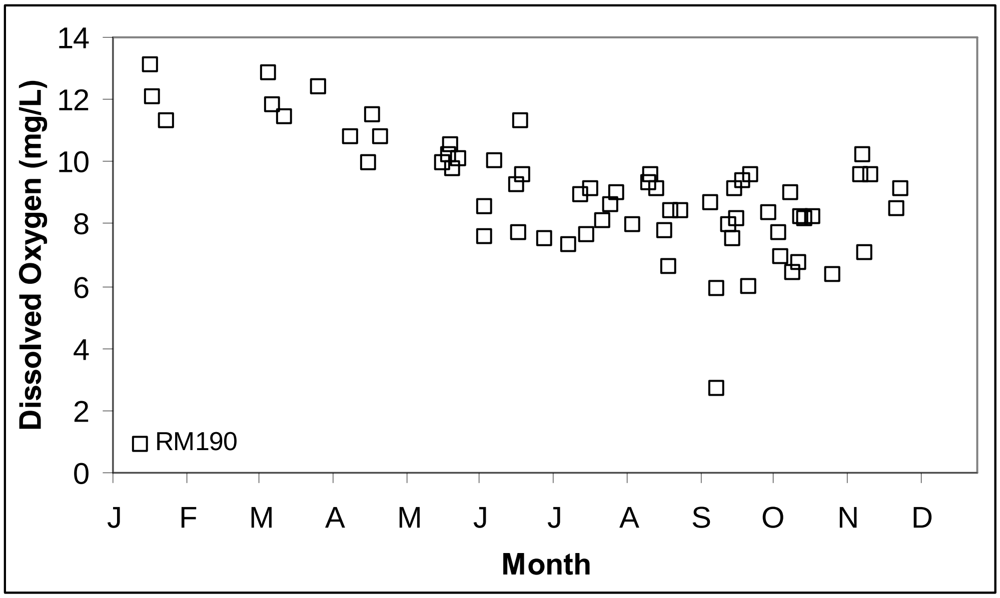

Figure 5.2-7. Values of dissolved oxygen measured in the Klamath below Iron Gate dam (RM 190) at various times of the year in 2001 through 2007.

Copco Reservoir and Iron Gate Hydrologic Subareas

Thermal stratification in both Copco and Iron Gate reservoirs allows anoxia to develop in part of the hypolimnion in summer. Photosynthesis in the epilimnion results in supersaturation and large diurnal swings. This is a natural consequence of the climate regime in the area and the high concentration of nutrients that are contributed from sources upstream of the Project. Table 5.2-9 shows the 100 percent saturation values of dissolved oxygen concentration at Iron Gate and Copco reservoirs. Only a small fraction of temperature values at the surface of the reservoirs are 8°C or less. Thus the standard cannot be met due to natural conditions, and there are no controllable factors to achieve the criteria. Although conditions that may stress fish can occur in shallow stratified lakes and reservoirs when the surface warms and the depths become oxygen deficient, this is not the case in Copco and Iron Gate reservoirs. There are areas in both reservoirs where generally recognized conditions of temperature (less than 20°C) and dissolved oxygen (greater than 6.0 mg/L) are supportive of resident warm-water fish.

5.2.1.4 Hornbrook Hydrologic Subarea

Thermal stratification allows anoxia to develop in the hypolimnion of Iron Gate reservoir. The position of the power intake allows water with low dissolved oxygen to be discharged to the river, typically in the summer as illustrated in Figure 5.2-8. Decreases in dissolved oxygen in the Iron Gate powerhouse discharge can be seen in the late spring (May) as stratification develops in the reservoir, and then increases in the fall (November) as well-oxygenated surface water mixes down to the level of the power intake.

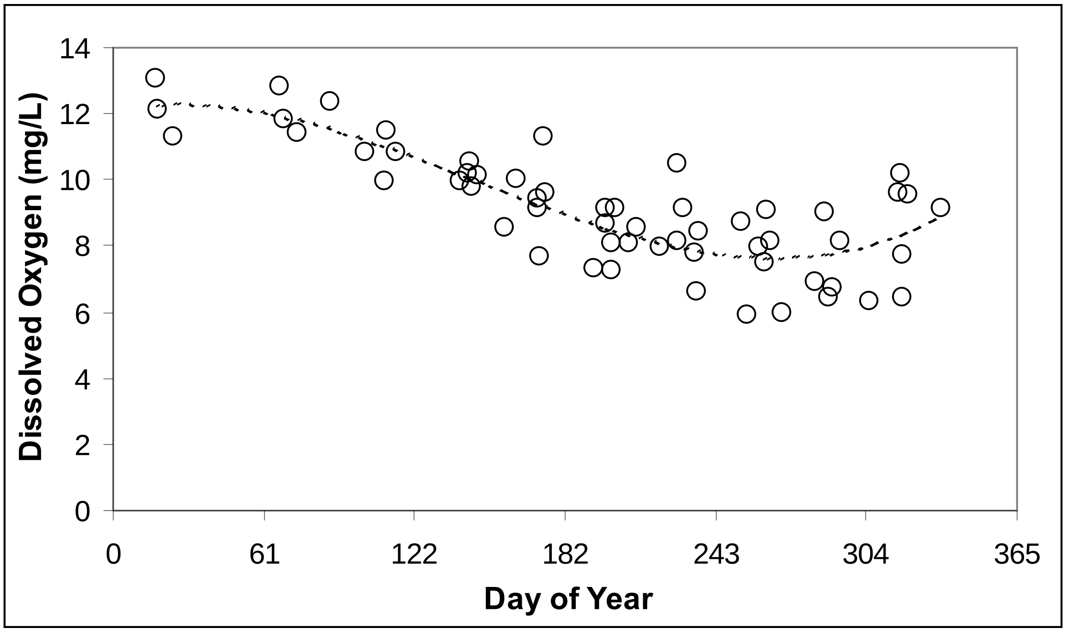

Figure 5.2-8. Measured Dissolved Oxygen Data Collected by PacifiCorp Below Iron Gate dam during 2000 to 2005. (Hatched line represents a smoothed curve fit of the data).

As discussed above, dissolved oxygen concentrations within the Klamath River vary as a function of water temperature and gas saturation. Results of water quality monitoring and modeling for the Klamath River system show that low dissolved oxygen concentrations below Iron Gate dam may occur seasonally. Seasonal water temperatures as well as the effects of phytoplankton and other physical and biological processes affect the seasonal patterns and magnitude of dissolved oxygen at various locations within the river. The most sensitive of the reaches within the mainstem for salmonid production is the reach immediately downstream of Iron Gate dam where salmonid spawning and egg incubation occur. An action that has been used effectively to improve dissolved oxygen concentrations downstream of an impoundment is the installation and operation of a hypolimnetic oxygenation system. As described below, PacifiCorp is evaluating turbine venting and implementation of an oxygenation system within Iron Gate reservoir to increase dissolved oxygen concentrations and to bring dissolved oxygen conditions immediately downstream of the dam into compliance with water quality objectives.

5.2.1.5 Proposed Measures

Klamath River from Stateline to Copco Reservoir

No activity or facility of the Project adversely influences dissolved oxygen in this segment of the river. Dissolved oxygen values are a naturally occurring condition. No measures or activities with respect to dissolved oxygen are proposed.

Copco Reservoir Hydrologic Subarea

Dissolved oxygen values in the reservoir are the result of natural occurring conditions (i.e., temperature, barometric pressure and nutrient loading). Dissolved oxygen generally meets the water quality objectives in the epilimnion of the reservoir, and any deviations are driven largely by inputs of nutrients and organic matter from upstream or natural conditions. PacifiCorp proposes to implement a reservoir management program to improve reservoir water quality (Appendix B). This plan is targeted at management of reservoir water quality conditions resulting from in-reservoir response to external loads, and will have the affect of improving dissolved oxygen conditions in Copco reservoir. The appropriate forum to address control of the large loads of nutrients and organic matter from upstream sources is the TMDL process that is currently being developed by the NCRWQCB (in California) and ODEQ (in Oregon). Therefore, this reservoir management program is an important adjunct to the TMDLs, and provides a proactive response by PacifiCorp to implementation of the anticipated TMDLs as pertinent to Project facilities.

The RMP (Appendix B) is a revised version of a similar plan developed in March 2006 (PacifiCorp 2007b). This revised version of the RMP contains updated information on the process PacifiCorp is following for identifying, testing, implementing, and monitoring measures to enhance water quality conditions in Copco reservoir. For example, during 2008, PacifiCorp plans to complete an assessment of the feasibility and design of an oxygenation system in Copco reservoir to improve water quality by introducing oxygen to the bottom waters of the reservoir.

In 2007, PacifiCorp retained Mobley Engineering Inc. (MEI) to conduct a study to assess alternative design configurations and effectiveness of hypolimnetic oxygenation in Copco reservoir (MEI 2007, provided in the attached Appendix D). Based on the results of this study, including detailed CE-QUAL-W2 modeling of alternative system configurations, MEI (2007) concluded that it is feasible to maintain dissolved oxygen levels of 6 to 8 mg/L throughout the reservoir even with the large incoming loads of nutrients and organic matter. CE-QUAL-W2 model results show clear and dramatic improvements in reservoir dissolved oxygen levels with the conceptual oxygen diffuser systems in operation.

Although the MEI (2007) evaluation indicates that an oxygenation system in Copco reservoir would substantially enhance reservoir dissolved oxygen levels, PacifiCorp is not prepared to proceed with implementation at this time. Further consultation with the State Water Board and other applicable regulatory authorities is needed to determine the full extent of the specific dissolved oxygen objectives and requirements that must be achieved throughout the reservoir. In addition, details of the design of an oxygenation system in Copco reservoir needs further evaluation. The tasks associated with further consultation on, and evaluation of the system are described in the RMP (Appendix B).

During 2008, PacifiCorp also plans to assess the potential effectiveness and feasibility of constructing wetlands upstream and/or along Copco reservoir based on study, analysis, and design tasks as described in the RMP (Appendix B). Given that water quality conditions in Copco reservoir, including dissolved oxygen, is largely driven by the large nutrient and organic loads from upstream sources (particularly UKL), construction of properly designed wetlands is a promising technology that could offer a means of capturing and removing particulates and nutrients in upstream river inflow to the reservoir. Such wetlands could augment the presence and settling function of Copco reservoir that already beneficially reduces the annual net nutrient and organic loading to the Klamath River (PacifiCorp 2006).

Iron Gate Hydrologic Subarea

Dissolved oxygen values in Iron Gate reservoir are the result of naturally occurring conditions (i.e., temperature, barometric pressure and nutrient loading). Dissolved oxygen generally meets the water quality objectives in the epilimnion of the reservoir and deviations are driven largely by inputs of nutrients and organic matter from upstream. PacifiCorp proposes to implement a reservoir management program (Appendix B), including hypolimnetic oxygenation in Iron Gate reservoir, to improve water quality in the reservoir and in immediate downstream reaches. This plan is targeted at management of reservoir water quality conditions resulting from in-reservoir response to external loads and will have the effect of improving DO conditions in the reservoir. The appropriate forum to address control of the large loads of nutrients and organic matter from upstream sources is the TMDL process that is currently being developed by the NCRWQCB (in California) and ODEQ (in Oregon). The reservoir management program is an important adjunct to the TMDLs, and provides a proactive response by PacifiCorp to implementation of the anticipated TMDLs as pertinent to Project facilities.

The RMP (Appendix B) contains updated information on the process PacifiCorp is following for identifying, testing, implementing, and monitoring measures to enhance water quality conditions in Iron Gate reservoir. For example, during 2008, PacifiCorp plans to complete an assessment of the feasibility and design of an oxygenation system in Iron Gate reservoir to improve water quality by introducing oxygen to the bottom waters of the reservoir.

In 2005, PacifiCorp evaluated the feasibility of a hypolimnetic oxygen diffuser system that would be located in the deepest portion of Iron Gate reservoir upstream of the dam to enhance dissolved oxygen conditions in the hypolimnion of the reservoir and in releases to the Klamath River from the Iron Gate powerhouse (MEI 2005, provided in the attached Appendix C). The MEI (2005) design is based on providing 1 to 3 mg/L of dissolved oxygen uptake to the full 1,735 cfs hydropower turbine flow capacity, and providing hypolimnetic oxygenation in the reservoir to improve water quality conditions. The system would maintain oxygenated conditions in most of the reservoir hypolimnion and maintain dissolved oxygen levels in the hydropower releases of 6 to 8 mg/L.

In 2007, PacifiCorp retained Mobley Engineering Inc. (MEI) to conduct an additional study to assess alternative design configurations and effectiveness of hypolimnetic oxygenation in Iron Gate reservoir (MEI 2007, provided in the attached Appendix D). As with Copco reservoir (as discussed above), the MEI (2007) evaluation indicates that an oxygenation system in Iron Gate reservoir would substantially enhance reservoir dissolved oxygen levels, However, PacifiCorp is not prepared to proceed with implementation at this time. Further consultation with the State Water Board and other applicable regulatory authorities is needed to determine the full extent of the specific dissolved oxygen objectives and requirements that must be achieved throughout the reservoir. In addition, details of the design of an oxygenation system in Iron Gate reservoir needs further evaluation. The tasks associated with further consultation on, and evaluation of the system are described in the RMP (Appendix B).

During 2008, PacifiCorp also plans to assess the potential effectiveness and feasibility of constructing wetlands upstream and/or along Iron Gate reservoir based on study, analysis, and design tasks as described in the RMP (Appendix B). This would be part of a larger feasibility study that would also include potential constructed wetlands upstream and/or along Copco reservoir (as discussed above) and J.C. Boyle reservoir in Oregon (PacifiCorp 2008a). Construction of properly designed wetlands could offer a means of capturing and removing particulates and nutrients in upstream river inflow to the reservoirs, and augment the beneficial function of the reservoirs in reducing the annual net nutrient and organic loading to the Klamath River (PacifiCorp 2006).

Hornbrook Hydrologic Subarea

Hypolimnetic oxygen deficits in Iron Gate reservoir affect compliance with the water quality objective below Iron Gate as water drawn from the reservoir passes into the river below the dam. Measures taken in Iron Gate reservoir as desribed in the RMP (Appendix B) should allow the water quality objective to be met below the dam more often, but ambient conditions (seasonally warm temperatures and the elevation of the site) will likely still prevent meeting the 50 percentile value of 10 mg/L or the spawning value of 9.0 mg/L during certain times of the year. Thus, controllable factors are available during some periods, but not all of the time.

During 2008, PacifiCorp plans to proceed with testing and evaluation of a turbine venting system at the Iron Gate powerhouse to enhance dissolved oxygen in the Klamath River downstream of Iron Gate dam. In concept, turbine venting uses a “reaeration valve” to allow the induction of atmospheric air into the water passageways within a turbine to aerate the releases from a dam. Such turbine aeration utilizes the low pressures of the water passing through the turbine to entrain air for tailrace dissolved oxygen enhancement. PacifiCorp plans to conduct field tests to verify air flow and dissolved oxygen increases that can be obtained, and to quantify the effects of the increased air flow on turbine efficiency. The tasks associated with testing of the system are described in the RMP (Appendix B).

In 2005, MEI (2005) estimated the potential effectiveness of turbine venting at the Iron Gate powerhouse (MEI 2005, provided in the attached Appendix C). MEI (2005) used modeling to estimate air admission rates, dissolved oxygen uptake, and potential total dissolved gas (TDG) for the observed powerhouse operating conditions. MEI (2005) estimated that turbine air admission could result in dissolved oxygen uptake of 1.5 to 2.7 mg/L depending on turbine headcover valve operation and the potential inclusion of baffles. Such uptake could provide an appreciable benefit to dissolved oxygen concentration in the tailwaters of Iron Gate dam. PacifiCorp also notes that the FERC FEIS (FERC 2007) concluded that turbine venting would be effective in achieving increases in dissolved oxygen in the Klamath River downstream of Iron Gate dam. On this basis, FERC (2007) recommends a licensing measure to include turbine venting and follow-up dissolved oxygen monitoring at Iron Gate.

5.2.2 pH

5.2.2.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:
pH shall conform to those limits listed in Table 3-1. For waters not listed in Table 3-1 and where pH objectives are not prescribed, the pH shall not be depressed below 6.5 nor raised above 8.5.

Changes in normal ambient pH levels shall not exceed 0.2 units in waters with designated marine (MAR) or saline (SAL) beneficial uses nor 0.5 units within the range specified above in fresh waters with designated COLD or WARM beneficial uses.

North Coast Basin Plan, Table 3.1 at 3-5.00 to 3-7.00 establishes the following specific pH objectives for the segments of the Klamath River:

	Max	**Min**
Middle Klamath HA		
Klamath River above Iron Gate Dam including Iron Gate and Copco Reservoirs	8.5	7.0
Klamath River below Iron Gate Dam	8.5	7.0
Lower Klamath HA		
Klamath River	8.5	7.0

5.2.2.2 Present Conditions

pH is a measure of hydrogen ion (H^+) activity. Watershed hydrology, geology, and meteorology play an important role in pH of aquatic systems. Natural waters typically have a pH that ranges from 6 to 9, which is well above the pH of rainfall (pH 5.6). The reason for the discrepancy between the pH of rainfall and that of natural waters is largely due to rainfall interaction (e.g., infiltration) with the soil buffering system. Further, weakly buffered systems are predisposed to elevated pH if sufficient primary production results in depressed dissolved CO_2 concentrations (Horne and Goldman, 1994). Another aspect of water quality that affects pH is related to low dissolved oxygen. Specifically, as oxygen concentration approaches zero and anoxic conditions appear, reduction processes (wherein an electron is gained) dominate. Under such conditions, pH values often fall in response to respiratory, fermentation, and other nonphotosynthetic processes (Wetzel, 2002). Such processes reverse as oxygen is reintroduced.

The Klamath River is a weakly buffered system with alkalinity generally less than 100 mg/L as $CaCO_3$. This makes it subject to fluctuation in pH in response to changes in dissolved CO_2 caused by the effects of photosynthesis by plants and respiration by plants, bacteria, and other organisms. The concentration of available nutrients in the Klamath River below Stateline is substantial as a result of loading from upstream sources, particularly UKL, and is capable of supporting abundant phytoplankton growth in the river and reservoirs of the Project. It is not surprising, therefore, to observe fluctuations in pH in the Klamath River. Summer pH values tend to be higher and more variable that winter values (Figure 5.2-9). This relative difference is most likely caused by increased primary production during summer periods as well as rainfall dominated runoff (lower pH) during winter periods.

Measurements for pH have been made approximately monthly between March and November from 2000 through 2005, and June through November in 2007 at a number of sites in the relevant segments of the Klamath River. These sites are identified in Table 5.2-9. Vertical profile measurements of pH have been made in Copco and Iron Gate reservoirs on the same schedule. As shown in Table 5.2-10, pH measurements at all sites sampled exceed 8.5, and at some depths in Copco and Iron Gate reservoirs and in the Klamath River below Iron Gate dam, pH levels were lower than 7.0.

Table 5.2-9. Site ID and River Mile for Locations in the Klamath River.

Location	SITE ID	RM
Klamath River above Shovel Creek	KR20642	206
Copco Reservoir	KR19874	198
Copco No. 2 Powerhouse discharge	KR19645	196
Iron Gate Reservoir	KR19019	190
Klamath River below Iron Gate Dam	KR18973	189
Klamath River at I-5 Freeway	KR17600	176
Klamath River above the Shasta River	KR17300	173

Table 5.2-10. Descriptive statistics for pH Measured in the Klamath River.

	KR17600	KR18973	KR19019	KR19645	KR19874	KR20642
N	30	71	1470	52	1202	72
Mean	8.0	7.8	7.5	7.9	7.7	8.0
Minimum	6.8	6.6	6.2	6.5	6.1	6.8
1st Quartile	7.6	7.5	7.1	7.6	7.3	7.8
Median	8.1	7.9	7.4	7.8	7.7	8.0
3rd Quartile	8.5	8.3	7.8	8.1	8.1	8.2
Maximum	8.8	9.2	9.9	8.9	9.2	8.9

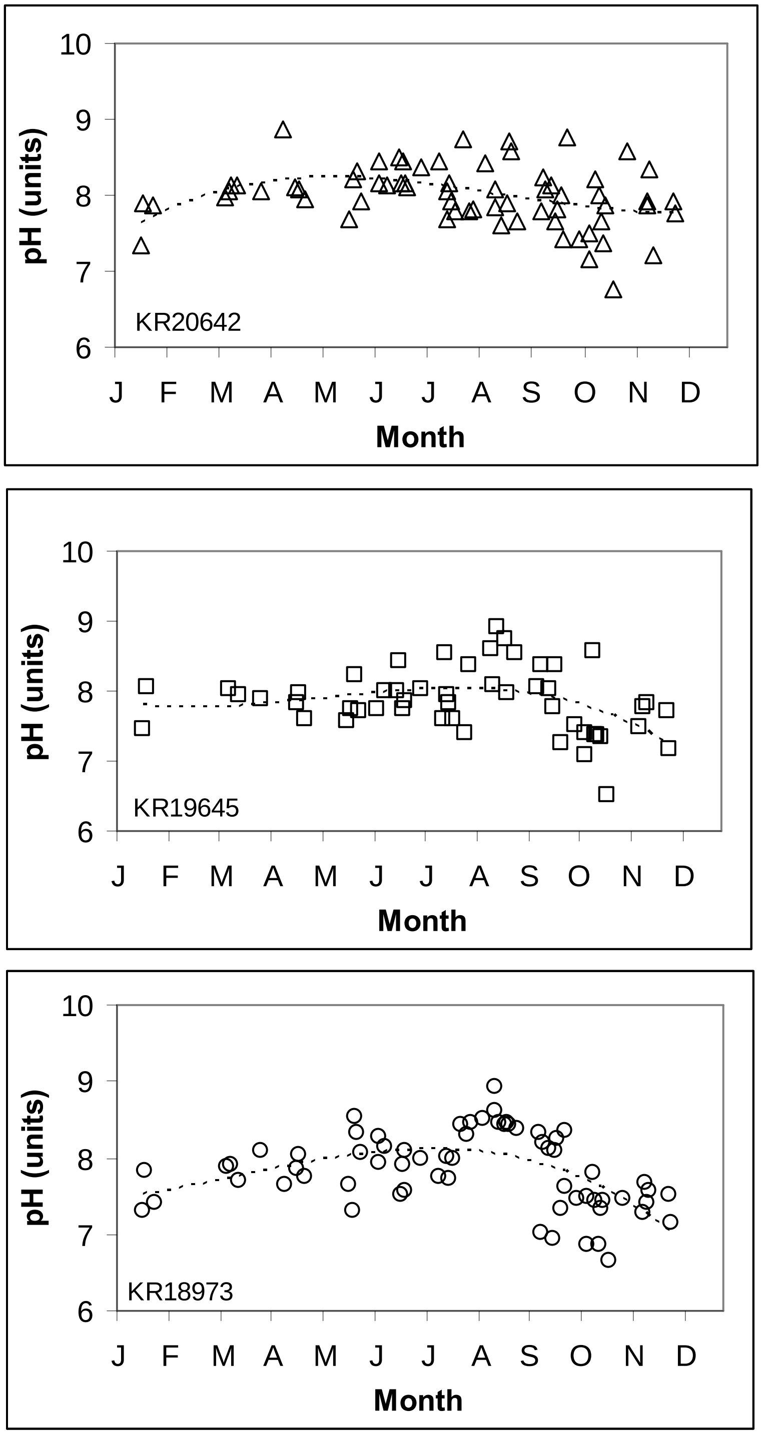

Figure 5.2-9. Seasonal variation in pH values measured in the Klamath River above Copco reservoir near Shovel Creek (KR20642), below Copco 2 powerhouse (KR19645), and below Iron Gate dam (KR18973).

<u>Klamath River from Stateline to Copco Reservoir</u>

Measurements of pH were made in this river segment at RM 206 (KR20642) near Shovel Creek. Descriptive statistics are shown in Table 5.2-10. A summary of the measurements with respect to the water quality objectives is provided in Table 5.2-11. Measurements made during daylight hours are likely to be higher than at other times because of the effect of photosynthetic activity in the poorly buffered river water.

Copco Reservoir Hydrologic Subarea

Depth profiles of pH were made in Copco reservoir at the deepest point near the dam. A summary of the measurements is provided in Table 5.2-11. The distribution of pH values reflects the algal response to in puts of nutrients from upstream in the Klamath Basin. Photosynthesis in the epilimnion, where light is available, disrupts the carbon dioxide (CO_2) equilibrium resulting in high pH. At depth, CO_2 is produced as a result of respiration of organic matter resulting in low pH.

Iron Gate Hydrologic Subarea

Depth profiles of pH were made in Iron Gate reservoir at the deepest point near the dam. A summary of the measurements is provided in Table 5.2-11. The distribution of pH values reflects the algal response to in puts of nutrients from upstream in the Klamath River. Photosynthesis in the epilimnion, where light is available, disrupts the carbon dioxide (CO_2) equilibrium resulting in high pH. At depth, CO_2 is produced as a result of respiration of organic matter resulting in low pH.

Hornbrook Hydrologic Subarea

Measurements of pH were made at three locations below Iron Gate Dam; immediately below the dam, at Collier rest area on Highway I-5, and just above the mouth of the Shasta River. The site immediately below Iron Gate dam may be influenced by Iron Gate reservoir and the Klamath River. The other two sites reflect only the influence of conditions in the Klamath River. A summary of the measurements is provided in Table 5.2-11.

Table 5.2-11. Summary of pH values measured in the Klamath River below the Oregon-California border in 2000 through 2007.

Location	**Summary of pH values**				
	N	**N > 8.5**	**% > 8.5**	**N < 7.0**	**% < 7.0**
Klamath River above Shovel Creek	72	7	9.7	1	1.4
Copco Reservoir	1202	148	12.3	84	7.0
Copco Reservoir < 8 m	494	144	29.1	6	1.2
Copco Reservoir > 18 m	391	1	0.3	68	17.4
Iron Gate Reservoir	1470	116	7.9	189	41.9
Iron Gate Reservoir < 8 m	485	25	19.6	8	1.6
Iron Gate Reservoir > 20 m	613	0	0.0	135	22.0
Below Iron Gate Dam	71	3	4.2	4	5.6
Klamath River at I-5	30	7	23.3	2	6.7
Klamath River near Shasta River	7	6	85.7	0	0.0

5.2.2.3 Project Contribution

Klamath River from Stateline to Copco Reservoir

Primary production in this segment of the river is in response to nutrients from upstream of the Project, primarily from UKL. Although productivity is relatively modest, excursions of pH above 8.5 still occur because of the weakly buffered nature of the system. There are no nutrients contributed by the hydroelectric project and no substances are released that could modify pH.

Copco Reservoir Hydrologic Subarea and Iron Gate Hydrologic Subarea

The high rate of photosynthetic activity in the epilimnion of Copco and Iron Gate reservoirs leads to high pH and large diurnal range of pH values in the epilimnion at times during the year when the reservoirs are stratified. The high rate of respiration in the hypolimnion leads to low pH during the same periods (Figure 5.2-9). The high rate of photosynthesis is attributed to the high levels of nutrients from upstream of the Project. There are no nutrients contributed by the Hydroelectric project and no substances are released that could modify pH. It is possible that nutrients could be released from the sediment of the reservoir during periods of anoxia. Such nutrients, however, are sequestered in the hypolimnion during the period of stratification, and may not contribute to phytoplankton productivity in the epilimnion. During the winter when released nutrients might become mixed to the surface and thus be available for the succeeding summer, they are flushed from the reservoir by high flows in the Klamath River.

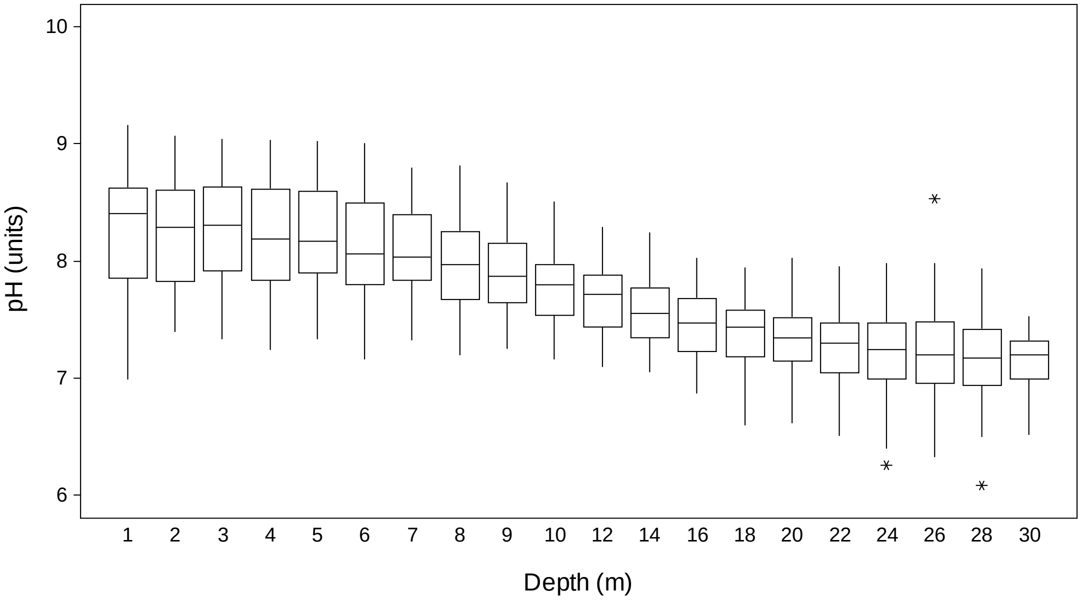

Figure 5.2-9. Distribution of pH Values Measured at Different Depths in Copco Reservoir during 2000 through 2005.

Hornbrook Hydrologic Subarea

Because water is released from Iron Gate reservoir from a point approximately 10 m below the surface, the released water lacks the extreme range of pH found at the surface of the reservoir. The river below the dam is heavily populated with attached aquatic plants. Photosynthesis by these plants in this weakly buffered system has the effect of increasing the pH during the daytime in the segment of the river below

Iron Gate dam. As a consequence, it is not unusual to measure pH of 9.0 or above in the Klamath River upstream of the Shasta River. However, the operation of the Project is not a controlling factor of pH in this reach.

pH is an important factor affecting both chemical and biological reactions within freshwater aquatic environments. The degree of dissociation of weak acids and bases is affected by changes in pH. For example, the toxicity of many compounds is affected by the degree of dissociation in response to changes in pH. Ammonia, metals, and other compounds vary in their toxicity to various life-history stages of salmonids in response to variation in pH. A pH range from approximately 6.5 to 9.0 is not expected to directly impact freshwater aquatic organisms, including salmonids and other fish species inhabiting the Klamath River. Similarly, pH within the range from 6.5 to 9.0 is not expected to adversely affect production of aquatic macroinvertebrates, such as mayflies and caddisflies that serve as an important component in the diet of rearing and resident salmonids. pH within the Klamath River is typically within the range considered to be suitable for salmonids, and would not be expected to result in direct adverse affects on salmonid growth or survival.

As a result of the low buffering capacity of the Klamath River, in combination with a variety of other factors including photosynthetic activity by phytoplankton, maximum pH conditions naturally occur that exceed the recommended range for salmonids and other freshwater aquatic species. As a result of the interaction between nutrient loading, phytoplankton production, and changes in water quality conditions including pH within the river, the most effective means to address the potential effects of elevated pH, although at a relatively low frequency of occurrence, within the Klamath River on habitat quality for salmonids is a reduction in nutrient loading and associated phytoplankton production contributed from above the Project.

5.2.2.4 Proposed Measures

The excursions of pH beyond the limits specified in the water quality objective observed in the Klamath River between the Oregon-California border and the mouth of the Shasta River are the natural consequence of the low buffering capacity of the river and the abundant photosynthetic activity supported by the large loads of nutrients in the river. The nutrients that support such photosynthesis are contributed from upstream of the Project, particularly from nutrient-rich UKL. Klamath River inflows from upstream (Oregon) may already be in excess of the standard, and little can be done to ameliorate this condition (Oregon has a pH criteria for natural waters between 6.5 and 9, while the acceptable range in California is between 6.5 and 8.5). In general, the river reaches are largely beyond the control of PacifiCorp. Although short-term variations can occur, the Project reservoirs retain and reduce a substantial portion of the nutrient loads in the Lower Klamath River (PacifiCorp 2006, Kann and Asarian 2007, Kann and Asarian 2005). No substances are released by Project operations of facilities that could modify pH. Thus, the Project is not a controlling factor of pH in these areas.

PacifiCorp proposes to implement a reservoir management program for improving reservoir water quality (Appendix B). This plan is targeted at management of reservoir water quality conditions resulting from in-reservoir response to external loads and is anticipated to improve pH conditions. However, control of the large loads of nutrients and organic matter from upstream sources is most appropriately and effectively addressed through the TMDL process that are currently being developed by the NCRWQCB (in California) and ODEQ (in Oregon). Therefore, this reservoir management program is an important adjunct to the TMDLs, and provides a proactive response by PacifiCorp to implementation of the anticipated TMDLs as pertinent to Project facilities.

The RMP (Appendix B) is a revised version of a similar plan developed in March 2006 (PacifiCorp 2007b). This revised version of the RMP contains updated information on the process PacifiCorp is following for identifying, testing, implementing, and monitoring measures to enhance water quality conditions in Copco and Iron Gate reservoirs, including to reduce primary production within the reservoirs, and thereby also reduce reservoir pH fluctuations.

5.2.3 Temperature

5.2.3.1 Applicable Criteria

The applicable water temperature objective in the North Coast Basin Plan, at 3-3.00 to 3-4.00, is set forth below:

Temperature objectives for COLD interstate waters, WARM interstate waters, and Enclosed Bays and Estuaries are as specified in the "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays of California" including any revisions thereto.

In addition, the following temperature objectives apply to surface waters:

> *The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses.*
>
> *At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.*
>
> *At no time or place shall the temperature of WARM intrastate waters be increased more than 5°F above natural receiving water temperature.*

5.2.3.2 Present Conditions

Current water temperature conditions in the Project reaches in California are described based on water temperature modeling of existing conditions for years 2000 through 2004 at several locations in the Project reaches in California. Detailed discussions of water temperature modeling methods and results for the Project are provided in PacifiCorp 2004b, 2004f, 2005a, 2005b, 2005c, and 2005d.

Figure 5.2-10 shows histograms of average annual water temperature (in degrees C, calculated over the entire set of hourly values for the years 2000 and 2001 as examples) in the Klamath River at several locations in Oregon from mouth of Link River (RM 252.7) to Stateline (RM 209.2), and downstream sites in California from Stateline to near the mouth of the river at Turwar (RM 5.3). It is most common for river systems to increase in ambient water temperature as waters flow downstream, in correlation with declining elevation and warming air temperatures (Sullivan et al. 2000). However, the histograms in Figure 5.2-10 indicate that annual heating actually declines slightly in a downstream direction from Keno dam (RM 232.9) to below J.C. Boyle powerhouse (RM 220.2). The lack of change in the histogram bars between the top of J.C. Boyle reservoir and J.C. Boyle dam (RM 224.3) suggests that the operation of J.C. Boyle reservoir adds little net heat to the system on an annual basis. The subsequent decline in histogram bars from J.C. Boyle dam to below the J.C. Boyle powerhouse suggests additional cooling, resulting mostly from the approximately 250 cfs of spring flow that discharges into the J.C. Boyle bypass reach. Farther downstream, the cooling effects of the spring inflow dissipate, and ambient water temperature again follow an expected increase as waters flow downstream. Average annual water temperatures are highest at the mouth of the river near Turwar (RM 5.3) (Figure 5.2-10).

More details on these conditions are described in the following reach-specific sections.

Klamath River from Stateline to Copco Reservoir

On an annual and seasonal basis, existing water temperature conditions in the Klamath River from Stateline (RM 209.2) to Copco reservoir (RM 203.6) are largely controlled by annual and seasonal solar and climatological conditions (Figure 5.2-11). Existing water temperatures in this reach are also influenced on a short-term (i.e. hourly, daily) basis by the operation of the J.C. Boyle dam (RM 224.3) and powerhouse (RM 220) in Oregon upstream of Stateline. J.C. Boyle dam and powerhouse are typically operated in load-following (i.e., peaking) mode when available flows in the river are less than the powerhouse hydraulic capacity of about 2,850 cfs (when flows are greater, the powerhouse typically operates continuously). During peaking, flows in the river can fluctuate on a short-term (i.e., hourly, daily) basis as the powerhouse peaks from non-generation baseflows to higher turbine generation flows.

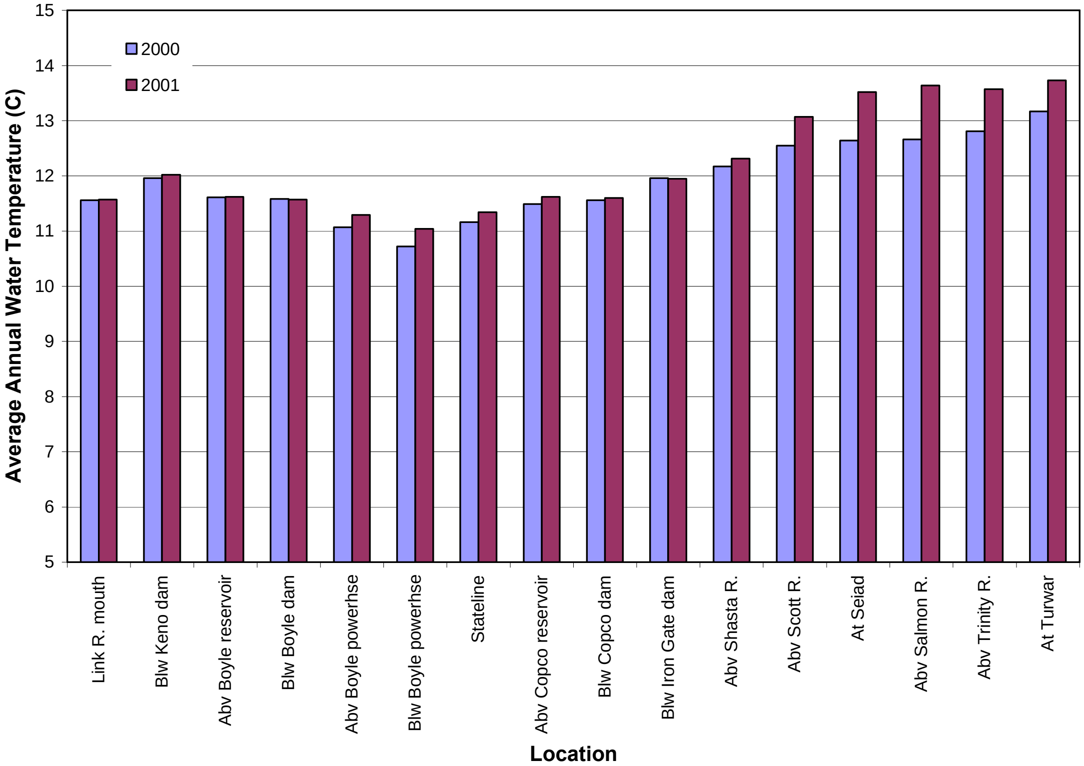

Figure 5.2-10. Histograms of Average Annual Water Temperature (in degrees C, calculated over the entire set of hourly values for the year 2000 and 2001 as examples) in the Klamath River at Locations from the Mouth of Link River (RM 252.7) to Turwar (RM 5.3).

The relatively cold water flowing in the J.C. Boyle bypass reach, combined with the fluctuation in discharge from the J.C. Boyle powerhouse during peaking operations, have an effect on the water temperature regime in the Klamath River below the J.C. Boyle peaking reach. The diurnal pattern of water temperature variation is similar to sites not affected by peaking operation, but the range of variation is larger (Figure 5.2-12). The range of daily water temperature variation below the powerhouse is greatly reduced, relative to unaffected sites, under conditions of constant daily discharge (Figure 5.2-12). This reduction in range is largely the result of warmer minimum daily water temperatures because the influence of cool groundwater is reduced.

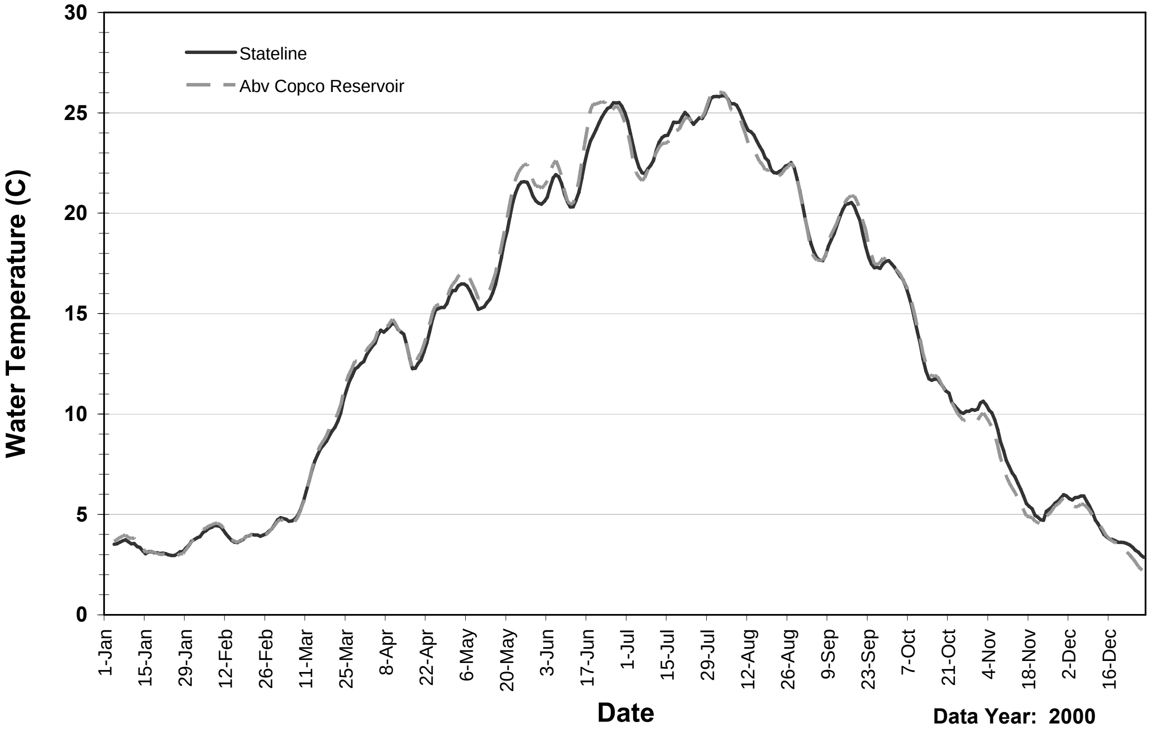

Figure 5.2-11. Annual time-series of Water Temperature (in degrees C, based on the 7-day average of maximum daily water temperature) in the Klamath River at Stateline and just above Copco Reservoir under Existing Conditions for 2000.

The interaction of varying discharge rates and travel time has an effect on the diurnal water temperature pattern at the downstream end of the J.C. Boyle peaking reach. Figure 5.2-13 shows the diurnal water temperature cycle measured in the peaking reach just upstream from Copco reservoir (as reported in PacifiCorp 2004a) during peaking operation (for the example period of July 1-5, 2002) and during constant daily discharge (October 1-5, 2002). The “notch” in the July curve between approximately 1:00 p.m. and 6:00 p.m. marks the arrival at the site of cooler water leaving the J.C. Boyle bypass reach when flow through the power turbines is shut off. That pattern is absent from the site during constant discharge operations in October. However, by October, temperatures in the river are similar to those in the bypass reach, so that this pattern is not discernable.

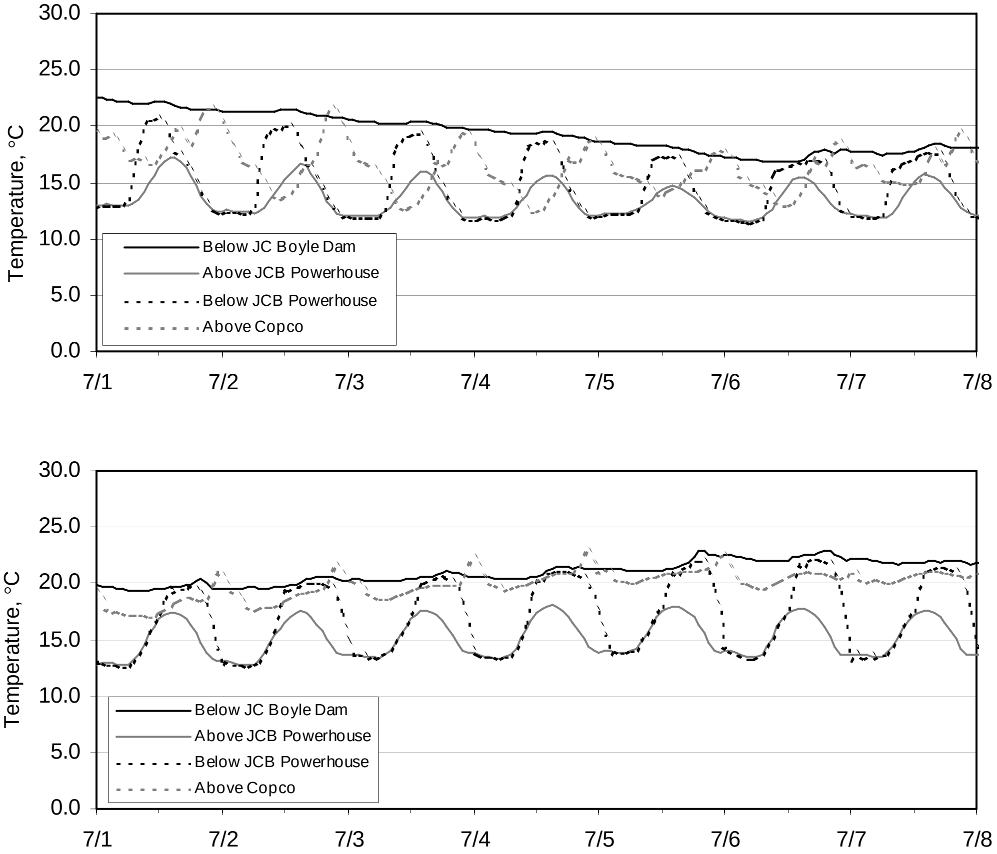

Figure 5.2-12. J.C. Boyle Bypass and Peaking Reach Water Temperatures under Existing Conditions during an Example Period of Typical Summertime Peaking in July 2000 (top) and 2001 (bottom).

<u>Copco and Iron Gate Reservoirs</u>

Copco reservoir undergoes annual thermal stratification. Copco reservoir stratification occurs around early March and remains stratified for approximately 200 days. Example isopleth diagrams for Copco reservoir for years 2000 and 2001 are presented in Figure 5.2-14. Maximum difference between epilimnetic and hypolimnetic temperatures is about 10°C.

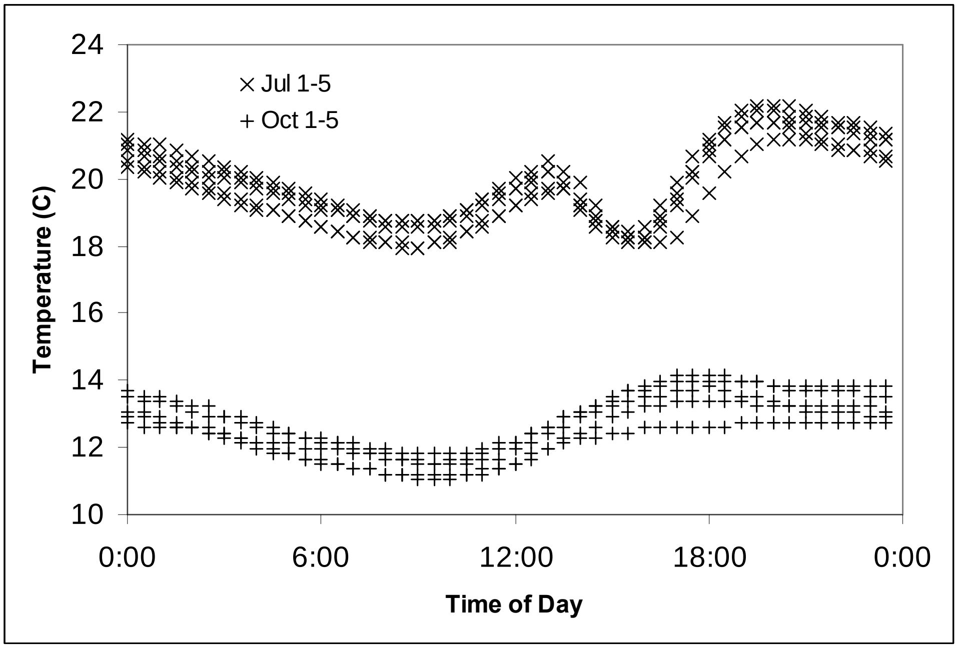

Figure 5.2-13. Water Temperatures Measured in the Klamath River above Shovel Creek (KR20645) during Periods of Peaking Operation (July, top) and during Nonpeaking Discharge (October, bottom) in 2002.

Copco reservoir turns over in mid- to late October (about a month earlier than Iron Gate reservoir) largely due to a wide range of river inflow temperatures responding to local meteorological conditions, resulting in denser flows that enter the reservoir and plunge or sink. These cool inflows to Copco reservoir in the fall, coupled with convective cooling, serve to break down stratification.

During summer periods, when peaking operations are occurring at J.C. Boyle powerhouse, model simulations and field data indicate that cold waters from the J.C. Boyle bypass reach can arrive at Copco reservoir before the waters from peaking operations do. Thus, throughout the summer there are small, but cold, quantities of water plunging into Copco reservoir. This provides mixing energy that limits Copco reservoir from stratifying as strongly as Iron Gate reservoir. The end result is that Copco reservoir has a warmer (12° to 15°C) hypolimnion than Iron Gate reservoir.

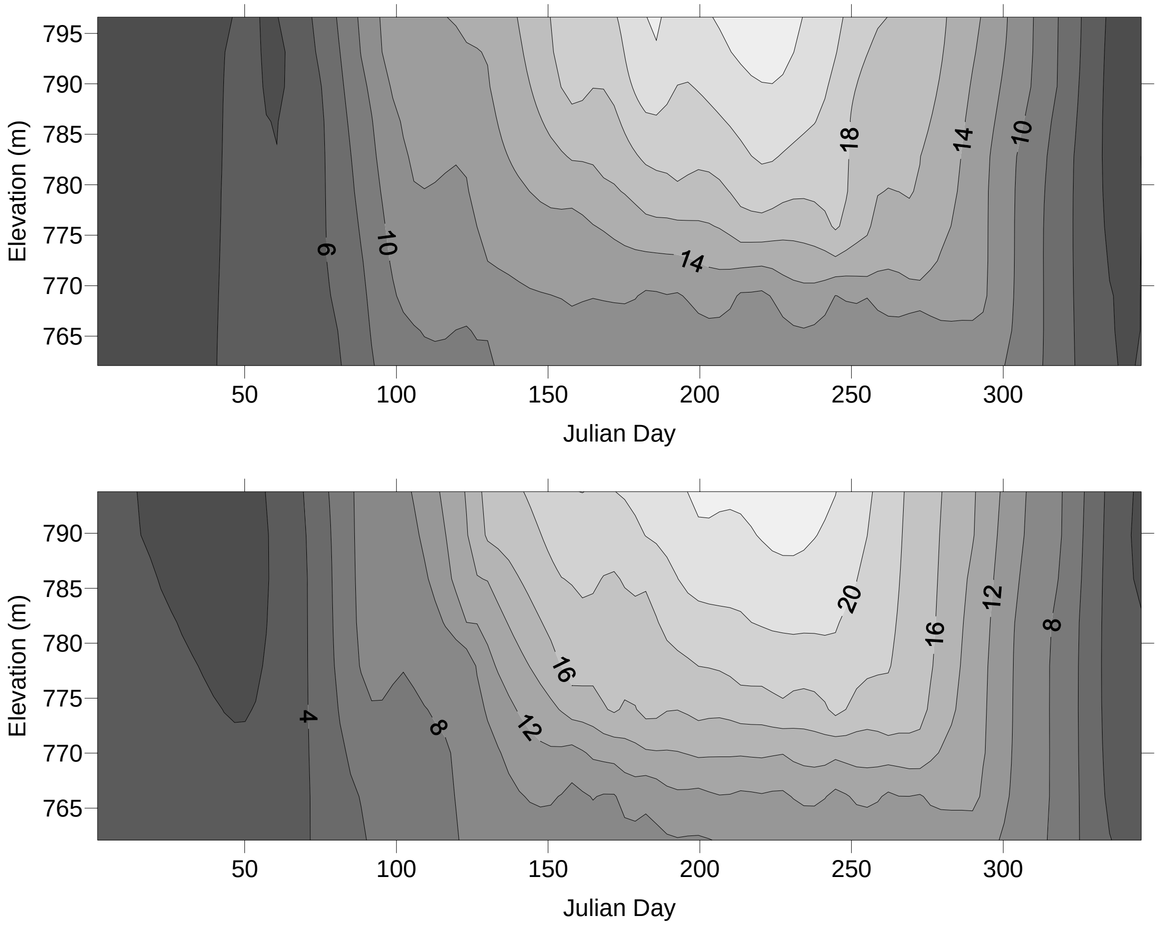

Figure 5.2-14. Copco Reservoir Temperature (°C) Isopleths under Existing Conditions for 2000 (top) and 2001 (bottom).

Iron Gate reservoir thermal stratification occurs around early March and remains stratified slightly longer than Copco reservoir, extending into November. Example isopleth diagrams for Iron Gate reservoir for years 2000 and 2001 are presented in Figure 5.2-15. Maximum difference between epilimnetic and hypolimnetic temperatures is about 16°C.

Stratification ends in Iron Gate reservoir in mid to late November (about a month later than Copco reservoir). The relative short distance between Copco dam (RM 198.6) and Iron Gate reservoir (RM 197.2) (about 1.4 miles) does not allow the waters to cool so as to provide density-driven flows that would accelerate destratification. The result is that Copco reservoir preserves Iron Gate reservoir's hypolimnetic cold water supply. Thus, deep water temperatures in Iron Gate reservoir are about 8°C. A substantial volume of the Iron Gate reservoir cold water pool is used at the Iron Gate fish hatchery located just downstream of Iron Gate dam (RM 190.5).

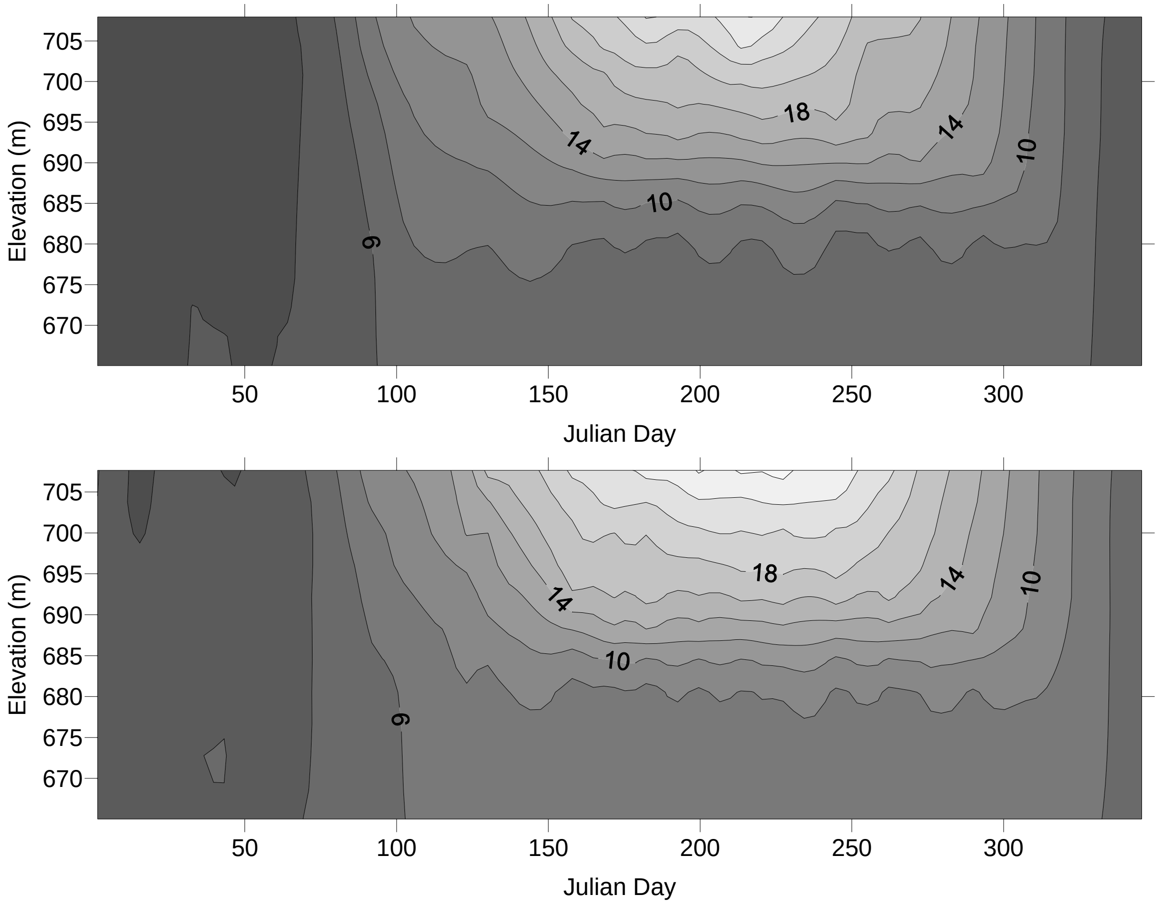

Figure 5.2-15. Iron Gate Reservoir Temperature (°C) Isopleths: EC for 2000 (top) and 2001 (bottom).

Typical of reservoirs, Copco and Iron Gate reservoirs create a thermal phase shift ("thermal lag"), whereby the releases from Copco dam and Iron Gate dam during spring are slightly cooler and during fall are slightly warmer than inflowing conditions (Figure 5.2-16). This is due to the large thermal mass of Copco and Iron Gate reservoirs compared to river reaches. River reaches can cool and heat relatively quickly compared to the larger and deeper reservoir volumes. Because of the thermal mass, Copco and Iron Gate reservoirs also have a moderating effect on water temperatures such that the annual maximum water temperature is less in dam releases than in reservoir inflows. For example, Figure 5.2-16 shows that a peak maximum daily temperature of about 26°C in the Klamath River above Copco reservoir, compared to peak maximum daily temperature of about 24°C at Copco dam and about 23°C at Iron Gate dam (Figure 5.2-16).

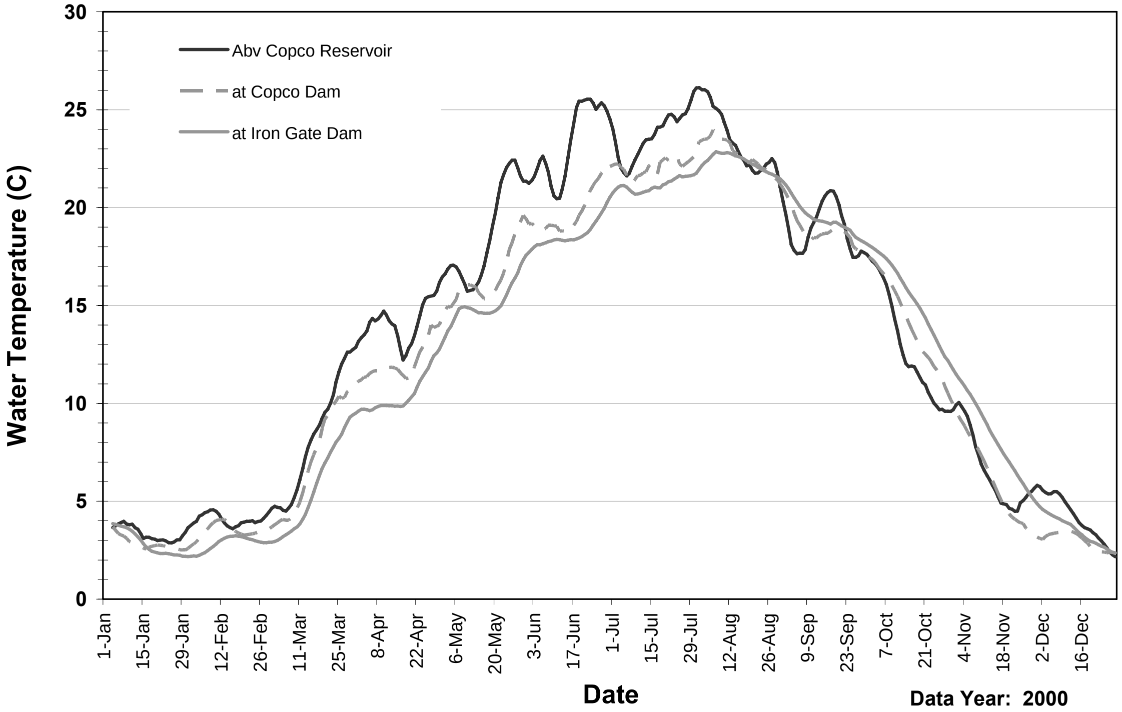

Figure 5.2-16. Annual Time-series of Water Temperature (in degrees C, based on the 7-day average of maximum daily water temperature) in the Klamath River just above Copco Reservoir, at Copco No. 1 dam, and at Iron Gate dam under Existing Conditions for 2000.

Klamath River Downstream of Iron Gate Dam

The moderating effect of Copco and Iron Gate dams on annual maximum water temperatures dissipates as flows in the Klamath River reach to just above the Shasta River (RM 177.5) (Figure 5.2-17). Continuing downstream, the annual maximum water temperatures are generally similar at Seiad Valley (RM 129) and at the Salmon River (RM 67) (Figure 5.2-17), indicating that the lower Klamath River is generally at or near equilibrium temperature throughout its length during summer meteorological conditions. The typical magnitude of reservoir releases from Iron Gate dam are not sufficient to have significant downstream effects on maximum daily temperatures during summer months compared to the influence of climatological conditions, river morphology and downstream tributary inflows.

Field observations indicate that the warmest reach of the Klamath River during summertime is the reach between approximately Seiad Valley (RM 129.0) and Clear Creek (RM 98.8). Maximum daily temperatures in this reach can approach 30°C and daily minimum temperatures in the 20°C to 24°C range are common during summer. Downstream of this reach, the river experiences considerable accretion and the aspect ratio of the channel changes from a broad shallow stream to a deeper river.

The diurnal range in temperature is moderated in the lower river as well. Temperatures in the lower river are lower during summer periods, with highs generally in the vicinity of 25°C; however, daytime lows remain in the 20°C to 24°C range. As the river approaches the coast, marine influences can moderate river temperatures even more. When clear, warm conditions prevail, water temperatures respond accordingly. During winter, the lower river locations may be warmer than the locations closer to Iron Gate dam due to more mild meteorological conditions near at the lower elevations (for example, see the January-February period in Figure 5.2-17). The major tributaries generally enter the Klamath River at similar temperatures that are also close to equilibrium.

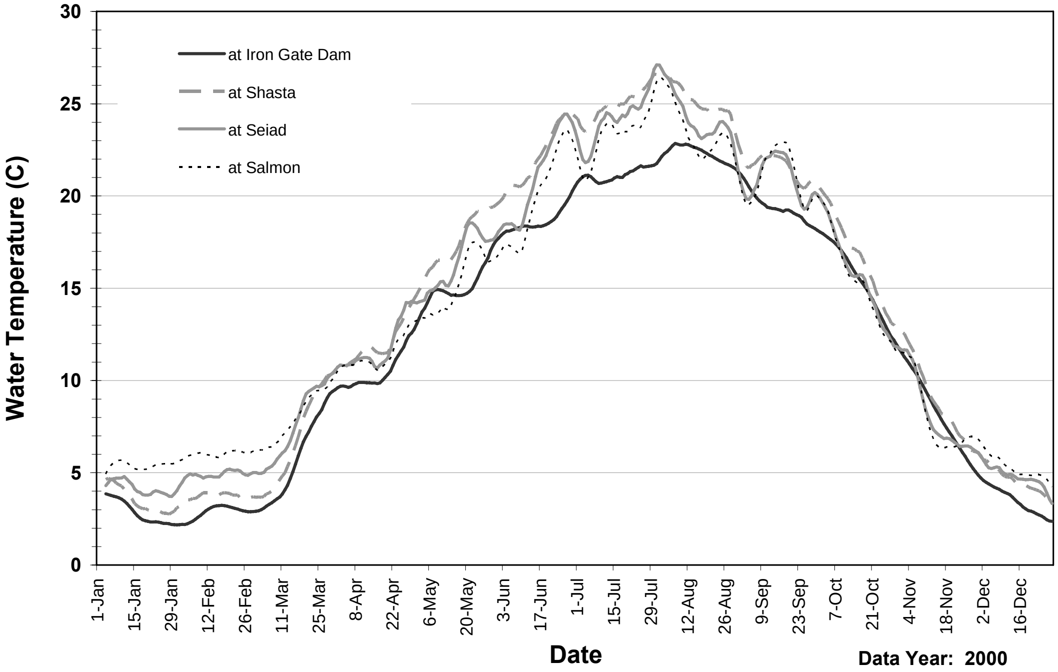

Figure 5.2-17. Annual Time-series of Water Temperature (in degrees C, based on the 7-day average of maximum daily water temperature) in the Klamath River at Iron Gate dam (RM 109.5), just above the Shasta River (RM177.5), at Seiad Valley (RM 129.0), and just above the Salmon River (RM 66.9) under Existing Conditions for 2000.

5.2.3.3 Project Contribution

The extent to which the Project contributes to current water temperature conditions in the Project reaches in California are described below. These effects are described based on field observations and supported by water temperature modeling of existing conditions for years 2000 through 2004 at several locations in the Project reaches in California. Detailed discussions of water temperature modeling methods and results for the Project are provided in PacifiCorp 2004b, 2004g, 2005a, 2005b, 2005c, and 2005d.

Klamath River from Stateline to Copco Reservoir

As described above, existing water temperature conditions in the Klamath River from Stateline to Copco reservoir are largely controlled by annual and seasonal solar and climatological conditions (Figure 5.2-11). Existing water temperatures in this reach are also affected on a short-term (i.e. hourly, daily) basis by the operation of the J.C. Boyle dam and powerhouse in Oregon upstream of the Stateline. The relatively cold, spring flow-dominated water flowing in the J.C. Boyle bypass reach, combined with the fluctuation in discharge from the J.C. Boyle powerhouse during peaking operations, have an effect on the water temperature regime in the California portion of the peaking reach between Stateline and Copco reservoir. The range of daily water temperature variation below the powerhouse is greatly reduced, relative to unaffected sites, under conditions of constant daily discharge (Figure 5.2-12). This reduction in range is largely the result of warmer minimum daily water temperatures because the influence of cool groundwater is reduced.

Figures 5.2-18 and 5.2-19 provide the annual time-series of water temperature under existing and proposed Project operation conditions in the Klamath River at Stateline and above Copco reservoir for the years 2000 and 2001. The figures provide a comparison of water temperatures under existing and proposed Project operation conditions (based on the 7-day average of maximum daily water temperature) to the California water temperature objective (assumed as no more than 5°F [2.8°C] increase above hypothetical without-Project[17] water temperatures [based on model simulations]). These comparisons indicate that the thermal regime in this reach of the Klamath River meets the California water temperature objective at all times under existing and proposed Project operations conditions in this reach. Similar figures are provided in Appendix A for other model simulation years (i.e., 2002, 2003, and 2004); these other figures also indicate that the thermal regimes in these other simulation years meet the California water temperature objective. As discussed elsewhere in this application, the Project does not adversely affect the attainment of beneficial uses in this reach.

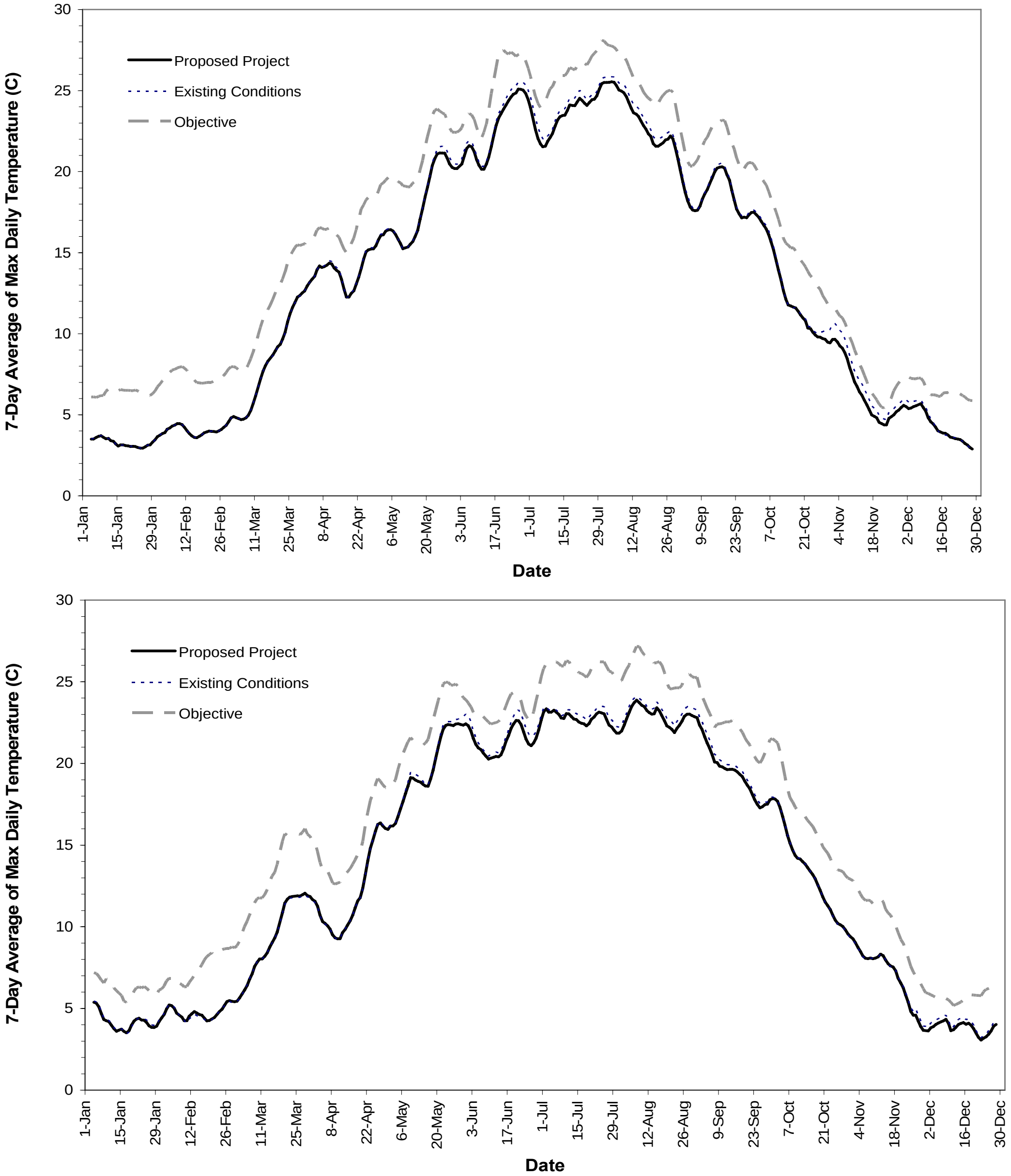

Figure 5.2-18. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Stateline (RM 209.2), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

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[17] In these analyses, the simulations assume that Project facilities (i.e., dams and powerhouses at the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments) are absent from the river.

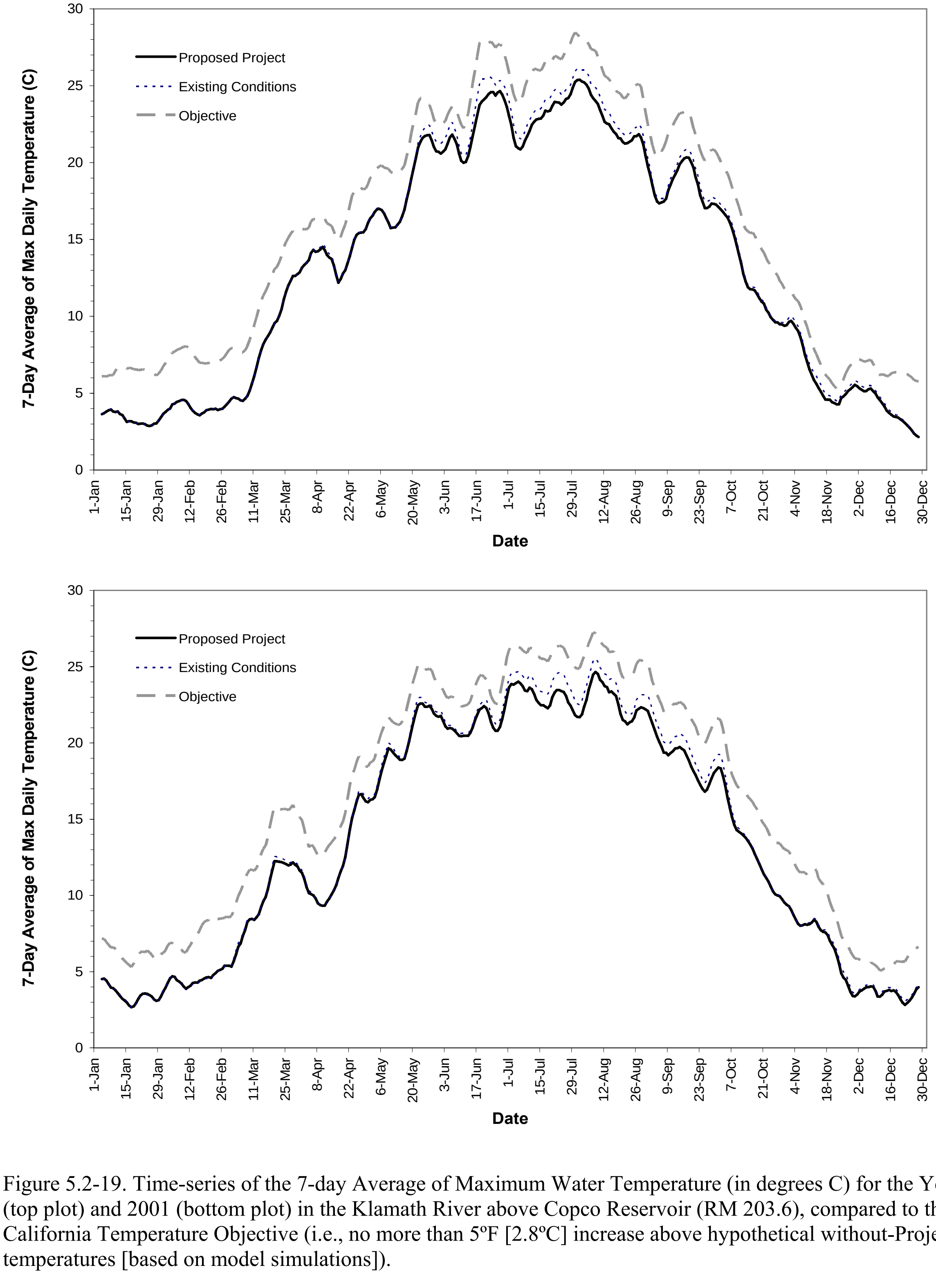

Figure 5.2-19. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the Year 2000 (top plot) and 2001 (bottom plot) in the Klamath River above Copco Reservoir (RM 203.6), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

Copco and Iron Gate Reservoirs

As described above, Copco and Iron Gate reservoirs undergo annual thermal stratification (Figures 5.2-14 and 5.2-15). The temperature regimes observed in both reservoirs are normal for an impounded mainstem reservoir (Thornton et al. 1990). On an average annual basis, presence and operation of the reservoirs add little net heat to the system. Average annual temperatures are no more than about 0.4°C higher than the without-Project water temperature [as estimated using water temperature model simulations]).

Copco and Iron Gate reservoirs create a thermal phase shift ("thermal lag"), wherein Copco and Iron Gate dam release temperatures during spring are slightly cooler and during fall are slightly warmer than inflowing conditions (Figure 5.2-16). This is due to the large thermal mass of Copco and Iron Gate reservoirs compared to river reaches. River reaches can cool and heat relatively quickly compared to the larger and deeper reservoir volumes. Because of their thermal mass, Copco and Iron Gate reservoirs also have a moderating effect on water temperatures such that the annual maximum water temperature is less in dam releases than in reservoir inflows. For example, Figure 5.2-16 shows that a peak maximum daily temperature of about 26°C in the Klamath River above Copco reservoir, compared to peak maximum daily temperature of about 24°C at Copco dam and about 23°C at Iron Gate dam (Figure 5.2-16).

Figure 5.2-20 shows the annual time-series of water temperature at Copco dam (for the years 2000 and 2001) under existing or proposed[18] operations conditions (based on the 7-day average of maximum daily water temperature). The figure provides comparisons to the California water temperature objective (assumed as no more than 5°F [2.8°C] increase above hypothetical without-Project water temperatures [based on model simulations]). These comparisons indicates that the thermal regime in the water discharged from Copco dam meets the California water temperature objective at all times under existing (or proposed) operations conditions. Similar figures are provided in Appendix A for other model simulation years (i.e., 2002, 2003, and 2004); these other figures also indicate that the thermal regimes in these other simulation years meet the California water temperature objective. As discussed elsewhere in this application, the Project does not adversely affect the attainment of beneficial uses in this reach.

Figure 5.2-21 shows the annual time-series of water temperature at Iron Gate dam (for the years 2000 and 2001) under existing or proposed operations conditions (based on the 7-day average of maximum daily water temperature). The figure provides comparisons to the California water temperature objective (assumed as no more than 5°F [2.8°C] increase above hypothetical without-Project water temperatures [based on model simulations]). These comparisons indicate that the thermal regime in the water discharged from Iron Gate dam meets the California water temperature objective most of the time during the year under existing or proposed operations conditions. The objective cannot be attained with reasonable controllable water quality factors during occasional brief periods in the fall from about mid-September to mid November. In these instances, the temperature can exceed the objective by about 0.1 to 1.5°C.

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[18] The predicted temperatures under existing and proposed Project operations conditions are coincident from Copco dam downstream.

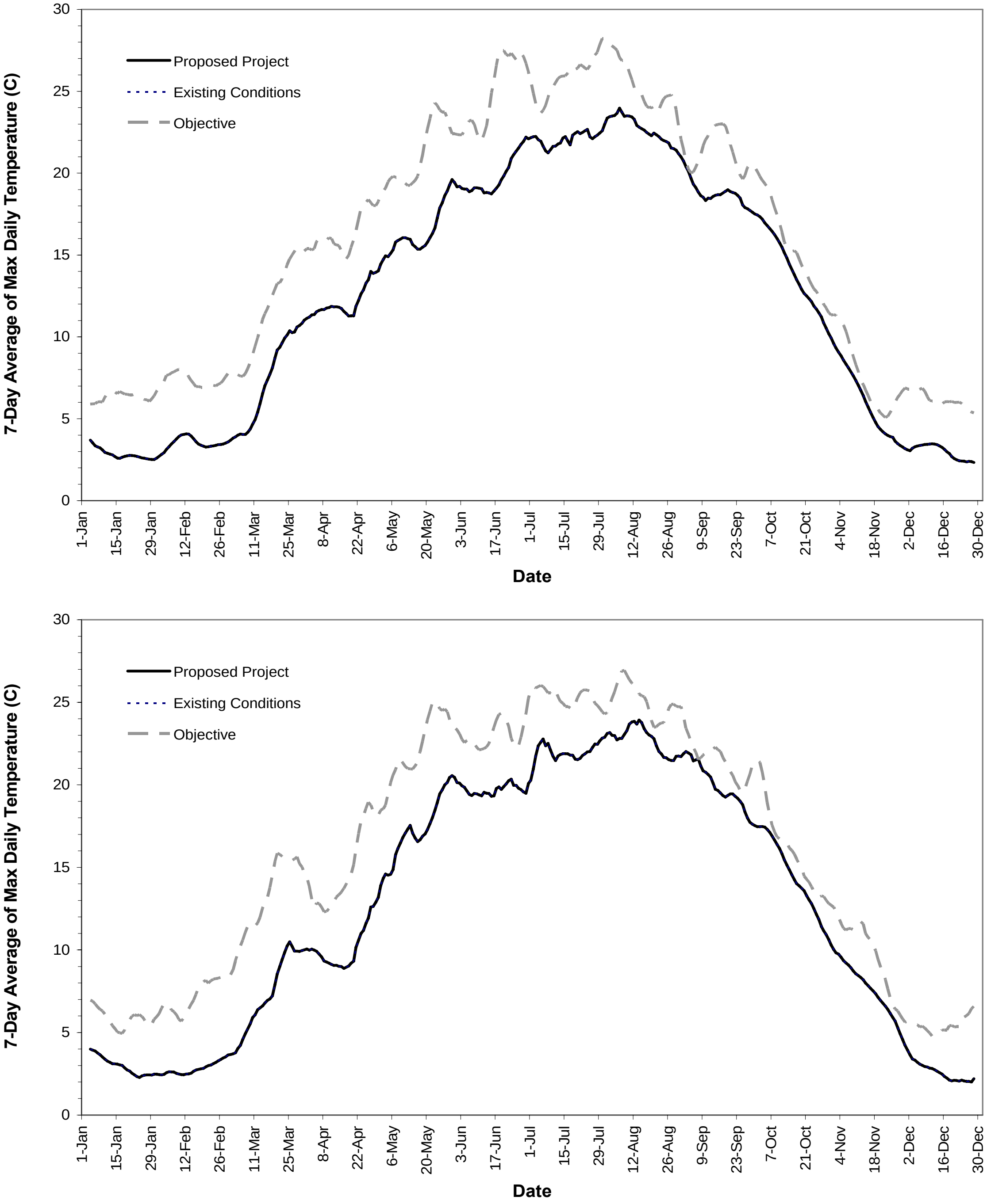


Figure 5.2-20. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Copco No. 1 dam (RM 198.6), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

It is important to note that these occasional brief periods of exceedances typically occur as a consequence of the onset of relatively cold short-term weather events. In the model simulations, the presence of such events results in a more-pronounced reduction in temperature in the without-Project simulations as compared to existing (or proposed) conditions. A lesser short-term temperature drop is simulated for existing (or proposed) conditions because of the dampening effect of the reservoir's stored water mass. As such, these infrequent exceedances are not the result of reservoir heating effects, but rather are the result of sudden cooling of the riverine system that would otherwise occur in the theoretical without-Project scenario in response to these short-term weather events. As discussed below, because of the relatively minimal cold water pool at Iron Gate reservoir and the cold water demands of the Iron Gate Hatchery, controllable water quality factors limit opportunities to bring temperatures more in line with these fluctuating natural conditions.

Klamath River below Iron Gate Dam Temperature Effects on Fish

The brief periods of exceedances below Iron Gate dam during the fall do not result in any significant adverse effects to anadromous fish that use the reach below the dam at that time for migration, spawning, and egg incubation. These brief periods occur when reservoir release temperatures are in their typical fall decline from about 18°C in mid September to about 10°C in late November. As such, even with the temperature lag, temperatures generally are within the optimal or suitable range for the anadromous fish using the area. Chinook salmon move upstream to spawn in the area below Iron Gate dam mostly from about mid-September to late October (USFWS 1998). During this time, reservoir release temperatures are gradually declining from about 18°C in mid September to about 12°C in late October. The literature generally describes the suitable range of water temperatures for migration and holding of Chinook salmon in the 10°–17°C (Myrick and Cech 2001; Bell 1986; McCullough et al. 1999, 2001). Chinook spawning and the start of egg incubation below Iron Gate dam occurs mostly from about mid October through November. During this time, reservoir release temperatures are gradually declining from about 15°C in mid October to about 10°C in late November. The literature generally describes the suitable range of water temperatures for spawning Chinook salmon as 10°–15°C and for egg incubation is 6°–12°C (USEPA 2001; USEPA 2003; Sullivan et al. 2000).

Klamath River Farther Downstream of Iron Gate Dam

As described above, Copco and Iron Gate reservoirs have a moderating effect on annual maximum water temperatures in the Klamath River just downstream of the Iron Gate dam, but the moderating effect mostly dissipates as flows in the Klamath River reach the Klamath River above the Shasta River (RM 177.5) (Figure 5.2-17). Continuing downstream, the annual maximum water temperatures are generally similar at Seiad Valley (RM 129) and at the Salmon River (RM 67) (Figure 5.2-17), indicating that the lower Klamath River is generally at or near equilibrium temperature throughout its length during summer meteorological conditions. This indicates that the moderated temperature releases from Iron Gate dam do not significantly influence or control water temperatures in the Lower Klamath River during summer months, compared to the influence on water temperatures of climatological conditions and downstream inflows from various tributary rivers (i.e., Shasta, Scott, Salmon, Trinity).

Figures 5.2-22, 5.2-23, 5.2-24, and 5.2-25 provide comparisons (for 2000 and 2001) of the annual time-series of water temperature (based on the 7-day average of maximum daily water temperature) to the California water temperature objective for four locations in the Klamath River downstream of the Iron Gate dam. The locations include the Klamath River just above the Scott River (RM 143.9; Figure 5.2-22), at Seiad Valley (RM 129.0; Figure 5.2-23), just above the Salmon River (RM 66.9; Figure 5.2-24), and at Turwar (RM 5.3; Figure 5.2-25).

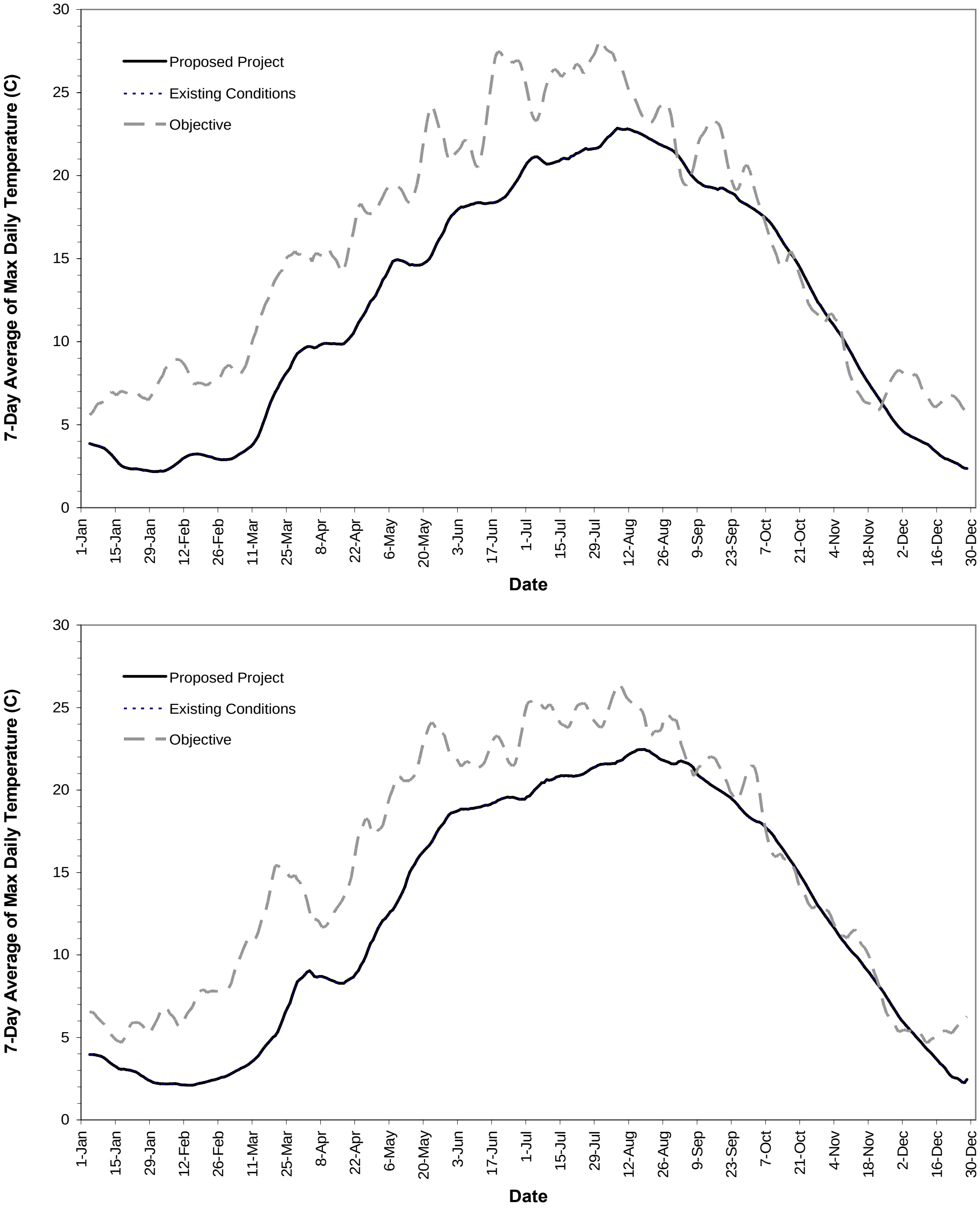


Figure 5.2-21. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Iron Gate dam (RM 190.5), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

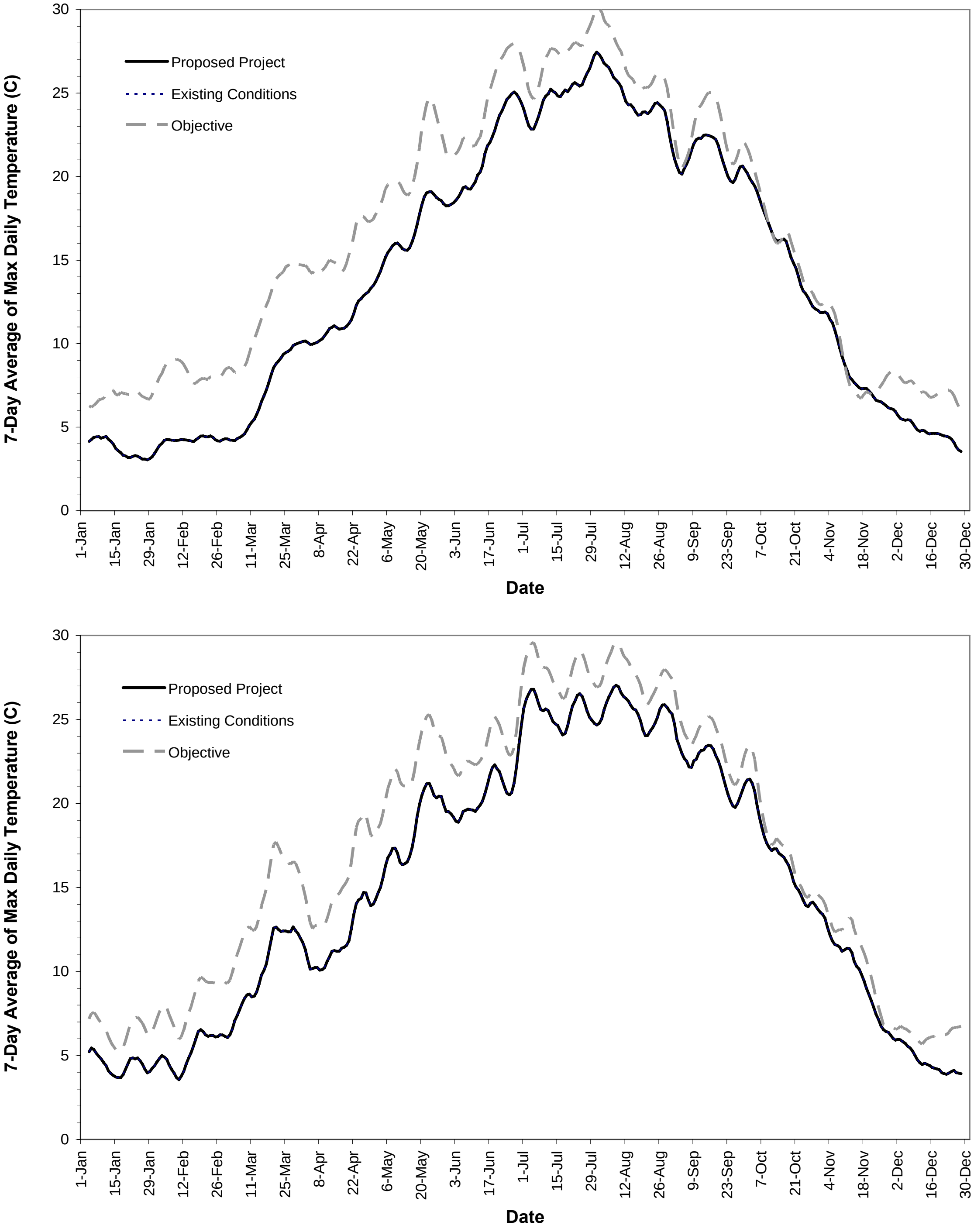


Figure 5.2-22. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at the Scott River (RM 144), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

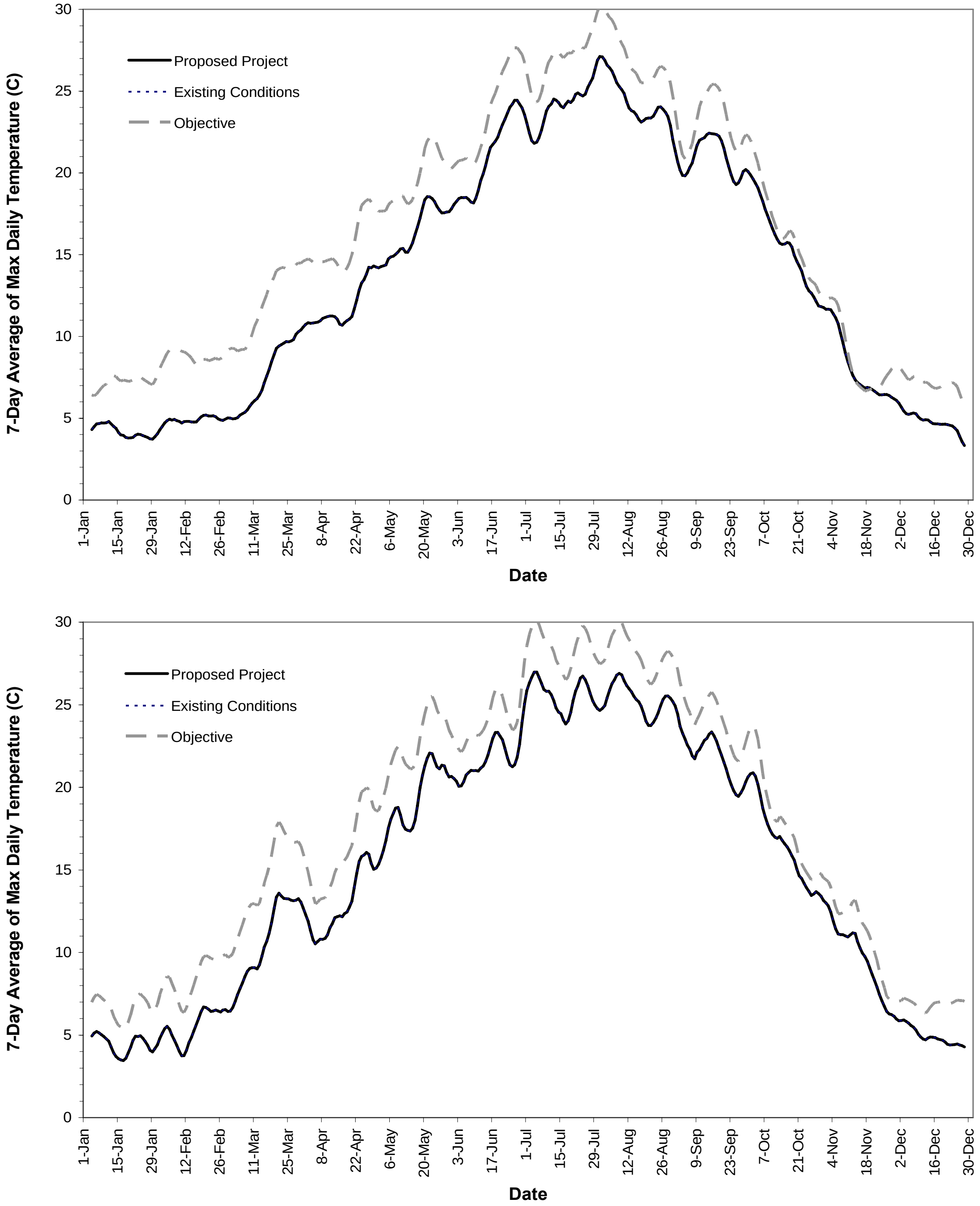
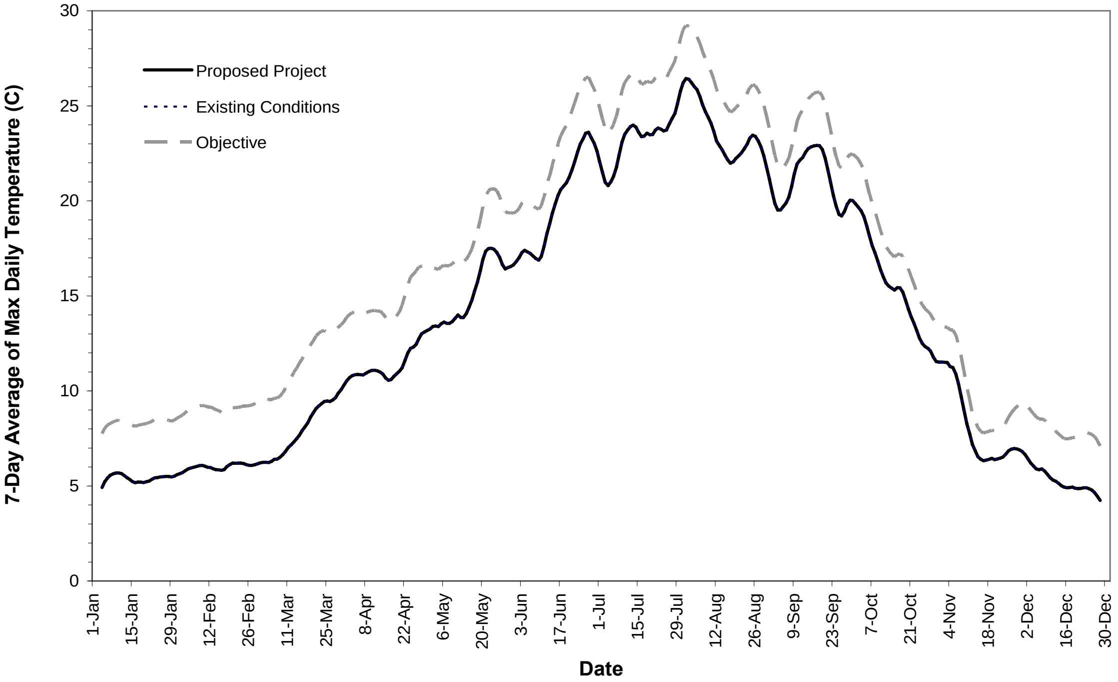


Figure 5.2-23. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Seiad Valley (RM 129), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).



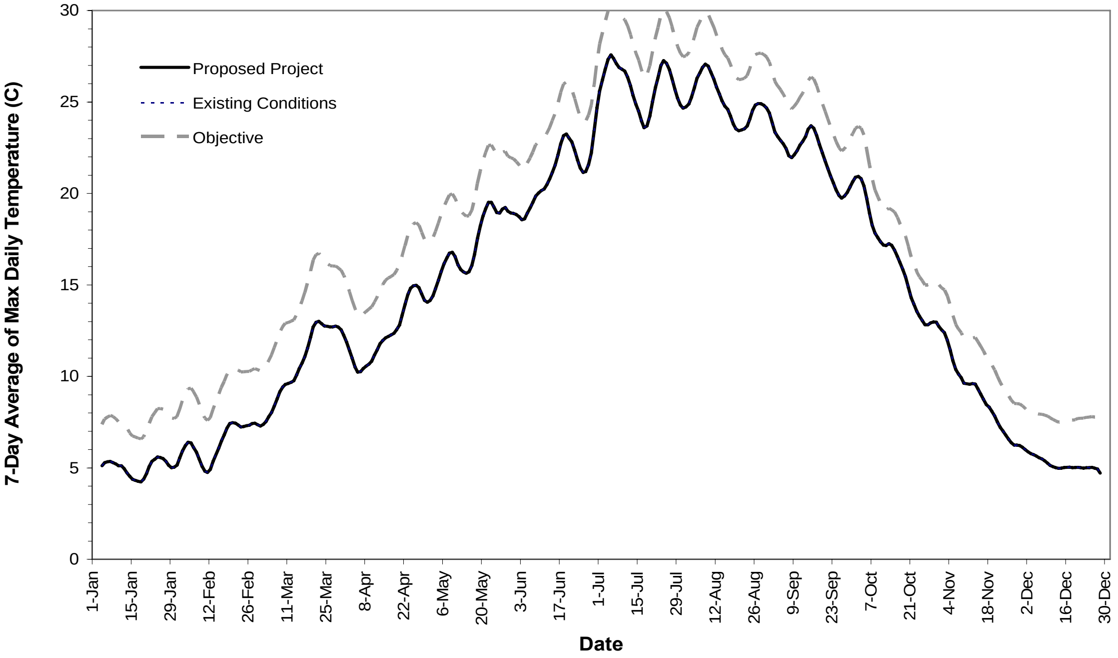


Figure 5.2-24. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at the Salmon River (RM 66.9), compared to the California Temperature objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

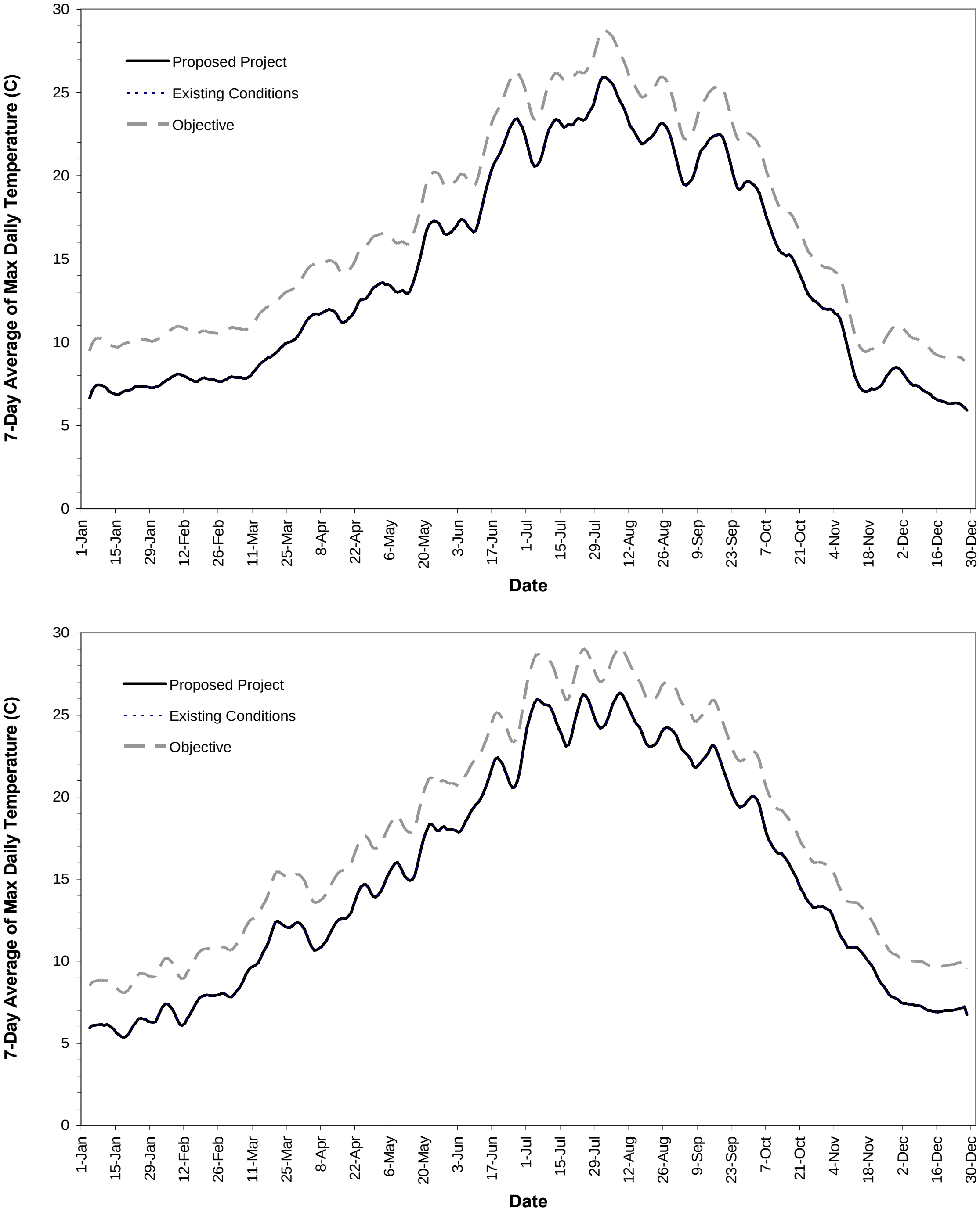


Figure 5.2-25. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Turwar (RM 5.3), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

For the Scott River and Seiad Valley locations (Figures 5.2-22 and 5.2-23), the comparisons indicate that the thermal regime meets the California water temperature objective nearly all the time in 2000 simulations and all times in 2001 simulation. In 2000 simulations, the objective is not met at the Scott River location specifically during two short periods in the fall: one in mid October, and another in mid November. During these periods, the temperature exceeded the objective by a minor amount (about 0.1 to 0.6°C). In 2000 simulations, the objective is not met at the Seiad Valley location during one period in mid November. During this period, the temperature exceeded the objective by a minor amount (about 0.1 to 0.2°C). As discussed, these infrequent and minor changes are not detrimental to anadromous fish species, since temperatures under current conditions are already within the optimal or suitable range for the anadromous fish that are using the area at that time. Thus, there is no adverse effect on beneficial uses.

For the Salmon River and Turwar locations (Figures 5.2-24 and 5.2-25), the comparisons indicate that the thermal regimes at these locations in the lower Klamath River meet the California water temperature objective at all times under existing (or proposed) conditions. Similar figures are provided in Appendix A for other model simulation years (i.e., 2002-2004); these other figures also indicate that the thermal regimes at these locations in the other simulation years also meet the California water temperature objective.

Effects of Water Temperature Conditions on Anadromous Fish Species Downstream of Iron Gate Dam

As described above, Copco and Iron Gate reservoirs create a thermal phase shift ("thermal lag") that causes Iron Gate dam release temperatures to be slightly warmer during fall than would theoretically occur in the absence of the reservoirs. This thermal phase shift is a common effect of reservoirs on river systems, due to the much larger thermal mass of a reservoir compared to a river. The thermal phase shift effect on releases from Iron Gate explains the occasional exceedance of the water temperature objective during fall, since the natural thermal potential upon which the objective is based does not include or account for the reservoir's phase shift effect. Because of the limited cold water pool at Iron Gate dam and the cool water demands on the Iron Gate Hatchery, there are limited controllable water quality factors to bring these temperature releases closer to modeled "natural" temperatures.

Assessment Methods. The potential effects of Iron Gate dam release temperatures on downstream uses by anadromous fish species were further evaluated to assess whether water temperature conditions are protective of uses by these species, specifically fall-run Chinook salmon, coho salmon, and steelhead/rainbow trout. Table 5.2-12 summarizes the average daily water temperature ranges generally used to define a suitable range for these species and life stages, a range of low-to-moderate stress, and a range of high stress/lethal effects for these species. Suitable conditions reflect a water temperature range behaviorally selected by a species within which growth and survival are high, and susceptibility to other stressors (e.g., disease) is reduced. Low to moderate stressful conditions reflect water temperatures where growth rates are reduced, behavioral avoidance may occur, and susceptibility to other stressors is increased. High stress/lethal temperatures result in severe physiological impairment, loss of equilibrium, and/or direct mortality (e.g., incipient lethal threshold LT10). The temperature ranges have been synthesized from information available in the scientific literature on the biological response of salmonid life-history stages to water temperature conditions including, but not limited to, McCullough (1999), Sullivan et al. (2000), McCullough et al. (2001), Myrick and Cech (2001), and USEPA (2003).

Table 5.2-12. Literature-based Ranges of Average Daily Water Temperature for Designation of Suitable and Stressful to Lethal Effects for Target Salmon Species in the Klamath River.

Species	Life-History Stage	Suitable	Low to Moderate Stress	High Stress
Chinook salmon	Adult migration, pre-spawning, spawning	<17	18-21	>21
	Egg to emergence	<12	13-14	>14
	Juvenile rearing and emigration	<15	16-23	>23
Coho salmon	Adult migration, pre-spawning, spawning	<17	18-21	>21
	Egg to emergence	<12	13-14	>14
	Juvenile rearing and emigration	<15	16-23	>23
Steelhead	Adult migration, pre-spawning, spawning	<17	18-21	>21
	Egg to emergence	<12	13-14	>14
	Juvenile rearing and emigration	<15	16-23	>23
	Steelhead smoltification	<12	13-18	>18

Note: The analysis for steelhead will be used as representative of habitat conditions for resident rainbow trout.

Three metrics were used for this analysis: annual exposure, degree-day exposure, and habitat suitability. These are the same metric previously used by Bartholow *et al.* (2005) to evaluate the effects on dam removal on water temperature conditions and habitat suitability for Chinook salmon in the Klamath River. Annual exposure equals the number of days during the year that water temperatures exceed the literature-based criteria for suitable habitat conditions (referred to as index of annual exposure). Degree-day exposure equals the sum of the differences between mean daily water temperatures above and below a range of “suitable” temperatures during the appropriate time periods and locations within the river. Habitat “suitability” equals the linear distance within a river reach that average daily water temperatures were within the range identified as suitable habitat conditions. Habitat suitability was also evaluated based on average weekly water temperatures at various locations downstream of Iron Gate dam (running average). These analyses were performed using the average daily water temperatures derived from modeling for 2000 and 2001 existing conditions and without-Project scenarios.

The seasonal distribution of the various salmonid life-history stages in the Klamath River assumed in the assessment are presented in Table 5.2-13. The seasonal periodicity assumptions reflect when various lifestages of a target species will occur in the river and when lifestage-specific water temperature criteria apply.

Assessment Results: Fall-run Chinook Salmon. Fall-run Chinook salmon utilize the Klamath River downstream of Iron Gate dam as an adult migration corridor, habitat for spawning and egg incubation, juvenile rearing, and as a juvenile emigration corridor. Although Chinook salmon respond to both high and low water temperatures, the primary focus of concern regarding hydroelectric facility operations on habitat suitability has been on seasonally elevated temperatures. As a result, the following analyses emphasize the occurrence of elevated water temperatures (e.g., seasonally low temperatures have been included within the thermal zone identified, for purposes of the analysis of suitable habitat conditions for a given lifestage of fall-run Chinook salmon and other salmonids).

Table 5.2-13. Estimated Fish Periodicity—Klamath River, updated to include stakeholder comments to PacifiCorp. Current and potential life history strategies from Iron Gate to Link River dams

Species/Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fall Chinook-Type II (fall juvenile migrant)												
Adult migration								■	■	■		
Adult spawning									░	■	░	
Incubation	■	■	■							■	■	■
Fry emergence		■	■	■								
Rearing		■	■	■	■	■	■	■				
Juvenile Outmigration									■	■	■	
Fall Chinook-Type I (ocean type)												
Adult migration								■	■	■		
Adult spawning									░	■	░	
Incubation	■	■	■							■	■	■
Fry emergence	■	■	■	■								
Rearing	■	■	■	■	■	░						
Juvenile Outmigration				■	■	■	■					
Coho												
Adult migration	■								░	■	■	■
Adult spawning	■										■	■
Incubation	■	■	■								■	■
Fry emergence		■	■	░								
Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Outmigration		■	■	■	■	■	■					
Steelhead-Fall/Winter												
Adult migration									■	■	■	
Adult spawning	■	■	■	■								■
Incubation	■	■	■	■								■
Fry emergence			■	■	■	■						
Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Outmigration			■	■	■	■	░					

Note: For anadromous juvenile emigration, timing reflects fish migration from Project area, not when they reach the estuary. Anadromous salmonid life histories represent stocks currently in the Klamath Basin from Iron Gate dam to Salmon River. Dark shading equals peak use period.

Adult fall-run Chinook salmon migrate upstream within the Klamath River during the seasonal period from August -- October (Table 5.2-13). Results of water temperature modeling show a general seasonal pattern with elevated temperatures occurring during August and declining during September and October. Results of the water temperature modeling showed a consistent pattern of diminishing differences in water temperatures between existing and hypothetical without Project conditions as a function of distance downstream from Iron Gate dam.

Results of the temperature modeling also show that during the fall migration period water temperatures under both existing and without Project conditions reach a thermal equilibrium where water temperatures are virtually identical under existing and without Project conditions in the lower reaches of the river below Seiad Valley. Hydroelectric operations at Iron Gate dam, therefore, have no affect on water temperature conditions in these reaches and would not affect water temperature conditions, thermal exposure, or behavioral response of adult fall-run Chinook salmon entering the Klamath River.

Water temperatures within the Klamath River show a consistent pattern of temperatures considered to be unsuitable for adult upstream migration throughout the entire reach from Iron Gate dam to Turwar during August under both existing and without Project conditions with temperatures decreasing seasonally during September into the range considered to be low to moderately stressful throughout the mainstem river (Table 5.2-14). Water temperatures generally decreased and remained within a range considered to be suitable for adult upstream migration beginning in early October and continuing through the end of the migration period. The seasonal pattern in water temperatures was generally similar between 2000 and 2001.

Results of the comparison of the average weekly temperatures (Table 5.2-15) showed temperatures above a 16°C average weekly average during approximately 75 to 80 percent of the days within the migration period. The frequency of these average weekly temperatures was similar at mainstem locations extending from Iron Gate dam downstream to Turwar. This pattern was similar under both existing and without Project conditions occurred based on analyses of average weekly temperature (Table 5.2-15).

The biological significance of the incremental temperature exposure in the reach just downstream of Iron Gate dam under existing conditions was evaluated to assess potential effects of temperature exposure to pre-spawning adults on subsequent egg viability and hatching success. An investigation of the relationship between temperature exposure for pre-spawning fall-run Chinook salmon and egg viability was conducted by Mann and Peery 2005. The observed relationship between pre-spawning adult temperature exposure, expressed as degree days above 18 and 20°C and corresponding estimates of percent mortality for incubating eggs from each female, show that the incremental increase in egg mortality over a range of pre-spawning adult temperature exposures is typically less than approximately 5 percent.

Assuming that a female adult Chinook salmon entered the Klamath River on September 15 and migrated upstream to spawn in the reach downstream of Iron Gate dam (equal duration of exposure to temperatures within each reach) the degree-day exposure to water temperatures above 18 and 20°C was estimated to be 14.5 and 59.2 degree-days, respectively under existing conditions and 13.2 and 46.4 degree days under hypothetical without Project conditions. Under these simulated conditions, temperature exposure under existing conditions would be similar to without Project conditions and would be expected to contribute to an incremental increase in egg mortality of less than 5 percent. Results of these analyses are consistent with observations for fall-run Chinook salmon spawned at the Iron Gate hatchery, which show high egg viability under existing project operational conditions (Kim Rushton, Iron Gate Hatchery Manager, CDFG).

Table 5.2-14. Habitat suitability based on average daily water temperatures for adult fall-run Chinook salmon migration at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date		**Iron Gate Dam**	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
		RM 190.5	**RM 177.5**	**RM 156.8**	**RM 143.9**	**RM 129.0**	**RM 99.0**	**RM 66.9**	**RM 57.6**	**RM 49.0**	**RM 43.3**	**RM 39.5**	**RM 15.9**	**RM 5.3**
8/15/2001	EC	21.9	23.1	23.8	23.8	23.7	23.5	23.5	23.5	23.1	22.9	22.6	22.6	22.8
	WOP	21.3	22.3	22.8	23.2	23.5	23.5	23.5	23.5	23.1	22.9	22.6	22.5	22.8
8/29/2001	EC	21.4	22.7	23.5	23.7	23.8	23.9	23.9	23.8	23.2	22.8	21.0	22.2	22.7
	WOP	19.6	21.2	23.0	23.6	23.9	23.8	23.9	23.7	23.2	22.9	21.1	22.2	22.7
9/12/2001	EC	20.4	20.3	19.8	19.7	20.0	20.1	20.0	19.9	19.6	19.4	18.9	19.1	19.4
	WOP	16.5	17.5	18.2	18.7	19.4	19.7	19.8	19.7	19.4	19.3	18.8	19.2	19.5
9/26/2001	EC	18.9	18.1	17.6	17.6	18.0	18.8	19.0	18.9	18.5	18.3	17.9	18.0	18.2
	WOP	14.3	15.0	15.8	16.2	17.3	18.4	18.8	18.8	18.5	18.5	18.0	18.1	18.2
10/10/2001	EC	17.2	16.4	15.3	14.9	14.5	14.9	15.2	15.2	15.0	14.9	14.9	14.8	14.8
	WOP	10.1	10.4	11.2	11.7	12.6	14.2	14.6	14.8	14.8	14.8	14.8	14.9	14.9
10/24/2001	EC	14.1	13.1	11.8	11.4	11.7	12.4	12.2	12.2	12.2	12.3	12.5	12.5	12.4
	WOP	7.2	8.0	9.1	9.7	10.6	11.8	11.7	11.8	12.0	12.1	12.5	12.5	12.4
11/7/2001	EC	11.0	10.3	9.5	9.4	9.5	9.6	9.3	9.6	9.9	10.0	10.5	10.5	10.4
	WOP	6.0	6.7	7.5	8.0	8.4	9.0	8.9	9.4	9.9	10.1	10.6	10.6	10.6
11/21/2001	EC	8.6	8.4	8.2	8.1	8.4	8.3	7.7	8.3	8.4	8.5	9.0	9.1	9.2
	WOP	6.5	6.6	7.1	7.3	7.9	7.9	7.3	8.1	8.2	8.3	9.0	9.1	9.2
12/5/2001	EC	5.5	5.2	5.1	4.9	5.0	5.4	5.4	5.8	6.1	6.4	6.9	7.0	7.1
	WOP	1.4	1.8	2.9	3.0	3.6	4.7	5.0	5.5	5.9	6.1	6.8	6.9	7.0
*12/19/2001	EC	3.1	2.9	3.3	3.3	4.1	4.7	4.7	5.5	5.7	5.9	6.7	6.8	6.7
	WOP	2.4	2.3	2.9	3.0	3.8	4.4	4.6	5.4	5.6	5.8	6.7	6.7	6.7

*Lifestage ends 12/15/2001, but for the sake of including the period from 12/19/2001 through the end of the lifestage, this date is also shown

🟩 suitable: <17°C	🟨 low to moderate stress: 17-21 °C	🟥 high stress: >21 °C

Table 5.2-15. Number of days during life stages that running average weekly temperature is above the threshold, based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Species/Life Stage	Life Stage Period			Temp. Threshold (C)	Number of Days Temperature Above Threshold							
					Blw Iron Gate Dam		At Seiad Valley		Abv Trinity River		At Turwar	
	Start	End	No. Days		EC	WOP	EC	WOP	EC	WOP	EC	WOP
Chinook Salmon												
Adult Migration	Aug 1	Oct 31	92	16	73	49	70	60	69	68	69	69
Egg to emergence	Oct 1	Mar 31	182	12	28	18	27	21	23	27	31	32
Juvenile Rearing	Feb 1	Jun 30	150	15	45	55	58	64	49	50	46	48
Juvenile Emigration	Apr 1	Jul 31	122	15	76	86	89	93	80	81	77	79
Coho Salmon												
Adult Migration	Sep 15	Jan 31	139	16	28	11	25	17	24	23	24	24
Egg to emergence	Nov 1	Apr 15	166	12	0	8	0	11	0	11	9	12
Juvenile Rearing	Jan 1	Dec 31	365	15	157	147	166	165	157	153	154	155
Juvenile Emigration	Feb 1	Jul 31	181	15	76	86	89	95	80	81	77	79
Steelhead												
Adult Migration	Sep 1	Nov 30	91	16	42	18	39	29	38	37	38	38
Egg to emergence	Dec 1	Jun 30	212	12	55	74	59	77	66	81	78	84
Juvenile Rearing	Jan 1	Dec 31	365	15	157	147	166	165	157	153	154	155
Smoltification	Mar 1	Jul 15	137	12	70	89	92	100	92	96	93	94

Fall-run Chinook salmon egg incubation occurs between October and March (Table 5.2-13). Water temperatures show a typical seasonally declining trend during the early portion of egg incubation followed by a seasonal increase in water temperatures during the later period of incubation prior to fry emergence in the spring. Examination of the average weekly temperatures during the egg incubation period (Table 5.2-15) showed a similar pattern with approximately 21 percent of the observations exceeding 10°C within the reach immediately downstream of Iron Gate dam, 20 percent within reach upstream of Shasta River, 25 percent upstream of the Scott River, and 28 percent upstream of Clear Creek under existing project operations. Under the without Project conditions average weekly water temperatures exceeded 10°C in 17 percent of the observations within the reach immediately downstream of Iron Gate dam, 18 percent within reach upstream of Shasta River, 20 percent upstream of the Scott River, and 24 percent upstream of Clear Creek.

Table 5.2-16 presents a comparison of habitat suitability conditions for egg incubation under existing and without Project conditions assuming temperature suitability criteria presented in Table 5.2-12. Results of these comparisons show a consistent pattern of exposure to elevated water temperatures under both existing and without Project conditions in early October. Water temperature exposure under existing project operations, although declining seasonally, are within the range during early October that would contribute to reduced egg viability. The significance of egg exposure to elevated temperatures during early October under existing project operations is reduced, in part, as a result of fewer salmon spawning during the early portion of the spawning period. The peak of Chinook salmon spawning occurs during the latter portion of October when seasonally declining water temperatures have less effect on the viability and successful hatching of incubating eggs.

Habitat conditions for egg incubation in the reach downstream of Iron Gate dam potentially could be improved if water temperatures released from the dam during early to mid-October could be reduced under existing conditions. Reducing early to mid-October water temperatures would be expected to improve potential egg viability for those adult Chinook salmon spawning early while continuing to provide water temperatures during the late fall that would be warmer when compared to hypothetical without Project conditions. Continuing to provide warmer water temperatures under existing conditions that are suitable for egg incubation would accelerate embryonic development and early fry emergence.

As a result of this analysis, PacifiCorp evaluated the potential of selective withdrawal of reservoir hypolimnetic water to cool releases from Iron Gate reservoir during the fall Chinook spawning and incubation period. The use of selective withdrawal from Copco and Iron Gate reservoirs has been previously evaluated by PacifiCorp, and it has been previously concluded that selective withdrawal would have modest, if any, thermal benefits to the river downstream owing to the limited cool water volume in the reservoirs (PacifiCorp 2005a, 2005b). Subsequently, for purposes of this 401 evaluation, PacifiCorp conducted additional evaluation of selective withdrawal specifically focused on the fall run Chinook spawning and egg incubation period. This additional evaluation is described below in Proposed Avoidance and Mitigation Measures (Iron Gate Reservoir).

Juvenile Chinook salmon (ocean type migrants) rearing and emigration occurs between February and July (Table 5.2-13). Results of water temperature modeling during the juvenile rearing period has shown that water temperatures are lower under existing conditions when compared to hypothetical without Project conditions in the reach immediately downstream of Iron Gate dam. Temperature modeling has shown that differences in water temperature between existing and without Project conditions diminish as a function of distance downstream from the dam as water temperatures reach thermal equilibrium within the river.

Table 5.2-16. Habitat suitability based on average daily water temperatures for fall-run Chinook salmon egg incubation at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

		Iron Gate Dam	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
Date		**RM 190.5**	**RM 177.5**	**RM 156.8**	**RM 143.9**	**RM 129.0**	**RM 99.0**	**RM 66.9**	**RM 57.6**	**RM 49.0**	**RM 43.3**	**RM 39.5**	**RM 15.9**	**RM 5.3**
10/1/2000	EC	18.0	18.6	19.1	19.3	19.6	19.7	19.8	19.7	19.4	19.3	18.8	19.0	19.2
	WOP	16.6	17.7	18.4	18.6	19.0	19.5	19.6	19.6	19.3	19.2	18.7	18.9	19.2
10/15/2000	EC	15.5	15.2	15.0	15.0	15.0	14.9	14.7	14.6	14.5	14.4	14.4	14.5	14.6
	WOP	11.2	11.7	12.3	12.5	12.9	13.3	13.3	13.4	13.5	13.6	13.8	14.1	14.2
10/29/2000	EC	11.9	11.3	10.8	10.6	10.6	11.0	11.1	11.0	11.1	11.1	11.3	11.3	11.4
	WOP	6.8	7.4	8.4	8.8	9.3	10.0	10.1	10.3	10.4	10.5	10.9	11.2	11.3
11/12/2000	EC	8.8	8.0	7.5	7.0	6.5	6.1	6.0	5.9	6.3	6.4	7.0	7.1	7.1
	WOP	2.6	2.7	3.6	3.7	3.9	4.4	4.9	5.2	5.6	5.9	6.7	6.9	6.9
11/26/2000	EC	5.5	5.3	5.1	5.0	5.3	5.7	6.0	6.4	6.7	6.8	7.1	7.4	7.5
	WOP	2.5	2.3	2.8	2.9	3.6	4.4	5.1	5.5	5.9	6.1	6.5	7.0	7.1
12/10/2000	EC	3.9	4.1	4.5	4.7	5.1	5.5	5.6	6.0	6.3	6.5	7.1	7.3	7.3
	WOP	4.2	4.3	4.4	4.6	5.0	5.5	5.7	6.1	6.4	6.6	7.2	7.4	7.4
12/24/2000	EC	2.4	2.6	3.1	3.3	3.9	4.8	5.1	5.4	5.5	5.6	6.1	6.1	6.1
	WOP	3.0	3.3	3.7	3.9	4.5	5.0	5.2	5.5	5.6	5.6	6.1	6.1	6.1
1/7/2001	EC	3.9	4.2	4.5	4.5	4.4	4.6	4.6	4.7	4.9	5.1	5.3	5.5	5.5
	WOP	3.3	3.9	4.3	4.3	4.3	4.5	4.5	4.6	4.9	5.1	5.3	5.5	5.5
*1/21/2001	EC	3.0	3.8	4.1	4.0	4.0	3.9	4.1	4.1	4.4	4.6	4.9	5.1	5.1
	WOP	3.3	3.5	3.9	3.9	3.7	3.2	3.4	3.5	3.8	4.0	4.5	4.7	4.8

*Lifestage ends 1/15/2001, but for the sake of including the period from 1/7/2001 through the end of the lifestage, this date is also shown.

🟩 suitable: <12°C	🟨 low to moderate stress: 13-14°C	🟥 high stress: >14°C

For example, for juvenile rearing, the running average weekly temperatures exceeded temperature criterion on 45 days (30 percent) under existing conditions within the Iron Gate dam reach when compared with 55 occurrences (37 percent) under hypothetical without Project conditions. In contrast, there was no difference in the frequency of exceeding the temperature criterion between existing and without Project conditions in the lower reaches of the river upstream of the confluence with the Trinity River or at Turwar (Table 5.2-15).

Table 5.2-17 presents a comparison of habitat suitability at various locations within the river for juvenile rearing and emigration based on temperature criteria presented in Table 5.2-12. Results of these analyses show that water temperature conditions under both existing and without Project conditions are within the range considered to be suitable for juvenile rearing and emigration throughout the river through approximately late April. Beginning in May and continuing through June water temperatures throughout the river under both existing and without Project conditions were within the range considered to reflect low to moderate stress. Temperature conditions, particularly within the lower reaches of the river in July were within the range characterized by high stress/lethal under both existing and without Project conditions.

Exposure of juvenile Chinook salmon to seasonally reduced water temperatures under existing project operations, primarily within the Iron Gate dam reach, would be expected to benefit the overall health and condition of juvenile rearing salmon. Exposure to reduced water temperatures within the Iron Gate dam reach during the spring and early summer juvenile rearing period would contribute to reduced vulnerability of juveniles to disease and infection. Operation of Iron Gate dam also serves to substantially reduce daily variation in water temperatures during the spring and early summer, which would contribute to a reduction in variation in metabolic demands on rearing juveniles and improve growth, when compared to more highly variable temperature conditions that would occur under without Project conditions.

Although exposure of juvenile salmon to seasonally reduced water temperatures during the spring and early summer rearing period offers benefits in terms of a reduced risk of disease and infection, it was also determined that exposure to lower water temperatures under existing project operations would not result in reduced juvenile growth rates. Results of studies by Marine and Cech (2004) show that juvenile Chinook salmon growth rates are virtually identical over a temperature range from 13-16°C and 17-20°C reflecting the general range of seasonal temperatures expected to occur during the juvenile rearing period under existing conditions in the reach downstream of Iron Gate dam. Results of these growth studies show no evidence that lower spring and early summer water temperatures under existing project operations would adversely impact juvenile salmon growth rates.

Based on results of these analyses it is concluded that habitat conditions within the reach downstream of Iron Gate dam provide better rearing conditions for juvenile fall-run Chinook salmon when compared to water temperature conditions occurring under hypothetical without Project conditions. As a result of thermal warming within the river, the benefits of project operations on juvenile rearing habitat diminish with distance downstream of the dam. Within the lower reaches of the river, project operations have no effect on water temperature conditions affecting habitat suitability for juvenile rearing period.

PacifiCorp's conclusions with regard to Project-related water temperature effects on fall-run Chinook salmon are supported by other recent independent analyses. In an analysis of the effects on fall Chinook of hypothetical temperature conditions with and without Project dams and reservoirs, Bartholow et al. (2005) concluded that water temperature conditions for juvenile rearing life stages are better with Project dams and reservoirs than without, especially immediately below Iron Gate dam. In a subsequent analysis of factors limiting fall Chinook production potential, Bartholow and Henriksen (2006) concluded that water temperature during spawning and egg incubation is not a significant factor affecting fall Chinook freshwater production in the Klamath River.

Table 5.2-17. Habitat suitability based on average daily water temperatures for juvenile fall-run Chinook salmon rearing at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

		Iron Gate Dam	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
Date		**RM 190.5**	**RM 177.5**	**RM 156.8**	**RM 143.9**	**RM 129.0**	**RM 99.0**	**RM 66.9**	**RM 57.6**	**RM 49.0**	**RM 43.3**	**RM 39.5**	**RM 15.9**	**RM 5.3**
2/1/2001	EC	2.1	2.3	2.6	2.6	2.9	3.3	3.8	4.1	4.5	4.7	5.1	5.3	5.4
	WOP	2.1	1.9	2.1	2.2	2.5	3.2	3.8	4.0	4.4	4.6	5.0	5.3	5.3
2/15/2001	EC	2.1	2.5	3.1	3.3	3.7	4.2	4.6	4.8	5.1	5.3	5.5	5.9	6.0
	WOP	3.3	3.4	3.6	3.6	3.9	4.2	4.6	4.7	5.0	5.2	5.5	5.9	6.0
3/1/2001	EC	2.6	3.1	4.3	4.7	5.5	6.5	7.0	7.1	7.2	7.3	7.1	7.4	7.5
	WOP	4.5	5.0	5.7	6.0	6.4	7.1	7.5	7.4	7.5	7.6	7.2	7.4	7.5
3/15/2001	EC	4.1	4.8	6.2	6.8	8.0	9.0	9.3	9.3	9.2	9.2	8.9	9.2	9.3
	WOP	7.5	8.0	8.8	9.1	9.7	10.0	9.9	9.8	9.6	9.6	9.1	9.4	9.5
3/29/2001	EC	7.3	8.9	10.7	11.6	12.7	12.5	12.1	12.0	11.8	11.7	11.7	11.6	11.7
	WOP	12.1	12.7	13.0	13.0	13.4	12.9	12.5	12.3	12.1	12.0	11.8	11.7	11.8
4/12/2001	EC	7.9	8.6	9.0	9.3	9.8	10.5	10.6	10.6	10.6	10.6	10.4	10.6	10.8
	WOP	7.7	8.4	9.1	9.4	9.9	10.3	10.5	10.5	10.4	10.4	10.3	10.5	10.6
4/26/2001	EC	9.1	11.0	13.4	14.6	16.0	15.8	15.6	15.6	15.2	15.0	14.7	14.8	15.0
	WOP	17.1	17.5	18.1	18.2	18.5	17.4	16.6	16.2	15.7	15.5	15.0	14.9	15.0
5/10/2001	EC	12.4	13.8	15.4	15.9	17.1	16.2	15.8	16.0	15.4	15.2	14.9	14.8	15.0
	WOP	16.2	17.3	18.0	18.3	18.7	17.5	16.4	16.4	15.6	15.3	14.9	14.8	15.0
5/24/2001	EC	16.3	17.7	19.2	19.8	20.4	19.2	18.5	18.9	17.8	17.6	17.3	17.0	17.3
	WOP	21.2	21.6	22.0	21.8	21.7	19.6	18.8	19.1	18.1	17.7	17.4	17.1	17.4
6/7/2001	EC	18.2	18.8	19.2	19.2	19.4	18.7	18.4	18.4	17.8	17.6	17.3	17.2	17.4
	WOP	17.3	17.5	17.7	17.8	18.1	17.7	17.6	17.8	17.3	17.1	17.0	16.9	17.1
6/21/2001	EC	18.5	20.0	21.4	22.0	22.5	22.8	23.1	22.9	22.3	22.0	21.2	21.3	21.7
	WOP	20.5	21.4	22.2	22.5	22.8	22.7	22.9	22.8	22.1	21.9	21.1	21.2	21.5
*7/5/2001	EC	19.0	22.1	24.6	25.3	25.7	25.9	26.3	26.0	25.1	24.8	24.0	24.1	24.5
	WOP	23.0	24.6	25.5	25.8	26.0	26.1	26.3	26.0	25.2	24.9	24.1	24.2	24.6

*Lifestage ends 7/01/2001, but for the sake of including the period from 7/05/2001 through the end of the lifestage, this date is also shown

🟩 suitable: <15°C	🟨 low to moderate stress: 16-23 °C	🟪 high stress: >23 °C

In the recent EPAct trial-type proceeding, the presiding administrative judge (ALJ) ruled, based on the testimony of agency fisheries experts, that existing temperatures conditions will not preclude successful fall Chinook spawning and egg incubation. The ALJ concluded that the fall Chinook spawning period (early September through late October) coincides with declining river temperatures in the suitable range, which by early November are within the optimal range for the developing embryos (i.e., 4-12°C) (see Findings of Fact 2A-27 and 2A.6 in McKenna 2007).

In a similar situation to the Klamath River, Geist et al. (2006) conducted research on water temperature effects on fall Chinook salmon spawning in the Snake River downstream of Hells Canyon dam. The key objective of the research by Geist et al. (2006) was to determine whether various temperature exposures from 13°C to 17°C during the first 40 days of spawning egg incubation followed by declining temperature of approximately 0.28°C per day (to mimic the thermal regime of the Snake River) affected survival, development, and growth of fall Chinook salmon embryos, alevins, and fry. Geist et al. (2006) determined that there were no significant differences in embryo survival at initial temperature exposures up to 16.5°C. Geist et al. (2006) further determined that there were no significant differences in alevin and fry size at hatch and emergence across the range of initial temperature exposures. On the basis of their research, Geist et al. (2006) concluded that an exemption to the state water quality standards for temperature was warranted for the portions of the Snake River where fall Chinook salmon spawning occurs.

Assessment Results: Coho Salmon. Coho salmon utilize the mainstem Klamath River primarily as a migration corridor for the upstream movement of adults and downstream movement of juveniles. Coho primarily spawn within tributaries to the river where egg incubation and juvenile rearing occurs. Although spawning, egg incubation, and a substantial portion of juvenile rearing occurs within the tributaries that are not affected by existing Project operations, this analysis assumed all life stages of coho inhabit the Klamath River.

Coho, like Chinook salmon, are sensitive to seasonal water temperature conditions that affect quality and availability of habitat for various lifestages, growth and survival, behavior, vulnerability to disease, and other biological responses. Although the seasonal time periods of occurrence of coho vary from those described for Chinook salmon temperature criteria used in this analysis are similar for the two species (Table 5.2-12).

Adult coho salmon upstream migration within the Klamath River occurs from approximately mid-September through January (Table 5.2-13). Results of temperature analyses show that water temperatures are declining during the fall and winter coho adult migration period. As a result of the seasonally declining temperature conditions, habitat is generally suitable throughout the river under both existing conditions and hypothetical without Project conditions beginning in approximately October and extending through January (Table 5.2-18). In general, there is very little difference in the suitability of river temperature conditions for adult coho migration under existing and without Project conditions (Table 5.2-18). Overall habitat suitability for adult coho migration within the mainstem river, particularly conditions affecting attraction and entry into the river during upstream migration, is independent of Project operations.

Coho salmon egg incubation occurs from November through April (Table 5.2-13). Water temperature conditions during the winter and early spring are naturally low and are generally within the range considered to be suitable for coho egg incubation. Habitat suitability criteria (Table 5.2-19) consistently show that water temperatures are typically within the range considered to be suitable for coho egg incubation. A comparison of water temperature conditions within the Iron Gate reach show the frequency of occurrence of elevated water temperatures during the coho egg incubation period is less under existing project operations when compared to hypothetical without Project conditions (Table 5.2-15).

Juvenile coho salmon rear within freshwater rivers and tributaries throughout the year (Table 5.2-13). Project operations result in cooler water temperatures during the spring and early summer months within the reach immediately downstream of Iron Gate dam under existing operations when compared to without project conditions. Lower water temperatures during the spring and early summer months within the Iron Gate reach under existing project operations would improve opportunities and conditions for juvenile coho rearing and emigration. During the spring and summer months, water temperatures increase within the river, and differences in water temperature conditions between existing conditions and hypothetical without Project conditions become less as a function of distance downstream from the dam (Table 5.2-20). During the mid-summer water temperatures, particularly in the lower reaches of the river, may reach levels under both existing and without Project conditions that are considered to be highly stressful for juvenile coho rearing (Table 5.2-20).

Juvenile coho emigration using the mainstem Klamath River as a migratory corridor occurs during the period from February through July (Table 5.2-13). Water temperature conditions throughout the Klamath River are within the range considered to be suitable for juvenile coho salmon emigration during the period from February through approximately mid-May (Table 5.2-20). Water temperatures during the spring and early summer months are colder within the reach immediately downstream of Iron Gate dam under existing Project operations. However, temperatures within the lower reaches of the river that serve as the migratory corridor for coho salmon are not affected by Project operations.

The NMFS (2007) BiOp for the Project addressed the effects of the Project on coho salmon regarding water temperature. The NMFS (2007) BiOp concludes that water temperatures conditions in the lower Klamath River from about the Clear Creek confluence (RM 99) upstream to Iron Gate dam (RM 190) can be stressful for juvenile coho salmon rearing during summer. However, the NMFS (2007) BiOp suggests that these conditions occur from ambient conditions and not from release temperature from Iron Gate dam. For example, the NMFS (2007) BiOp states that “water temperatures increase rapidly to a daily maximum in excess of 26°C within the first 15 miles of river as cooler Iron Gate Dam releases enter the shallow Klarnath River and are heated by hot ambient air temperatures”. The NMFS (2007) BiOp further indicates that maximum water temperatures can approach 30°C within the reach between Seiad Valley (about RM 129) and Clear Creek (RM 99) largely due to the continued influence of warm air temperatures and constant exposure to solar heating, as well as diminished tributary accretion from the Scott River, Shasta River, and other large tributaries.

To survive these conditions, the NMFS (2007) BiOp suggests that juvenile coho salmon likely utilize thermal refugia during the day and opportunistically forage on abundant food within the mainstem at night. The NMFS (2007) BiOp points out that Karuk Tribal biologists have documented large numbers of juvenile coho salmon rearing throughout the summer within mainstem refugial sites between Iron Gate Dam and Seiad Valley where water temperatures and velocities are low and aquatic cover is plentiful (Soto 2007). Further downriver, particularly below the Trinity River confluence (about RM 43), the NMFS (2007) BiOp concludes that water temperatures conditions support high migration and rearing survival of outmigrating coho salmon smolts.

The NMFS (2007) BiOp also concludes that water temperatures conditions in the lower Klamath River likely do not affect migrating adult coho salmon. The NMFS (2007) BiOp indicates that lower Klamath River water temperatures are largely below the upper threshold of 22^{o}C by mid-September, which coincides with the start of the adult coho salmon migration, and that water temperatures are typically below 17^{o}C when coho salmon migration peaks between late October and mid-November.

Table 5.2-18. Habitat suitability based on average daily water temperatures for adult coho salmon migration at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

		Irongate Dam	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
Date	**Scenario**	**RM 190.54**	**RM 177.52**	**RM 156.79**	**RM 143.86**	**RM 129.04**	**RM 99.04**	**RM 66.91**	**RM 57.58**	**RM 49.03**	**RM 43.33**	**RM 39.5**	**RM 15.95**	**RM 5.28**
9/15/2000	EC	19.2	19.3	19.7	20.1	20.3	20.3	20.5	20.5	20.2	20.2	20.0	20.0	20.1
	WOP	18.3	19.1	20.1	20.3	20.4	20.3	20.5	20.4	20.2	20.1	19.9	19.9	20.1
9/29/2000	EC	18.1	18.4	18.5	18.6	18.7	18.3	18.1	18.1	17.9	17.8	17.5	17.7	17.8
	WOP	16.1	17.0	17.6	17.9	18.1	17.9	17.8	17.9	17.7	17.6	17.4	17.6	17.8
10/13/2000	EC	15.9	15.7	15.1	14.8	14.6	14.3	14.1	14.1	14.1	14.1	14.1	14.2	14.3
	WOP	10.6	10.8	10.9	11.0	11.5	12.4	13.0	13.3	13.4	13.5	13.8	14.1	14.2
10/27/2000	EC	12.6	12.3	11.9	11.8	11.6	11.4	11.7	11.8	11.9	11.9	12.0	12.0	12.0
	WOP	8.5	9.0	9.3	9.3	9.8	10.7	11.1	11.1	11.1	11.2	11.5	11.6	11.6
11/10/2000	EC	9.3	8.6	7.9	7.7	7.6	7.6	7.8	7.9	8.1	8.2	8.7	8.8	8.8
	WOP	3.9	4.1	4.8	5.1	5.7	6.4	6.9	7.2	7.5	7.7	8.3	8.5	8.5
11/24/2000	EC	6.0	5.7	5.6	5.5	5.8	5.9	5.9	6.1	6.4	6.5	6.9	7.0	6.9
	WOP	3.8	3.6	3.8	3.6	4.0	4.9	5.5	6.0	6.4	6.6	7.3	7.5	7.5
12/8/2000	EC	4.1	4.1	4.3	4.3	4.5	4.8	4.9	5.2	5.6	5.8	6.5	6.6	6.6
	WOP	3.3	3.4	3.9	3.9	4.3	4.6	4.9	5.2	5.6	5.8	6.5	6.6	6.6
12/22/2000	EC	2.9	3.8	4.6	4.7	4.7	4.4	4.5	4.8	5.1	5.3	5.7	5.8	5.9
	WOP	3.8	4.3	4.8	4.8	4.7	4.3	4.3	4.7	5.0	5.1	5.6	5.8	5.9
1/5/2001	EC	3.9	4.1	4.3	4.4	4.3	4.3	4.4	4.4	4.7	4.9	5.2	5.4	5.4
	WOP	3.6	3.8	4.0	4.0	4.2	4.3	4.1	4.2	4.5	4.7	5.1	5.4	5.4
1/19/2001	EC	2.8	3.1	3.1	2.9	3.1	3.1	3.2	3.3	3.8	3.9	4.3	4.5	4.6
	WOP	1.7	1.4	1.5	1.5	1.6	2.0	2.6	2.9	3.4	3.6	4.1	4.4	4.4
2/2/2001	EC	2.1	3.0	3.7	3.7	3.9	4.2	4.4	4.6	4.9	5.1	5.5	5.7	5.8
	WOP	3.7	3.7	3.7	3.5	3.7	3.9	4.3	4.5	4.8	4.9	5.4	5.6	5.7

*Lifestage ends 1/31/2001, but for the sake of including the period from 2/2/2001 through the end of the lifestage, this date is also shown.

suitable: <17°C	low to moderate stress: 18-21 °C

Table 5.2-19. Habitat suitability based on average daily water temperatures for coho salmon egg incubation at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	Scenario	Iron Gate Dam RM 190.54	Above Shasta River RM 177.52	At Walker Bridge RM 156.79	Above Scott River RM 143.86	At Seiad Valley RM 129.04	Above Clear Creek RM 99.04	Above Salmon River RM 66.91	At Orleans RM 57.58	Above Bluff Creek RM 49.03	Above Trinity River RM 43.33	At Martins Ferry RM 39.5	At Blue Creek RM 15.95	At Turwar RM 5.28
11/1/2000	EC	11.4	11.0	10.8	10.7	10.5	10.3	9.9	10.0	10.1	10.2	10.6	10.7	10.7
	WOP	6.8	7.2	8.0	8.2	8.3	8.5	9.0	9.2	9.4	9.5	10.1	10.3	10.4
11/15/2000	EC	8.0	7.4	7.0	6.6	6.5	5.8	5.4	5.5	5.7	5.9	6.3	6.3	6.2
	WOP	2.5	2.5	3.1	3.0	3.4	3.8	3.9	4.2	4.7	5.0	5.7	5.8	5.8
11/29/2000	EC	4.4	5.2	5.9	6.0	6.1	6.6	6.7	7.2	7.3	7.5	8.0	8.1	8.2
	WOP	5.3	5.7	5.8	5.9	5.8	6.0	6.1	6.7	6.9	7.1	7.7	7.9	8.0
12/13/2000	EC	3.6	3.5	3.6	3.5	3.5	3.8	4.0	4.5	4.9	5.2	5.9	6.1	6.2
	WOP	2.3	2.2	2.4	2.2	2.6	3.6	4.1	4.6	5.0	5.2	5.9	6.2	6.2
12/27/2000	EC	2.3	2.3	2.5	2.6	2.8	3.2	3.6	4.1	4.4	4.7	5.3	5.5	5.5
	WOP	1.7	1.8	2.1	2.2	2.5	3.2	3.8	4.2	4.6	4.8	5.4	5.6	5.7
1/10/2001	EC	3.7	3.3	3.3	3.2	3.6	4.2	4.8	4.9	5.2	5.3	5.6	5.6	5.6
	WOP	1.8	2.0	2.6	2.8	3.2	4.0	4.7	4.9	5.1	5.2	5.6	5.7	5.7
1/24/2001	EC	2.7	2.9	3.9	4.3	5.1	5.3	5.5	5.7	5.9	6.0	6.2	6.3	6.3
	WOP	3.6	3.8	4.7	4.9	5.4	5.5	5.4	5.6	5.7	5.8	6.1	6.1	6.1
2/7/2001	EC	2.1	1.8	2.0	2.1	3.0	4.7	5.4	5.6	5.8	6.0	6.1	6.5	6.6
	WOP	1.6	1.9	3.0	3.6	4.5	5.7	6.2	6.2	6.5	6.6	6.5	7.0	7.1
2/21/2001	EC	2.3	3.8	5.5	6.0	6.7	6.9	7.1	7.2	7.3	7.4	7.4	7.6	7.7
	WOP	5.2	5.8	6.4	6.7	7.2	7.3	7.4	7.5	7.5	7.6	7.5	7.7	7.8
3/7/2001	EC	3.1	4.7	6.6	7.3	8.1	8.6	8.6	8.6	8.6	8.5	8.4	8.5	8.5
	WOP	9.0	9.1	9.2	9.2	9.3	8.8	8.5	8.5	8.5	8.4	8.4	8.3	8.3
3/21/2001	EC	5.0	7.2	9.1	9.9	11.4	11.9	12.2	12.1	11.8	11.7	11.3	11.4	11.6
	WOP	13.1	13.4	13.8	14.0	14.2	13.6	13.2	12.8	12.4	12.3	11.6	11.6	11.7
4/4/2001	EC	8.5	8.7	8.7	8.7	9.0	9.0	9.3	9.4	9.5	9.5	9.5	9.7	9.8
	WOP	6.5	6.9	7.3	7.5	8.2	9.0	9.7	9.7	9.8	9.9	9.7	10.0	10.1
4/18/2001	EC	7.9	8.1	9.3	9.9	11.1	11.9	12.2	12.3	12.2	12.1	12.0	12.2	12.3
	WOP	10.3	10.6	11.2	11.5	12.3	12.7	12.6	12.6	12.4	12.3	12.1	12.2	12.3
5/2/2001	EC	11.3	11.5	11.4	11.5	12.5	12.9	12.9	13.1	12.8	12.7	12.7	12.6	12.7
	WOP	9.9	10.9	12.0	12.5	13.3	13.3	13.0	13.2	12.9	12.8	12.7	12.7	12.7

*Lifestage ends 4/30/2001, but for the sake of including the period from 5/2/2001 through the end of the lifestage, this date is also shown.

suitable: <12°C | low to moderate stress: 13-14 °C | high stress: >14 °C

Table 5.2-20. Habitat suitability based on average daily water temperatures for juvenile coho salmon rearing at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	Scenario	Iron Gate Dam RM 190.54	Above Shasta River RM 177.52	At Walker Bridge RM 156.79	Above Scott River RM 143.86	At Seiad Valley RM 129.04	Above Clear Creek RM 99.04	Above Salmon River RM 66.91	At Orleans RM 57.58	Above Bluff Creek RM 49.03	Above Trinity River RM 43.33	At Martins Ferry RM 39.5	At Blue Creek RM 15.95	At Turwar RM 5.28
1/1/2001	EC	4.0	4.1	3.8	3.9	4.0	4.1	4.1	4.2	4.5	4.5	4.9	4.8	4.6
	WOP	2.2	3.0	3.8	3.9	4.1	4.1	4.1	4.2	4.4	4.5	4.9	4.7	4.4
1/15/2001	EC	3.1	2.8	2.7	2.6	2.9	3.6	4.0	4.3	4.6	4.8	5.4	5.5	5.5
	WOP	1.0	1.1	1.6	1.7	2.5	3.4	3.7	4.0	4.3	4.5	5.2	5.3	5.2
1/29/2001	EC	2.3	2.7	3.2	3.1	3.6	4.1	4.5	4.7	4.9	5.1	5.6	5.7	5.7
	WOP	2.4	2.6	3.0	3.1	3.5	3.9	4.2	4.4	4.7	4.9	5.4	5.6	5.6
2/12/2001	EC	1.9	2.1	2.5	2.7	3.3	4.1	4.4	4.5	4.8	5.0	5.4	5.6	5.6
	WOP	1.9	2.1	2.5	2.6	3.4	4.1	4.1	4.3	4.5	4.7	5.2	5.4	5.5
2/26/2001	EC	2.5	3.5	4.7	5.2	5.6	6.2	6.6	6.7	6.8	6.9	7.1	7.3	7.4
	WOP	5.4	5.5	5.5	5.5	5.6	6.2	6.7	6.8	7.0	7.0	7.2	7.4	7.5
3/12/2001	EC	3.5	4.7	6.0	6.5	7.6	8.2	8.6	8.7	8.7	8.7	8.6	8.8	9.0
	WOP	7.8	7.7	7.7	7.8	8.3	8.6	9.1	9.2	9.2	9.2	8.9	9.1	9.2
3/26/2001	EC	6.9	7.6	8.9	9.4	10.9	11.6	12.0	11.6	11.4	11.3	10.7	10.8	10.9
	WOP	9.5	10.0	11.3	11.9	12.5	12.8	13.0	12.3	12.1	12.1	11.1	11.3	11.4
4/9/2001	EC	8.0	8.3	8.5	8.7	9.1	9.2	9.4	9.4	9.5	9.5	9.5	9.6	9.7
	WOP	6.7	6.8	7.0	7.4	8.3	8.9	9.4	9.5	9.5	9.6	9.5	9.6	9.7
4/23/2001	EC	8.3	9.8	11.0	11.4	12.3	12.4	12.5	12.6	12.4	12.4	12.2	12.2	12.4
	WOP	13.4	13.3	13.0	12.8	13.1	12.9	12.8	12.8	12.5	12.4	12.3	12.2	12.3
5/7/2001	EC	12.1	13.7	15.0	15.5	16.4	15.4	15.0	15.1	14.5	14.4	14.1	14.0	14.3
	WOP	15.6	15.9	16.1	16.2	17.0	15.8	15.2	15.2	14.6	14.4	14.1	14.0	14.3
5/21/2001	EC	15.8	17.3	18.5	18.9	19.5	18.3	17.8	18.2	17.2	16.9	16.6	16.4	16.7
	WOP	18.1	18.9	19.8	20.0	20.2	18.4	17.9	18.2	17.3	17.0	16.7	16.4	16.6
6/4/2001	EC	18.4	18.1	17.7	17.4	17.1	16.5	16.4	16.6	16.2	16.1	15.9	15.8	15.9
	WOP	13.6	14.0	14.6	14.8	15.5	16.0	16.5	16.7	16.3	16.2	15.9	15.8	16.0
6/18/2001	EC	18.2	18.6	18.8	19.0	19.6	20.4	20.7	20.7	20.2	20.0	19.5	19.5	19.7
	WOP	16.6	17.5	18.3	18.8	19.5	20.3	20.6	20.6	20.1	20.0	19.4	19.4	19.6
7/2/2001	EC	18.5	21.0	22.4	22.7	22.9	22.7	22.7	22.5	22.1	21.8	21.2	21.3	21.6
	WOP	21.0	22.0	22.1	22.2	22.3	22.4	22.4	22.3	21.8	21.6	21.1	21.1	21.4

Table 5.2-20. Habitat suitability based on average daily water temperatures for juvenile coho salmon rearing at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	Scenario	Iron Gate Dam	Above Shasta River	At Walker Bridge	Above Scott River	At Seiad Valley	Above Clear Creek	Above Salmon River	At Orleans	Above Bluff Creek	Above Trinity River	At Martins Ferry	At Blue Creek	At Turwar
		RM 190.54	RM 177.52	RM 156.79	RM 143.86	RM 129.04	RM 99.04	RM 66.91	RM 57.58	RM 49.03	RM 43.33	RM 39.5	RM 15.95	RM 5.28
7/16/2001	EC	20.1	20.5	21.0	21.2	21.3	21.3	21.4	21.5	21.2	21.0	21.0	20.7	20.8
	WOP	19.0	20.1	21.0	21.3	21.4	21.4	21.4	21.5	21.3	21.2	21.1	21.0	21.2
7/30/2001	EC	20.9	21.0	21.0	21.3	22.0	22.2	22.3	22.4	22.0	21.8	21.7	21.6	21.8
	WOP	17.8	19.5	20.5	21.1	22.0	22.0	22.3	22.4	21.9	21.7	21.7	21.6	21.9
8/13/2001	EC	21.6	22.1	22.6	22.8	22.9	23.3	23.3	23.3	22.8	22.7	22.4	22.3	22.5
	WOP	20.0	21.4	22.6	22.9	23.0	23.4	23.3	23.2	22.8	22.6	22.4	22.5	22.8
8/27/2001	EC	21.5	22.5	23.5	23.7	23.5	23.0	22.8	22.7	22.2	22.0	21.6	21.7	22.0
	WOP	20.0	21.5	22.6	23.0	23.0	22.8	22.7	22.6	22.2	22.0	21.5	21.7	22.1
9/10/2001	EC	20.6	20.8	21.0	20.9	20.6	20.2	20.4	20.4	20.1	19.9	19.7	19.7	19.9
	WOP	16.8	18.3	19.3	19.7	19.7	19.7	20.1	20.2	20.0	20.0	19.7	19.8	20.1
9/24/2001	EC	19.1	18.8	18.8	18.9	19.3	19.6	19.5	19.4	19.0	18.8	18.3	18.5	18.7
	WOP	15.5	16.8	17.9	18.3	18.7	19.2	19.4	19.3	18.9	18.8	18.3	18.5	18.8
10/8/2001	EC	17.7	17.3	17.2	17.2	17.3	17.5	17.5	17.4	16.9	16.8	16.5	16.5	16.6
	WOP	12.8	14.8	15.6	16.1	16.5	17.1	17.3	17.2	16.7	16.6	16.3	16.5	16.7
10/22/2001	EC	14.6	14.7	14.6	14.5	14.4	14.1	13.9	13.9	13.6	13.6	13.5	13.6	13.7
	WOP	10.8	11.9	12.7	12.9	13.0	13.1	13.1	13.3	13.3	13.3	13.4	13.6	13.7
11/5/2001	EC	11.4	11.5	11.4	11.4	11.5	10.8	10.6	10.9	11.0	11.1	11.4	11.6	11.7
	WOP	8.6	9.4	9.8	9.9	10.3	10.1	10.3	10.7	10.8	10.9	11.3	11.6	11.7
11/19/2001	EC	8.6	9.2	9.1	8.8	8.4	7.7	7.6	8.3	8.6	8.8	9.4	9.5	9.5
	WOP	6.4	7.0	7.4	7.3	7.3	7.4	7.6	8.2	8.5	8.7	9.4	9.5	9.5
12/3/2001	EC	5.9	5.3	5.0	4.9	5.3	5.7	5.8	6.1	6.4	6.6	7.2	7.2	7.2
	WOP	2.3	2.5	3.1	3.2	3.8	4.8	5.2	5.7	6.0	6.2	6.9	7.0	7.0
12/17/2001	EC	3.7	3.6	4.3	4.4	5.0	5.0	4.9	5.6	5.8	6.1	6.8	6.9	6.9
	WOP	2.5	2.5	3.6	3.8	4.6	4.7	4.6	5.4	5.6	5.8	6.7	6.8	6.8
12/31/2001	EC	1.9	2.0	2.8	2.9	3.9	4.5	4.7	5.8	5.8	6.1	7.5	7.3	7.2
	WOP	4.1	3.7	3.9	3.8	4.4	4.7	4.8	5.8	5.8	6.0	7.4	7.3	7.2

*Lifestage ends 4/30/2001, but for the sake of including the period from 5/2/2001 through the end of the lifestage, this date is also shown.

suitable: <15°C	low to moderate stress: 16-23 °C	high stress: >23 °C

Assessment Results: Steelhead. Steelhead, like both Chinook and coho salmon, are sensitive to exposure to elevated water temperatures. Like coho salmon, steelhead primarily use the mainstem Klamath River as a migratory corridor for upstream adult and downstream juvenile movement. Spawning, egg incubation, and juvenile rearing primarily occur within the tributaries.

Adult steelhead upstream migration within the Klamath River occurs from approximately September through November (Table 5.2-13). Results of temperature analyses show that during the adult steelhead migration period water temperatures are declining during the fall and winter months. As a result of the seasonally declining temperatures conditions are generally suitable throughout the river under both existing and without Project conditions beginning in approximately October and extending through January. In general, there is very little difference in the suitability of river temperature conditions for adult steelhead migration under existing and without Project conditions at locations in the lower reaches of the river (Table 5.2-21). As a result of the elevated water temperatures within the lower reaches of the river under both existing and without Project conditions during September, behavior response and entry of adult steelhead into the river would be independent of Project operations.

Steelhead egg incubation occurs from December through April with fry emergence between March and June (Table 5.2-13). Water temperature conditions during the winter and early spring are naturally low and are generally within the range considered to be suitable for steelhead egg incubation and fry emergence (Table 5.2-22). Analysis of average weekly temperatures show that the frequency of temperatures above 12°C is greater under hypothetical without Project conditions within the Iron Gate reach when compared to existing project operations with the differences declining with distance downstream of the dam (Table 5.2-15).

During the latter part of the egg incubation period, water temperatures under existing conditions are colder than spring temperatures predicted under the without Project scenario. Therefore, existing operations would provide better habitat conditions for steelhead egg incubation and fry emergence within the reach immediately downstream of Iron Gate dam (both egg viability and rate of embryonic development) when compared to without Project conditions. Warming within the river during the spring months reduces the temperature difference between existing operations and without project conditions as a function of distance downstream from the dam.

Juvenile steelhead rear within freshwater rivers and tributaries throughout the year (Table 5.2-13). As discussed above, seasonal water temperature conditions significantly affect habitat quality and availability for juvenile rearing within the mainstem river. Project operations result in cooler water temperatures during the spring and early summer months within the reach immediately downstream of Iron Gate dam under existing operations when compared to hypothetical without Project conditions. Lower water temperatures during the spring and early summer months within the Iron Gate reach under existing project operations would improve opportunities and conditions for juvenile steelhead rearing. During the spring and summer months water temperatures increase within the river and differences in water temperature conditions between existing and without Project conditions become less as a function of distance downstream from the dam.

During the summer and early fall months water temperatures throughout the river increase to a range considered a low to moderately stressful for juvenile steelhead rearing. During the mid-summer, water temperatures may reach levels under both existing and without Project conditions that are considered to be highly stressful for juvenile steelhead rearing, particularly in the lower reaches of the river (Table 5.2-23). The occurrence of these high temperatures, under both existing and without Project conditions, limits year-round steelhead rearing within the mainstem Klamath River (perhaps with the exception of limited microhabitat areas providing coldwater refuges).

Table 5.2-21. Habitat suitability based on average daily water temperatures for adult steelhead migration at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	**Scenario**	**Iron Gate Dam**	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
		RM 190.54	**RM 177.52**	**RM 156.79**	**RM 143.86**	**RM 129.04**	**RM 99.04**	**RM 66.91**	**RM 57.58**	**RM 49.03**	**RM 43.33**	**RM 39.5**	**RM 15.95**	**RM 5.28**
9/1/2000	EC	21.2	18.9	18.4	18.4	18.9	18.8	18.6	18.6	18.5	18.5	18.6	18.4	18.4
	WOP	15.2	16.2	17.3	17.8	18.4	18.5	18.4	18.5	18.4	18.3	18.6	18.3	18.4
9/15/2000	EC	19.2	19.3	19.7	20.1	20.3	20.3	20.5	20.5	20.2	20.2	20.0	20.0	20.1
	WOP	18.3	19.1	20.1	20.3	20.4	20.3	20.5	20.4	20.2	20.1	19.9	19.9	20.1
9/29/2000	EC	18.1	18.4	18.5	18.6	18.7	18.3	18.1	18.1	17.9	17.8	17.5	17.7	17.8
	WOP	16.1	17.0	17.6	17.9	18.1	17.9	17.8	17.9	17.7	17.6	17.4	17.6	17.8
10/13/2000	EC	15.9	15.7	15.1	14.8	14.6	14.3	14.1	14.1	14.1	14.1	14.1	14.2	14.3
	WOP	10.6	10.8	10.9	11.0	11.5	12.4	13.0	13.3	13.4	13.5	13.8	14.1	14.2
10/27/2000	EC	12.6	12.3	11.9	11.8	11.6	11.4	11.7	11.8	11.9	11.9	12.0	12.0	12.0
	WOP	8.5	9.0	9.3	9.3	9.8	10.7	11.1	11.1	11.1	11.2	11.5	11.6	11.6
11/10/2000	EC	9.3	8.6	7.9	7.7	7.6	7.6	7.8	7.9	8.1	8.2	8.7	8.8	8.8
	WOP	3.9	4.1	4.8	5.1	5.7	6.4	6.9	7.2	7.5	7.7	8.3	8.5	8.5
11/24/2000	EC	6.0	5.7	5.6	5.5	5.8	5.9	5.9	6.1	6.4	6.5	6.9	7.0	6.9
	WOP	2.5	2.5	3.0	3.2	3.8	4.5	4.8	5.1	5.5	5.6	6.3	6.5	6.5
12/8/2000	EC	4.1	4.1	4.3	4.3	4.5	4.8	4.9	5.2	5.6	5.8	6.5	6.6	6.6
	WOP	3.3	3.4	3.9	3.9	4.3	4.6	4.9	5.2	5.6	5.8	6.5	6.6	6.6

*Lifestage ends 11/30/2000, but for the sake of including the period from 11/24/2001 through the end of the lifestage, this date is also shown.

suitable: <17°C	low to moderate stress: 18-21 °C	high stress: >21 °C

Table 5.2-22. Habitat suitability based on average daily water temperatures for steelhead egg incubation and fry emergence at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	Scenario	Iron Gate Dam	Above Shasta River	At Walker Bridge	Above Scott River	At Seiad Valley	Above Clear Creek	Above Salmon River	At Orleans	Above Bluff Creek	Above Trinity River	At Martins Ferry	At Blue Creek	At Turwar
		RM 190.54	RM 177.52	RM 156.79	RM 143.86	RM 129.04	RM 99.04	RM 66.91	RM 57.58	RM 49.03	RM 43.33	RM 39.5	RM 15.95	RM 5.28
12/1/2000	EC	4.7	4.5	4.5	4.5	4.9	5.7	6.1	6.5	6.7	6.8	7.5	7.7	7.7
	WOP	3.7	3.9	4.5	4.7	5.3	5.9	6.0	6.4	6.6	6.7	7.5	7.6	7.6
12/15/2000	EC	3.4	4.3	4.8	4.8	4.7	4.8	4.8	5.2	5.4	5.5	6.2	6.2	6.2
	WOP	3.3	4.1	4.3	4.3	4.2	4.2	4.3	4.7	4.9	5.0	5.8	5.9	6.0
12/29/2000	EC	2.3	2.3	2.4	2.4	2.5	2.9	3.3	3.6	4.1	4.3	4.8	5.1	5.1
	WOP	2.1	2.2	2.3	2.1	2.2	2.8	3.2	3.5	4.0	4.2	4.8	5.1	5.1
1/12/2001	EC	3.5	3.4	3.7	3.6	3.8	3.9	4.0	4.3	4.6	4.8	5.3	5.5	5.6
	WOP	2.3	2.3	2.5	2.5	2.9	3.4	3.8	4.1	4.4	4.6	5.2	5.4	5.5
1/26/2001	EC	2.6	2.6	2.7	2.7	3.2	3.8	4.5	4.8	5.1	5.3	5.7	5.8	5.8
	WOP	1.6	1.7	2.4	2.7	3.3	4.1	4.8	5.0	5.3	5.4	5.7	5.9	5.9
2/9/2001	EC	2.2	1.9	2.0	1.9	2.2	2.7	3.1	3.3	3.8	4.1	4.5	4.9	4.9
	WOP	1.1	0.7	0.9	1.1	1.8	2.6	3.5	3.8	4.3	4.5	4.8	5.2	5.3
2/23/2001	EC	2.4	2.7	3.4	3.8	4.9	6.0	6.6	6.7	6.9	6.9	7.0	7.1	7.2
	WOP	4.1	4.2	4.7	5.0	5.8	6.4	6.8	6.9	7.0	7.1	7.0	7.2	7.3
3/9/2001	EC	3.2	4.0	5.7	6.5	7.9	8.6	8.8	8.9	8.8	8.8	8.6	8.7	8.8
	WOP	7.3	8.1	9.3	9.7	10.2	10.0	9.7	9.5	9.4	9.3	8.8	8.9	8.9
3/23/2001	EC	5.2	7.9	10.3	11.3	12.9	13.2	13.2	13.0	12.8	12.6	12.2	12.4	12.5
	WOP	14.0	14.7	15.1	15.2	15.4	14.8	14.5	13.9	13.6	13.5	12.6	12.7	12.8
4/6/2001	EC	8.6	8.4	8.9	9.1	9.9	10.0	10.0	10.0	9.9	9.9	9.8	9.9	9.9
	WOP	7.6	8.2	8.7	8.8	9.6	9.5	9.6	9.7	9.7	9.7	9.7	9.8	9.9
4/20/2001	EC	7.9	8.6	9.3	9.6	10.1	10.5	11.1	11.2	11.3	11.3	11.1	11.5	11.7
	WOP	10.2	10.3	10.5	10.7	10.9	11.2	11.7	11.7	11.8	11.9	11.4	11.7	11.9
5/4/2001	EC	11.3	12.4	13.5	13.9	14.7	13.9	13.6	13.9	13.5	13.4	13.3	13.3	13.5
	WOP	13.2	13.5	13.7	13.7	14.4	13.7	13.8	14.0	13.6	13.5	13.3	13.3	13.5
5/18/2001	EC	15.5	16.4	16.9	17.0	16.9	15.8	15.4	15.5	15.0	14.8	14.5	14.3	14.5
	WOP	16.3	16.8	17.6	17.7	17.2	16.0	15.4	15.5	15.0	14.7	14.5	14.3	14.4
6/1/2001	EC	17.8	18.5	19.8	20.3	20.7	20.0	19.4	19.7	18.6	18.3	17.9	17.7	18.0
	WOP	19.6	20.5	21.1	21.0	21.0	19.6	19.2	19.5	18.6	18.3	17.9	17.7	18.0
6/15/2001	EC	18.0	18.6	19.1	19.4	19.8	20.0	20.0	19.9	19.5	19.3	18.9	18.9	19.0
	WOP	17.2	18.0	18.3	18.4	18.7	18.9	19.4	19.5	19.2	19.1	18.7	18.7	18.9

Table 5.2-22. Habitat suitability based on average daily water temperatures for steelhead egg incubation and fry emergence at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	**Scenario**	**Iron Gate Dam**	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
		RM 190.54	**RM 177.52**	**RM 156.79**	**RM 143.86**	**RM 129.04**	**RM 99.04**	**RM 66.91**	**RM 57.58**	**RM 49.03**	**RM 43.33**	**RM 39.5**	**RM 15.95**	**RM 5.28**
6/29/2001	EC	18.6	19.8	20.7	21.1	21.3	21.2	21.3	20.9	20.6	20.4	19.8	19.8	20.0
	WOP	18.4	19.1	19.5	19.7	20.2	20.9	21.1	20.7	20.3	20.1	19.6	19.5	19.7
7/13/2001	EC	20.0	21.7	22.9	23.2	23.6	24.0	24.5	24.4	23.9	23.6	23.1	23.1	23.5
	WOP	21.1	22.5	23.1	23.3	23.8	24.1	24.5	24.4	23.9	23.6	23.1	23.1	23.5

*Lifestage ends 6/30/2000, but for the sake of including the period from 6/29/2001 through the end of the lifestage, this date is also shown

suitable: <12°C | low to moderate stress: 13-14°C | high stress: >14°C

Table 5.2-23. Habitat suitability based on average daily water temperatures for juvenile steelhead rearing at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

		Iron Gate Dam	**Above Shasta River**	**At Walker Bridge**	**Above Scott River**	**At Seiad Valley**	**Above Clear Creek**	**Above Salmon River**	**At Orleans**	**Above Bluff Creek**	**Above Trinity River**	**At Martins Ferry**	**At Blue Creek**	**At Turwar**
Date	**Scenario**	**RM 190.54**	**RM 177.52**	**RM 156.79**	**RM 143.86**	**RM 129.04**	**RM 99.04**	**RM 66.91**	**RM 57.58**	**RM 49.03**	**RM 43.33**	**RM 39.5**	**RM 15.95**	**RM 5.28**
1/1/2001	EC	4.0	4.1	3.8	3.9	4.0	4.1	4.1	4.2	4.5	4.5	4.9	4.8	4.6
	WOP	2.2	3.0	3.8	3.9	4.1	4.1	4.1	4.2	4.4	4.5	4.9	4.7	4.4
1/15/2001	EC	3.1	2.8	2.7	2.6	2.9	3.6	4.0	4.3	4.6	4.8	5.4	5.5	5.5
	WOP	1.0	1.1	1.6	1.7	2.5	3.4	3.7	4.0	4.3	4.5	5.2	5.3	5.2
1/29/2001	EC	2.3	2.7	3.2	3.1	3.6	4.1	4.5	4.7	4.9	5.1	5.6	5.7	5.7
	WOP	2.4	2.6	3.0	3.1	3.5	3.9	4.2	4.4	4.7	4.9	5.4	5.6	5.6
2/12/2001	EC	1.9	2.1	2.5	2.7	3.3	4.1	4.4	4.5	4.8	5.0	5.4	5.6	5.6
	WOP	1.9	2.1	2.5	2.6	3.4	4.1	4.1	4.3	4.5	4.7	5.2	5.4	5.5
2/26/2001	EC	2.5	3.5	4.7	5.2	5.6	6.2	6.6	6.7	6.8	6.9	7.1	7.3	7.4
	WOP	5.4	5.5	5.5	5.5	5.6	6.2	6.7	6.8	7.0	7.0	7.2	7.4	7.5
3/12/2001	EC	3.5	4.7	6.0	6.5	7.6	8.2	8.6	8.7	8.7	8.7	8.6	8.8	9.0
	WOP	7.8	7.7	7.7	7.8	8.3	8.6	9.1	9.2	9.2	9.2	8.9	9.1	9.2
3/26/2001	EC	6.9	7.6	8.9	9.4	10.9	11.6	12.0	11.6	11.4	11.3	10.7	10.8	10.9
	WOP	9.5	10.0	11.3	11.9	12.5	12.8	13.0	12.3	12.1	12.1	11.1	11.3	11.4
4/9/2001	EC	8.0	8.3	8.5	8.7	9.1	9.2	9.4	9.4	9.5	9.5	9.5	9.6	9.7
	WOP	6.7	6.8	7.0	7.4	8.3	8.9	9.4	9.5	9.5	9.6	9.5	9.6	9.7
4/23/2001	EC	8.3	9.8	11.0	11.4	12.3	12.4	12.5	12.6	12.4	12.4	12.2	12.2	12.4
	WOP	13.4	13.3	13.0	12.8	13.1	12.9	12.8	12.8	12.5	12.4	12.3	12.2	12.3
5/7/2001	EC	12.1	13.7	15.0	15.5	16.4	15.4	15.0	15.1	14.5	14.4	14.1	14.0	14.3
	WOP	15.6	15.9	16.1	16.2	17.0	15.8	15.2	15.2	14.6	14.4	14.1	14.0	14.3
5/21/2001	EC	15.8	17.3	18.5	18.9	19.5	18.3	17.8	18.2	17.2	16.9	16.6	16.4	16.7
	WOP	18.1	18.9	19.8	20.0	20.2	18.4	17.9	18.2	17.3	17.0	16.7	16.4	16.6
6/4/2001	EC	18.4	18.1	17.7	17.4	17.1	16.5	16.4	16.6	16.2	16.1	15.9	15.8	15.9
	WOP	13.6	14.0	14.6	14.8	15.5	16.0	16.5	16.7	16.3	16.2	15.9	15.8	16.0
6/18/2001	EC	18.2	18.6	18.8	19.0	19.6	20.4	20.7	20.7	20.2	20.0	19.5	19.5	19.7
	WOP	16.6	17.5	18.3	18.8	19.5	20.3	20.6	20.6	20.1	20.0	19.4	19.4	19.6
7/2/2001	EC	18.5	21.0	22.4	22.7	22.9	22.7	22.7	22.5	22.1	21.8	21.2	21.3	21.6
	WOP	21.0	22.0	22.1	22.2	22.3	22.4	22.4	22.3	21.8	21.6	21.1	21.1	21.4

Table 5.2-23. Habitat suitability based on average daily water temperatures for juvenile steelhead rearing at locations downstream from Iron Gate dam based on 2000 and 2001 water temperature modeling results for existing conditions (EC) and hypothetical without-Project (WOP) scenarios.

Date	Scenario	Iron Gate Dam RM 190.54	Above Shasta River RM 177.52	At Walker Bridge RM 156.79	Above Scott River RM 143.86	At Seiad Valley RM 129.04	Above Clear Creek RM 99.04	Above Salmon River RM 66.91	At Orleans RM 57.58	Above Bluff Creek RM 49.03	Above Trinity River RM 43.33	At Martins Ferry RM 39.5	At Blue Creek RM 15.95	At Turwar RM 5.28
7/16/2001	EC	20.1	20.5	21.0	21.2	21.3	21.3	21.4	21.5	21.2	21.0	21.0	20.7	20.8
	WOP	19.0	20.1	21.0	21.3	21.4	21.4	21.4	21.5	21.3	21.2	21.1	21.0	21.2
7/30/2001	EC	20.9	21.0	21.0	21.3	22.0	22.2	22.3	22.4	22.0	21.8	21.7	21.6	21.8
	WOP	17.8	19.5	20.5	21.1	22.0	22.0	22.3	22.4	21.9	21.7	21.7	21.6	21.9
8/13/2001	EC	21.6	22.1	22.6	22.8	22.9	23.3	23.3	23.3	22.8	22.7	22.4	22.3	22.5
	WOP	20.0	21.4	22.6	22.9	23.0	23.4	23.3	23.2	22.8	22.6	22.4	22.5	22.8
8/27/2001	EC	21.5	22.5	23.5	23.7	23.5	23.0	22.8	22.7	22.2	22.0	21.6	21.7	22.0
	WOP	20.0	21.5	22.6	23.0	23.0	22.8	22.7	22.6	22.2	22.0	21.5	21.7	22.1
9/10/2001	EC	20.6	20.8	21.0	20.9	20.6	20.2	20.4	20.4	20.1	19.9	19.7	19.7	19.9
	WOP	16.8	18.3	19.3	19.7	19.7	19.7	20.1	20.2	20.0	20.0	19.7	19.8	20.1
9/24/2001	EC	19.1	18.8	18.8	18.9	19.3	19.6	19.5	19.4	19.0	18.8	18.3	18.5	18.7
	WOP	15.5	16.8	17.9	18.3	18.7	19.2	19.4	19.3	18.9	18.8	18.3	18.5	18.8
10/8/2001	EC	17.7	17.3	17.2	17.2	17.3	17.5	17.5	17.4	16.9	16.8	16.5	16.5	16.6
	WOP	12.8	14.8	15.6	16.1	16.5	17.1	17.3	17.2	16.7	16.6	16.3	16.5	16.7
10/22/2001	EC	14.6	14.7	14.6	14.5	14.4	14.1	13.9	13.9	13.6	13.6	13.5	13.6	13.7
	WOP	10.8	11.9	12.7	12.9	13.0	13.1	13.1	13.3	13.3	13.3	13.4	13.6	13.7
11/5/2001	EC	11.4	11.5	11.4	11.4	11.5	10.8	10.6	10.9	11.0	11.1	11.4	11.6	11.7
	WOP	8.6	9.4	9.8	9.9	10.3	10.1	10.3	10.7	10.8	10.9	11.3	11.6	11.7
11/19/2001	EC	8.6	9.2	9.1	8.8	8.4	7.7	7.6	8.3	8.6	8.8	9.4	9.5	9.5
	WOP	6.4	7.0	7.4	7.3	7.3	7.4	7.6	8.2	8.5	8.7	9.4	9.5	9.5
12/3/2001	EC	5.9	5.3	5.0	4.9	5.3	5.7	5.8	6.1	6.4	6.6	7.2	7.2	7.2
	WOP	2.3	2.5	3.1	3.2	3.8	4.8	5.2	5.7	6.0	6.2	6.9	7.0	7.0
12/17/2001	EC	3.7	3.6	4.3	4.4	5.0	5.0	4.9	5.6	5.8	6.1	6.8	6.9	6.9
	WOP	2.5	2.5	3.6	3.8	4.6	4.7	4.6	5.4	5.6	5.8	6.7	6.8	6.8
12/31/2001	EC	1.9	2.0	2.8	2.9	3.9	4.5	4.7	5.8	5.8	6.1	7.5	7.3	7.2
	WOP	4.1	3.7	3.9	3.8	4.4	4.7	4.8	5.8	5.8	6.0	7.4	7.3	7.2

Lifestage ends 6/30/2000, but for the sake of including the period from 6/29/2001 through the end of the lifestage, this date is also shown

suitable: <15°C	low to moderate stress: 16-23°C	high stress: >23°C

Juvenile steelhead outmigration using the mainstem Klamath River as a migratory corridor occurs primarily during the period from March through June and potentially early July (Table 5.2-13). Water temperature conditions throughout the Klamath River are within the range considered be suitable for juvenile steelhead emigration during the period from March through approximately mid-May (Table 5.2-23). Water temperatures during the spring and early summer months are colder within the reach immediately downstream of Iron Gate dam under existing project operations, however temperatures within the lower reaches of the river that serve as the migratory corridor for steelhead are independent of project operations. Under existing conditions and without project conditions seasonal water temperatures increase during the summer, particularly in the lower reaches of the river, where temperatures are typically within the range considered to be low to moderately stressful during June and high stress/lethal during July. The frequency and occurrence of these elevated water temperatures during the juvenile steelhead emigration period within the lower reaches of the river are independent of Project operations.

5.2.3.4 Proposed Measures

This section describes measures proposed by PacifiCorp for addressing Project contributions to water temperature effects and how these measures may affect beneficial uses.

Klamath River from Stateline to Copco Reservoir

As described in PacifiCorp's FLA (PacifiCorp 2004a), instream flow and flow ramping measures are proposed in the J.C. Boyle peaking reach from the J.C. Boyle powerhouse to Copco reservoir. Flow up-ramp rates will not exceed 9 inches (in water level) per hour in the J.C. Boyle peaking reach. Flow down-ramp rates will not exceed 9 inches per hour for flows exceeding 1,000 cfs, and will not exceed 4 inches per hour for flows less than 1,000 cfs (as measured at USGS gauge No. 11510700 downstream of the J.C. Boyle powerhouse).

Peaking operations will continue at the powerhouse. However, the daily Project-controlled flow change (i.e., the difference between lowest and highest flow in 24-hour period) during peaking operations will not exceed 1,400 cfs (as measured at USGS gauge No. 11510700 downstream of the J.C. Boyle powerhouse). The limit of flow change to 1,400 cfs per daily period will prohibit no-load to full two-unit peaking events during low to medium river flow periods.

These measures will provide greater flow stability for aquatic resources, while continuing to provide a balance of whitewater boating and angling opportunities (periods of optimal wading-based fishing and standard whitewater boating flows) because one unit can provide raftable flows. Although water temperatures under current operations meet the California water temperature objective, these proposed enhancement measures will provide additional benefits to water temperatures in the J.C. Boyle peaking reach by further reducing daily maximum temperatures during summer (by as much as 1.9°C in the reach just above Copco reservoir; see Figure 5.2-19).

Copco and Iron Gate Reservoirs

As discussed in Section 3.2.4, the proposed use of selective withdrawal from both Copco and Iron Gate reservoirs for water temperature management has been previously evaluated by PacifiCorp, and it has been previously determined that selective withdrawal would have modest, if any, thermal benefits to the river downstream owing to the limited cool water volume in the reservoirs (PacifiCorp 2005a, 2005b, 2005c, 2005d). Even in Iron Gate reservoir (which stratifies more strongly and has much greater cool water storage than Copco reservoir), the volume of cool water stored in the hypolimnion is only sufficient to reduce release temperatures from Iron Gate dam by about a degree or two (C) for about 2-4 weeks.

PacifiCorp's analyses considered several hypothetical selective withdrawal scenarios, including three scenarios aimed at enhancing temperatures to the extent possible during separate periods starting early in August, September, and October, respectively. Each of these periods is assumed to represent a particular management objective (to be discussed and evaluated with the State Water Board and the fisheries agencies). For example, the hypothetical selective withdrawal period in August could be aimed at maintaining temperatures at 20°C or less to the extent possible. The selective withdrawal scenario in September could be aimed at enhancing temperatures during Chinook spawner immigration, while the scenario in October is aimed at enhancing temperatures during Chinook spawning and egg incubation.

Because of the limited cool water volume, the selective withdrawal would be most efficiently implemented by mixing low-level releases (from Iron Gate reservoir elevation 2173 ft msl) with flows from the normal power conduit level (about elevation 2320 ft msl). The modeling indicates that the best balance of temperature enhancement in terms of magnitude (i.e., degrees reduced) and duration (i.e., days reduced) would be achieved by ramping up the low-level releases gradually to a maximum rate of about 200 to 400 cfs (while reducing flows from the normal power conduit level in corresponding fashion). Figure 5.2-26 shows the modeling results of the hypothetical selective withdrawal scenarios aimed at enhancing temperatures to the extent possible during August, September, and October. The August scenario (top plot in Figure 5.2-26) results in an average reduction in temperature of about 1.5°C for 36 days. The September scenario (middle plot in Figure 5.2-26) results in an average reduction in temperature of about 1.0°C for 30 days, while the October scenario (bottom plot in Figure 5.2-26) results in an average reduction in temperature of about 1.0°C for 18 days. These results indicate that the efficiency of temperature enhancement (in terms of magnitude and duration of reduction achieved) is reduced the later into the fall that selective withdrawal is used. This is due to the gradual warming of the hypolimnion (and, hence, available cool water volume) as reservoir thermal conditions move toward turnover conditions in November.

The potential effects of Iron Gate dam release temperatures from these selective withdrawal scenarios on downstream uses by anadromous fish species were further evaluated to assess resultant benefits to these species. Reductions in water temperature during early and mid-October would enhance habitat conditions and improve seasonal water temperatures affecting the viability of chinook salmon spawning in early to mid-October, but controllable factors are limited. Results of modeling simulations indicate that the duration of exposure to low or moderately stressful water temperatures during mid-October could be reduced by less than one week, and that the date that average daily temperatures were reduced below 12°C was not changed under the selective withdrawal scenarios. Results of these analyses suggest minimal or insignificant incremental biological benefit to improving water temperature conditions and egg viability under existing conditions.

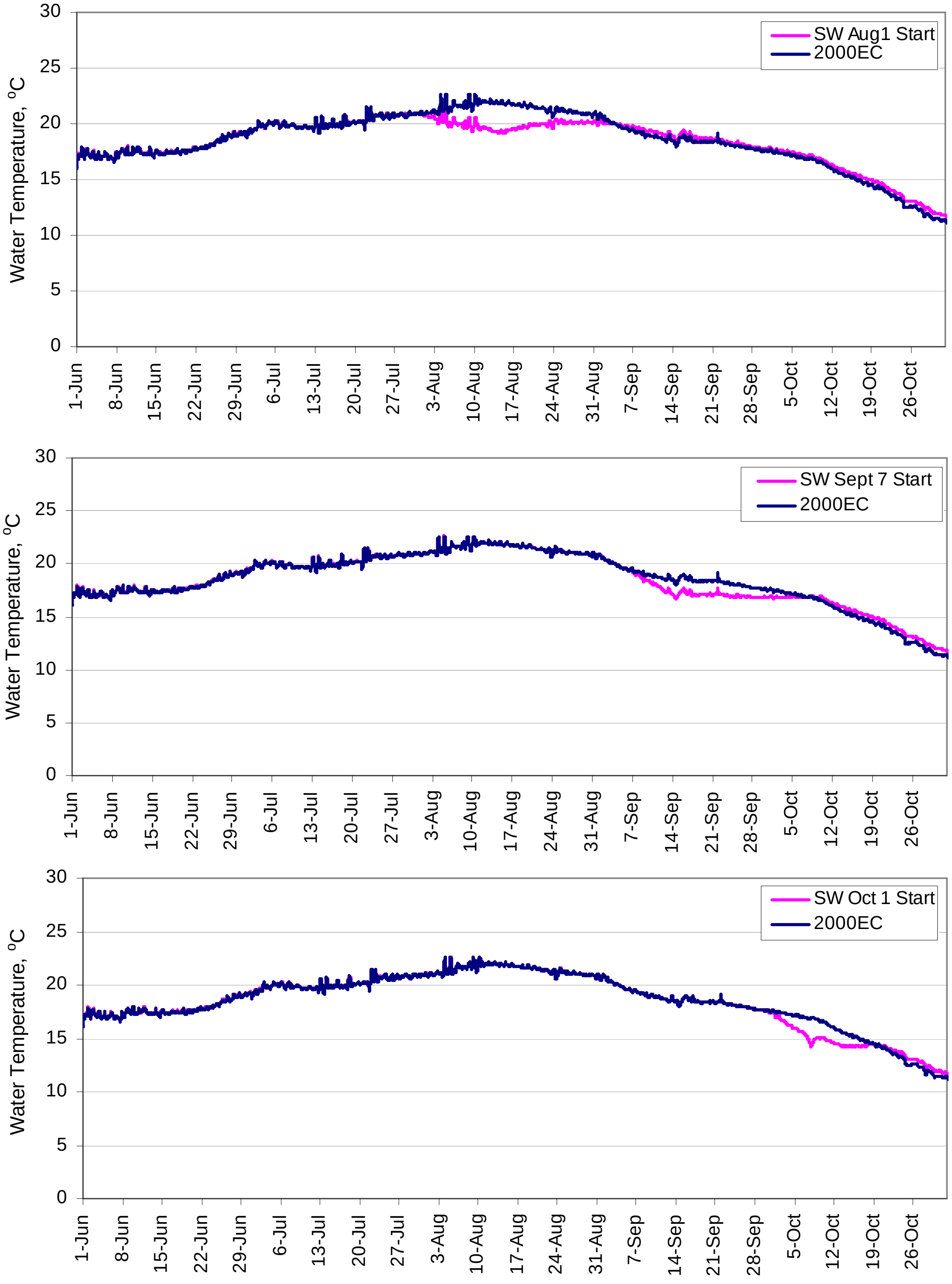


Figure 5.2-26. Water temperature (in degrees C) for the year 2000 in the Klamath River at Iron Gate dam (RM 190.5) under existing conditions, compared to a hypothetical selective withdrawal scenario aimed at enhancing temperatures to the extent possible during August (top plot), September (middle plot), and October (bottom plot) (based on model simulations).

Finally, it is important to note that the use of the cool water volume in the Iron Gate reservoir will affect and compete with operation of the Iron Gate Hatchery. Currently, the hatchery relies on Iron Gate's cool hypolimnetic water for controlling and maintaining suitable rearing temperatures in the hatchery. Use of Iron Gate's cool hypolimnetic water for downstream temperature management via selective withdrawal would significantly reduce or possibly eliminate cold water available to the hatchery.

In the FEIS for the Project (FERC 2007), FERC staff independently assessed the potential effectiveness of selective withdrawal, and concur with PacifiCorp's assessment of the limited coldwater release capabilities at Copco No. 1 and Iron Gate dams. However, FERC staff recommend development of a temperature management plan that would include: (1) a feasibility study to assess modifications of existing structures at Iron Gate dam to enable release of the maximum volume of cool, hypolimnetic water during "emergency circumstances" to be completed within 1 year of license issuance; (2) an assessment of methods to increase the dissolved oxygen of waters that may be released on an emergency basis; and (3) development of protocols that would be implemented to trigger the release of hypolimnetic water by using existing, unmodified structures at Iron Gate or, if determined to be feasible, modified structures, within 2 years of license issuance. FERC staff indicate that "emergency circumstances" would be if and when temperature conditions for downstream juvenile anadromous fish survival approach critical levels. In addition, FERC staff suggest that the feasibility study would assess alternative or supplemental Iron Gate Hatchery water supply options that could provide temporary cool water supplies to the hatchery during any use of hypolimnetic water under emergency circumstances.

In consultation with the State Water Board and other applicable regulatory authorities, PacifiCorp will evaluate the effectiveness and feasibility of the implementation of a low-level release of cooler hypolimnetic water from Iron Gate reservoir during summer to provide some targeted cooling of the Klamath River below the Project area, consistent with the cold water needs of the Iron Gate fish hatchery. The low-level release would likely require retrofitting an existing low-level outlet at Iron Gate dam to permit controlled release of water from the bottom of Iron Gate reservoir and to release that water in a manner that would provide the greatest benefit to temperature conditions in the Klamath River.

5.2.4 Total Dissolved Solids

5.2.4.1 Applicable Criteria

North Coast Basin Plan Table 3.1 establishes water quality objectives for total dissolved solids for certain water bodies in the North Coast region, but does not include water quality objectives for the Middle Klamath HA (Klamath River above Iron Gate dam including Iron Gate and Copco reservoirs, Klamath River below Iron Gate dam, other streams, and groundwaters) or the Lower Klamath HA (Klamath River, other streams, and groundwaters)

5.2.4.2 Present Conditions

The available measurements for TDS made in the Klamath River between 2000 and 2004 are summarized in Table 5.2-24.

Table 5.2-24. Summary of TDS and specific conductance SPC values measured in the Klamath River in 2000 through 2005.

Descriptive Statistics	TDS mg/L	SPC µS/cm
N	26	2572
Mean	130.73	190.88
Minimum	76.000	6.0000
1st Quartile	113.50	169.00
Median	131.00	188.00
3rd Quartile	147.75	212.00
Maximum	183.00	354.00

5.2.4.3 Project Contribution

The Project conducts no activity and releases no substance that would affect the total dissolved solids or specific conductance of the Klamath River.

Effects on Fish and Aquatic Life

The effects of short-duration (acute) and long-duration (chronic) total dissolved solids exposure on various life-history stages of salmonids have been investigated by Stekoll et al. (2003). Results of these investigations focused specifically on fertilization and embryonic development, which were identified as the most sensitive of the salmonid life-history stages. Results of 24- and 96-hour exposure durations (acute tests) show that the no observed effects concentration (NOEC) was estimated to be 1,250 mg/L and the lowest observed effects concentration (LOEC) was estimated to be 1,875 mg/L. Results of long-duration exposure identified a NOEC of 750 mg/L and an estimated LOEC of 1,250 mg/L.

Results of water quality monitoring within the Klamath River showed total dissolved solid concentrations consistently lower than the “no observed effects” concentrations identified for coho salmon eggs in these investigations. These water quality results are consistent with observations at the Klamath River fish hatchery of high egg fertilization and hatching success.

5.2.4.4 Proposed Measures

Even though there is no water quality objective specified for the relevant segments of the Klamath river, TDS does not appear to be a problem in or below the Project area. PacifiCorp proposes no measures with respect to total dissolved solids.

5.2.5 Turbidity

5.2.5.1 Applicable Criteria

North Coast Basin Plan, at 3.3.00:

Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

5.2.5.2 Present Conditions

PacifiCorp's Final License Application Exhibit E (PacifiCorp, 2004) describes turbidity conditions in the Klamath River in the vicinity of the Project area. Minimum, maximum, and average turbidity values at several sample sites in the Klamath River from Link River to Orleans are summarized in Table 5.10-1 for the periods 1980 to 1986 (from the historical database), 1995 to 2001 (from the historical database), and 2003 (from PacifiCorp sampling data). The turbidity measurements indicate a general trend of increasing water clarity in the downstream direction on an average basis (Table 5.12-25). Maximum and average turbidity values are highest at the Link River mouth sampling site, probably reflecting the high loading of algae and organic matter to the river from hypereutrophic UKL, particularly during summer.

The reduction in turbidity from Link River to Iron Gate dam during 2003, particularly in summer, is probably attributable to two main factors: (1) dilution effects of flow accretion between these two locations (from RM 234 to RM 189.5); and (2) settling or sedimentation of a portion of the organic load in the river during transit through Copco and Iron Gate reservoirs. For example, about 250 cfs of high-quality spring flows discharge directly to the Klamath River between the J.C. Boyle dam (RM 224) and powerhouse (RM 220). The turbidity of these high-quality spring flows is unknown, but is likely very low, and the flows are assumed to contribute to improved water clarity in the bypass reach downstream of J.C. Boyle dam.

Table 5.2-25. Minimum, maximum, and average turbidity values at sample sites in the Klamath River from Link River to Orleans from 1980 to 1986 (from historic database), 1995 to 2001 (from historic database), and in 2003 (PacifiCorp data). (NA = not sampled during the time period listed under.)

Sample Site	River Mile	Minimum/Average/Maximum Turbidity Values, in NTUs (Number of samples in parentheses)		
		1980-1986	**1995-2001**	**2003**
Link River at Mouth (Klamath Falls)	253	3/9.6/19 (41)	5/15.5/65 (40)	6.9/13.8/22.5 (8)
Klamath River at Highway 66 (Keno)	234	2/8.7/20 (37)	2/13.9/76 (28)	4.6/8.0/13.1 (8)
Klamath River below J.C. Boyle Dam	224	NA	NA	2.9/7.1/14.4 (8)
Klamath River above Copco Reservoir	206.4	NA	NA	2.0/5.2/11.4 (8)
Klamath River below Copco 2 Dam	196.5	NA	NA	1.7/4.3/7.0 (8)
Klamath River below Iron Gate Dam	189.5	0/7.1/42 (97)	NA	1.4/3.1/6.1 (8)
Klamath River near Seiad Valley	128	1/7.3/170 (120)	NA	NA
Klamath River at Orleans	59	0/4.7/35 (117)	NA	NA

NA = Not applicable.

Figure 5.2-27 provides a time-series graphs of 2003 turbidity data from sites at the outflow of Link River, and J.C. Boyle, Copco, and Iron Gate reservoirs. This graph further indicates a general trend of increasing water clarity in the downstream direction. Also shown is a strong seasonal trend in turbidity at the Link River site associated with the algal growing season, during which peak algal growth occurs in summer. For example, the high July and August 2003 turbidity values (at or above about 20 NTU) occurred on dates coincident with very high chlorophyll-*a* values (230 to 250 µg/L).

Comparisons of turbidity values in the 2003 inflow vs. outflow samples from Copco and Iron Gate reservoirs were used to determine differences. These differences are assumed indicative of reservoir influence on particulate materials that contribute to turbidity. The calculated differences are shown in Figure 5.2-28, where a negative difference represents a reduction in turbidity and a positive difference suggests an increase in turbidity. The differences vary over time and across location, but indicate that the reservoirs mostly act to reduce turbidity during reservoir transit.

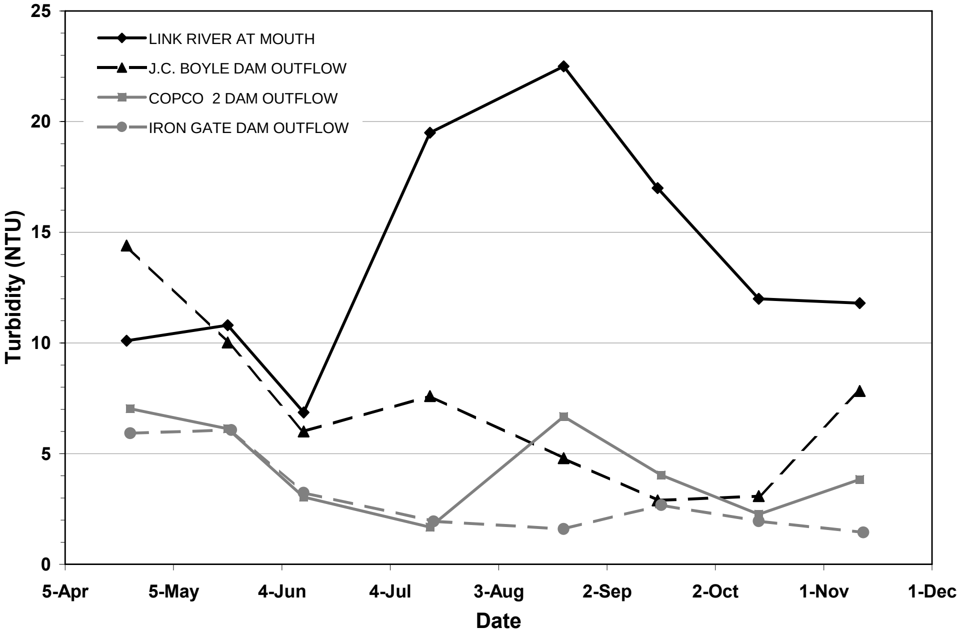


Figure 5.2-27. Turbidity values from samples taken during April-November 2003 at the mouth of Link River (RM 253), the Klamath River below J.C. Boyle dam (RM 224), the Klamath River below Copco No. 2 dam (RM 196.5), and the Klamath River below Iron Gate dam (RM 189.5).

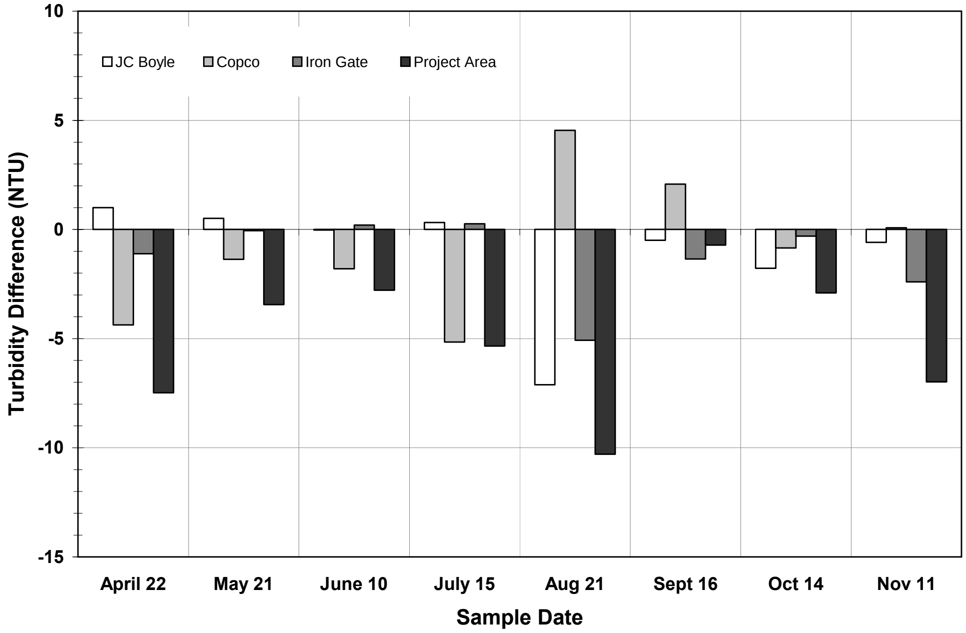


Figure 5.2-28. Differences in turbidity samples taken during April-November 2003 above and below J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, and for the Project area (above J.C. Boyle reservoir to Iron Gate dam outflow).

5.2.5.3 Project Contribution

Under normal conditions, the Project conducts no activity and discharges no substance that would increase turbidity in the Klamath River. The Project decreases turbidity in the river reaches below the dams by allowing upstream material to settle in Project reservoirs. Emergency conditions as a result of natural catastrophe or unexpected operations upset may create conditions that increase turbidity. Under those circumstances, an emergency permit or waiver would be sought as described in the water quality objective.

Effects on Fish and Aquatic Life

Turbidity is typically caused by the suspension of fine-grained particles (less than 1 um) that affects water clarity and visibility. Increased turbidity reduces light penetration and therefore affects the photic zone and production of phytoplankton and other aquatic plants. No specific thresholds for biological responses of salmonids to turbidity have been identified. Under very high turbidity levels, such as those associated with heavy precipitation and stormwater runoff, foraging by juvenile and adult salmonids may be temporarily reduced until turbidity levels return to background conditions. Salmonids and other fish inhabiting the Klamath River are naturally exposed to a wide range of turbidities resulting from stormwater runoff. Project operations do not result in an increase in turbidity. Based on the levels of turbidity measured in the river, and the high seasonal variability in naturally occurring turbidity, there is no evidence that Project operations are resulting in adverse effects to salmonids or other fish species as a result of changes in river turbidity.

5.2.5.4 Proposed Measures

Turbidity is generally not a problem in the Project area, and PacifiCorp's operations are consistent with the applicable water quality objective. Proper scheduling of regular Project maintenance activities will reduce the likelihood of increasing turbidity in the River. PacifiCorp also proposes to eliminate two-unit peaking operations at the J.C. Boyle powerhouse, which will substantially reduce ramping in the J.C. Boyle peaking reach and turbidity increases, if any, associated with ramping. PacifiCorp will seek an emergency permit or waiver as described in the water quality objective in the event of an unusual, emergency turbidity event.

5.2.6 Color

5.2.6.1 Applicable Criteria

North Coast Basin Plan, at 3.2.00:

Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.

5.2.6.2 Present Conditions

The measurements of available color data taken in the Project area (from August 9 to 11, 2004) are shown in Figure 5.2-29. The results indicate a consistent declining trend in color, from highly colored[19] water

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[19] Waters are considered highly colored at color concentrations greater than about 50 PCU (Klein 1962). U.S. secondary drinking water regulations establish a secondary maximum contaminant goal of 15 PCU in public drinking water systems.

(80 PCU) in the Klamath River below Keno dam (RM 234), to moderately-colored water (34 PCU) below Iron Gate dam (RM 189.5), to low-colored water (14 PCU) in the Klamath River above the confluence with the Trinity River (RM 43.5). The highly colored water (80 PCU) in the river below Keno dam is not surprising given the high organic loading to the river from hypereutrophic UKL and other upstream sources, particularly during summer.

The relatively low-colored water (27 PCU) in the Klamath River in the lower end of the bypass reach above the J.C. Boyle powerhouse reflects the substantial spring flow accretion in the bypass reach. During diversion of flow to the J.C. Boyle powerhouse, flows in the bypass reach consist of about 100 cfs of water released from J.C. Boyle dam and about 250 cfs of spring flow accretion. The spring-fed inflows are assumed to consist of very low-colored water (on the order of about 10 PCU[20]).

The appreciable reduction in color from Keno dam (80 PCU) to Iron Gate dam (34 PCU) cannot be fully explained by the dilution effects of flow accretion between these two locations (from RM 234 to RM 190). USGS gauge records show that average flows from August 9 to 11, 2004, were approximately 350 cfs at the Keno gauge and 615 cfs at the Iron Gate gauge. If accretion inputs between these locations were assumed to have a color of 10 PCU (as back-calculated for bypass reach spring inflows), a conservative calculation of color at Iron Gate equates to about 50 PCU. Even if accretion inputs between these locations were assumed to have no color (zero PCU), a conservative calculation of color at Iron Gate equates to about 45 PCU[21]. Comparison of these theoretical, conservative estimates to the actual measured value below Iron Gate dam (34 PCU) suggests that Project operations in the Klamath River between Keno dam and Iron Gate dam are not causing an increase in water color, and may in fact act to reduce color, perhaps via reduction of color-causing organic materials in the river during reservoir transit.

Light Extinction

The light extinction coefficients calculated in the Project area from measurements taken from August 9 to 11, 2004, are shown in Figure 5.2-30. The results indicate a general declining trend in light extinction coefficients, from 2.6 m^{-1} in the Klamath River below Keno dam (RM 234), to 1.2 m^{-1} below Iron Gate dam (RM 189.5), to 0.8 m^{-1} in the Klamath River above the confluence with the Trinity River (RM 43.5)[22]. This general downstream increase in light penetration corresponds with similar general trends of downstream reductions in turbidity, and water color as described above, and with total suspended solid (TSS) as described in PacifiCorp's FLA (PacifiCorp 2004a, 2004b).

The lower light penetration (2.6 m^{-1}) in the river below Keno dam is not surprising given the high organic loading to the river from hypereutrophic UKL and other upstream sources, particularly during summer. The relatively high light penetration (0.9 m^{-1}) in the Klamath River in the lower end of the bypass reach above the J.C. Boyle powerhouse reflects the dominance of substantial spring flow accretion in the bypass reach. During diversion of flow to the J.C. Boyle powerhouse, flows in the bypass reach consist of about 100 cfs of water released from J.C. Boyle dam and 250 cfs of clear, non-turbid spring flow accretion.

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[20] Color of spring inflows can be estimated at about 10 PCU by back-calculation by taking the product of color and flow as measured in the bypass reach (say, C_BQ_B), subtracting the product of color and flow as measured below J.C. Boyle dam (C_DQ_D), and then dividing the remainder by the spring accretion quantity (Q_s).

[21] A theoretical, conservative estimate of color at Iron Gate can be estimated by taking the product of color and flow as measured at Keno (say, C_KQ_K), adding the product of assumed color and flow of accretion (C_AQ_A), and then dividing the sum by the flow as measured at Iron Gate (Q_{IG}). By conservatively assuming that color of accretion flows is zero, the second term (C_AQ_A) also is zero, and can be dropped in the formulated estimate.

[22] The extinction coefficient is generally related to the amount of particulate and dissolved matter in the water column—the lower the value of the coefficient the deeper light will penetrate in the water column. More matter in the water, generally means a larger extinction coefficient. For example, an extinction coefficient of 0.35 m^{-1} will have light penetrating much deeper than an extinction coefficient of 0.90 m^{-1}.

5.2.6.3 Project Contribution

No physical activity or biological process associated with the Project increases the color of water.

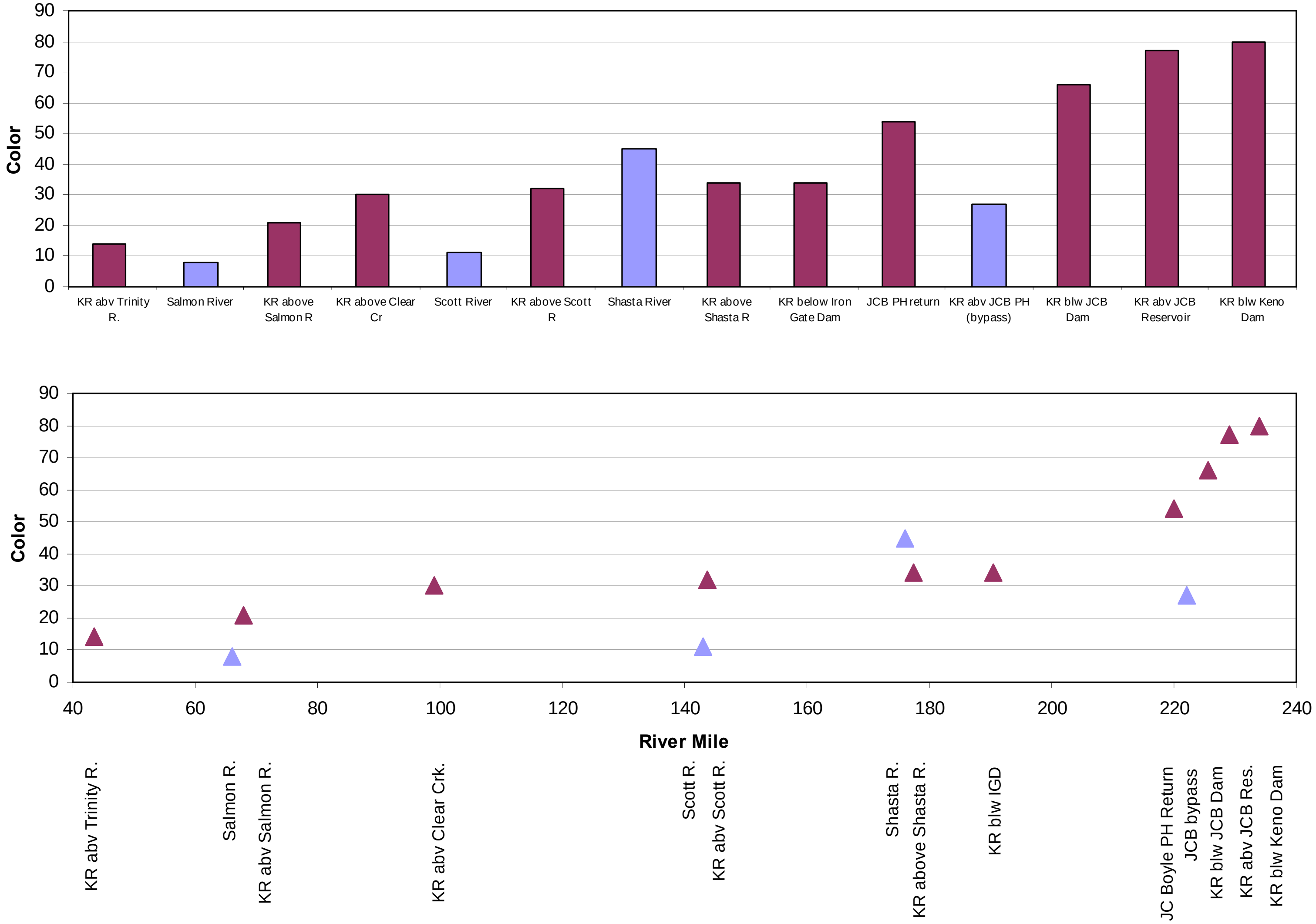

Figure 5.2-29. Color in water (Platinum-Cobalt units) at various locations in the Klamath River measured August 9-11, 2004.

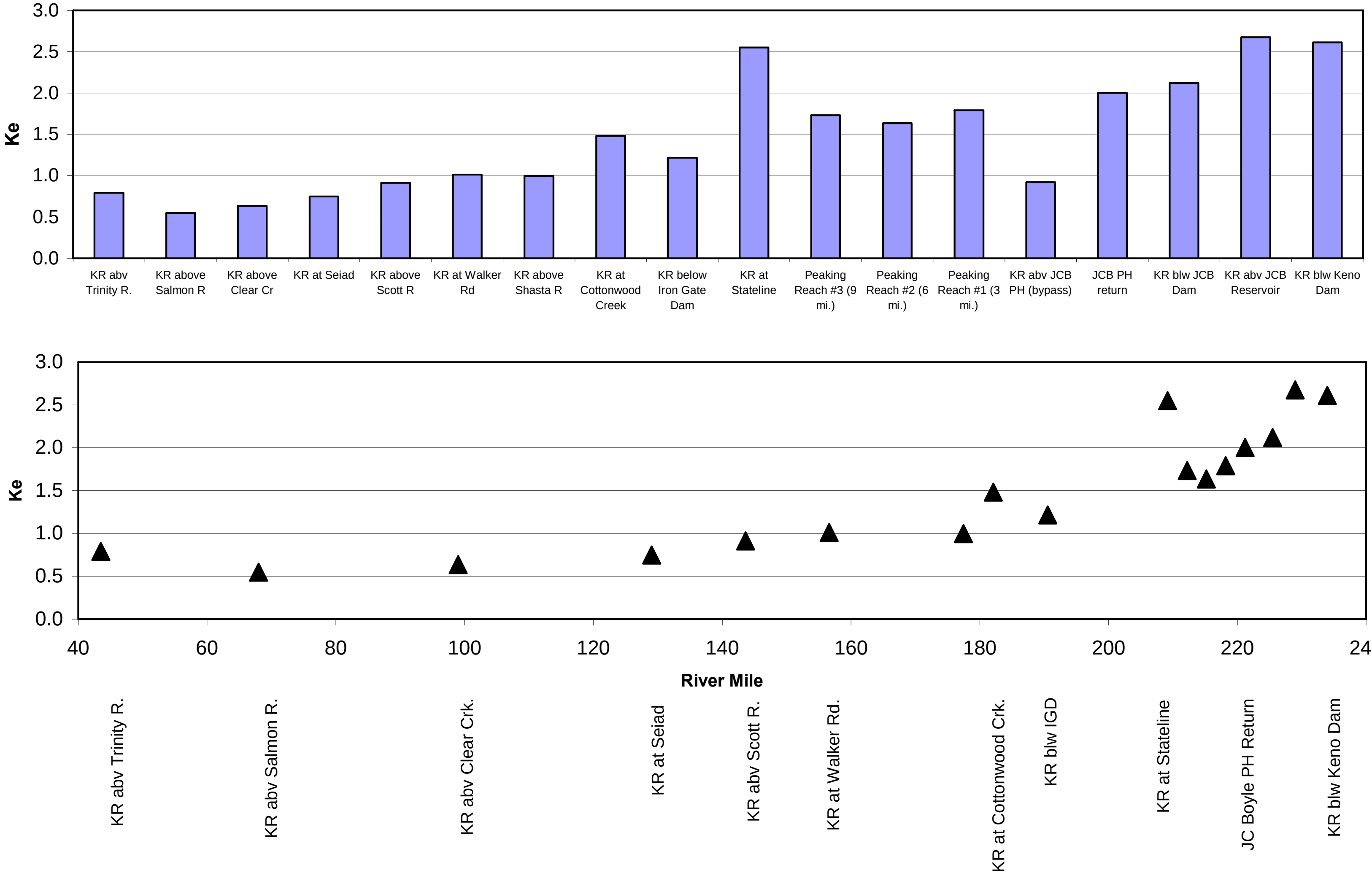

Figure 5.2-30. Light extinction coefficients (Ke; 1/m) at various locations in the Klamath River measured August 9-11, 2004.

5.2.6.4 Effects on Fish and Aquatic Life

A review of the available scientific literature found no biological relationships between color and survival of various life-history stages of salmonids. There is no evidence that color has adversely affected habitat conditions in the Klamath River for salmonids or other freshwater aquatic species.

5.2.6.5 Proposed Measures

PacifiCorp proposes no measures with respect to color.

5.2.7 Taste and Odor

5.2.7.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:

Waters shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance or adversely affect beneficial uses.

5.2.7.2 Present Conditions

No quantitative data are available with respect to taste and odor. During conversation with anglers on the river and reservoirs of the Project the subject of objectionable tastes of fish has not been mentioned. Based on recreational user surveys conducted for PacifiCorp’s FLA (PacifiCorp 2004a), there is anecdotal evidence of objectionable odors caused by algae blooms in waters in the Project vicinity.

5.2.7.3 Project Contribution

The project discharges no substances and adds no nutrients to the water that would provide an opportunity for the introduction or production of objectionable tastes or odors. Also, since waters in the Project area are not used for drinking water supply, there are no effects to potability of drinking water.

Abundant algal growth, such as can occur seasonally in Copco and Iron Gate reservoirs, can potentially create tastes or odors in water . However, any such abundant algae growth is primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly UKL. In any event, as evidenced by the actions and activities described in the RMP (Appendix B), PacifiCorp is engaged in a proactive process to help control algae in the Project reservoirs, which would reduce or eliminate any odor issues that may be associated with that algae.

5.2.7.4 Effects on Fish and Aquatic Life

There is no evidence or information to suggest that taste and odor have adversely affected habitat conditions on the Klamath River for salmonids or other freshwater aquatic species.

5.2.7.5 Proposed Measures

PacifiCorp proposes no specific measures with respect to the taste or odor criteria. As mentioned above, the RMP (Appendix B) being implemented by PacifiCorp includes actions and activities aimed at control of algae in the Project reservoirs, which would reduce or eliminate any odor issues that may be associated with that algae.

5.2.8 Floating Material

5.2.8.1 Applicable Criteria

North Coast Basin Plan, at 3-2.00:

Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.

5.2.8.2 Present Conditions

No specific measurements have been made to quantify the presence of foams or scums in the waters of the Project in California. White foam, sometimes quite abundant, is frequently seen in the Klamath River above Copco reservoir. This is a natural phenomenon that results from the agitation of the abundant proteinaceous matter in the river water as it is agitated passing through the rapids between J.C. Boyle dam and Copco reservoir.

During the summer, dense blooms of algae (particularly blue-green algae) may be blown by wind and accumulate near shore and in protected inlets in Copco and Iron Gate reservoirs. *Microcystis aeruginosa* is one of the bloom-forming species present in the reservoirs, and is capable of producing toxins that can pose a health risk to humans and other animals when present in sufficient concentration. As discussed in Section 5.2.14, dense accumulations of *Microcystis* and its associated toxin microcystin have been observed and systematically quantified since 2004.

5.2.8.3 Project Contribution

Abundant algal growth, such as can occur seasonally in Copco and Iron Gate reservoirs, can result in the production of surface foam or floating material. However, any such abundant algae growth is primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly UKL. The Project adds no nutrients or organic matter to the water that would result in the production of surface foam or floating material. Although the project adds no nutrients to the water, nutrients may be released from the sediments of the reservoirs during periods of hypolimnetic oxygen deficit. Because these nutrients are sequestered in the hypolimnion, they are not available to promote algal growth during the growing season, and they are rapidly flushed from the reservoirs during high flow in the winter.

There is no evidence that floating material has adversely affected habitat conditions on the Klamath River for salmonids or other freshwater aquatic species, or otherwise affect beneficial uses.

5.2.8.4 Proposed Measures

The RMP (Appendix B) being implemented by PacifiCorp includes actions and activities aimed at control of algae in the Project reservoirs, which would reduce or eliminate potentially adverse production of surface foam or floating material. PacifiCorp also is supporting and funding further studies of bloom-forming blue-green algae in the Klamath River basin, particularly *Microcystis aeruginosa*. In addition, the RMP (Appendix B) will address water quality conditions in the reservoirs resulting from contribution of nutrients and organic matter from upstream sources that is expected to have a beneficial affect on algae floating material. In addition, the pending TMDL for dissolved oxygen and nutrients is expected to address loads of organic material contributed from upstream sources, which will further improve water quality conditions affecting algae species and floating material.

5.2.9 Suspended Material

5.2.9.1 Applicable Criteria

North Coast Basin Plan, at 3-2.00:

Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

5.2.9.2 Present Conditions

Total suspended solids were measured on samples from seven locations in the Klamath River between the Oregon border and the mouth of the Shasta River. Summary statistics for total suspended solids are presented in Table 5.2-26.

Table 5.2-26. Summary statistics for total suspended solids values measured in the Klamath River between the Oregon border and the mouth of the Shasta River in 2000 through 2007. One high value was obtained from a sample taken from a dense algal bloom on Copco Reservoir. All other values were relatively low; 90 percent of values were less than 12 mg/L. Nuisance levels of suspended materials have not been observed.

Total Suspended Solids (mg/L)	
Count	171
Mean	4.3
Maximum	280
75th percentile	3.6
Median	2
25th percentile	1
Minimum	0

5.2.9.3 Project Contribution

No physical activity or biological process associated with the Project would result in the production of suspended materials in the water.

Effects on Fish and Aquatic Life

There is no evidence that suspended material has adversely affected habitat conditions on the Klamath River for salmonids or other freshwater aquatic species, or otherwise affect beneficial uses.

5.2.9.4 Proposed Measures

PacifiCorp proposes no specific measures with respect to suspended material, although the proposed reservoir management plan could have a beneficial effect on suspended materials (see Appendix B).

5.2.10 Oil and Grease

5.2.10.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:

Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

5.2.10.2 Present Conditions

Although no quantitative data are available with respect to oil and grease, there is no evidence or information (based on more than 60 field visits to the Project) to indicate that objectionable films or coatings are present in the Project area. There is no evidence that oil and grease adversely affect habitat conditions on the Klamath River for salmonids or other freshwater aquatic species, or otherwise adversely affect beneficial uses.

5.2.10.3 Project Contribution

Nothing is added to the water by the Project to cause objectionable visible film or coating on the water.

5.2.10.4 Proposed Avoidance or Mitigation Measures

No measures are proposed with respect to oil and grease. Current spill prevention and response plans are maintained at all project facilities in order to facilitate rapid response in the unlikely event of an accidental release to Project waters.

5.2.11 Biostimulatory Substances

5.2.11.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:

Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

5.2.11.2 Present Conditions

UKL is subject to very large blooms of phytoplankton, and exports large quantities of algae, organic matter, and algal nutrients to Keno reservoir. Organic matter and algal nutrients are augmented by discharges to Keno reservoir from irrigation return flows from agricultural activities in the upper basin. As water from UKL moves downstream, biological and physical processes act on the nutrients and organic matter, converting particulate organic matter to dissolved nutrients, and altering the form of some nutrients—for example, ammonia nitrogen to nitrate nitrogen. In the free-flowing river segments, these processes may be limited by high velocity, short residence time, and limited light availability because of the high light extinction that exists in the Klamath River. Despite these processes, however, the Klamath River flows into California abundantly supplied with nutrients that promote algal growth.

Chlorophyll *a* data collected approximately monthly between March and November 2000 through 2005 are presented in Figure 5.2-31 for both Oregon and California. Nutrient data have been collected approximately monthly between March and November 2000 through 2005, and June through November 2007, and are presented below by river segment.

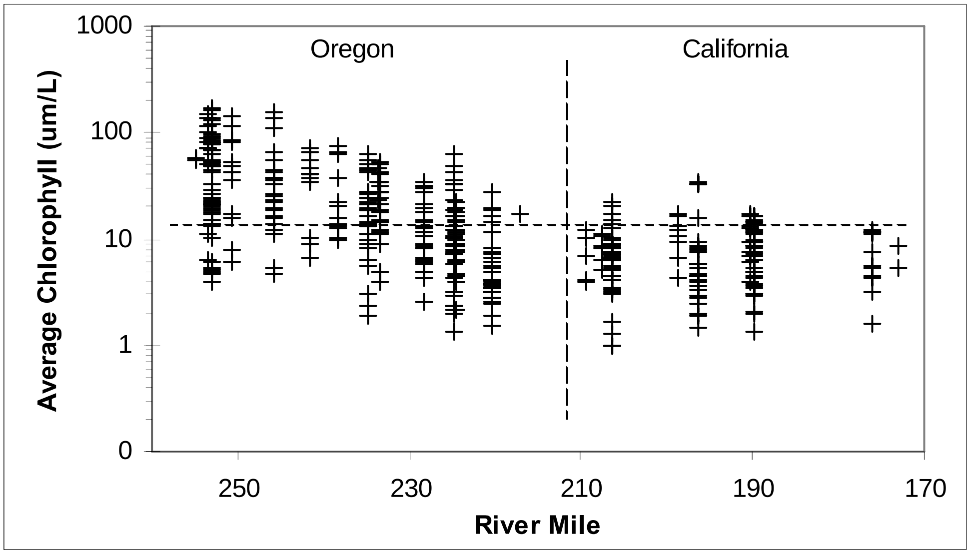

Figure 5.2-31. Average chlorophyll *a* concentration of sequential sets of three consecutive monthly values for data collected from 2000 through 2005 at various locations in the Klamath River. Note the logarithmic scale on the Y axis. The horizontal dashed line marks a 0.015 mg/L (15 µg/L) guidance value, the vertical dashed line marks the approximate location of the Oregon-California border.

Klamath River from Stateline to Copco Reservoir

The composition of the water in this reach changes from mostly spring-fed ground water when the project is not operating, to dominantly Klamath River water originating from UKL when power is being generated. As a consequence, the concentration of nutrients increase as the water from UKL dominates this reach. Total nitrogen, phosphorus, and organic carbon are all lower at the bottom of this river segment than at the top. The reduction is mostly the result of dilution of UKL water by the springs below J.C. Boyle dam.

Summary statistics for nutrient concentration measured in the Klamath River at RM 206 are presented in Table 5.2-27.

Table 5.2-27. Summary statistics for nutrient values measured in the Klamath River at RM 206 in 2000 through 2007.

	NO_3	NH_3	PO_4	PT	TKN
N	62	58	62	56	57
Mean	0.479	0.101	0.119	0.172	0.869
Minimum	0.000	0.000	0.000	0.020	0.000
1st Quartile	0.239	0.031	0.053	0.078	0.504
Median	0.424	0.050	0.405	0.150	0.800
3rd Quartile	0.708	0.080	0.170	0.210	1.105
Maximum	1.400	2.070	0.390	0.670	2.200

Copco Reservoir Hydrologic Subarea

Copco Reservoir is eutrophic as a result of nutrient loads from upstream sources. The nutrient processes in Copco reservoir are complex. Field observations indicate that Copco reservoir water quality responds strongly to inflow and variations in the quantity and quality of the influent water. Copco reservoir acts as a net sink for both total nitrogen and total phosphorus (Kann and Asarian, 2005), but there may be periods of the year when discharge of nutrients from the reservoir exceed inputs (making it appear that the reservoir is a source of nutrients to Iron Gate reservoir). In fact, algal blooms, severe anoxia, fish kills and the associated water quality conditions that occur in UKL and Keno reservoir may produce large inputs of nutrient and organic matter into Copco reservoir. This material is processed in the reservoir and after a delay of days or perhaps weeks, may show up as increased nutrient flux at the Copco reservoir outlet.

Water quality conditions in Copco reservoir are also affected by Klamath River inflows (as compared to spring-dominated flows) which are relatively warm and tend to stay near the surface where the nutrients are more readily available to promote algal growth.

Summary statistics for nutrient concentration measured in Copco reservoir are presented in Table 5.2-28. Median values for nutrients measured at different depths are presented in Table 5.2-29.

Table 5.2-28. Summary statistics for nutrient values (mg/l) measured in Copco reservoir in 2000 through 2005.

	NH_3	**NO_3**	**PO_4**	**PT**	**TKN**
N	151	150	151	121	120
Mean	0.244	0.316	0.180	0.258	1.019
Minimum	0.000	0.000	0.000	0.020	0.180
1st Quartile	0.070	0.079	0.068	0.105	0.700
Median	0.110	0.298	0.120	0.170	0.900
3rd Quartile	0.270	0.480	0.240	0.355	1.200
Maximum	1.600	1.230	0.940	1.350	3.800

Table 5.2-29. Median values for nutrients (mg/L) measured at different depths (meters) in Copco reservoir.

Depth Range	**N**	**NO_3**	**NH_3**	**PO_4**	**PT**	**TKN**
1-6	47	0.230	0.070	0.100	0.161	0.937
6-12	34	0.245	0.090	0.097	0.137	0.875
12-18	37	0.340	0.120	0.130	0.190	0.800
18-24	20	.0305	0.450	0.280	0.320	1.235
24-30	39	0.333	0.190	0.157	0.370	1.040
30 +	5	0.333	0.335	0.256	0.324	1.117

Iron Gate Hydrologic Subarea

Iron Gate reservoir is eutrophic largely because of nutrient inputs from upstream sources. Tributary inputs are small in comparison to the Klamath River. Iron Gate reservoir acts as a net sink for both total nitrogen and total phosphorus (Kann and Asarian 2005). As with Copco reservoir, there are times during the year when Iron Gate reservoir may appear to act as a source of nutrients. However, as with Copco reservoir, the interaction of inflow, residence time, interflow, and in-reservoir processing actually drive nutrient output from the reservoirs.

Nutrients entering Iron Gate reservoir in the inflow from Copco reservoir may not always enter the eplimnion, but rather flow as an interflow at depth because of the its cooler temperature as a result of release at depth from Copco. Under calm conditions such nutrients may not be available to algae in the photic zone and organic matter may settle out more readily.

The entire volume of both Copco and Iron Gate reservoirs is replaced during the winter, thus limiting the opportunity to sequester nutrients in the sediment which would promote eutrophication through internal nutrient cycling. Nutrients that may be released from the sediments during summer stratification are not available to promote algal growth the following spring.

Summary statistics for nutrient concentration measured in Iron Gate reservoir are presented in Table 5.2-30. Median values for nutrients measured at different depths are presented in Table 5.2-31.

Table 5.2-30. Summary statistics for nutrient values (mg/l) measured in Iron Gate reservoir in 2000 through 2005.

	NO_3	**NH_3**	**PO_4**	**PT**	**TKN**
N	213	202	213	176	176
Mean	0.409	0.091	0.109	0.151	0.740
Minimum	0.000	0.000	0.000	0.013	0.200
1st Quartile	0.212	0.030	0.060	0.096	0.505
Median	0.380	0.070	0.101	0.125	0.674
3rd Quartile	0.596	0.120	0.150	0170	0.900
Maximum	1.100	0.730	0.380	0.500	2.120

Table 5.2-31. Median values for nutrients (mg/l) measured at different depths (meters) in Iron Gate reservoir.

Depth Range	**N**	**NO_3**	**NH_3**	**PO_4**	**PT**	**TKN**
1-6	48	0.136	0.060	0.099	0.130	0.900
6-12	33	0.222	0.070	0.100	0.130	0.068
12-18	34	0.350	0.062	0.096	0.140	0.630
18-24	17	0.530	0.065	0.100	0.123	0.618
24-30	30	0.453	0.090	0.127	0.155	0.594
30-36	26	0.650	0.073	0.920	0.130	0.681
36-42	23	0.600	0.080	0.130	0.145	0.726
42 +	2	0.751	0.025	0.045	0.049	1.030

Hornbrook Hydrologic Subarea

The Klamath River from Iron Gate dam to the Shasta River is eutrophic largely because of nutrients from sources upstream of the Project. Although Copco and Iron Gate are net sinks for total nutrients and particulates, they may also transform some nutrients into more soluble forms that are released to the lower river. Nutrients released from the dam, especially ammonia are taken up readily by algae in the river, and perhaps especially by attached macrophytes growing in the river between Iron Gate dam and the Shasta River. Nitrate and phosphorus decrease steadily with distance from Iron Gate dam.

Summary statistics for nutrient concentration measured in the Klamath River at RM 176 are presented in Table 5.2-32.

Table 5.2-32. Summary statistics for nutrient values (mg/l) measured in the Klamath River at RM 176 near Interstate 5 in 2000 through 2007.

	NO_3	**NH_3**	**PO_4**	**PT**	**TKN**
N	30	30	30	30	24
Mean	0.217	0.120	0.097	0.135	0.725
Minimum	0.019	0.000	0.019	0.029	0.400
1st Quartile	0.088	0.023	0.028	0.029	0.751
Median	0.196	0.051	0.097	0.135	0.700
3rd Quartile	0.307	0.090	0.130	0.160	0.907
Maximum	0.820	2.030	0.210	0.240	1.300

5.2.11.3 Project Contribution

There is no process or discharge associated with the Project that contributes nutrients to the Klamath River. The nutrient concentrations observed in the relevant river segment are the result of input from upstream sources, particularly UKL, and as modified by physical and biological processes in the River.

PacifiCorp's relicensing studies (PacifiCorp 2004a, 2004h) and other more recent analyses (PacifiCorp 2006, Kann and Asarian 2005, Asarian and Kann 2006, Kann and Asarian 2007) provide substantial evidence that the reservoirs act as a net sink for nutrients (nitrogen and phosphorus). For example, the total annual net retention of nutrients in Copco and Iron Gate reservoirs is presented in Table 5.2-33 based on the analysis of Kann and Asarian (2005) using predominantly PacifiCorp 2002 nutrient data and the analysis of Kann, and Asarian (2007) based on data collected during 2005 and 2006 by the Karuk Tribe under contract to the State Water Board.

Table 5.2-33. Total net retention of nutrients (in metric tons) by Copco and Iron Gate reservoirs based on data from Kann and Asarian (2005, 2007). "NA" indicates data not available (Kann and Asarian [2007] did not perform loading calculations for total inorganic nitrogen and orthophosphate).

	From Kann and Asarian (2005) Analysis Using PacifiCorp Nutrient Data for April-November 2002		**From Kann and Asarian (2007) Analysis Using Karuk Tribe Nutrient Data for May 2005 to May 2006**	
Constituent	**Net Retention (tons)**	**Percent of Inflow Load (%)**	**Net Retention (tons)**	**Percent of Inflow Load (%)**
Total Nitrogen	142	23	618	18
Total Inorganic Nitrogen	100	43	NA	NA
Total Phosphorus	34	24	41	13
Orthophosphate	20	23	NA	NA

Both analyses (Kann and Asarian 2005, 2007) demonstrate that the total annual retention of nutrients by the reservoirs is substantial, especially for nitrogen. The analysis based on the 2002 data indicated that Iron Gate and Copco reservoirs retained 142 metric tons (or about 23 percent) of total nitrogen (TN) inflow. The analysis based on the 2005-2006 data indicated that the reservoirs retained 618 metric tons (or about 18 percent) of TN inflow. The analyses indicated that the reservoirs retained 34 and 41 metric tons (or about 24 percent and 13 percent), respectively, of total phosphorus (TP) inflow. The analysis based on the 2002 data further indicated that the reservoirs retained over 43 percent of total inorganic nitrogen (TIN) and 23 percent of orthophosphate (PO_4)—the soluble and more bioavailable form of the nutrients. (Note: Kann and Asarian [2007] did not perform loading calculations for TIN and PO_4 using the Karuk Tribe nutrient data for May 2005 to May 2006.)

Also, when viewed in shorter time intervals (e.g., monthly or twice-monthly), retention by Copco and Iron Gate reservoirs is relatively consistent through the year. As Figure 5.2-32 shows, the Kann and Asarian (2005) analysis shows substantial cumulative monthly net nutrient retention by the reservoirs throughout the 2002 period. Similarly, the Kann and Asarian (2007) analysis shows net retention of TN by the reservoirs in 20 of the 23 time intervals (approximately twice-monthly) used in the loading calculations for the analysis of the 2005-2006 nutrient data (see Table 6 in Kann and Asarian 2007). (Note: Of the three intervals without net retention, two occurred during winter, when nutrient effects on algae growth and water quality are low. The third occurred in July, but was of very small magnitude, and was both preceded and followed by intervals of large net retention.)

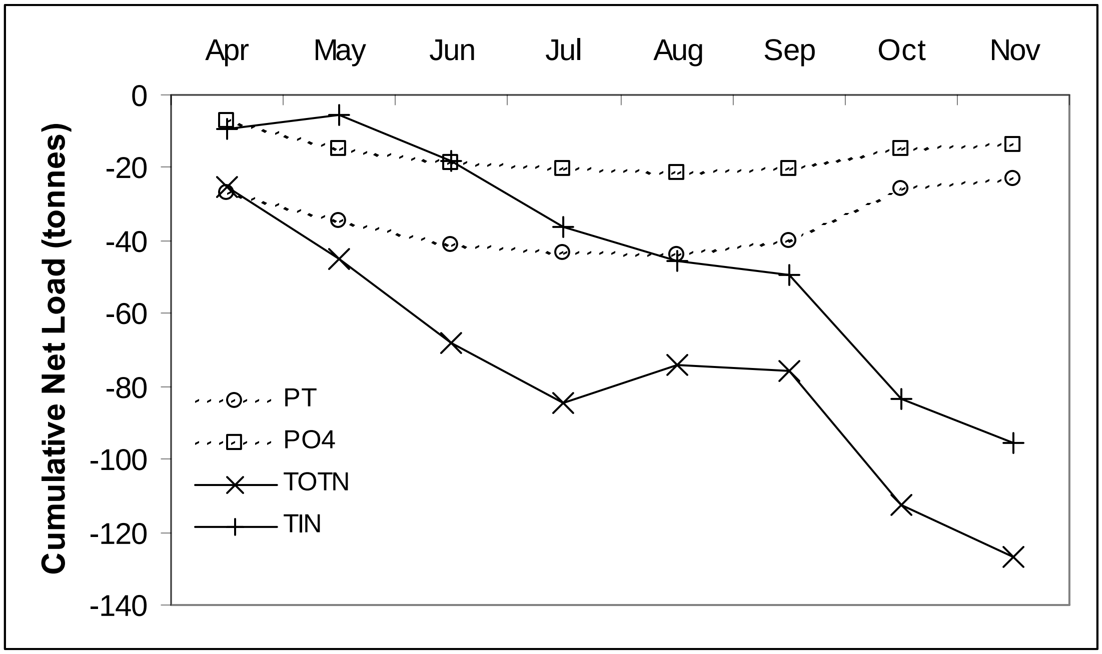

Figure 5.2-32. The cumulative difference in nutrient load (tons) between the Klamath River above Copco and the Klamath River below Iron Gate Dam. A negative value indicates that the load at Iron Gate is less than the load above Copco. (Data from Kann and Asarian, 2005).

In still another analysis, Asarian and Kann (2006) assessed nitrogen[23] loading and retention in Copco and Iron Gate reservoirs compared to the river reaches below Iron Gate dam for the June-October period. Nitrogen loading and retention calculations by Asarian and Kann (2006) for the river reaches below Iron

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[23] Asarian and Kann (2006) state that their analysis “focuses solely on nitrogen because it is generally considered to be the nutrient which most often drives plant and algal growth in the Klamath River” (page 1).

Gate dam are summarized in Table 5.2-34. For comparison purposes, we include nitrogen loading and retention calculations for Copco and Iron Gate reservoirs for the comparable June-October period based on the 2002 and 2005-2006 data (derived from information in Kann and Asarian 2005, 2007).

Table 5.2-34. Summary of net total nitrogen (TN, in metric tons) retention in Copco and Iron Gate reservoirs (based on analyses using 2002 and 2005-2006 data) compared to reaches of the Klamath River below Iron Gate dam for the June-October period as reported by Asarian and Kann (2006) based on 2001-2002 nutrient data

	Copco and Iron Gate Reservoirs	**Iron Gate to Seiad Valley**	**Seiad Valley to Happy Camp**	**Happy Camp to Orleans**	**Orleans to Martins Ferry**	**Martins Ferry to Klamath Glen**	**Total**
Length (RM)	RM 203 to RM 190	RM 190 to 129	RM 129 to 101	RM 101 to 59	RM 59 to 40	RM 40 to 5.8	RM 190 to 5.8
Length (miles)	13	61	28	42	19	34	184
TN Retention (metric tons)							
2001	--	104	28	115	-38	-92	117
2002	**70**	80	-37	87	-76	62	116
2005	**195**	--	--	--	--	--	--
TN Retention (metric tons per mile)							
2001	--	1.7	1.0	2.7	-2.0	-2.7	0.6
2002	**5.4**	1.3	-1.3	2.1	-4.0	1.8	0.6
2005	**15.0**	--	--	--	--	--	--

The information in Table 5.2-34 provides substantial evidence that net nutrient retention (reduction) in the reservoirs is much greater than nutrient retention in river reaches. For example, if all river reaches are considered, the overall total of the net TN retention calculated by Asarian and Kann (2006) for the 184 miles of the Klamath River from Klamath Glen to Iron Gate (RM 5.8 to 190) equals about 116 metric tons, or 0.6 metric tons per mile (Table 5.2-34). By comparison, information presented in Kann and Asarian (2005) indicates the overall total of the net TN retention in Copco and Iron Gate reservoirs during the comparable June-October period of 2002 equals about 70 metric tons, or 5.4 metric tons per mile. Moreover, information presented in Kann and Asarian (2007) indicates the overall total of the net TN retention in Copco and Iron Gate reservoirs during the comparable June-October period of 2005 equals about 195 metric tons, or 15.0 metric tons per mile. Comparison of these values indicates that the reservoirs have a substantial positive effect on TN retention when compared to the lower Klamath River as a whole.

In addition, PacifiCorp notes that there are clear cases where Asarian and Kann's (2006) derived retention values show consistent negative retention of nitrogen in river reaches (that is, the reaches are a "source" of nutrients with higher nutrient levels leaving the reach than entering the reach), such as Seiad Valley to Happy Camp based on 2002 data, Orleans to Martins Ferry based on 2001 and 2002 data, and Martins Ferry to Klamath Glen based on 2001 data (Table 5.2-34). In a comprehensive review of the literature on nitrogen retention in rivers, Bernot and Dodds (2005) indicate that long term data sets have shown that the capacity of rivers to remove instream nitrogen loads decreases as river size increases—that is, the larger the river, the greater the amount of nitrogen delivered downstream. Bernot and Dodds (2005) also report that in systems where baseline N loads and concentrations are high, uptake of nitrogen is limited—that is, with chronic N loading, N export in rivers increases and the rate of increase is proportional to the load.

5.2.11.4 Effects on Fish and Aquatic Life

Nitrogen and phosphorus, in the forms of nitrate and phosphate, are common nutrients within the Klamath River basin that stimulate phytoplankton production and contribute to eutrophic conditions. High phytoplankton production within the system contributes to a variety of water quality changes that affect habitat for salmonids and other fish and invertebrates. Phytoplankton contribute to local and seasonal changes in dissolved oxygen concentrations, pH, biological oxygen demand, and organic loading. Increased organic loading may affect habitat conditions for interim hosts and pathogens that ultimately affect the health and survival of fish.

Based on the concentrations of nutrients reported in the Klamath River downstream of Iron Gate dam, there is no evidence that nutrient exposure would result in direct mortality to salmonids. Westin (1974 cited in Pitt 2000) reported a 96-hour LC50 for juvenile rainbow trout exposed to nitrate at a concentration of 1,360 mg/L and a 7-day LC50 nitrate concentration of 1,060 mg/L. Nitrite has been found to be substantially more toxic to fish than nitrate. The 96-hour and 7-day LC50 concentrations reported by Westin (1974) for nitrite nitrogen for juvenile Chinook salmon was reported to be 0.9 and 0.7 mg/L, respectively. Yearling rainbow trout were reported by Smith and Williams (1974 cited in Pitt 2000) to suffer 55 percent mortality after 24-hour exposure to a nitrate concentration of 0.55 mg/L while fingerling rainbow trout suffered 50 percent mortality after 24-hour exposure at a nitrate concentration of 1.6 mg/L. These concentrations are well above those found in the Klamath River. Juvenile Chinook salmon were observed to have a similar toxicity response when exposed to nitrite as juvenile rainbow trout. Toxicity of nitrate and nitrite has been reported to be more severe for salmonids when compared to resident warm water fish species.

The indirect effects of nutrient stimulation resulting in high phytoplankton production and eutrophic conditions within the watershed affect quality and availability of habitat for various fish species within UKL, reservoirs, and within the river but are not the effects of Project operations. The specific effects of nutrient loading and eutrophication on fish and aquatic life within the Klamath River basin have not been extensively studied. The appropriate forum for addressing these conditions is the Klamath River TMDL process currently underway.

The Klamath River downstream of UKL is a eutrophic system in which water quality is affected by interactions of flow, geomorphology, meteorological conditions, tributary flow and quality, and other factors. With the onset of warm weather, water temperatures in the Klamath River from Iron Gate reservoir to the ocean are generally at or near equilibrium; the river has maximum daily temperatures approaching 30ºC in certain river segments. Certain reaches downstream of Iron Gate dam provide a suitable environment for aquatic vegetation and extensive periphyton growth. There are reaches where dissolved oxygen concentrations can deviate substantially from saturation levels, mostly in response to the appreciable organic load being carried by the river. Because the Klamath River is weakly-buffered, algal production processes can cause notable diurnal variations in pH; it is not uncommon for pH values to exceed 9.0 in the warmest parts of the day. All of these factors have the potential, singly or in combination, to affect fish and aquatic species.

5.2.11.5 Proposed Measures

The Project does not contribute to excess concentration of biostimulatory substances in the Klamath River. The abundance of chlorophyll *a*, and the growth of phytoplankton are a natural consequence of the occurrence of excess nutrients from upstream sources. The appropriate means to address chlorophyll concentrations within the project and other waters influenced by the project is to control the range load of nutrients as in implementation of TMDLs. Nevertheless, PacifiCorp’s RMP (Appendix B) is implementing several actions and activities aimed at addressing primary production in Copco and Iron

Gate reservoirs resulting from nutrient loading from upstream sources. It is anticipated that the RMP actions and activities will have the effect of reducing algae growth and thus reducing chlorophyll concentrations within the reservoirs.

5.2.12 Sediment

5.2.12.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

5.2.12.2 Present Conditions

Total suspended solids were measured on samples from the Klamath River collected in 2004, 2005, and 2007. Summary statistics are presented in Table 5.2-35. Total suspended solids concentrations in the Klamath River are relatively low. Total suspended solids decrease in magnitude from above Copco reservoir to below Iron Gate dam (Figure 5.2-33).

Table 5.2-35. Total suspended solids values (mg/L) measured on samples from the Klamath River.

Site ID	KR17300	KR17600	KR18973	KR19019	KR19645	KR19874	KR20642
River Mile	173	176	189	190	196	198	206
N	5	13	24	90	21	71	24
Mean	3.52	3.05	2.22	2.04	2.86	7.49	4.5
Minimum	0.8.	0.8	0.0	0.0	0.0	0.0	0.4
1st Quartile	1.2	1.8	0.4	0.8	1.4	1.2	2.8
Median	62.4	2.4	1.6	1.6	2.8	2.4	4.4
3rd Quartile	6.4	3.6	3.5	2.8	4.4	4.0	5.6
Maximum	9.6	9.6	8.0	12.8	6.4	280	12.0

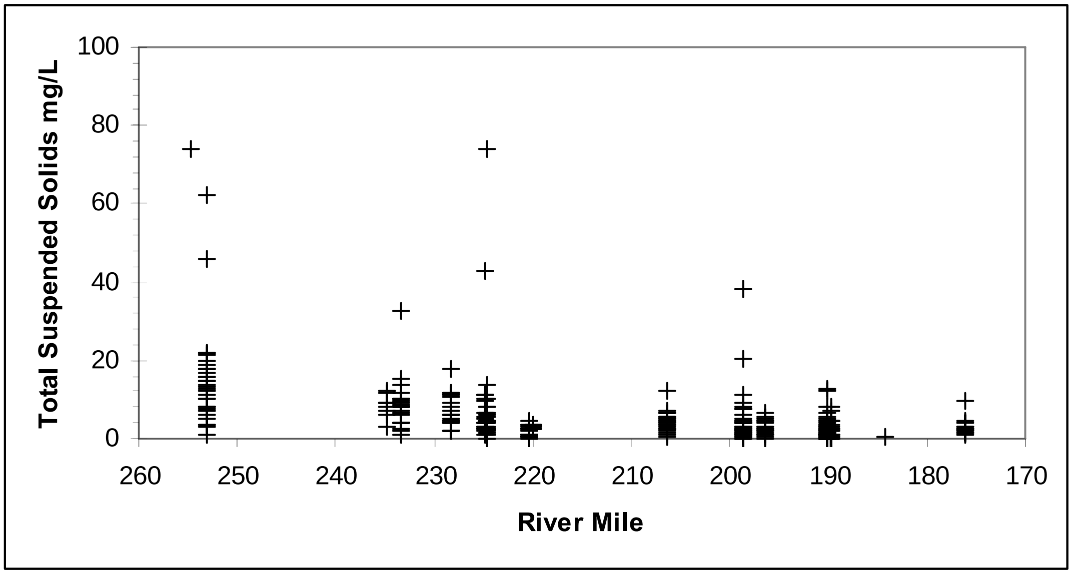


Figure 5.2-33. Total suspended solids measured on samples from the Klamath River between Link River in Oregon and the mouth of the Shasta River in California in 2001 through 2007.

5.2.12.3 Project Contribution

Under normal conditions the Project conducts no activity and discharges no substance that would increase suspended solids or turbidity in the Klamath River. To the extent emergency conditions (as a result of natural catastrophe or unexpected operations upset) may create conditions that increase suspended sediments, an emergency permit or waiver would be sought if the discharge were in conflict with this water quality objective.

Effects on Fish and Aquatic Life

The response of fish to suspended sediments varies among species and lifestages as a function of suspended particle size, particle shape (angularity), water velocities, suspended sediment concentration, water temperature, dissolved oxygen concentrations, contaminants, and exposure duration (Newcombe and Jensen 1996). Results of a literature review were used to assess potential lethal and/or sublethal effects on various lifestages of salmonids. The literature identifies five ways in which high concentrations of suspended sediment could adversely affect fish:

- Reduced rates of growth and reduced tolerance to disease or resulting in mortality (lethal concentrations of suspended sediments primarily kill by clogging gill rakers and gill filaments).

- Reductions in the suitability of spawning habitat and affecting the development of eggs, larvae and juveniles (these stages typically are the most susceptible to suspended sediment, much more so then adult fish).

- Modification of migration patterns.

- Reduction in the abundance of food available to fish due to a reduction in light penetration and prey capture (feeding activity), reduced primary production, and a reduction of habitat available to insectivore prey items.

- Effects on the efficiency of prey detection and foraging success, particularly in the case of visual feeders.

The dose response of fish to increased suspended sediment concentrations has been discussed within the literature. The principal of the dose response is that there is a relationship between a biological reaction or response, whether lethal or sublethal (the response) and the concentration of sediment the organism is exposed to over a given time period (the dose). An important element of this relationship is that there is a dose below which no response occurs or can be measured.

Responses to suspended sediments have been studied in depth for salmonids (Wilber and Clarke 2001). These studies include subtle reactions that could be indications of physiological stress such as increased cough reflexes, reduced swimming activity, gill flaring and territoriality. Short-term pulses of suspended sediments that involve a sharp increase within an hour can disrupt the feeding behavior and dominance hierarchies of juvenile salmon. These increases can also cause an alarm reaction that can lead to fish relocating to undisturbed areas. The behavioral response of juvenile coho salmon to sublethal concentrations of suspended sediments (Servizi and Martens 1992) showed less than a 5 percent avoidance response to suspended sediment concentrations up to 2,550 mg/L, although a more definite avoidance response was observed (25 percent) when suspended sediment concentrations increased to 7,000 mg/L. No specific data have been found on the effects of suspended sediment concentrations on migration of steelhead; however, studies by Redding and Schreck (1982) identified signs of sublethal stress for steelhead adults exposed to suspended sediment concentrations of 500 mg/L for 3 hours.

Salmonids inhabiting the Klamath River system are exposed naturally to a wide range of suspended sediment concentrations associated with basin runoff. There is no evidence or information, however, that Project operations contribute to increased suspended sediment exposure that would adversely affect salmonids or other resident or migratory fish within the river.

5.2.12.4 Proposed Measures

No measures are proposed with regard to total suspended solids.

5.2.13 Bacteria

5.2.13.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00:

The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels. In no case shall coliform concentrations in waters of the North Coast Region exceed the following:

In waters designated for contact recreation (REC-1), the median fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed 50/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml (State Department of Health Services).

At all areas where shellfish may be harvested for human consumption (SHELL), the fecal coliform concentration throughout the water column shall not exceed 43/100 ml for a 5-tube decimal dilution test or 49/100 ml when a three-tube decimal dilution test is used (National Shellfish Sanitation Program, Manual of Operation).

5.2.13.2 Present Conditions

No data are available with regard to bacteria.

5.2.13.3 Project Contribution

There is no Project-related discharge of raw or treated sewage or animal waste into Project waters, or any other activity that would contribute bacteriological degradation. Domestic wastes at Project facilities are treated in on-site septic systems.

Effects on Fish and Aquatic Life

Although disease, including bacterial infections, is a concern for salmonid health on the Klamath River there is no evidence of a linkage between concentrations of bacteria, such as fecal coliform, and salmonid health or survival.

5.2.13.4 Proposed Measures

No measures are proposed to address this criterion. PacifiCorp will continue to comply with the applicable state regulations for on-site domestic waste treatment facilities.

5.2.14 Toxicity

5.2.14.1 Applicable Criteria

North Coast Basin Plan, at 3-4.00:

All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Water Board.

The survival of aquatic life in surface waters subjected to a waste discharge, or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge, or when necessary for other control water that is consistent with the requirements for "experimental water" as described in Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992). As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed. Where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

5.2.14.2 Present Conditions

Toxic Substances

While no toxic substances are produced or released by the Project, PacifiCorp conducted a study at the request of third parties to assess whether toxic substances have been introduced into the sediments in the project reservoirs and, from there, into the food chain. Details of the study were presented in a technical report titled “Screening Level Determination of Chemical Contaminants in Fish Tissue in Selected Project Reservoirs,” July 2004.

Fish samples were collected from each of the Project reservoirs and UKL. Largemouth bass (*Micropterus salmoides*) was the primary target species, but black bullhead catfish (*Ameiurus melas*) were used for samples from Keno reservoir and UKL, where largemouth bass were unavailable. These species were chosen because they are the most sought after game species in these reservoirs, and consequently represent the potentially greatest risk related to consumption.

Full fillets (skin on for Bullheads, skin on and scaled for bass) were analyzed for synthetic organic compounds and trace elements (metals).

Un-ionized Ammonia

Conditions of temperature, pH, and ammonia concentration occur in the Klamath River downstream from Oregon-California border that may permit harmful concentrations of un-ionized ammonia to occur, but they are rare. No combinations of temperature, pH, and ammonia nitrogen concentration were measured in 2000 – 2007 in the Klamath River that would lead to exceedence of the EPA chronic criteria concentration for un-ionized ammonia for waters with fish early life stages present.

Cyanobacterial (Blue-Green Algae) Toxins.

Cyanobacteria have been a major component of the phytoplankton community in the Klamath basin for some time. *Aphanizomenon flos-aquae* grows in such abundance in UKL that it has supported a major harvesting program to manufacture food supplements. Recent studies (Eilers et al. 2001) suggest that the dominance of *Aphanizomenon* in UKL has come about in the last century, but cyanobacteria have been a major part of the phytoplankton community for the past 1000 years. Negative effects of algal blooms in UKL have been noted since the mid-1800s, and fish kills have been observed for more than 150 years. Conditions in UKL have a direct influence on conditions in the Klamath River and downstream reservoirs.

Aphanizomenon flos-aquae is also an abundant species in Copco and Iron Gate reservoirs, as it is in UKL. Cyanobacteria are a potential nuisance throughout the world because of the ability of some species to produce substances toxic to humans and other organisms. Although Aphanizomenon in the Klamath basin does not appear to be toxic, several potentially toxic species have been observed in samples collected from the Klamath basin. PacifiCorp has monitored the presence and abundance of phytoplankton species in the area of the Klamath hydropower project since 2001 using a consistent methodology designed to characterize the phytoplankton community. Four species from three genera of cyanobacteria known to be potentially toxic to vertebrates have been observed in the Klamath River between the Oregon-California border and the mouth of the Shasta River in samples collected by PacifiCorp in 2001 through 2005. *Anabaena flos-aquae* was observed in 25 samples, *Anabaena planctonica* was observed in one sample, *Microcystis aeruginosa* was observed in 67 samples, and *Gloeotrichia echinulata* was observed in four samples**.** *Microcystis aeruginosa* is capable of producing compounds (microcystins) that, when present in high enough abundance, may have both chronic and acute adverse effects when ingested by people or animals.

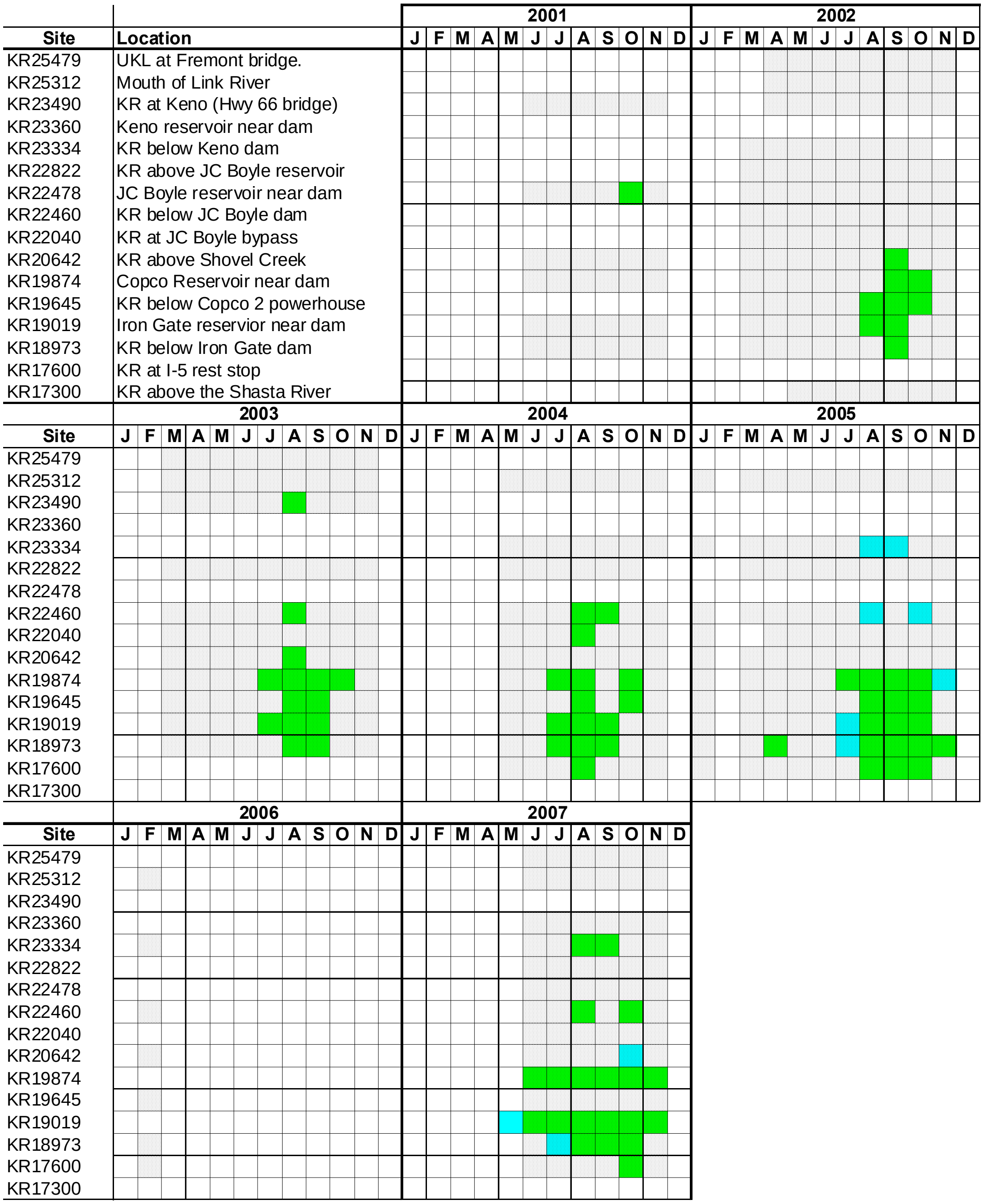
Microcystis aeruginosa was most frequently observed in samples collected from Copco reservoir and Iron Gate reservoir, and at the river stations immediately below these two reservoirs. *Microcystis aeruginosa* was not commonly found at the sites a short distance downstream from Iron Gate dam. In the sampling period from 2001 through 2005, *Microcystis aeruginosa* has usually been observed in Copco and Iron Gate reservoirs in July through September in relatively low numbers, and occasionally in October. A summary of the months and locations that *Microcystis aeruginosa* was observed is shown in Figure 5.2-34.

The frequency of occurrence, distribution, and abundance of *Microcystis aeruginosa* appears to have increased during the period of sampling; from one occurrence at one location (3.4 percent of samples) in 2001 to 27 occurrences at 7 locations (19.4 percent of samples) in 2005, as illustrated in Figure 5.2-35. Preliminary data from 2007 suggest this trend has continued. There has been no change in the configuration or operation of the Project during this period, therefore it is likely that this apparent increase is the result of some external factor, such as increased nutrient loading from upstream.

The PacifiCorp algae sampling program has been designed to characterize the phytoplankton community as a whole, and has not been specifically focused on detecting localized concentrations of potentially toxic algae. However, biweekly sampling by other groups since 2004 (Kann 2006, Kann and Asarian 2006, Fetcho 2007) has been specifically focused on finding and identifying high concentrations potentially toxic algae, in particular *Microcystis aeruginosa* and its toxin, microcystin. Between 2004 and 2007, *Microcystis aeruginosa* was observed in at least one sample during 32 of 39 growing season focused sampling events (Kann 2006, Kann and Asarian 2006, Fetcho 2007).

Microcystin toxin was present at greater than the detection limit in 62 percent (n = 78) of the samples collected from river sites in the Klamath River in Oregon (Kann 2006, Kann and Asarian 2006, Fetcho 2007). For those events for which samples were collected throughout the Klamath River, microcystin concentration was typically highest in Link River, just below Upper Klamath Lake, and generally decreased in concentration downstream. For several events there was a marked increase in microcystin concentration at approximately river mile 43, near Weitchpec (Figure 5.2-36). For several sampling events, notably August of 2006 and 2007, microcystin concentration was quite high in Link River (RM 254), and also below Iron Gate dam (RM 190). During these events the increase in microcystin concentration at Weitchpec (RM 43) was not as pronounced (Figure 5.2-37).

The distribution of MSAE and microcystin in the environment is not uniform. Very high local abundance of MSAE can result from the ability of the organism to control its buoyancy and be concentrated in coves or on windward shores by the wind. Sampling for MSAE and microcystin in 2004 through 2007 in Copco and Iron Gate reservoirs focused on detecting such high concentrations (Kann 2006, Kann and Asarian 2006, Fetcho 2007), and resulted in some notably high (e.g. Kann 2007) values for MSAE abundance and microcystin concentration when samples were collected from highly concentrated surface accumulations. Samples taken from the Klamath River had consistently lower MSAE abundance and microcystin values (Figure 5.2-38). Exposure of pets or humans to highly concentrated algal surface accumulations could pose a health risk. The potential risk varies, however, depending on the particular location. Samples collected from highly concentrated algae accumulations in shoreline areas had both the highest values for MSAE abundance and microcystin and more exceedences of guidance values compared with samples taken in the open waters of the reservoirs or at river (i.e., non-reservoir) sites (Figure 5.2-38).



Site	Location
KR25479	UKL at Fremont bridge.
KR25312	Mouth of Link River
KR23490	KR at Keno (Hwy 66 bridge)
KR23360	Keno reservoir near dam
KR23334	KR below Keno dam
KR22822	KR above JC Boyle reservoir
KR22478	JC Boyle reservoir near dam
KR22460	KR below JC Boyle dam
KR22040	KR at JC Boyle bypass
KR20642	KR above Shovel Creek
KR19874	Copco Reservoir near dam
KR19645	KR below Copco 2 powerhouse
KR19019	Iron Gate reservior near dam
KR18973	KR below Iron Gate dam
KR17600	KR at I-5 rest stop
KR17300	KR above the Shasta River

Figure 5.2-34. The occurrence of Microcystis aeruginosa in the vicinity of the Klamath hydropower project in Oregon and California. The stippled blocks indicate months and locations where samples were collected by PacifiCorp. The colored blocks indicate times when *Microcystis aeruginosa* was observed in the sample. Green = observed by PacifiCorp, Blue = observed by others. 2007 data are preliminary and may change.

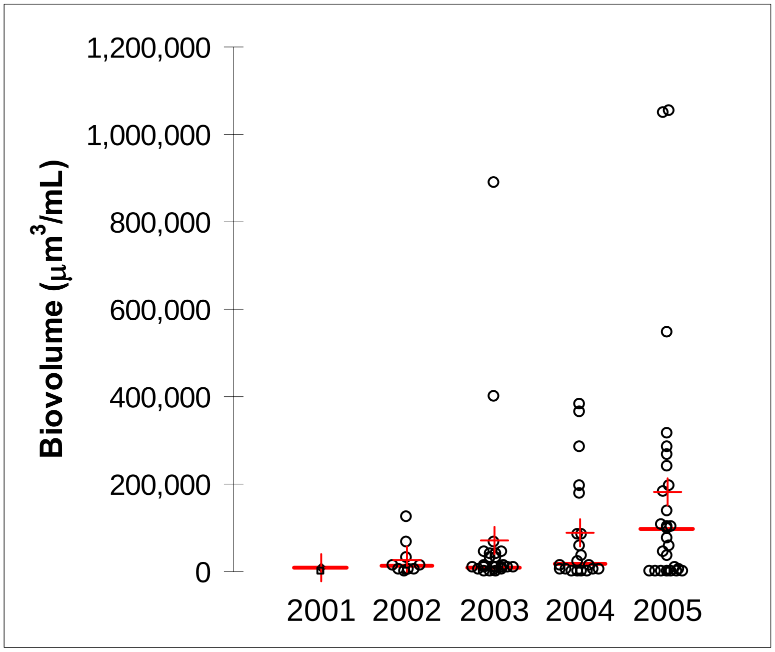


Figure 5.2-35. Scattergram showing the frequency and abundance of Microcystis aeruginosa at locations in the Klamath River between Upper Klamath Lake and the Interstate 5 freeway. The horizontal line indicates the median, the cross indicates the mean.

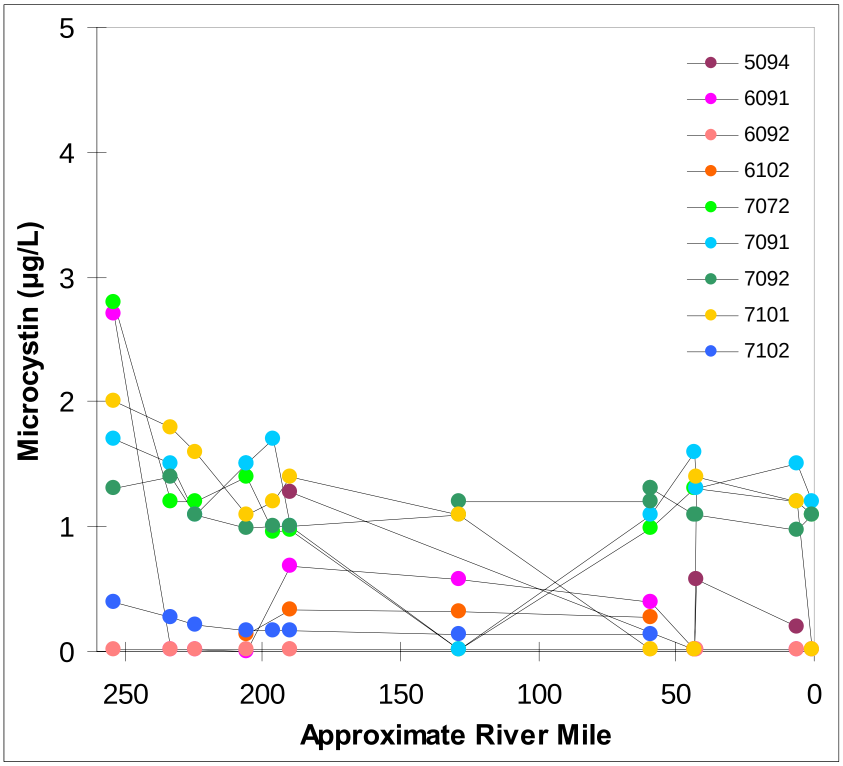


Figure 5.2-36. Microcystin concentration measured in the Klamath River on various dates showing the more typical longitudinal pattern of high concentration at Link River (RM 254), lower concentration at Orleans (RM 59), with increased concentration at Weitchpec (RM 43). The first digit of the key refers to the year, the second two digits to the month, and the last digit indicates the sampling event in that month. Not all sampling events collected microcystin samples from all sites.

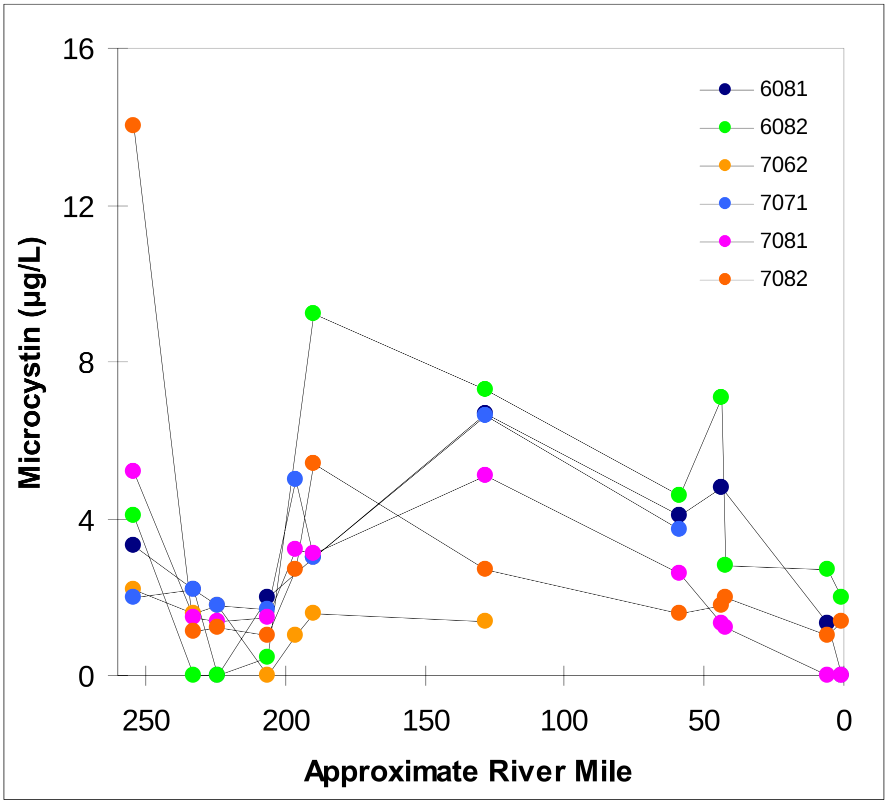


Figure 5.2-37. Microcystin concentration measured in the Klamath River on various dates showing the less typical longitudinal pattern of very high concentration at Link River (RM 254), higher concentration below Iron Gate dam, lower concentration at Orleans (RM 59), and increased concentration at Weitchpec (RM 43). The first digit of the key refers to the year, the second two digits to the month, and the last digit indicates the sampling event in that month. Not all sampling events collected microcystin samples from all sites.

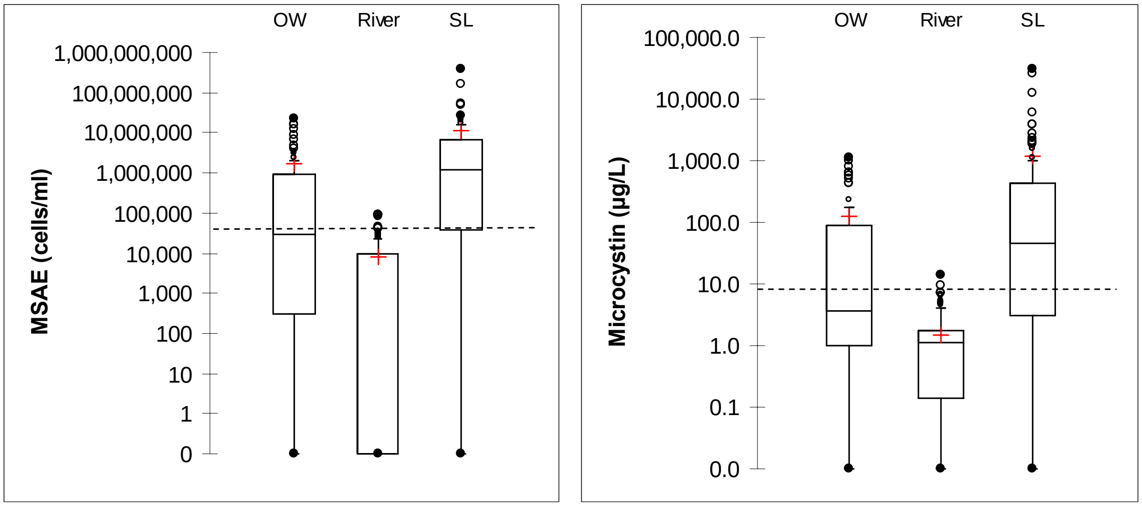


Figure 5.2-38. *Microcystis aeruginosa* abundance and microcystin concentration measured at open water reservoir sites (OW), river (i.e., non-reservoir) sites (River), and reservoir shoreline sites (SL) in the Klamath River in 2005 through 2007 (Kann 2006, Kann and Asarian 2006, Fetcho 2007). The horizontal dashed lines indicate the California recreational waters guidance value for *M. aeruginosa* (40,000 cells/mL) and microcystin (8 µg/L) (Blue Green Algae Work Group of the State Water Board et al. 2007).

5.2.14.3 Project Contribution

The history of the Upper Basin (above Keno reservoir) as a location for industrial development and as a receiving water for agricultural, municipal, and industrial discharges prompted examination of reservoir sediments throughout the Project. Screening level analysis of sediments from project reservoirs does not suggest a serious problem with toxic substances. Most compounds analyzed for were below the detection limit of the analytical methodology or the relevant screening levels. The most commonly detected compounds, PCBs, are ubiquitous in the environment. The Klamath Hydroelectric Project introduces no toxic substances to the waters of the Klamath River.

Conditions of pH, temperature, and ammonia nitrogen concentration that may cause excessive concentration of free ammonia in the water may exist in the Project waters, but they appear to be rare and short-lived. The causes that give rise to such conditions are consequences of the natural climate in the vicinity of the Project and of the input of nutrients from sources outside the project. Water temperature in the segment of the Klamath River from the Oregon –California border to the mouth are largely in equilibrium with ambient climatic conditions with the exception of a segment of the Klamath River below Iron Gate dam. High pH in the Klamath River is the natural consequence of abundant photosynthesis in a poorly buffered system, and both the high concentration of ammonia nitrogen and the abundant photosynthesis are the result of nutrient inputs from UKL and agricultural return flow from the KIP.

Cyanobacteria capable of producing toxins harmful to humans and other animals are present in UKL, the Klamath River, and a variety of other lakes in California, Oregon, and throughout the country. Their presence is a natural consequence of the environmental conditions that exist in UKL. Currently, they appear to be present at times in Copco and Iron Gate reservoirs in sufficient abundance to cause a potential health risk to humans, domestic animals, or wildlife.

5.2.14.4 Proposed Measures

Any adverse effects on beneficial uses are the result of natural conditions or factors not caused by the Project. Consequently, no measures are proposed with respect to toxic substances. The appropriate means to address toxicity byproducts from primary production in Copco and Iron Gate reservoirs are in the pending TMDL process. PacifiCorp does not have the ablility to control sources of nutrient and organic matter above the project (which result in algae production within the reservoirs). Nonetheless, to address water quality problems in the reservoirs that result from upstream loads of nutrient and organic matter, PacifiCorp is proposing a reservoir management plan (Appendix B). The reservoir management plan is anticipated to reduce algae growth in the reservoirs, and thus potentially reduce toxic algae species. PacifiCorp is also supporting and funding further studies of cyanophytes in the Klamath River basin. Hypolimnetic oxygenation in the reservoirs, proposed as part of the reservoir management plan, is expected to result in containment of nutrients from the sediments of the reservoirs and thereby help to further reduce growth of algae.

5.2.15 Pesticides

5.2.15.1 Applicable Criteria

North Coast Basin Plan, at 3-4.00:

No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life.

Waters designated for use as domestic or municipal supply shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 4, Section 64444.5 (Table 5).

5.2.15.2 Present Conditions

No data are available regarding pesticide concentrations in the Klamath River in the vicinity of the Project.

5.2.15.3 Project Contribution

No pesticides are added to the water by any process or activity related to the Project. Any pesticide application conducted at Project facilities is in accordance with the label of the compound in use.

5.2.15.4 Proposed Measures

No measures are proposed with respect to pesticides.

5.2.16 Chemical Constituents

5.2.16.1 Applicable Criteria

North Coast Basin Plan, at 3-4.00:

Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 (Tables 2 and 3), and Section 64444.5 (Table 5), and listed in Table 3-2 of this Plan.

Waters designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts which adversely affect such beneficial use.

Numerical water quality objectives for individual waters are contained in Table 3-1. Specific conductance levels applicable to the Klamath River in the Project vicinity include:

Above Iron Gate dam	425 umhos (at 77ºF) – 90 percent exceedance
	275 umhos (at 77ºF) – 50 percent exceedance
Below Iron Gate dam	450 umhos (at 77ºF) – 90 percent exceedance
	275 umhos (at 77ºF) – 50 percent exceedance

5.2.16.2 Present Conditions

Specific conductance has been measured at various sites in the Klamath River and reservoirs from 2000 through 2005. Of 2,576 specific conductance measurements taken in the Klamath River at sites between the Oregon-California border and the mouth of the Shasta River, 99.8 percent have been below 350 umhos and 97.2 percent have been below 275 umhos.

5.2.16.3 Project Contribution

No chemical constituents are added to the water by any process or activity related to the Project.

5.2.16.4 Proposed Measures

The water quality objective is met. No measures are proposed with respect to chemical constituents.

5.2.17 Boron

5.2.17.1 Applicable Criteria

North Coast Basin Plan, Table 3-1:

	90% Upper Limit [24]	**50% Upper Limit** [25]
Middle Klamath HA		
Klamath River above Iron Gate Dam including Iron Gate and Copco Reservoirs	0.3	0.2
Klamath River below Iron Gate Dam	0.5	0.2
Other Streams	0.1	0.0
Groundwaters	0.3	0.1
Lower Klamath HA		
Klamath River	0.5 [26]	0.2 [27]
Other Streams	0.1 [28]	0.0 [29]
Groundwaters	0.1	0.0

5.2.17.2 Present Conditions

No data are available for boron in the Klamath River in the vicinity of the Project.

5.2.17.3 Project Contribution

Boron is not added to the water by any process or activity related to the Project.

5.2.17.4 Proposed Measures

No measures are proposed with respect to boron.

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[24] "90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit." North Coast Basin Plan, at 3-7.00.

[25] "50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit." Id.

[26] Does not apply to estuarine areas. North Coast Basin Plan, at 3-7.00.

[27] *Id.*

[28] *Id.*

[29] *Id.*

5.2.18 Radionuclides

5.2.18.1 Applicable Criteria

North Coast Basin Plan, at 3-3.00 to 3-4.00:

Radionuclides shall not be present in concentrations which are deleterious to human, plant, animal or aquatic life nor which result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or indigenous aquatic life.

Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of radionuclides in excess of the limits specified in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 4, Section 64443, Table 4, and listed below:

MCL Radioactivity

Maximum Contaminant Constituent Level, pCi/l

Combined Radium-226 and Radium-228	*5*
Gross Alpha particle activity	*15*
(including Radium-226 but excluding Radon and Uranium)	
Tritium	*20,000*
Strontium-90	*8*
Gross Beta particle activity	*50*
Uranium	*20*

5.2.18.2 Present Conditions

No data are available concerning radionuclides in the Klamath River in the vicinity of the Project

5.2.18.3 Project Contribution

No radionuclides are being added to the water by the Project, and there are no known naturally occurring problems with radionuclides.

5.2.18.4 Proposed Measures

No measures are proposed with respect to radionuclides.

5.3 ANTIDEGRADATION POLICY

5.3.1 Applicable Antidegradation Policies

The state antidegradation policy is incorporated into the Basin Plan at 3-2.00 as follows:

> *Whenever the existing quality of water is better than the water quality objectives established herein, such existing quality shall be maintained unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68-16, 'Statement of Policy with Respect to Maintaining High Quality of Waters in California,' including any revisions thereto.*

Relative to this application, the state antidegradation policy provides:

> *Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until is has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.* (State Water Board, Res. No. 68-16.)

The state policy incorporates the federal antidegradation policy (State Water Board WQO 86-17, 24-25, 35). The federal policy is found at 40 CFR Section 131.12 and requires:

> *(1) Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.*
>
> *(2) Where the quality of the waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the State shall assure water quality adequate to protect existing uses fully. Further, the State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.*
>
> *(3) Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.*
>
> *(4) In those cases where potential water quality impairment associated with a thermal discharge is involved, the antidegradation policy and implementing method shall be consistent with section 316 of the Act.*

Relative to this application, it is important to emphasize that the state and federal Antidegradation Policies are designed to protect "existing" water quality. The Policy "is not a 'zero-discharge' standard but rather a policy statement that existing water quality be maintained when it is reasonable to do so." (State Water Board, Order WQ 86-8, 29, (1986), emphasis added; see also State Water Board Order WQ 2000-07, 16-17 [2000]). "Existing uses" are those uses which were actually attained in the water body on or after November 28, 1975." (See Basin Plan, p. 2-13.00.)

The Project was fully constructed and became operational by the 1960s, prior to the establishment of the federal antidegradation policy in the 1970s and prior even to the adoption of State Water Board

Resolution No. 68-16. The Project has been in continuous operation since that time. In applying the state and federal Antidegradation Policies to this application, therefore, the potential water quality affects of the Project are to be assessed by comparing existing water quality to the water quality that result from proposed changes to the Project, including measures designed to protect or improve water quality or beneficial uses.

5.3.2 Application of Antidegradation Policies to Project

The changes proposed to the Project, as described in this application and in the Final License Application to FERC, will have neutral or positive effects on water quality within and below the Project, relative to existing water quality conditions. As such, the Project as proposed is consistent with both the state and federal antidegradation policies. Existing water quality will not be degraded as a result of the Project.

6.0 LITERATURE CITED

American Public Health Assoc., American Water Works Assoc., and Water Environment Federation (APHA). 1995. Standard Methods for the examination of water and wastewater, 19th Ed. Editors: A.E. Eaton, L.S. Clesceri, and A.E. Greenberg. Washington D.C.

Asarian, E. and J. Kann. 2006. Klamath River Nitrogen Loading and Retention Dynamics, 1996-2004. Kier Associates Final Technical Report to the Yurok Tribe Environmental Program, Klamath, California. 56 pp. + appendices.

Bartholow, J.M. and J. Heasley. 2005. J.C. Boyle Bypass Segment Temperature Analysis. USGS Administrative Report: September 20, 2005. Administrative Report to the U.S. Fish and Wildlife Service and Bureau of Land Management. U.S. Department of the Interior. U.S. Geological Survey.

Biggs, R.B. and L.E. Cronin. 1981. Special Characteristics of Estuaries. In Estuaries and Nutrients, Ed. B.J. Neilson and L.E. Cronin. Humana Press, Clifton NJ. 643 pp.

Blue Green Algae Work Group of the State Water Resources Control Board, Department of Health Services, and Office of Environmental Health Hazard Assessment. 2007. Cyanobacteria in California Recreational Water Bodies. Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. DRAFT. May 2007.

Borchardt, M.A. 1996. “Nutrients.” In Algal Ecology. Academic Press. San Diego. 753 pp.

Bortleson, G.C., and Fretwell, M.O. 1993. A review of possible causes of nutrient enrichment and decline of endangered sucker populations in Upper Klamath Lake, Oregon. U.S. Geological Survey Water-Resources Investigations Report 93-4087, 24 pp.

Bowie, G.L., W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W. Chan, and S.A. Gherini. 1985. Rates, constants and kinetics formulations in surface water quality modeling, 2nd Ed. EPA/600/3-87/700. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA. May 1985.

California Regional Water Quality Control Board, North Coast Region. 1993. Water Quality Control Plan for the North Coast Region (Basin Plan). Last amended June 28, 2001.

Carmichael, W.W. 2007. A world overview—One-hundred twenty-seven years of research on toxic cyanobacteria—Where do we go from here? Chapter 4 in H. Kenneth Hudnell (ed.): Proceedings of the Interagency, International Symposium on Cyanobacterial Harmful Algal Blooms Advances in Experimental Medicine & Biology, 95-115.

Chapra, S.C. 1997. Surface Water Quality Modeling. McGraw Hill Companies, Inc. New York. 844 pp.

City of Klamath Falls. 1986. Application for License for the Salt Caves Hydroelectric Project. Volume II: Exhibit E. Sections 1.0, 2.0, and 3.0. Submitted to the Federal Energy Regulatory Commission. November 1986.

Cole, T.M. and H.H. Hannan. 1990. “Dissolved Oxygen Dynamics.” In Reservoir Limnology. John Wiley and Sons, Inc. New York. 246 pp.

Colt, J., S. Mitchell, G. Tchobanoglous, and A. Knight. 1979. The use and potential for aquatic species for wastewater treatment: Appendix B, the environmental requirements of fish. Publication No. 65, California State Water Resources Control Board, Sacramento, CA.

Cooke, G.D., and Kennedy, R.H. 1989. “Water quality management for reservoirs and tailwaters: report 1, in reservoir water quality management techniques.” Technical Report E-89-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cooke, G.D., E.B. Welch, S. Peterson, and S.A. Nichols. 2005. Restoration and management of lakes and reservoirs. Third edition. Taylor and Francis/CRC Press. 616 pp.

Dortch, M.S. 1979. “Artificial destratification of reservoirs.” Technical Report E-79-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Dunsmoor, L.K. 2006. Observations and significance of fish and invertebrate stranding during the first few major peaking cycles in 2006 downstream of the J. C. Boyle Hydroelectric Project. Technical memorandum to the Klamath Tribes, Chiloquin, Oregon. 28 July 2006.

Eilers. J. 2005. Klamath River Bathymetry. (A compilation of bathymetric data and maps prepared for PacifiCorp for Ewauna to Keno, J.C. Boyle reservoir, Copco reservoir, and Iron Gate reservoir.) Draft.

Eilers, J., J. Kann, J. Cornett, K. Moser, A. St. Amand, and C. Gubala, 2001. Recent paleolimnology of Upper Klamath Lake. Report to U.S., Bureau of Reclamation, Klamath Falls, Oregon.

Elwood, J.W.; J.D. Newbold; R.V. O’Neill; W. van Winkle. 1983. “Resource Spiraling: An Operational Paradigm for Analyzing Lotic Ecosystems”. Dynamics of Lotic Ecosystems. Ed. Thomas D. Fontaine, III and Steven M. Bartell. Michigan: Ann Arbor Science. pp 3-27.

Federal Energy Regulatory Commission (FERC). 2006. Draft Environmental Impact Statement For Hydropower License. Klamath Hydroelectric Project. FERC Project No. 2082-027. Oregon and California. Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC. September 25, 2006.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement For Hydropower License. Klamath Hydroelectric Project. FERC Project No. 2082-027. Oregon and California. Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC. November 16, 2007.

Fetcho, K. 2007. 2006 Klamath River Blue-Green Algae Summary Report. Yurok Tribe Environmental Program. March 2007. 34 pp.

Fischer, H.B., List, E.J., Koh, R. C. Y., Imberger, J., and Brooks, N.H. 1979. Mixing in Inland and Coastal Waters. Academic Press, San Diego.

Ford, D.E. 1990. “Reservoir Transport Processes.” In Reservoir Limnology. John Wiley and Sons, Inc. New York. 246 pp.

Geist, D.R., C.S. Abernethy, K.D. Hand, V.I. Cullinan, J.A. Chandler, and P.A. Groves. 2006. Survival, Development, and Growth of Fall Chinook Salmon Embryos, Alevins, and Fry Exposed to

Variable Thermal and Dissolved Oxygen Regimes. Transactions of the American Fisheries Society 135:1462–1477.

Gorham. P.R. and W.W. Carmichael. 1979. Phycotoxins from Blue-Green Algae. Pure & Appl. Chem. 52: 165-174. Pergamon Press Ltd.

Hill, W.R. 1996. "Effects of Light." In Algal Ecology. Academic Press. San Diego. 753 pp.

Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. North American Lake Management Society and Terrene Institute, in cooperation with the U.S. Environmental Protection Agency. Distributed for the North American Lake Management Society. December 2002. 382 pp.

Holland, J.P. 1983. "Localized mixing to enhance reservoir release quality." Environmental and water quality operational studies bulletin, Vol E-83-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Holland, J.P. and Tate, Jr., C.H. 1984. "Investigation and discussion of techniques for hypolimnion aeration/oxygenation," Technical Report E-84-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Horne, A.J. and C.R. Goldman. 1994. Limnology. McGraw-Hill, Inc. New York. 576 pp.

Jacoby, J.M., and J. Kann. 2007. The occurrence and response to toxic cyanobacteria in the Pacific Northwest, North America. Lake and Reservoir Management 23(2): 123-143.

Kalff, J. 2002. Limnology: Inland Water Ecosystems. New Jersey: Prentice Hall. pp 592.

Kann, J. 2006a. *Microcystis aeruginosa* Occurrence in the Klamath River System of Southern Oregon and Northern California. Prepared for the Yurok Tribe Environmental and Fisheries Programs by Aquatic Ecosystem Sciences LLC, Ashland, Oregon. Available online at: http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20060329-5117.

Kann, J. 2006b. Partial Seasonal Summary of 2006 Toxic *Microcystis aeruginosa* Trends in Copco and Iron Gate Reservoirs and the Klamath River, CA. Prepared for the Karuk Tribe Department of Natural Resources by Aquatic Ecosystem Sciences LLC, Ashland, Oregon. 16 pp.

Kann, J. 2006c. Provisional Compilation of Klamath Tribes Upper Klamath Lake Water Quality Data, 1990-2005. Prepared for the Klamath Tribes Natural Resources Department.

Kann, J. 2007. Toxic Cyanobacteria Results for Copco/Iron Gate Reservoirs: October 29-30, 2007. Technical Memorandum. Aquatic Ecosystem Sciences, Ashland, OR . November 6, 2007.

Kann, J. and D. Gilroy. 1998. Ten Mile Lakes Toxic Microcystis Bloom, September - November 1997. Environmental Services and Consultation Center for Environment and Health Systems. Toxicology Unit, Oregon Health Division, Portland, OR.

Kann, J., and E. Asarian. 2005. 2002 Nutrient and Hydrologic Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, California. 59 pp + appendices.

Kann, J. and E. Asarian. 2006. Technical Memorandum: Longitudinal Analysis of Klamath River Phytoplankton Data 2001-2004. Prepared by Kier Associates and Aquatic Ecosystem Sciences for the Yurok Tribe Environmental Program, Klamath, California. 36 pp.

Kann, J. and S. Corum. 2006. Summary of 2005 Toxic *Microcystis aeruginosa* Trends in Copco and Iron Gate Reservoirs on the Klamath River, CA. Prepared by Aquatic Ecosystem Sciences and the Karuk Tribe Department of Natural Resources for the Karuk Tribe, Orleans, California. 35 pp.

Kann, J., and Asarian, E. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005-May 2006. Final Technical Report to the State Water Resources Control Board, Sacramento, California

Kennedy, R. H., and W.W. Walker. 1990. Reservoir nutrient dynamics. Chapter 5 in K. W. Thornton, B. L. Kimmel, and F. E. Payne (ed). Reservoir limnology: Ecological perspectives. Wiley & Sons, New York.

Kimmel, B.L., O.T. Lind, and L.J. Paulson. 1990. Reservoir primary production. Chapter 6 in K. W. Thornton, B. L. Kimmel, and F. E. Payne (ed). Reservoir limnology: Ecological perspectives. Wiley & Sons, New York.

Kirk, J.T.O. 1994. Light and Photosynthesis in Aquatic Ecosystems. 2nd Ed. Cambridge University Press. Canberra. 509 pp.

Klamath County Historical Society. 1967. “Lake Algae Office Closes; HQ Moves to Corvallis,” November 5, 1967, newspaper clipping, Vertical File 9-179, “Ewauna, Klamath, etc., Lakes, Klamath County.” Klamath Falls, Oregon.

Lewis, M. E. 2006. Dissolved Oxygen (version 23.0): U.S. Geological Survey Techniques of Water-Resources Investigations. Book 9, Chapter A6, Section 6.2. May 2006.

Mann, R. and C. Peery. 2005. “Effects of Water Temperature Exposure on Spawning Success and Developing Gametes of Migrating Anadromous Fish – 2004.” Study Code: ADS-00-05. Progress Report to the U.S. Army Corps of Engineers.

Martin, J.L. and S.M. McCutcheon. 1999. Hydrodynamics and Transport for Water Quality Modeling. Lewis Publishers, Boca Raton FL. 794 pp.

McKenna, P.L. 2007. Decision. Trial-type Proceeding Pursuant to Section 241 of the Energy Policy Act of 2005. In the Matter of the Klamath Hydroelectric Project (License Applicant PacifiCorp). FERC Project Number 2082. Issued by: Hon. Parlen L. McKenna, Presiding. Decision dated July 20, 2007.

Mobley, M.H. 1989. “Installation and testing of an oxygen diffuser system at Douglas Dam, Report WR28-1-20-108, TVA Engineering Laboratory, Norris, TN.

Mobley, M.H. 1993. “Forebay oxygen diffuser system to improve reservoir releases at Douglas dam,” Proceedings of North American Lake Management Society, December 1993, Seattle, WA.

Mobley, M.H., and Brock, W. G. 1994. “Widespread oxygen bubbles to improve reservoir releases,” Proceedings of ASCE National Conference on Hydraulic Engineering, August 1994, Buffalo, NY, ASCE, New York, NY.

Mobley, M.H., Tyson, W.C., Webb, J., and Brock, W.G. 1995. “Surface water pumps to improve dissolved oxygen content of hydropower releases.” Proceedings of WaterPower ‘95, San Francisco, CA.

Mobley Engineering Inc. (MEI). 2007. Reservoir Oxygenation Feasibility Evaluation Report for Copco and Iron Gate Reservoirs. Prepared for PacifiCorp, Portland, Oregon. Prepared by Mobley Engineering Inc. with assistance from WolffWare and Reservoir Environmental Management Inc. October 2007. 41 pp. (Attached as Appendix D to PacifiCorp’s February 2008 401 Application to the California State Water Resources Control Board).

Moon, J.J., McLaughlin, D.K., and Moretti, P. M. 1979. “Enhancement of reservoir release water quality by localized mixing - hydraulic model investigation.” Phase 1 report, Contract No. DACW39-78-C-0045, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Moyle, P.B. 2002. Inland Fishes of California. University of California Press, Berkeley, California. 502 pp.

NALMS. 2001. Managing Lakes and Reservoirs. North American Lake Management Society and Terrene Institute, in cooperation with the U.S. Environmental Protection Agency. Distributed for the North American Lake Management Society. December 2002. 382 pp.

National Marine Fisheries Service (NMFS). 2001. Biological Opinion—Ongoing Klamath Project Operation.

National Marine Fisheries Service (NMFS). 2002. Biological Opinion. Klamath Project Operations. May 31, 2002.

National Marine Fisheries Service (NMFS). 2007. Endangered Species Act - Section 7 Consultation. Biological Opinion. Klamath Hydroelectric Project License (FERC No. 2082-027). Prepared by the National Marine Fisheries Service, Southwest Region. File No. 151422SWR2003AR8914. December 21, 2007.National Research Council (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. The National Academies Press. Washington D.C., 424 pp.

Newcombe, C.P. and J. O.T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. N. Amer. J. Fish. Man. 16:693-727.

Niemela, S.L. 1989. The influence of peaking hydroelectric discharges on habitat selection and movement patterns of rainbow trout (*Oncorhynchus mykiss*). Tennessee Technical College, Cookeville, Tennessee.

Oregon Department of Environmental Quality (ODEQ). 1995. Water Quality Model of the Klamath River between Link River and Keno Dam (Draft). Prepared by Scott Wells and CH2M HILL for Oregon Department of Environmental Quality. December.

Oregon Department of Human Services, 2005. Public Health advisory guidance for toxigenic Cyanobacteria in recreational waters.

PacifiCorp. 2000. First Stage Consultation Document and Klamath Hydroelectric Project Information: Klamath Hydroelectric Project, FERC No. 2082. December 15, 2000.

PacifiCorp. 2004a. Final License Application. Volume 1. Exhibits A, B, C, D, and H. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004b. Final License Application. Volume 2. Exhibit E. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004c. Final License Application. Volume 3. Exhibit F. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004d. Final License Application. Volume 4. Exhibit G. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004e. Final Technical Report, Fish Resources. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004f. Final Technical Report, Recreation Resources. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004g. Final Technical Report, Terrestrial Resources. Klamath Hydroelectric Project (FERC Project No. 2082). February 2004.

PacifiCorp. 2004h. Final Technical Report, Water Resources. Klamath Hydroelectric Project (FERC Project No. 2082). February 2004.

PacifiCorp. 2004i. Screening Level Determination of Chemical Contaminants in Fish Tissue in Selected Project Reservoirs, Final Technical Report. Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). February 2004.

PacifiCorp. 2005a. Status Report. Klamath River Water Quality Modeling. Response to FERC AIR GN-2. Klamath Hydroelectric Project Study 1.3 (FERC Project No. 2082). PacifiCorp. Portland, Oregon. April 2005.

PacifiCorp. 2005b. Response to FERC AIR AR-1 Part (a). Technical Report. Conceptual Design and Preliminary Screening of Temperature Control Alternatives. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp. Portland, Oregon. July 2005.

PacifiCorp. 2005c. Second Response to FERC AIR AR-1 Part (a). Supplemental Technical Report. Conceptual Design and Preliminary Screening of Temperature Control Alternatives. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp. Portland, Oregon. September 2005.

PacifiCorp. 2005d. Response to FERC AIR AR-1 Part (b). Technical Report. Evaluation of the Preferred Design for Temperature and Dissolved Oxygen Control of Waters Discharged in the Klamath River from Iron Gate Dam. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp. Portland, Oregon. September 2005.

PacifiCorp. 2005e. Instream Flow Studies Addendum Report. Development of Habitat Suitability Criteria and Simulation of Habitat Area. Response to FERC AIR GN-2. Klamath Hydroelectric Project Study 1.12 (FERC Project No. 2082). PacifiCorp. Portland, Oregon. April 2005.

PacifiCorp. 2006a. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act and ORS 468B.040 for the Klamath Hydroelectric Project (FERC Project No. 2082) in Klamath County, Oregon. February 2006.

PacifiCorp. 2006b. Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. November 2006. 77 pp.

PacifiCorp. 2007a. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2007.

PacifiCorp. 2007b. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board, Division of Water Quality, Water Quality Certification Unit, Sacramento. Prepared by: PacifiCorp, Portland, Oregon. February 2007.

PacifiCorp. 2007c. Comments on the Draft Biological Opinion on the Proposed Relicensing of the Klamath Hydroelectric Project. FERC Project No. 2082, Klamath River, Klamath County, Oregon and Siskiyou County, California. Letter to Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission and Phil Detrich, Field Supervisor, United States Fish and Wildlife Service, Yreka Fish and Wildlife Office. November 2, 2007.

PacifiCorp. 2007d. Comments on NMFS Draft Biological Opinion on the Proposed Relicensing of the Klamath Hydroelectric Project Klamath River, Klamath County, Oregon and Siskiyou County, California. Letter to Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission and Rodney R. McInnis, Regional Administrator, National Marine Fisheries Service, Southwest Region. November 19, 2007.

PacifiCorp. 2007e. Additional Comments on the Draft Biological Opinion on the Proposed Relicensing of the Klamath Hydroelectric Project. FERC Project No. 2082, Klamath River, Klamath County, Oregon and Siskiyou County, California. Letter to Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission and Phil Detrich, Field Supervisor, United States Fish and Wildlife Service, Yreka Fish and Wildlife Office. November 30, 2007.

PacifiCorp. 2008. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2008.

Paerl, H.W. 1988. Nuisance phytoplankton blooms in coastal, estuarine, and inland waters. Limnol Oceanogr 33:823–847.

Phinney, H. K. 1959. A Survey of the Phytoplankton Problems in Klamath Lake. Report to the Supporting Agencies. 52 pp.

Pastorok, R.A., Lorenzen, M. W., and Ginn, T. C. 1982. “Environmental aspects of artificial aeration and oxygenation of reservoirs: a review of theory, techniques, and experiences.” Technical Report E-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Pert, E.J. and D.C. Erman. 1994. Habitat use by adult rainbow trout under moderate artificial fluctuations in flow. Trans. Amer. Fish. Soc. 123:913-923.

Peterson, C.G. 1996. “Response of Benthic Algal Communities to Natural Physical Disturbance.” In *Algal Ecology*. Academic Press. San Diego. 753 pp.

Pitt, R.E. 2000. Water quality conditions in the Cahaba River and likely pollutant sources. University of Alabama at Birmingham. August 2000. 86 pp.

Price, R.E., and Meyer, E.B. 1992. “Water quality management for reservoirs and tailwaters: report 2, operational and structural water quality techniques.” Technical Report E-89-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Redding, J.M. and C.B. Scheck. 1982. Mount St. Helens ash causes sublethal stress response in steelhead trout. pp 300-307 *In* Mount St. Helens: effects on water resources. Washington State University. Washington Water Resources Center Report 41.

Reynolds, C.S. 1994. “The long, the short, and the stalled: on attributes of phytoplankton selected by physical mixing in lakes and rivers.” Hydrobiologia. 289: 9-21.

Reynolds, C.S. and J.P. Descy. 1996. “The production, biomass, and structure of phytoplankton in large rivers.” Arch. Hydrobiologia Suppl. 113: 161-187.

Reynolds, C.S., and A.E. Walsby. 1975. Water Blooms. Biological Review 50: 437-481.

Reynolds, C.S., G.H. Jaworski, H.A. Cmiech, and G.F. Leedale. 1981. On the annual cycle of the blue-green alga Microcystis aeruginosa Kütz Emend Elenkin. Phil. Trans. R. Soc. Lond. B 293, 419-477.

Servizi, J.A. and D. Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquatic Sci. 48:493-497.

State of Oregon, State of California, and the U.S. Public Health Service Report. 1955. Investigation of Pollution in the Klamath River System 1952-1953. June.

Stekoll, M.S., W.W. Smoker, I.A. Wang, and B.J. Failor. 2003. Salmon as a bioassay model for effects of total dissolved solids. Final report for ASTF Grant #98-1-012. University of Alaska Fairbanks. February 2003.89 pp.

Stevenson, R.J., 1996. “The Stimulation and Drag of Current.” In Algal Ecology. Academic Press. San Diego. 753 pp.

Sullivan, K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2000. An Analysis of the Effects of Temperature on Salmonids of the Pacific Northwest with Implications for Selecting Temperature Criteria. Sustainable Ecosystems Institute, Portland, OR

Sutton, R., M. Deas, M.R. Belchik, and S.M. Turo. 2002. “Klamath River Thermal Refugia Study,” A report for the United States Bureau of Reclamation, Mid-Pacific Region.

Taylor, D.W. 1981. Freshwater Mollusks of California: A Distributional Checklist. California Department of Fish and Game 67(3):140-163.

Tchobanoglous, G and E.D. Schroeder. 1985. Water Quality. Addison-Wesley Publishing Co., Inc. Menlo Park, CA.

Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Harper-Collins Publishers, Inc. New York. 644 pp.

Thornton, K.W. 1990. “Sedimentary Processes.” In Reservoir Limnology. John Wiley and Sons, Inc. New York. 246 pp.

Thornton, K.W., B.L. Kimmel, and F.E. Payne. 1990. Reservoir Limnology: Ecological Perspectives. Wiley-Interscience, John Wiley & Sons, Inc. 246 pp.

United Nations Environment Program (UNEP). 2004. Integrated Watershed Management—Ecohydrology & Phytotechnology—Manual. UNEP, Division of Technology, Industry and Economics, International Environmental Technology Center. 246 pp.

U.S. Army Corps of Engineers (Corps), San Francisco District. “Klamath River Basin, Oregon, Reconnaissance Report.” Summary, 49. September 1979.

U.S. Army Corps of Engineers (Corps), San Francisco District. 1982. “Upper Klamath Lake, Oregon, Water Resources Development Project: Potential Eutrophication Control Measures for Upper Klamath Lake, Oregon: Data Evaluation and Experimental Design.” 2-4. October 1982.

U.S. Bureau of Reclamation (USBR). 1992. Biological Assessment of the Klamath Project’s Continuing Operations on Southern Oregon/Northern California ESU Coho Salmon and Critical Habitat for Southern Oregon/Northern California ESU Coho Salmon. Draft. Mid-Pacific Region, Klamath Area Office. November 21.

U.S. Bureau of Reclamation (USBR). 2007. Klamath Project 2007 Operations Plan. Prepared for the U.S. Bureau of Reclamation. April 9, 2007.

U.S. Environmental Protection Agency (EPA). 1984. Ambient Water Quality Criteria for Ammonia – 1984. EPA 440/5-85-001. Washington D.C.

U.S. Environmental Protection Agency (EPA). 1987. Reservoir Water Quality Analysis. Chapter 2. Water Quality Parameters. EM 1110-2-1201. June 30.

U.S. Environmental Protection Agency (EPA). 2007a. Analytical Testing Results - Project R07W07. EPA Region 9 Laboratory, Richmond, CA. Report from Brenda Bettencourt, Director, EPA Region 9 Laboratory to Gail Louis, Nonpoint Source Office. September 21, 2007.

U.S. Environmental Protection Agency (EPA). 2007b. Analytical Testing Results - Project R07W07. EPA Region 9 Laboratory, Richmond, CA. Report from Brenda Bettencourt, Director, EPA Region 9 Laboratory to Gail Louis, Nonpoint Source Office. November 15, 2007.

U.S. Fish and Wildlife Service (USFWS). 1992. Biological Opinion on Effects of Long-term Operation of the Klamath Project. Klamath Falls, OR.

U.S. Fish and Wildlife Service (USFWS). 2001. Biological/conference opinion regarding the effects of operation of the Bureau of Reclamation's Klamath Project on endangered Lost River (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes brevirostris*), threaten bald eagle (*Haliaeetus leucocephalus*) and proposed critical habitat for the Lost River/shortnose suckers. California/ Nevada Operations Office, Sacramento, California.

U.S. Fish and Wildlife Service (USFWS). 2002. Biological Opinion on Effects of Long-term Operation of the Klamath Project. Klamath Falls, OR. May 31, 2002.

United States Fish and Wildlife Service (USFWS). 2007. Formal Consultation on the Proposed Relicensing of the Klamath Hydroelectric Project, FERC Project No. 2082, Klamath River, Klamath County, Oregon, and Siskiyou County, California. USFWS, Yreka Fish and Wildlife Office, Yreka, California. December 3, 2007.

Ward, J.V. and J.A. Stanford. 1983. "The Serial Discontinuity Concept of Lotic Ecosystems." Dynamics of Lotic Ecosystems. Ed. Thomas D. Fontaine, III and Steven M. Bartell. Michigan: Ann Arbor Science, pp 29-41.

Wee, S.R. and J.M. Herrick. 2005. Water Quality Of Upper Klamath Lake. A History of Scientific Investigations. Report by JRP Historical Consulting, Davis, CA. September 2005.

Welch, E.B. 1992. Ecological Effects of Wastewater. Applied Limnology and Pollutant Effects. Second Edition. Chapman & Hall Publishers.

Wetzel, R.G. 1972. Limnology. W.B. Saunders, Philadelphia.

Wetzel, R.G. 2001. Limnology: Lake and River Ecosystems, 3rd Ed. Academic Press, San Diego.

Wilber, D.H. and D.G. Clark. 2001. Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in Estuaries. N. Amer. J. Fish. Man. 21: 855-875.

APPENDIX A

Water Temperature Modeling Results
2002-2004 Tables

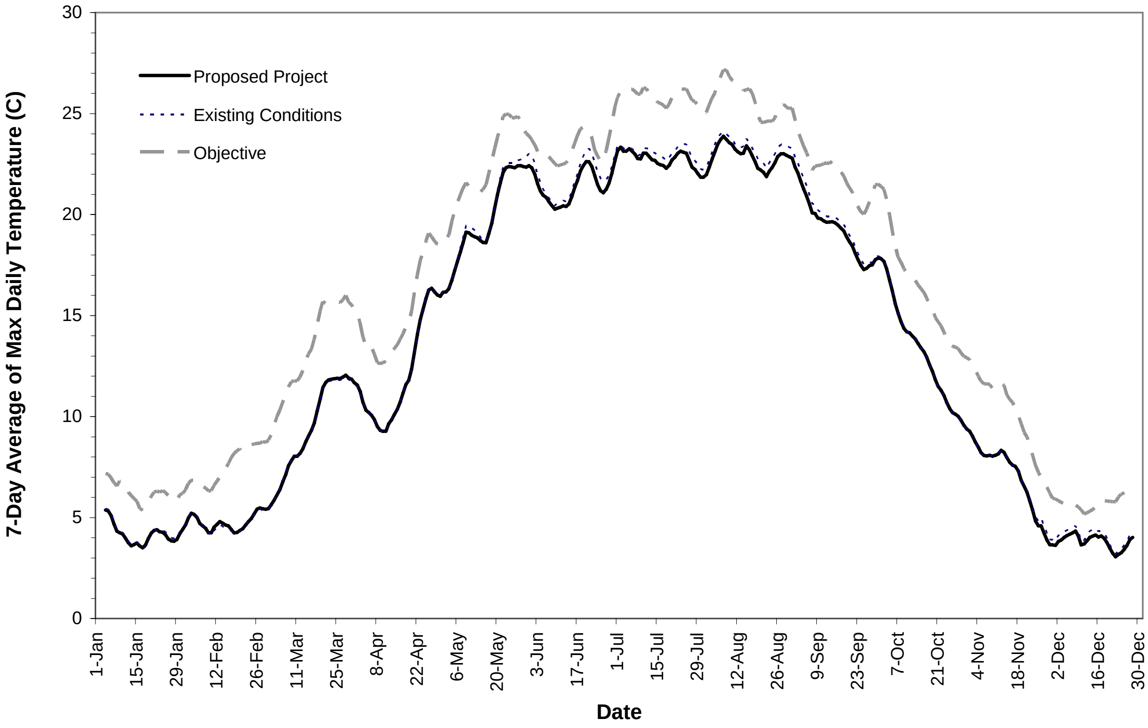

Figure 1. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Stateline (RM 209.2) compared to the California temperature objective (based on model simulations).

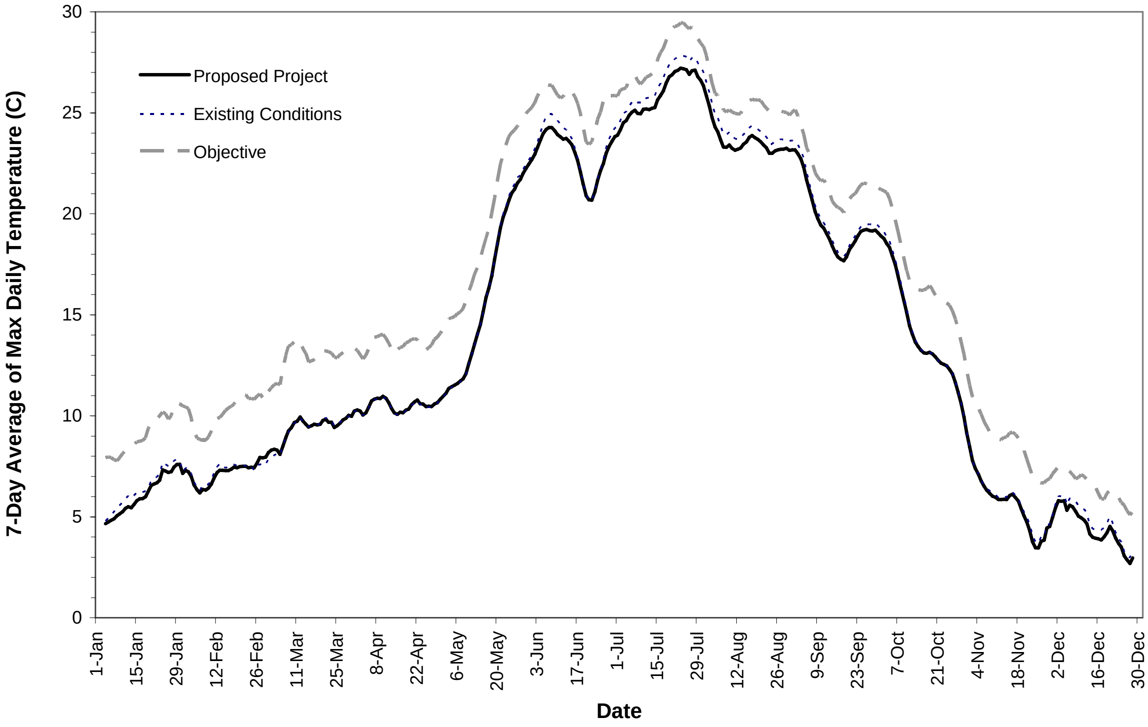

Figure 2. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Stateline (RM 209.2) compared to the California temperature objective (based on model simulations).

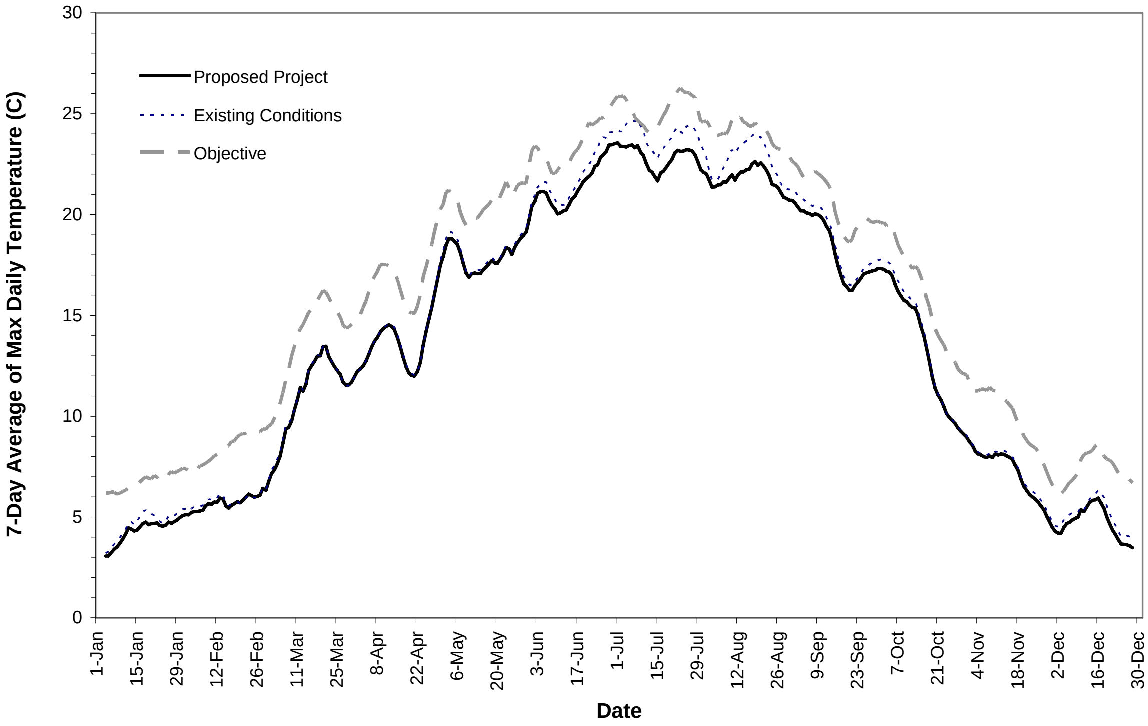

Figure 3. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Stateline (RM 209.2) compared to the California temperature objective (based on model simulations).

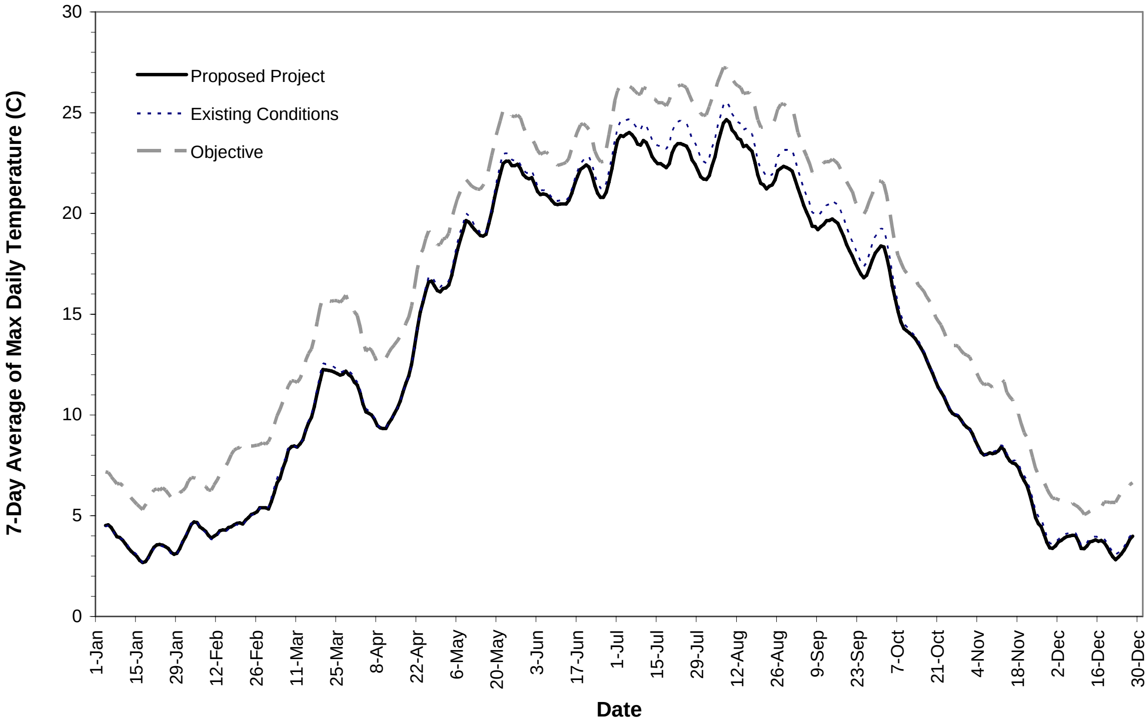

Figure 4. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River above Copco reservoir (RM 203.6) compared to the California temperature objective (based on model simulations).

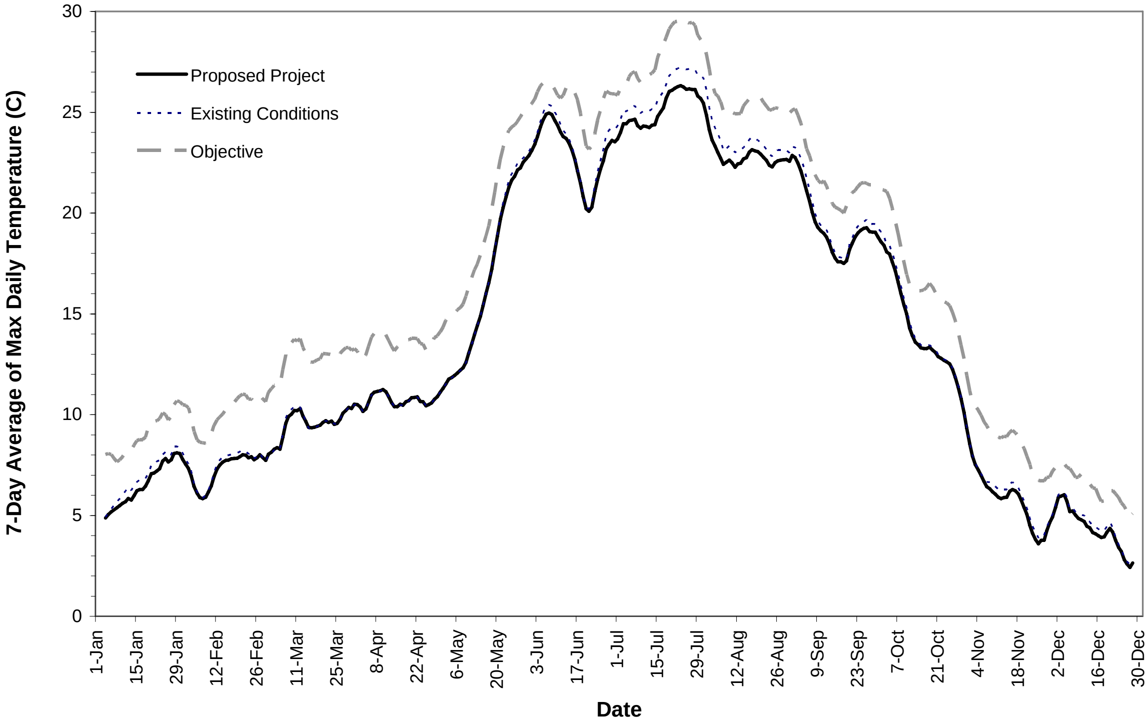

Figure 5. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River above Copco reservoir (RM 203.6) compared to the California temperature objective (based on model simulations).

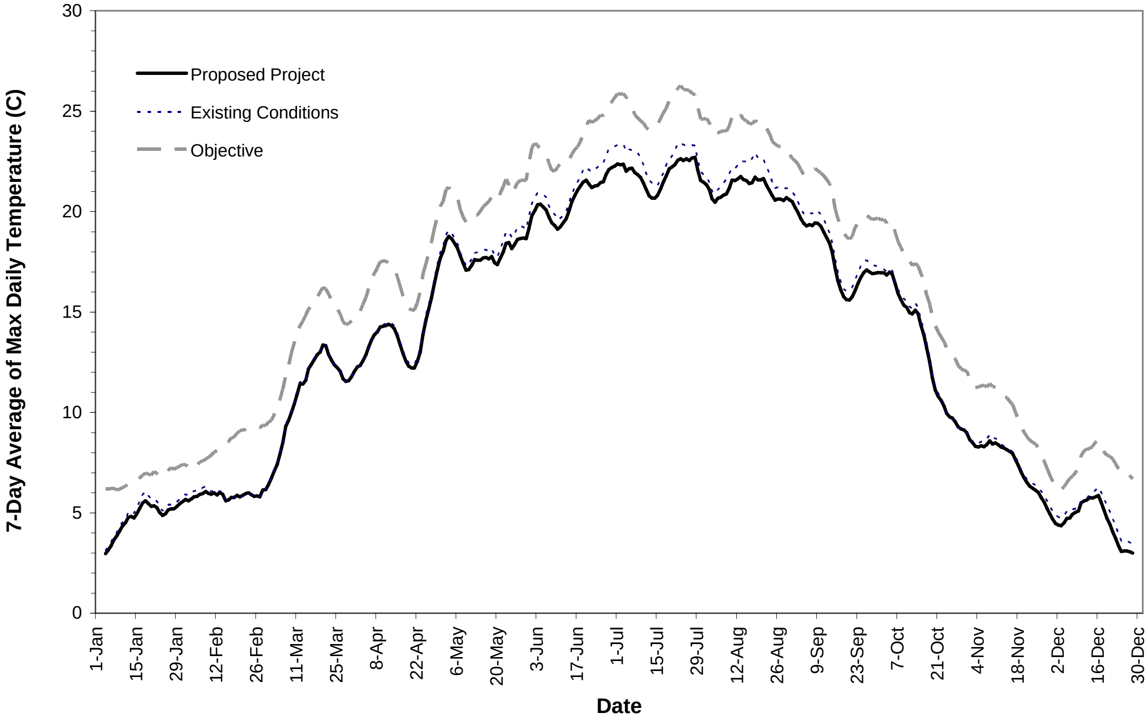

Figure 6. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River above Copco reservoir (RM 203.6) compared to the California temperature objective (based on model simulations).

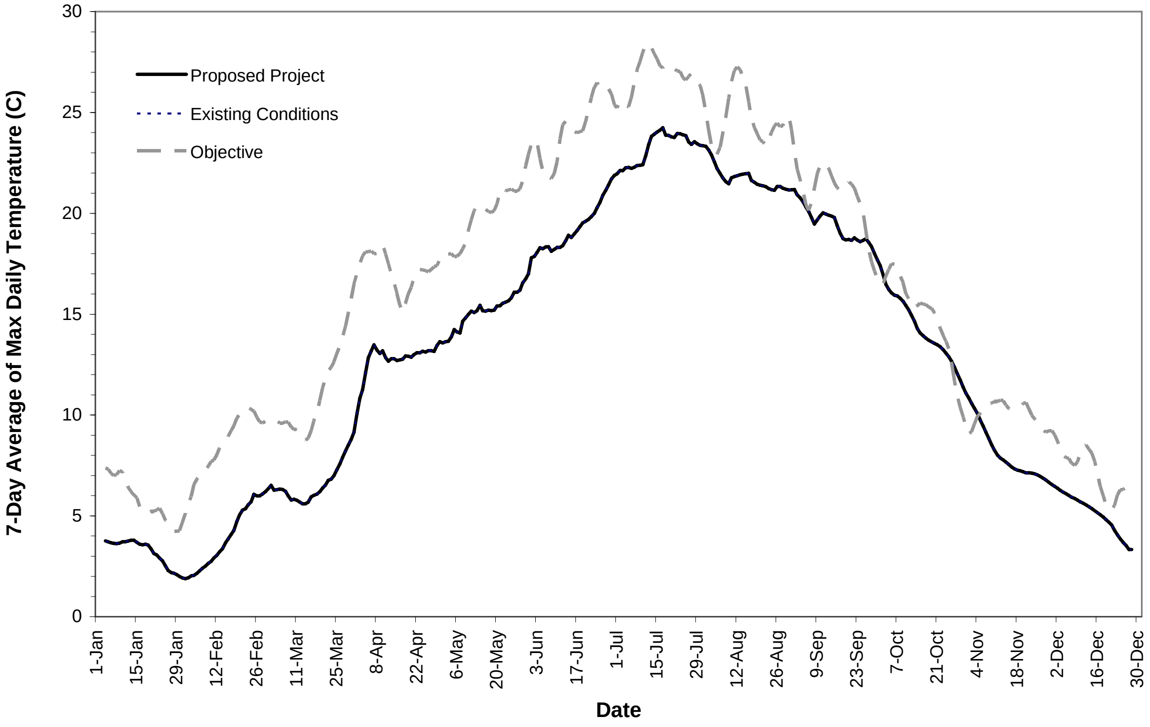

Figure 7. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Copco No. 1 dam (RM 198.6) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

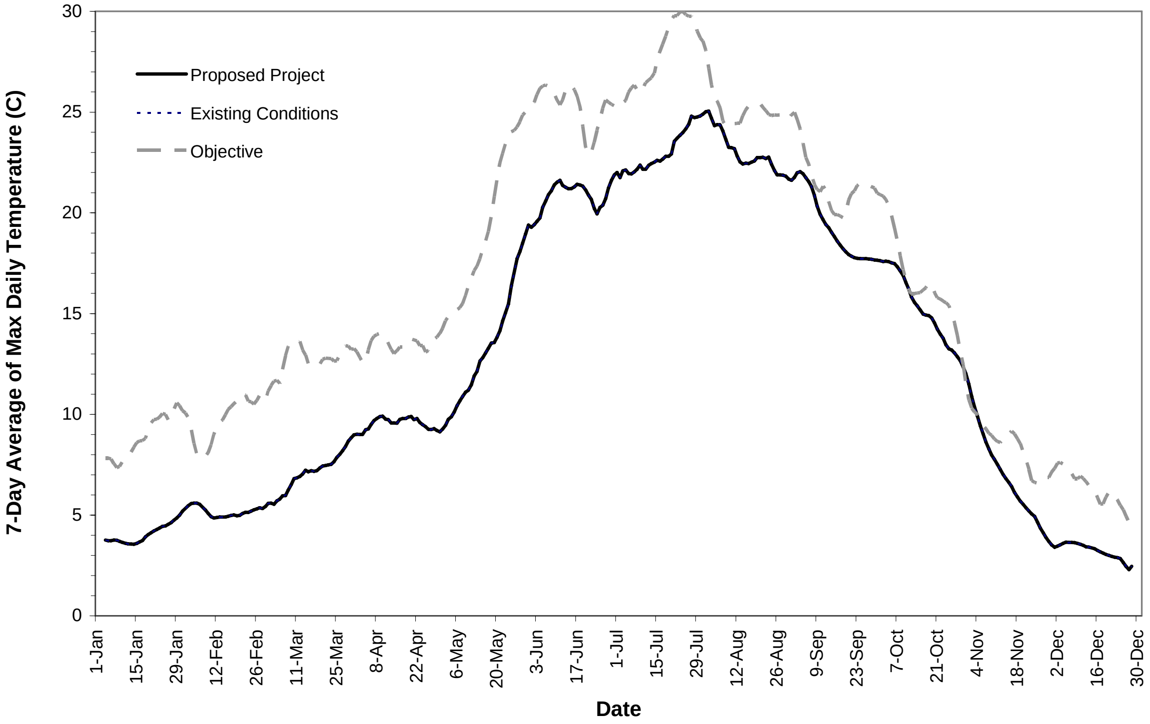

Figure 8. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Copco No. 1 dam (RM 198.6) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

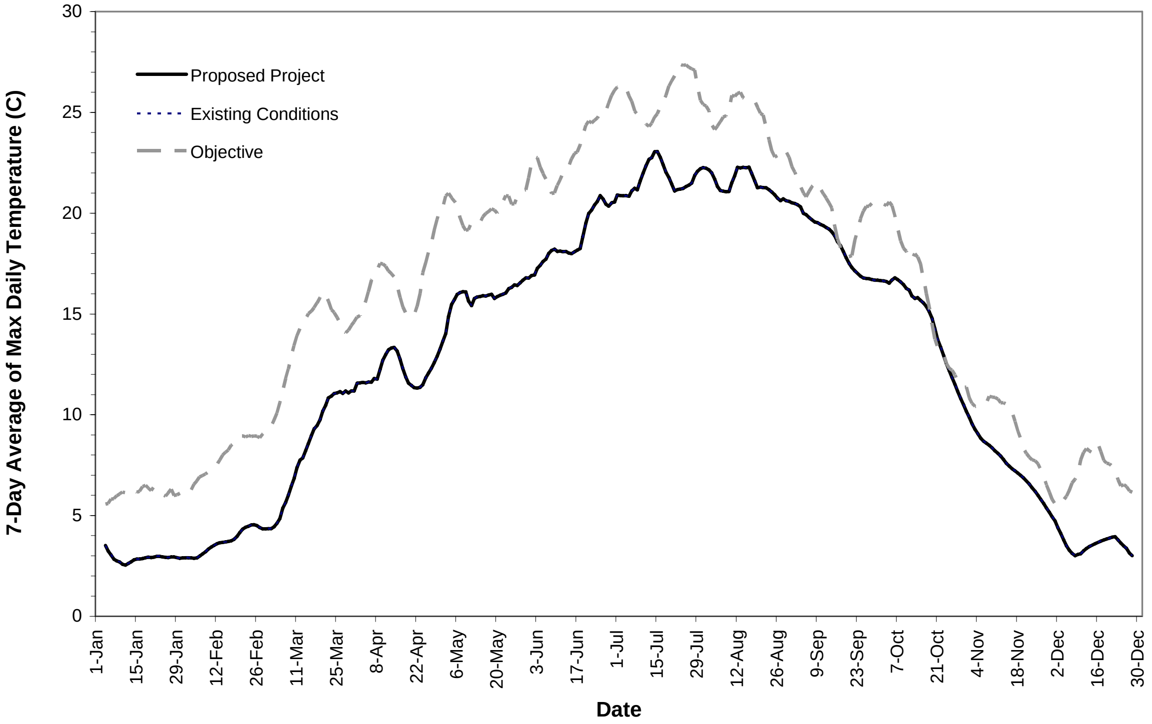

Figure 9. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Copco No. 1 dam (RM 198.6) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

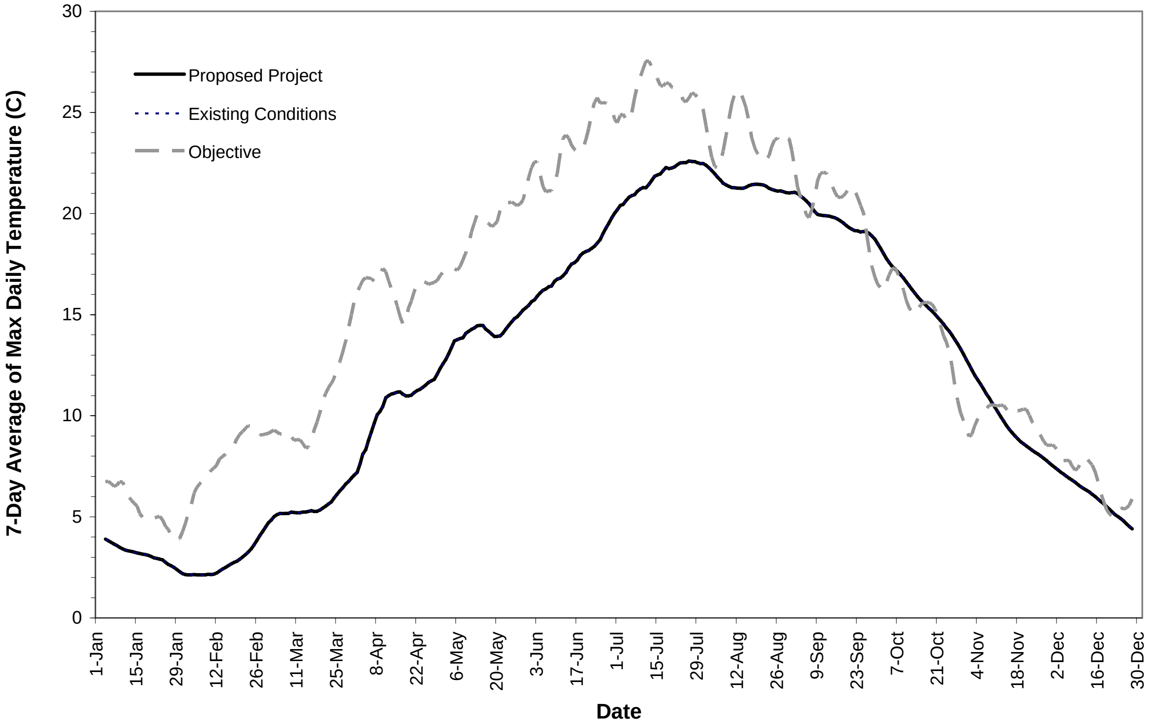

Figure 10. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Iron Gate dam (RM 190.5) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

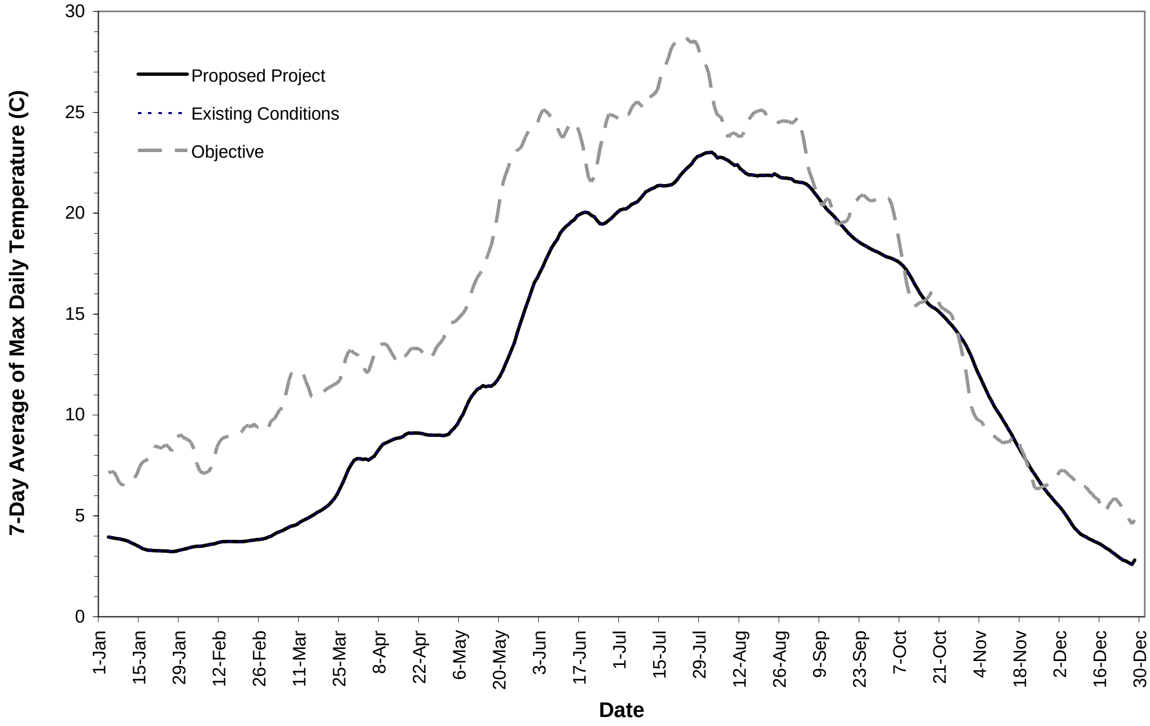

Figure 11. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Iron Gate dam (RM 190.5) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

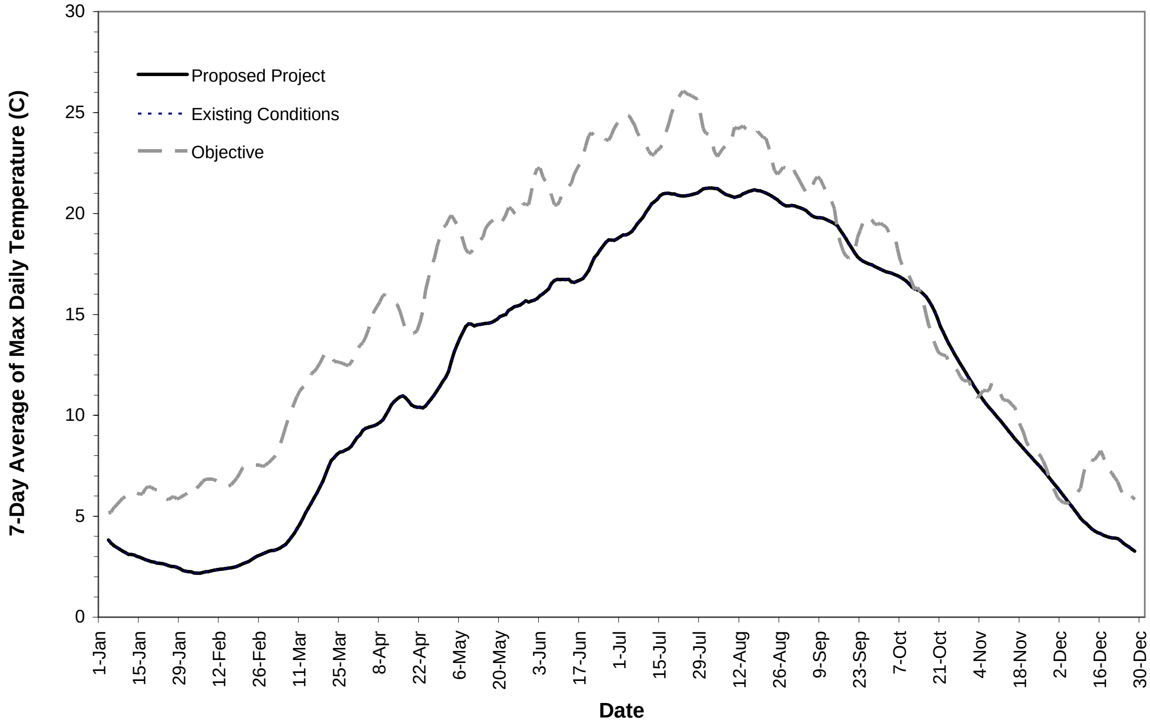

Figure 12. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Iron Gate dam (RM 190.5) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

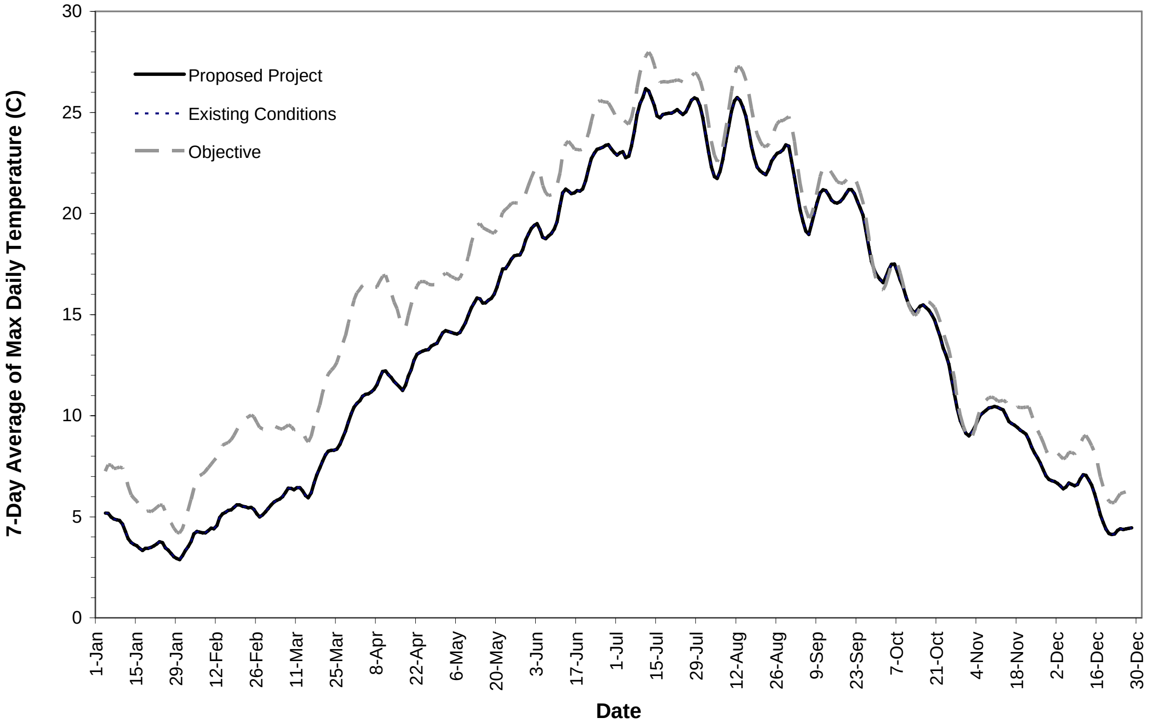

Figure 13. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at the Scott River (RM 144) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

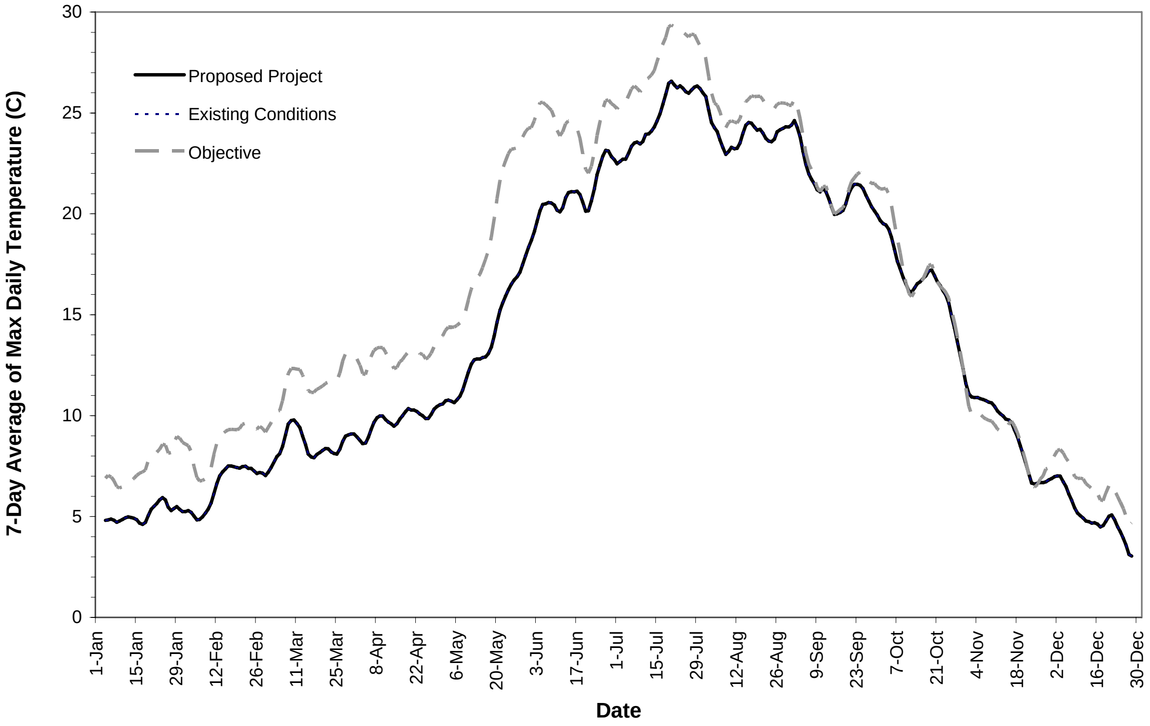

Figure 14. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at the Scott River (RM 144) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

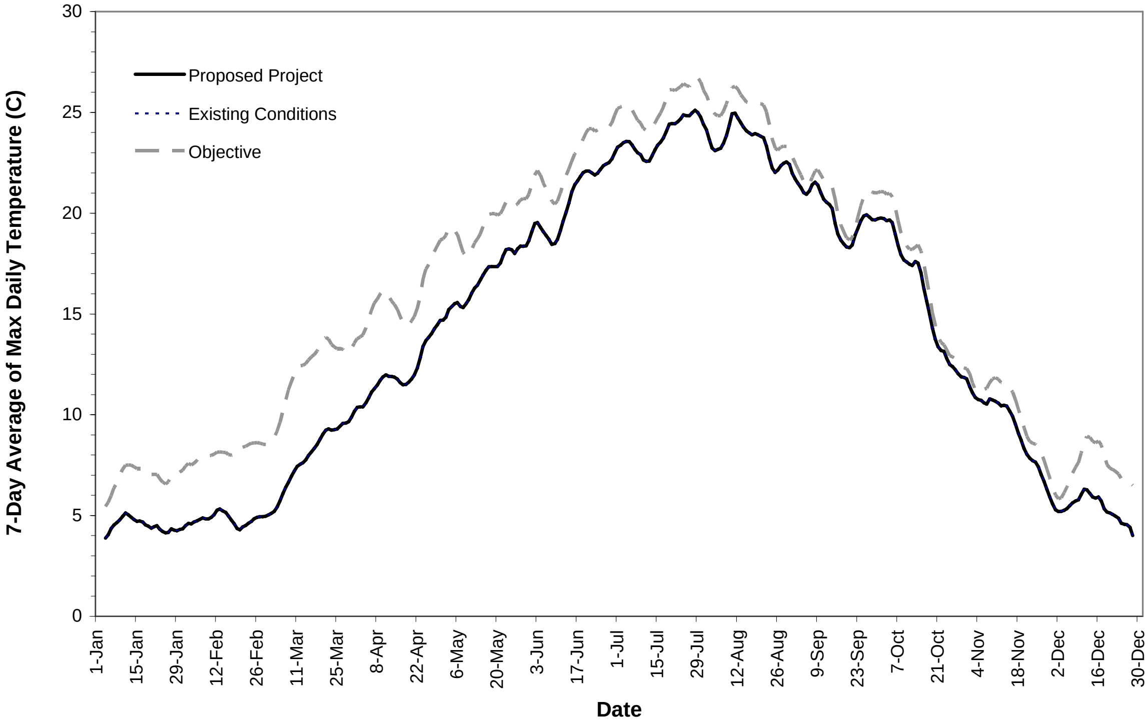

Figure 15. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at the Scott River (RM 144) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

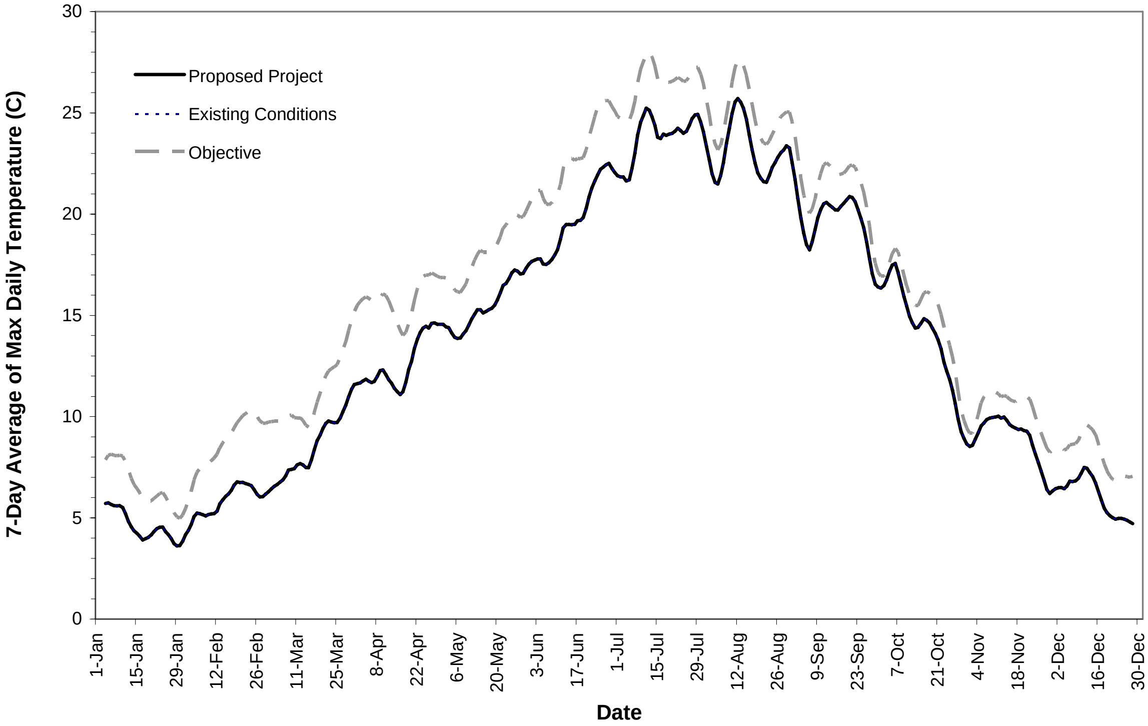

Figure 16. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Seiad Valley (RM 129) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

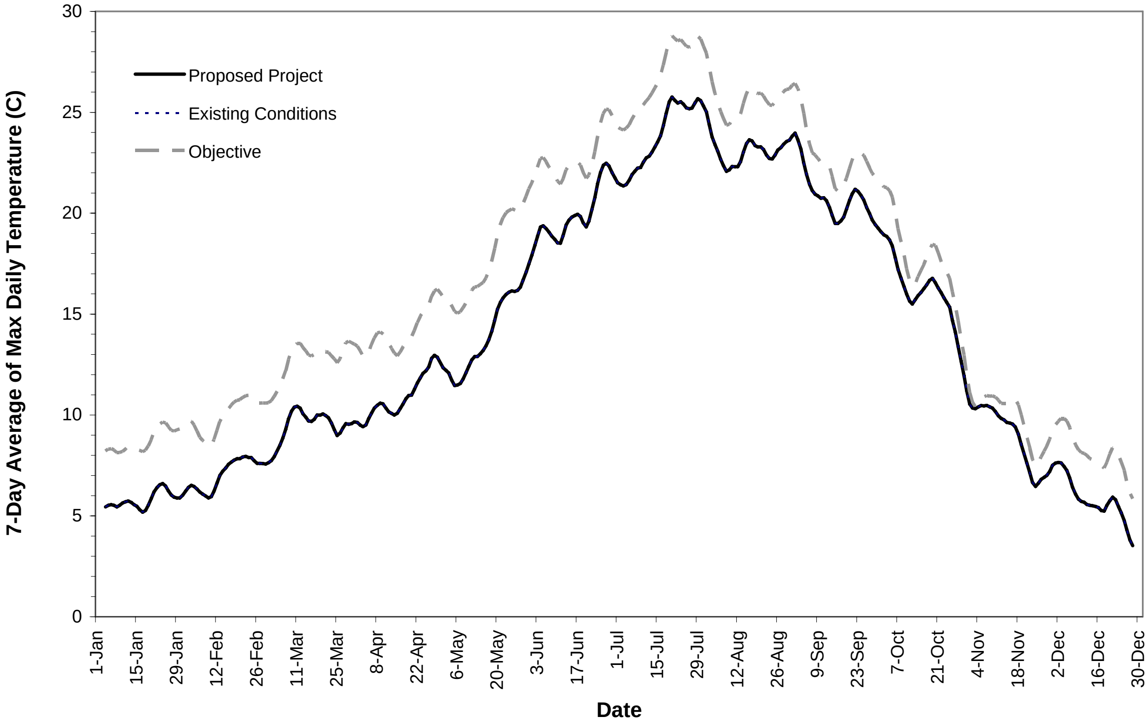

Figure 17. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Seiad Valley (RM 129) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

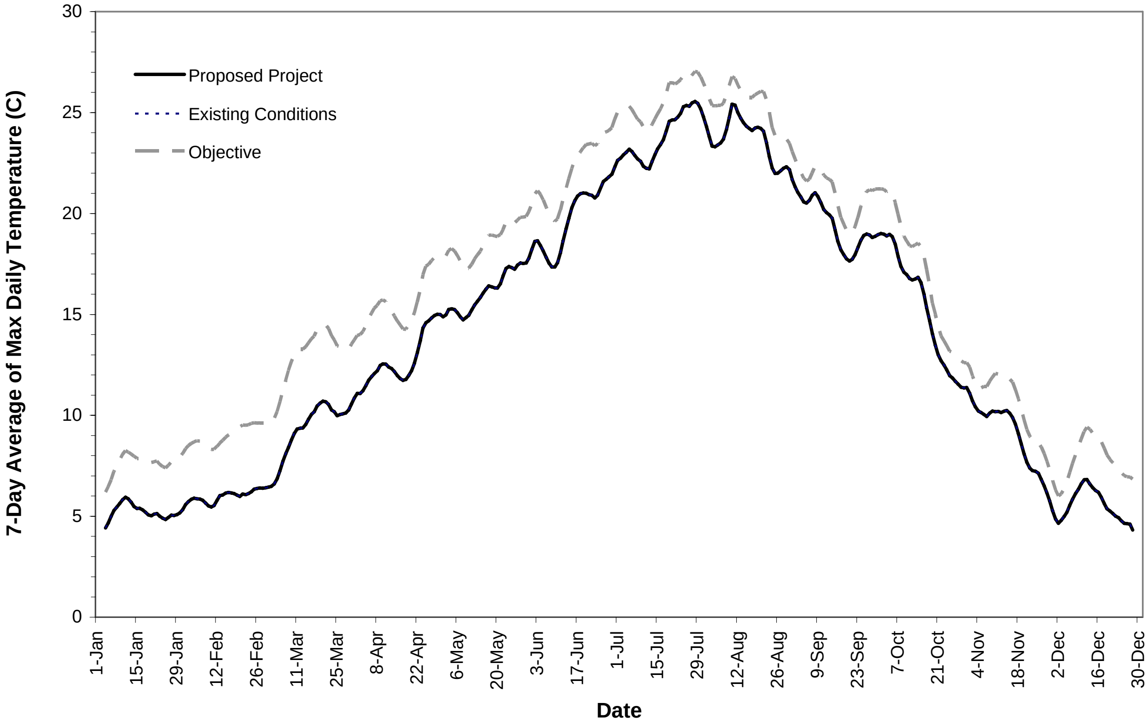

Figure 18. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Seiad Valley (RM 129) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

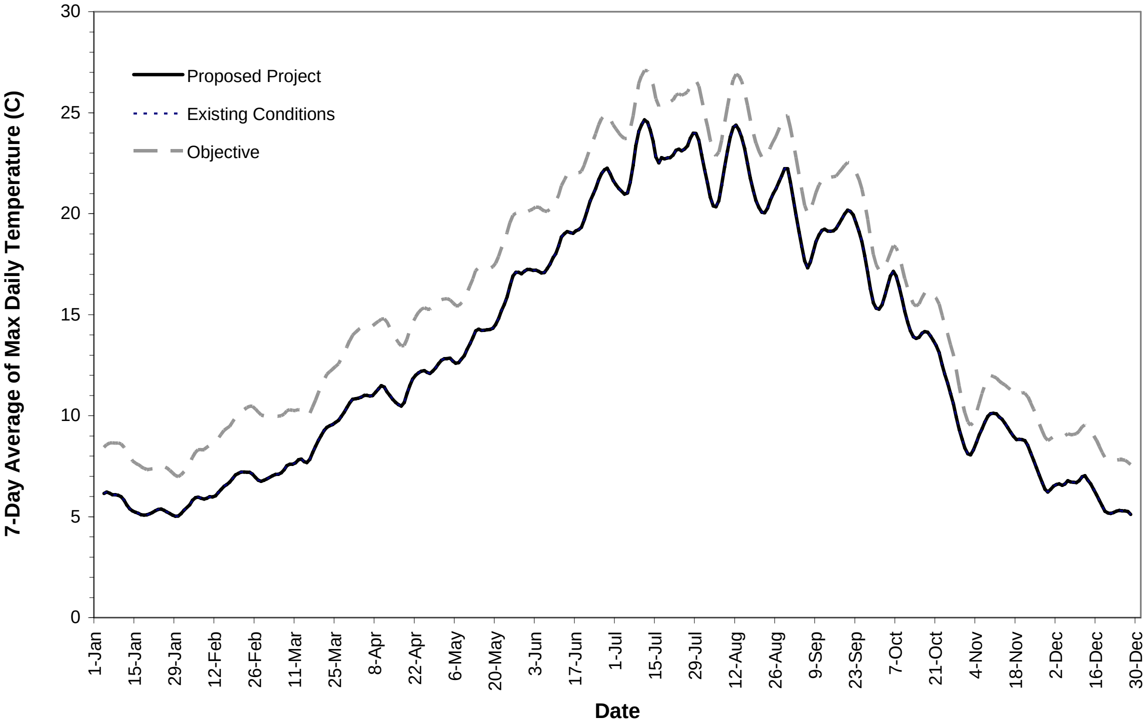

Figure 19. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at the Salmon River (RM 66.9) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

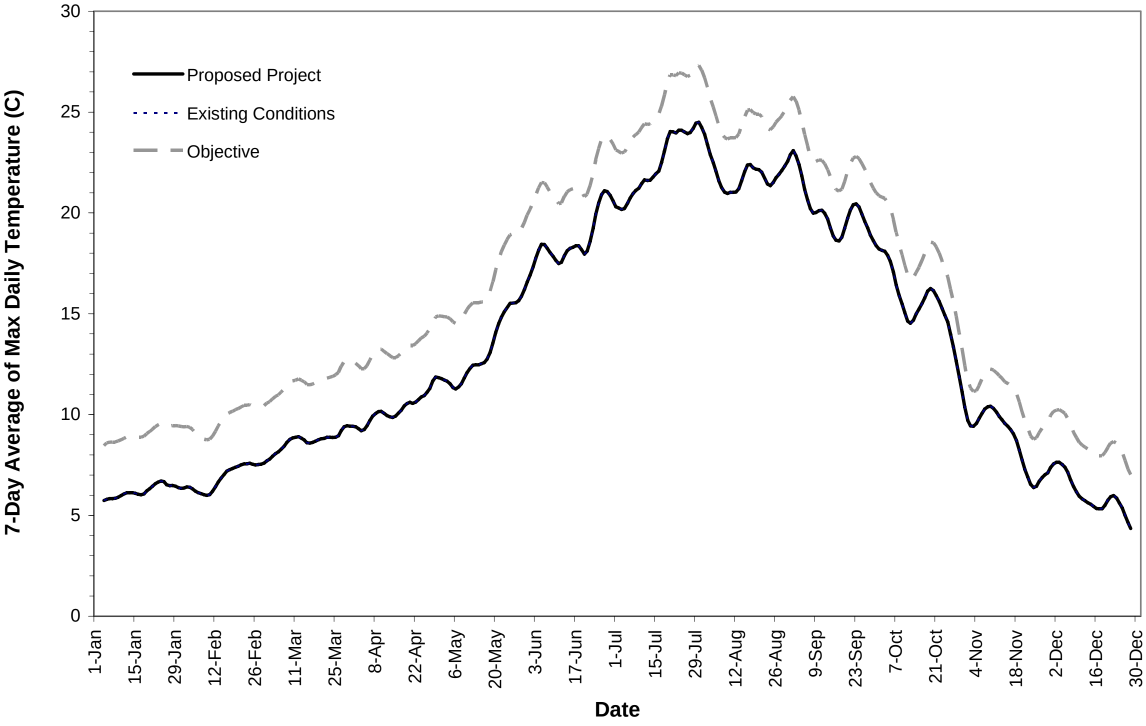

Figure 20. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at the Salmon River (RM 66.9) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

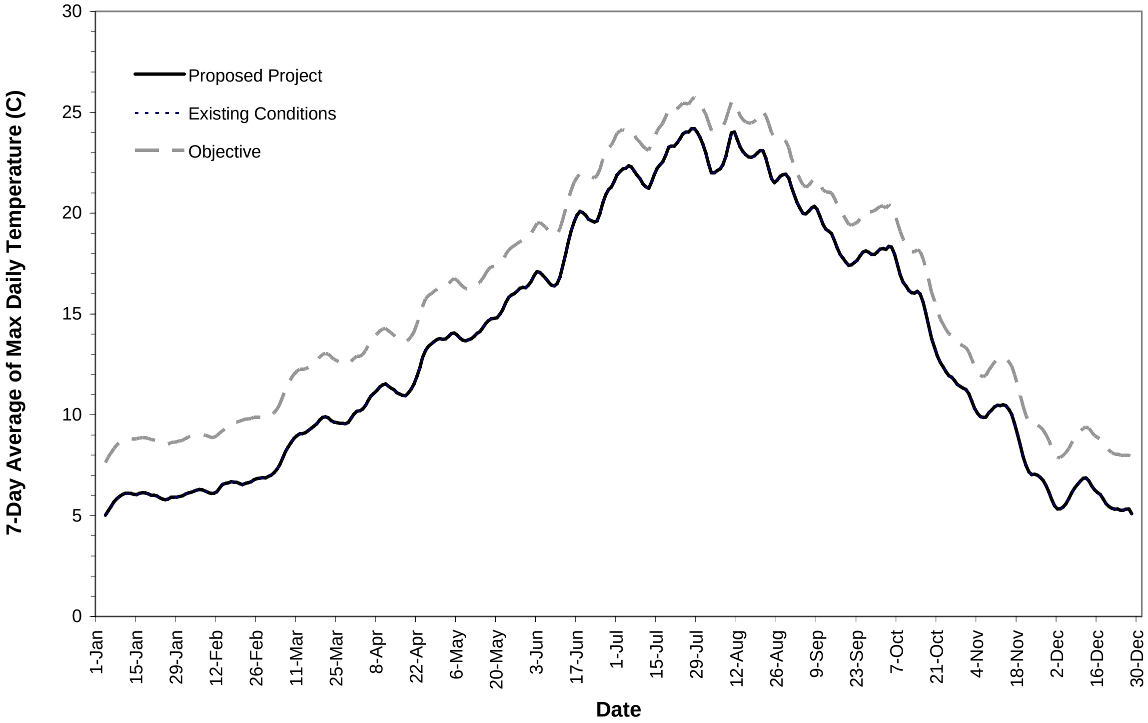

Figure 21. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at the Salmon River (RM 66.9) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

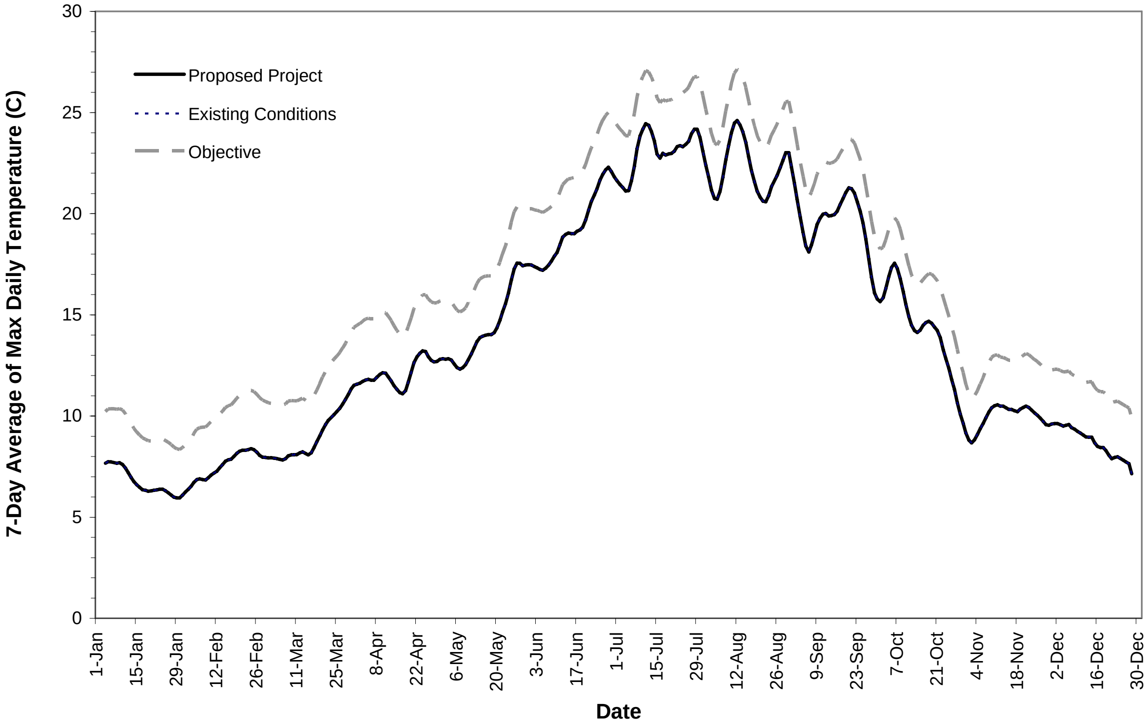

Figure 22. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Turwar (RM 5.3) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

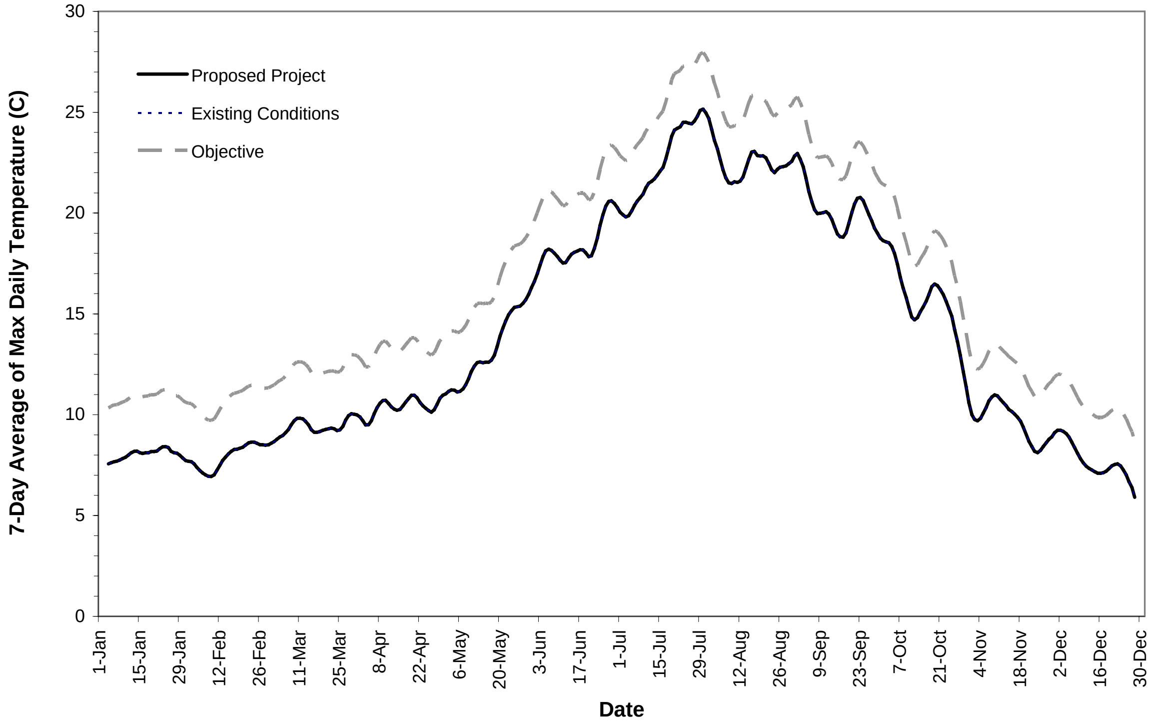

Figure 23. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Turwar (RM 5.3) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

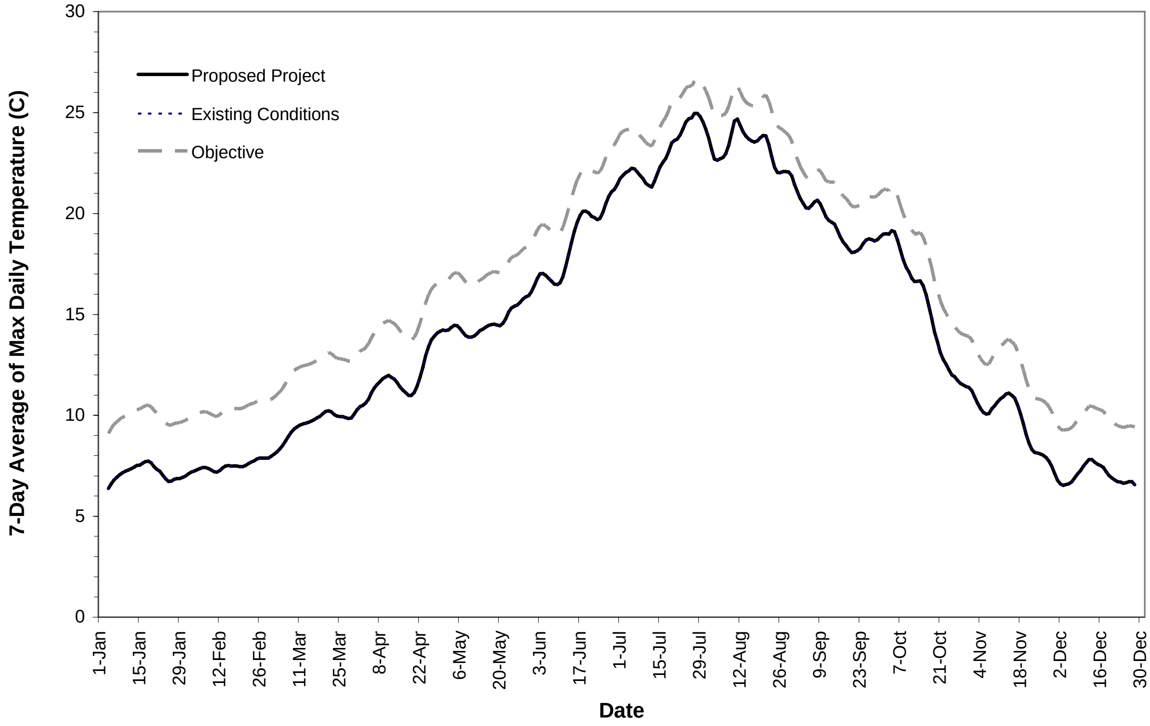

Figure 24. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Turwar (RM 5.3) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

APPENDIX B

RESERVOIR MANAGEMENT PLAN FOR COPCO AND IRON GATE RESERVOIRS

(REVISION: FEBRUARY 2008)

APPENDIX B
RESERVOIR MANAGEMENT PLAN FOR COPCO AND IRON GATE RESERVOIRS
(REVISION: FEBRUARY 2008)

B.1 INTRODUCTION

PacifiCorp is implementing a reservoir management plan for improving water quality in Copco and Iron Gate reservoirs. The reservoir management plan will evaluate the effectiveness and feasibility of several technologies and measures to more effectively control water quality conditions in Copco and Iron Gate reservoirs that result from significant loads of organic and nutrient matter originating from upstream of the Project. Based on the approach outlined in this plan, decisions regarding selection and implementation of specific technologies and measures will be made by PacifiCorp in consultation with the State Water Resources Control Board (State Water Board). This reservoir management plan is a revised version of a similar plan developed in March 2006 (PacifiCorp 2007a). This revised version of the reservoir management plan contains updated information on the process PacifiCorp is following for identifying, testing, implementing, and monitoring measures to enhance water quality conditions in Copco and Iron Gate reservoirs. Reservoir management actions and activities currently planned by PacifiCorp are described in Section B.3 of this plan, and specific tasks anticipated for implementing these actions and activities are described in Section B.4. Other potential reservoir management actions that may be identified as a result of these tasks will be presented in subsequent revisions or updates of the plan.

Copco and Iron Gate reservoirs are nutrient-enriched (eutrophic) as a result of large inflowing loads of nutrients and organic matter from sources upstream of the Project, particularly Upper Klamath Lake (PacifiCorp 2006). Management of these upstream sources is unaffected by and beyond the control of PacifiCorp's Project operations. As such, this reservoir management plan does not (and cannot) directly address the upstream loads of nutrients and organic matter. Control of the large inflow loads of nutrients and organic matter from upstream sources is most appropriately addressed by activities such as the implementation of Total Maximum Daily Loads (TMDLs) that are currently being developed by the State of California's North Coast Regional Water Quality Control Board (NCRWQCB) and the Oregon Department of Environmental Quality (ODEQ). Rather, actions to be implemented through this reservoir management plan are aimed at improving reservoir water quality conditions that are largely driven by the upstream loads of nutrients and organic matter (such as conditions resulting in algae blooms, low dissolved oxygen levels, and high pH levels). The reservoir management plan will also improve water quality in the Klamath River below the Project. Therefore, this reservoir management program is an important adjunct to the system-wide TMDLs, and provides a proactive response by PacifiCorp to implementation of the anticipated TMDLs, particularly as they may pertain to Copco and Iron Gate reservoirs.

B.2 BACKGROUND

As a result of upstream organic and nutrient loads, the reservoirs experience high primary production, including blue-green algae blooms, primarily during the June-October period. Recent systematic sampling by PacifiCorp and the Karuk Tribe have identified blooms of the toxin-producing blue-green algae species *Microcystis aeruginosa* in Copco and Iron Gate reservoirs, as well as other points along the Lower Klamath River. Significant concentrations of M*icrocystis* have been identified in numerous bodies of water in Oregon and California, including in Upper Klamath Lake.

The respiration and decay in the reservoirs of algae biomass from the large inflowing loads of nutrients and organic matter imparts an oxygen demand that contributes to low dissolved oxygen conditions in the hypolimnia of the reservoirs, primarily during the June-October period. In addition, the CO_2 uptake from high primary production in the reservoirs, coupled with naturally low buffering capacity in the Klamath River system, can cause occasional high pH levels in the reservoirs.

The intent of this reservoir management plan is to implement actions that will improve water quality conditions related to the primary production, respiration, and decay processes within the reservoirs (and attendant effects on summertime algae blooms, dissolved oxygen and pH conditions)[1]. The actions considered in this plan consist of proven techniques for lake and reservoir water quality management, such as described by Cooke and Kennedy (1989), Cooke et al. (2005), Holdren et al. (2001), Thornton et al. (1990), and UNEP (2004). Such techniques have resulted in appreciable water quality improvements in other water bodies (see the above-cited references).

As explained below, PacifiCorp is evaluating a number of water quality management techniques for application in Copco and Iron Gate reservoirs. These include techniques to control nutrients, algae, dissolved oxygen and pH, including constructed wetlands, hypolimnetic oxygenation, epilimnion (surface water) mixing and circulation, vertical (whole water column) mixing and destratification, reservoir drawdowns, and algaecide treatment. This plan includes testing and design analysis to assess effectiveness and feasibility of specific techniques, and implementation and monitoring of selected techniques. The implemented techniques, particularly when combined with implementation of TMDLs to control and reduce nutrient loads upstream of the Project, are expected to provide substantial and sustained water quality improvements in and below Copco and Iron Gate reservoirs.

B.3 IDENTIFICATION OF MANAGEMENT TECHNIQUES AND ACTIONS FOR WATER QUALITY IMPROVEMENTS IN COPCO AND IRON GATE RESERVOIRS

This section identifies techniques and actions for water quality improvements in Copco and Iron Gate reservoirs, and provides the rationale and justification for the specific actions that PacifiCorp is taking to assess and implement water quality enhancement measures under this management plan.

There are four basic categories of reservoir management techniques for water quality enhancements in reservoirs: (1) watershed/reservoir inflow treatment techniques, (2) in-reservoir physical treatment techniques, (3) in-reservoir chemical treatment techniques, and (4) in-reservoir biological treatment techniques. The techniques evaluated within each of these four categories relative to Copco and Iron Gate reservoirs were described in the previous reservoir management plan developed in March 2006 (PacifiCorp 2007a) and are summarized

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[1] As mentioned above, control of the large loads of nutrients and organic matter upstream of the Project is most appropriately addressed in the TMDLs that are currently under development.

below. More detailed information on these water quality management techniques are provided in Cooke and Kennedy (1989), Cooke et al. (2005), Holdren et al. (2001), Thornton et al. (1990), and UNEP (2004).

B.3.1 Watershed or Reservoir Inflow Management Options

This category of management options involves upstream watershed/inflow water quality management activities, such as:

- Watershed management for input nutrient reduction
- Point and non-point source control
- Nutrient trapping and filtering

Watershed and inflow water quality management is unaffected by and beyond the control of PacifiCorp's Project operations. However, given that water quality conditions in Copco and Iron Gate reservoirs are largely driven by the large nutrient and organic loads from upstream sources (particularly Upper Klamath Lake), improvements in watershed and upstream water quality (such as will be expected from implementing TMDLs that are currently being developed) will be essential to appreciable sustained water quality improvements in Copco and Iron Gate reservoirs and riverine reaches downstream of Upper Klamath Lake.

A potential technique is construction of properly designed wetlands that could offer a means of capturing and removing particulates and nutrients from upstream river inflow to the reservoirs. Such wetlands could augment the presence and settling function of Copco and Iron Gate reservoirs that already beneficially reduces the annual net nutrient and organic loading to the Klamath River below Iron Gate reservoir (City of Klamath Falls 1986, Kann and Asarian 2005, PacifiCorp 2006, and Kann and Asarian 2007). Beginning in 2008, PacifiCorp plans to assess the potential effectiveness and feasibility of constructing such wetlands upstream and/or along the reservoirs based on study, analysis, and design tasks as described below in Section B.4 of this plan.

Planned Action: ***Constructed Wetlands Feasibility and Design Assessment (as described in Section B.4 of this plan)***

B.3.2 Physical Water Quality Management Techniques

This category of management options involves in-reservoir physical techniques for water quality management. PacifiCorp is specifically evaluating the following techniques for effectiveness and feasibility in Copco and Iron Gate reservoirs:

- Hypolimnetic oxygenation
- Turbine venting
- Epilimnion (surface water) mixing and circulation
- Vertical (whole water column) mixing and destratification
- Reservoir drawdowns

In the following discussion, each of these in-reservoir physical techniques is defined and summarized, particularly for improving primary production and algae decay conditions caused by or related to loading of nutrients and organic matter from upstream sources (such as summertime algae blooms, dissolved oxygen, and pH).

B.3.2.1 Hypolimnetic Oxygenation

Hypolimnetic oxygenation is a technique that adds oxygen to the deeper part of the reservoirs (hypolimnion) without disrupting stratification. The addition of oxygen to the hypolimnion is used to prevent hypolimnetic anoxia (low oxygen in the bottom layer). This technique increases the amount of oxygenated water available to organisms that use the deeper and cooler waters of the reservoir, and retards the buildup of undecomposed organic matter and compounds (e.g., ammonium) in the hypolimnion.

Hypolimnetic oxygenation uses oxygen that is delivered using one of two primary approaches: a bubble system or a bubble-free system. The bubble systems consist of pipes with small holes laid throughout the reservoir. Gaseous oxygen is passed to the underwater pipes and fine oxygen bubbles rise, releasing oxygen to the water as they do so. If the hypolimnion is greater than 100 feet deep, the bubbles will essentially dissolve completely. Typically the efficiency of bubble plume oxygenation is about 85 percent. The method is effective for oxygenating most of the hypolimnion but does not fully oxygenate the sediments. The bubble-free systems consist of a pressuring device into which the deep water is pumped to compress the oxygen for an efficiency of almost 100 percent. Oxygen is often provided as liquid oxygen and stored lake-side, and also can be generated on site by a pressure swing compressor and molecular sieve.

Two popular types of bubble oxygenators are the unconfined fine bubble diffuser and the unconfined and diffuse bubble curtain. The fine bubble diffuser sends oxygen to the bottom at a few sites using discrete diffusers. The bubble curtain uses long arrays of hoses that emit fine bubbles over the entire length of the hose. Large bubble curtain systems, supplying up to 100 tons of oxygen a day, are currently in use in several reservoirs in the United States.

The bubble-free oxygenator systems send oxygen into a pressurized container where the gas mixes with water pumped from the reservoir. The pressurized container can be situated at the bottom of the lake, taking advantage of the natural pressure of deep water. The oxygenated water is then dispersed over the sediments via a short manifold or sometimes with a few direct pipes.

Relative to other reservoir water quality enhancements, hypolimnetic oxygenation provides the following advantages: (1) counteracts anoxia, thereby improving conditions for organisms that may prefer the deeper waters of the reservoir, (2) provides oxic conditions that retard the buildup of undecomposed organic matter and compounds (e.g., ammonium) in the hypolimnion, and (3) promotes binding and sedimentation of phosphorus at the sediment/water interface.

In 2005, PacifiCorp retained Mobley Engineering Inc. (MEI)[2] to evaluate the feasibility of a hypolimnetic oxygen diffuser system for the Iron Gate development to assist in enhancing dissolved oxygen conditions in the hypolimnion of Iron Gate reservoir and in releases to the

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[2] MEI and their team of associated experts have extensive experience in the evaluation, installation, and operation of dissolved oxygen (DO) enhancement technologies on reservoirs throughout the U.S.

Klamath River from the Iron Gate powerhouse (MEI 2005). To accomplish the oxygenation of hypolimnetic water, MEI (2005) recommended a reservoir oxygen diffuser system consisting of a single diffuser about 4,000 feet long that would be located in the deepest portion of Iron Gate reservoir upstream of the dam. To accomplish the oxygenation of hydropower releases, MEI (2005) recommended a additional diffuser system consisting of three shorter diffusers, approximately 1,500 feet long each and 60 to 90 feet deep, located just upstream of the powerhouse intake at the dam. This diffuser system is depicted in the figure titled "Conceptual Diffuser Layout at Iron Gate Reservoir" in MEI (2005).

The system would be operated early in the season, as soon as hypolimnetic dissolved oxygen levels start to drop, until reservoir turnover in the fall/early winter. The MEI (2005) design of the oxygen delivery capacity of the Iron Gate conceptual design is based on providing 1 to 3 mg/L of dissolved oxygen uptake to the full 1,735 cfs hydropower turbine flow capacity, and providing hypolimnetic oxygenation in the reservoir to improve water quality conditions. Hypolimnetic oxygenation would reduce or eliminate anoxic products such as iron, ammonia, manganese, and hydrogen sulfide in the reservoir and releases, and could reduce or eliminate nutrient releases from the reservoir's bottom sediment layer, if occurring. The system would maintain well-oxygenated conditions in most of the reservoir hypolimnion and in the hydropower releases.

An oxygen supply facility located near Iron Gate dam would supply oxygen at set flow rates to the diffusers. A facility utilizing a liquid oxygen storage tank, vaporizers, and trucked-in oxygen delivery would most likely be used. This type of system can be tied to turbine operation or utilize manually set flow rates. Manually set oxygen flow rates can be easily adjusted to match the slowly changing conditions.

In 2007, PacifiCorp again retained MEI to evaluate the feasibility of hypolimnetic oxygen diffuser systems for both Iron Gate and Copco reservoirs to maintain dissolved oxygen levels of 6 to 8 mg/L throughout both reservoirs (MEI 2007). Based on the results of this study, including detailed CE-QUAL-W2 modeling of alternative system configurations, MEI (2007) concluded that it is feasible to maintain desired oxygen levels in both reservoirs even with the large incoming loads of nutrients and organic matter. CE-QUAL-W2 model results show clear and dramatic improvements in reservoir dissolved oxygen levels with the conceptual oxygen diffuser systems in operation.

A reservoir oxygen diffuser system for Copco reservoir would include five long diffuser lines to place oxygen into the desired regions in the reservoir (MEI 2007). Two of the diffuser lines would place oxygen near the bottom of the reservoir at the upstream end of the reservoir to provide initial oxygenation of the incoming organic oxygen demands. These diffusers would be deployed close to the bottom in the deepest channel available at that location. Two other diffuser lines would place oxygen in the volumes of the hypolimnion upstream and downstream, respectively, of the reservoir's prominent bathymetric outcropping, and would also be deployed close to the reservoir bottom in the deepest areas available. A fifth diffuser would place oxygen in the metalimnion and would be deployed along the side of the reservoir to correspond to metalimnion elevation with minimum anchor cable lengths.

A reservoir oxygen diffuser system for Iron Gate reservoir would include three long diffuser lines to place oxygen into the desired locations in the reservoir (MEI 2007). One of the diffusers would place oxygen near the bottom of the reservoir at the upstream end of the reservoir to provide initial oxygenation of the incoming organic oxygen demands. This diffuser would be deployed close to the bottom in the deepest channel available at that location. The second diffuser would place oxygen in the hypolimnion just upstream of the dam and would also be deployed close to the reservoir bottom in the deepest areas available. The third diffuser would place oxygen in the metalimnion and would be deployed along the side of the reservoir to correspond to metalimnion elevation with minimum anchor cable lengths.

Oxygen supply facilities at both reservoirs would supply oxygen at set flow rates to the diffuser systems. Facilities utilizing a liquid oxygen storage tank, vaporizers, and trucked-in oxygen delivery would most likely be used at a location midway along both of the reservoirs, while small onsite oxygen generators might be used to supply oxygen to the hypolimnion near both Copco No. 1 and Iron Gate dams.

Although the MEI (2007) evaluation suggests that diffuser systems in both Copco and Iron Gate reservoir could substantially enhance reservoir dissolved oxygen levels, PacifiCorp is not prepared to proceed with implementation at this time. Further consultation with the State Water Board and other applicable regulatory authorities is needed to determine the full extent of the specific dissolved oxygen objectives and requirements that must be achieved throughout both reservoirs. In addition, although the diffusers and oxygen supply facilities that would be required are readily available, the specific methods and logistics of oxygen supply and delivery to the diffusers pose potential constraints that need further evaluation. This includes evaluation of optimization of oxygen use, further investigation of pressure swing adsorption[3] (PSA) versus liquid oxygen (LOx) supply systems, and further evaluation and specification of equipment needs. The tasks associated with further consultation on, and evaluation of these systems are described below in Section B.4 of this plan.

Planned Action: ***Further Consultation on and Evaluation of Oxygenation Systems in Both Copco and Iron Gate Reservoirs (as described in Section B.4 of this plan)***

B.3.2.2 Turbine Venting

In concept, turbine venting uses a "reaeration valve" to allow the induction of air into the water passageways within a turbine to aerate the releases from a dam. Such turbine aeration utilizes the low pressures of the water passing through the turbine to entrain air for tailrace dissolved oxygen enhancement. In 2005, a turbine venting system was assessed at the Iron Gate powerhouse (MEI 2005). MEI (2005) used modeling to estimate air admission rates, dissolved oxygen uptake, and potential total dissolved gas (TDG) for the observed powerhouse operating conditions. MEI (2005) estimated that turbine air admission could result in dissolved oxygen uptake of 1.5 to 2.7 mg/L depending on turbine headcover valve operation and the potential inclusion of baffles. Such uptake could provide an appreciable benefit to dissolved oxygen concentration in the tailwaters of Iron Gate dam.

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[3] PSA oxygen supply utilizes a molecular sieve to separate an oxygen stream from a compressed air supply, and is capable of supplying 10 to 15 times the oxygen volume flow of compressed air.

In the Final Environmental Impact Statement (FEIS) for the Project issued by the Federal Energy Regulatory Commission (FERC) in November 2007, FERC concluded that turbine venting would be effective in achieving increases in dissolved oxygen in the Klamath River downstream of Iron Gate dam. On this basis, FERC (2007) recommends a measure to include turbine venting and follow-up dissolved oxygen monitoring at Iron Gate.

PacifiCorp plans to proceed with further testing and evaluation of a turbine venting system at Iron Gate. PacifiCorp plans to conduct field tests to verify air flow and dissolved oxygen increases, and to quantify the effects of the increased air flow on turbine efficiency. The tasks associated with testing of the system are described below in Section B.4 of this plan.

Planned Action: ***Testing of Turbine Venting for Dissolved Oxygen Enhancement at Iron Gate (as described in Section B.4 of this plan)***

B.3.2.3 Circulation and Destratification

Circulation and destratification are techniques intended to improve water quality by mixing the algae out of the euphotic zone (i.e., the surface zones of reservoirs that provide sufficient light for algal growth), and also by introducing oxygen to the bottom waters of the reservoir, thereby reducing internal nutrient loading.

Circulation and destratification use the same basic principle of aeration-driven circulation and mixing. However, as used in this plan, circulation and destratification are differentiated by the extent and location of reservoir waters to be mixed, e.g., circulation involves mixing only surface layers or shallow locations of the reservoir (epiliminion), whereas destratification involves mixing of the entire water column.

Destratification is accomplished with unconfined plumes of air provided by compressors and distributed with a network of pipes and diffusers that float above the reservoir bottom. In smaller reservoirs, propellers have been used to mix reservoir waters and break down or impede thermal stratification. One approach to destratification involves extended seasonal mixing that delays the spring onset, or accelerates the fall turnover of seasonal stratification using compressed air injection. An intermittent destratification approach involves use of intermittent destratification to create alternating oxic and anoxic conditions in the hypolimnion, which would favor denitrification.

PacifiCorp does not propose to consider destratification further under this plan for Copco and Iron Gate reservoirs at this time for the following reasons. First, destratification could impair the availability and amount of cool water storage in Iron Gate reservoir that is used by the Iron Gate fish hatchery. Second, PacifiCorp is concerned that destratification might adversely raise reservoir release temperatures, depending on when it occurred. Lastly, destratification is difficult and uncertain in reservoirs that stratify strongly, such as in Iron Gate reservoir and to a lesser extent Copco reservoir.

PacifiCorp is proposing to implement vertical mixing of the entire water column in J.C. Boyle reservoir, located in Oregon about 20 miles upstream of Copco reservoir. J.C. Boyle is a much smaller reservoir that exhibits much less thermal stratification and more rapid flushing than Copco and Iron Gate reservoirs. As such, vertical mixing of the entire water column would be more effective in J.C. Boyle reservoir, and would enable the water quality in J.C. Boyle reservoir to better withstand and process the large loads of nutrients and organic matter flowing into the reservoir from upstream sources. See the "Reservoir Management Plan for J.C. Boyle Reservoir (Revision: February 2008)" for further information (that plan is contained in Appendix B to PacifiCorp 2007a).

For Copco and Iron Gate reservoirs, surface or epilimnetic circulation is being evaluated under this reservoir management plan as a means of mixing water and minimizing quiescent conditions in surface layers of the reservoirs, such as in the euphotic zone or in coves or embayments, to directly control algae growth. The surface mixing and agitation caused by this circulation is expected to reduce blue-green algae by reducing their light exposure (by mixing the algae out of the euphotic zone) and disrupting the generally quiescent conditions that may contribute to bloom formation.

Several types of aerators and circulators are available for potential application in this part of the reservoir management plan. Popular among these devices are solar-powered water "circulators" (e.g., SolarBee™, Pond Doctor™) that aerate by circulating surface water of the reservoir at the rate of up to 10,000 gallons per minute. The circulation from these devices occurs with a horizontal long-distance flow pattern that provides mixing action 24 hours a day. The specific water quality improvements and advantages offered by such circulation respond directly to certain aspects of water quality enhancements targeted by this plan, in particular conditions related to summertime algae blooms and attendant effects on dissolved oxygen and pH. According to manufacturers research, these solar-powered water circulators have proven to be effective in controlling blue-green algae blooms in over 200 water bodies worldwide (including over 80 municipal raw water storage reservoirs), including in controlling blooms of *Microcystis*.

In 2007, PacifiCorp conducted a pilot demonstration project of these solar-powered water circulators in Copco reservoir as a part of its reservoir management program. PacifiCorp initially retained Pond Doctor to install three solar-powered circulation units in Mallard Cove in Copco Reservoir. These three units were installed in Mallard Cove in June 2007, but were subsequently removed in July 2007 due to inconsistent function and operation. Rather than abort the pilot demonstration project entirely, PacifiCorp contacted SolarBee who had one solar-powered circulation unit readily available for installation in Copco reservoir. SolarBee subsequently installed the unit (SolarBee SB10000v12) in Beaver Cove in Copco reservoir. Because of its size and morphometry, Beaver Cove (approximately 16 acres, maximum depth about 30 ft) was considered more appropriate than Mallard Cove for a one-unit deployment.

The SolarBee unit operated continuously and reliably in field conditions experienced at Beaver Cove throughout the deployment period from August 4, 2007 to October 3, 2007 (Knud-Hansen et al. 2007). Field monitoring during the deployment period showed that the unit improved water quality in the treated zone relative to other untreated areas. Vertical profile data from seven monitoring sites, located at distances from about 275 ft to over 5,000 ft away from the unit, showed a statistically-significant ($P > 0.01$) decrease in pH (consistent with reduced algal production) moving toward the unit's zone of influence. Differences in algal concentrations, as indicated by the pH gradient described above, were indicated by aerial and on-the-water photos that illustrated differences between treated zones and untreated zones.

Although the demonstration of the SolarBee unit showed promise, PacifiCorp is not prepared to proceed with a more extensive implementation at this time. Rather, because of the inconsistent and limited testing that occurred in 2007, PacifiCorp plans further pilot-scale testing of circulators using additional units for a more extended deployment period. Such testing is needed to gain better reliability and effectiveness information prior to potential scale-up to more extensive implementation in Copco and Iron Gate reservoirs. The tasks associated with further pilot testing of circulators are described below in Section B.4 of this plan.

Planned Action: ***Additional Pilot Testing of Solar-Powered Circulators in Copco Reservoir (as described in Section B.4 of this plan)***

B.3.2.4 Reservoir Drawdown and Flushing

In theory, lowering reservoir water level can potentially facilitate water quality improvement in two ways. One is through exposing sediments to oxidize them and decrease their oxygen demand and long-term nutrient release rate. A second is through increasing the rate of reservoir flushing (by reducing reservoir volume) and thereby decreasing algae abundance through washout.

Drawdown has several important drawbacks and limitations, particularly when considered for application at Copco and Iron Gate reservoir. First, exposure and oxidation of sediments would not occur for the majority of sediments without draining the reservoirs; it would be difficult to dewater sediments sufficiently to get more than minor results. Second, nutrients released when the reservoirs are refilled may actually result in an increased flush of nutrients downstream. Third, any positive effects of drawdown on reducing in-reservoir algae growth would potentially be offset by or overwhelmed by the increased algae growth caused by significant upstream nutrient loads. Finally, drawdown temporarily would affect downstream hydrology (by eliminating the reservoirs' active water storage) and Iron Gate Hatchery operations (by disruption or elimination of cool water storage in the hypolimnion of Iron Gate reservoir that is used by the hatchery).

Flushing is a technique that involves adding large amounts of water to the reservoir, whether low in nutrients or not, to flush algae out of the reservoir faster than it can reproduce. This technique has been applied successfully to treat areas in hypereutrophic Moses Lake, Washington (Cooke et al. 2005). A flushing rate of 10 to 15 percent of the reservoir's volume per day is considered necessary for this purpose (Cooke et al. 2005). This equates to an inflow rate of at least 2,360 and 2,960 cfs for Copco and Iron Gate reservoirs, respectively. However, PacifiCorp has no control over total river flow quantities, and these quantities are typically not available during the primary June-October algae growth period.

For the reasons described above, PacifiCorp was not intending to consider drawdown further under this plan. However, in the Final Environmental Impact Statement (FEIS) for the Project issued in November 2007, FERC recommends an integrated fish passage and disease management program that includes a number of phased studies and actions (see FERC 2007). During "Phase I" studies (i.e., "Years 1 to 4" post-license issuance), FERC recommends a measure involving experimental drawdown of Copco and Iron Gate reservoirs to allow for an evaluation of the effects of decreased reservoir volume on juvenile fish passage survival through the reservoir, and on downstream water quality conditions, including presence of the microcystin, a toxin that can be produced by *Microcystis*. FERC (2007) assumes that reservoir drawdown could improve migration survival by increasing water velocities and migration speed. FERC (2007) further assumes that drawdown may also reduce algal blooms and resultant potential effects on downstream water quality. FERC (2007) recommends that the experimental drawdown of Copco and Iron Gate reservoirs consist of lowering the water elevations in each reservoir to minimum operating pool (about 22 feet below the normal pool level in both reservoirs) from May through November. FERC (2007) estimates that the volume of Copco and Iron Gate reservoirs would be reduced by about 40 percent and surface area would be reduced by 25 to 30 percent during such a drawdown.

Despite PacifiCorp's concerns with drawdown as described above, PacifiCorp plans to conduct a detailed model-based evaluation of drawdown of Iron Gate and Copco reservoirs to minimum operating pool (about 22 feet below the normal pool level in both reservoirs) from May through November. The model-based evaluation will utilize PacifiCorp's detailed models of the reservoirs to quantify water quality and hydraulic effects from such a drawdown. The tasks associated with this analysis are described below in Section B.4 of this plan.

Planned Action: ***Model-Based Analysis of Potential Drawdown of Copco and Iron Gate Reservoirs (as described in Section B.4 of this plan)***

B.3.3 Chemical Water Quality Management Techniques within Reservoirs

This category of management options includes in-reservoir chemical techniques for water quality management, such as:

- Algaecides
- Phosphorus inactivation or settling agents

Each of these techniques is described below with regard to application to Copco and Iron Gate reservoirs, particularly for improving water quality conditions caused by or related to loads of organic and nutrient matter from upstream sources (such as summertime algae blooms, dissolved oxygen, and pH). Of these two in-reservoir chemical techniques, PacifiCorp proposes to further consider algaecide treatment under this plan, most likely using sodium carbonate peroxyhydrate (PAK™27). PacifiCorp recognizes that any chemical application would have to go through the appropriate regulatory approval process.

B.3.3.1 Algaecides

Algaecides directly kill algae in waters to which they are applied. Copper has traditionally been the most widely used algaecide in lakes and reservoirs to prevent algae blooms. Copper treatments have been an important line of defense in drinking water supplies and have allowed safe swimming in many recreational lakes (Holdren et al. 2001). However, given general agency and public concern over copper pesticide use, PacifiCorp would probably not propose that copper be used in the reservoirs to control or prevent blue-green algae.

PacifiCorp is planning to evaluate sodium carbonate peroxyhydrate (PAK™27) application as one of the potential specific actions to be implemented in this management plan process. Sodium carbonate peroxyhydrate (PAK™27) is approved for use as an algaecide by the U.S. Environmental Protection Agency (EPA), and is also approved under NSF/ANSI Standard 60 (drinking water treatment chemicals). On February 27, 2006, the California Department of Pesticide Regulation (DPR) registered sodium carbonate peroxyhydrate (PAK™27) for aquatic application as an algaecide used to control blue-green algae (see Water Quality Order No. 2004-0009-DWQ NPDES No. CAG990005 National Pollutant Discharge Elimination System Permit for the Discharge of Aquatic Pesticides for Aquatic Weed Control in Waters of the United States, as amended by adoption of State Water Board Resolution No. 2006-0039).

The active ingredient of sodium carbonate peroxyhydrate is a compound consisting of sodium carbonate and hydrogen peroxide (H2O2). Sodium carbonate peroxyhydrate (PAK™27) is used as an algaestat or algaecide for the selective control of blue-green algae in lakes, ponds, and reservoirs. The product is applied by broadcasting granules of the compound, manually or via a mechanical spreader, over the surface of the water. At the appropriate application rate, the hydrogen peroxide component controls the growth of blue-green algae, but does not affect desirable green algae and zooplankton, and is non-toxic to the ecosystem.

PacifiCorp plans to proceed with effectiveness testing of sodium carbonate peroxyhydrate (PAK™27) applications in Copco and Iron Gate reservoirs based on test applications to limited and confined areas of the reservoirs or suitable separate enclosures using water taken from the reservoirs. PacifiCorp will seek the necessary approval from the State Water Board and other appropriate regulatory authorities prior to such testing. The tasks associated with this testing are described below in Section B.4 of this plan.

Planned Action: ***Effectiveness Testing of PAK™27 Applications in Copco and Iron Gate Reservoirs (as described in Section B.4 of this plan)***

B.3.3.2 Phosphorus Inactivation or Settling Agents

Phosphorus inactivation or settling agents control algae by limiting phosphorus availability through two processes: (1) using chemicals to remove (precipitate) phosphorus from the water column; and (2) adding phosphorus binder to the reservoir to prevent release of phosphorus from sediments. Application of aluminum sulfate (referred to as “alum”) is the most widely used method for phosphorus inactivation or settling. Aluminum sulfate has been used in dozens of lakes in the US and Europe to remove excess phosphorous and thus reduce algae blooms. Alum can be added to inflows and/or dispersed in the reservoir epilimnion. Typical dose rates are 12 mg/L (as Al).

Alum additions have not always been successful, despite the simple chemistry involved. Where failure to reduce algal biomass by reducing phosphate has occurred with alum addition, it has often been in situations where substantial new sources of phosphorous arrive each year. This new phosphorus is not held by the alum already in the sediments from previous years of treatment. In such cases, frequently repeated alum additions would probably have to be made.

PacifiCorp does not propose to consider phosphorus inactivation or settling (using alum) further under this plan. Copco and Iron Gate reservoirs are relatively fast-flushing impoundments and are subject to very high inflowing (external) phosphorus loads from upstream sources, particularly Upper Klamath Lake. As such, these reservoirs are not good candidates because these large phosphorus inputs would be difficult to control using alum application. Second, due to large phosphorous loads from upstream sources control, phosphorous control as a strategy to limit algal production is questionable.

B.3.4 Biological Water Quality Management Techniques within Reservoirs

This category of management options involves in-reservoir biological techniques for water quality management, such as

- Enhanced grazing (herbivorous zooplankton)
- Selective fish removal

Biological techniques can be a significant factor in controlling algal communities. Biological techniques can be accomplished in two ways: (1) by increasing the population of large-bodied zooplankton that graze on algae (enhanced "grazing"), and (2) reducing the number of fish that feed on zooplankton (planktivores). Even if productivity is high, these biological controls potentially can prevent algal biomass from accumulating to corresponding high levels. These procedures are often referred to as "biomanipulation."

While biomanipulation techniques are appealing in their use of natural ecological principles to control algae, these techniques are largely experimental or have a mixed record of success. In the case of Copco and Iron Gate reservoirs, reductions in the large number of medium and small-sized warmwater fish species in the reservoirs would be the logical approach if biomanipulation was attempted. However, appreciable removal of these fish would be difficult and would adversely affect the popular warmwater recreational fishery that exists in the reservoirs. Therefore, PacifiCorp has determined that biomanipulation is currently infeasible and impractical for application at Copco and Iron Gate reservoirs, and does not propose to consider biomanipulation further under this plan.

B.4 PLANNED ACTIVITIES FOR EVALUATION, TESTING, AND IMPLEMENTATION OF TECHNIQUES FOR WATER QUALITY IMPROVEMENTS IN COPCO AND IRON GATE RESERVOIRS

This section describes the specific planned activities and actions by PacifiCorp for further evaluation, testing, and implementation of techniques for water quality improvements in Copco and Iron reservoirs. As described above in Section B.3 of this plan, these actions include: (1) constructed wetlands feasibility and design assessment; (2) design and implementation planning of an oxygenation system in lower Iron Gate reservoir; (3) further consultation on and evaluation of hypolimnetic oxygenation in both Copco and Iron Gate reservoirs; (4) testing of turbine venting for dissolved oxygen enhancement at Iron Gate; (5) additional pilot testing of surface or epilimnetic circulation in Copco reservoir; (6) model-based analysis of potential drawdown of Copco and Iron Gate reservoirs; and (7) effectiveness testing of sodium carbonate peroxyhydrate (PAK™27) algaecide treatments in Copco and Iron Gate reservoirs.

B.4.1 Constructed Wetland Feasibility and Design Assessment

PacifiCorp plans to evaluate the feasibility of using constructed wetlands as a potential means for helping to process and reduce loads of nutrients and organic matter to the Project reservoirs from upstream sources. This feasibility study would be a first step in the evaluation process of potentially using constructed wetlands to enhance the water quality in the Klamath River. In concept, these constructed wetlands would pass a portion of river inflow through shallow emergent vegetation wetlands to allow chemical and biological processes to reduce concentrations of nutrients and organic matter. The dominant removal and reduction processes in wetlands are settling, biotransformation (microbial and plant-mediated), and plant uptake.

Design and implementation of constructed wetlands requires an iterative process. Prior to design and construction, site conditions must be evaluated to assess the efficacy of the proposed constructed wetlands. The tasks and activities to be performed for the constructed wetland feasibility and design assessment will include:

- Identify treatment objectives and the water budget for potential constructed wetlands. The treatment objectives will establish design guidelines for desired removal efficiency of nutrients and organic matter loads that flow through the wetlands. The water budget of potential wetlands will estimate the quantities of water inflows to the constructed wetlands systems from the river, and the outflows, including the net losses through evapotranspiration.
- Determine potential wetland site suitability. Site-specific conditions need to be addressed and characterized before selecting locations of constructed wetlands. GIS mapping and site reconnaissance will be done to identify potential wetlands site locations for the project (focus will be on potential sites upstream of project reservoirs). Considerations will include available land area and ownership, topography, soil types, hydrologic conditions, and presence of existing wetlands or sensitive flora and fauna on potential sites.
- Develop other essential pre-design information. Prior to any design, additional technical information will be developed to aid subsequent design. Such information includes estimates of wetland hydraulic loading rates, hydraulic residence times, and constituent reaction and removal rates that can be used to give sizing estimates for both the planning and design of the wetlands systems from projected inflow loads and desired removal efficiency.
- Estimate treatment capabilities and capacity of potential constructed wetlands. Calculations and/or modeling will be used to evaluate the reduction of biochemical oxygen demand (BOD), phosphate, nitrate (as N), and total suspended solids (TSS). Treatability will be estimated by percent concentration reduction as well as mass load of each constituent into and out of the wetlands.
- Determine feasibility and conceptual layouts of potential constructed wetlands. Results from the activities described above will be analyzed to identity the opportunities, constraints, and potential capacity of constructed wetlands. A conceptual layout for the project will be developed for further design consideration.
- Prepare a report of findings and recommendations. The information developed during the proposed work will be compiled in a technical report. The report will discuss the results of

the assessment and make recommendations regarding the feasibility of constructed wetlands, including a conceptual layout of the proposed system. The conclusions and recommendations of the feasibility study will serve as a guide for the next phase of project development and construction.

PacifiCorp plans to complete the work itemized above according to the schedule summarized in the following table:

Activity/Milestone	**Date or Period**
Preliminary Wetlands Feasibility Assessment	
Initial assessment period	Spring 2008
Wetland site suitability assessment	Spring 2008
Pre-design, feasibility, and concept development	Summer 2008
Technical report	Fall 2008

B.4.2 Further Consultation on and Evaluation of Oxygenation Systems in Copco and Iron Gate Reservoirs

Further consultation with the State Water Board and other appropriate regulatory authorities is needed to determine the specific dissolved oxygen objectives and requirements that must be achieved throughout both reservoirs before proceeding with further implementation and testing of an oxygen diffuser system. The tasks associated with further consultation and evaluation will include:

- Consult with appropriate regulatory agencies. PacifiCorp will consult with the State Water Board and other appropriate regulatory authorities prior to further implementation and testing of the systems.
- Based on the outcome of the above consultation, finalize details and planning of the diffuser systems to be implemented. PacifiCorp will finalize design and planning details, including the oxygen supply equipment and location, the oxygen flow control valves and distribution piping design, the supply piping and route to reservoir water lines, and confirmation of diffuser line layout as needed.

PacifiCorp plans to complete the work itemized above according to the schedule summarized in the following table:

Activity/Milestone	**Date or Period**
Further Consultation on and Evaluation of Copco and Iron Gate Oxygenation Systems	
Consultation	Spring 2008
Final system design and planning	Summer-Fall 2008

B.4.3 Testing of Turbine Venting for Dissolved Oxygen Enhancement at Iron Gate

PacifiCorp plans to proceed with further testing and evaluation of a turbine venting system at Iron Gate as described in Section B.3 above. The tasks and activities associated with testing of turbine venting at Iron Gate will include:

- Consult with appropriate regulatory agencies. PacifiCorp will consult with the State Water Board and other appropriate regulatory authorities prior to testing of turbine venting at Iron Gate.
- Conduct field tests of turbine venting at Iron Gate. These tests will verify air flow and dissolved oxygen increases that can be achieved with turbine venting. These tests will also quantify the effects of the increased air flow on turbine operation efficiency. Air entrainment will first be evaluated using existing piping and fully open vacuum breaker valves. If additional air is needed, PacifiCorp will evaluate other methods as appropriate to increase air entrainment (and presumably dissolved oxygen), such as hub baffles on vacuum breaker vents and draft tube air entrainment.
- Monitor effectiveness of turbine venting at Iron Gate. During the turbine venting tests, PacifiCorp will conduct monitoring of dissolved oxygen in the Project tailwaters and in the river just downstream. This monitoring will provide information on the effectiveness of turbine venting.
- Prepare a report of findings and recommendations. The information developed during the turbine venting tests will be compiled in a technical report. The report will discuss the results of the turbine venting tests. The conclusions and recommendations of the report will serve as a guide for potential implementation of turbine venting, including recommendations on modifications of valves or intake piping that would be needed to permanently increase turbine venting capacity.

PacifiCorp plans to complete the work itemized above according to the schedule summarized in the following table:

Activity/Milestone	Date or Period
Testing of Turbine Venting for Dissolved Oxygen Enhancement at Iron Gate	
Consultation and final planning of tests	Spring 2008
Turbine venting tests and monitoring	Summer 2008
Technical report	Fall 2008

B.4.4 Additional Pilot Testing of Solar-Powered Circulators in Copco Reservoir

PacifiCorp plans further pilot-scale testing of solar-powered circulators in Copco reservoir as described in Section B.3 above. Such testing is needed to gain better reliability and effectiveness information prior to potential scale-up to more extensive implementation in Copco and Iron

Gate reservoirs. The tasks and activities associated with further testing of circulators in Copco reservoir will include:

- Deploy and operate circulators in a selected cove at Copco reservoir during May through October. The pilot test will be conducted to assess two objectives: (1) to assess operational consistency and reliability in field conditions, and (2) to assess water quality improvement in the "treated" cove area relative to other "untreated" areas, particularly in controlling blooms of blue-green algae such as *Microcystis*. It is anticipated that two solar-powered circulators (SolarBee™ Model SB10000v12) will be installed in a selected cove for a six-month deployment period from May through October. However, the details of deployment and the configuration and number of units will be developed in consultation with the manufacturer to obtain optimum results. The circulator units will be equipped with a navigational beacon and boater safety kit.
- Monitor effectiveness of circulators. Water quality will be monitored before, during, and after deployment of the circulators, and will include in-situ sampling of water clarity (i.e., Secchi depth), vertical profiles (of temperature, dissolved oxygen, and pH), and epilimnetic chlorophyll *a* and phytoplankton composition. Monitoring will occur in the "treated" Beaver Cove area and other "untreated" areas in Copco reservoir to test for the effectiveness of the circulator's lateral mixing and circulation.
- Prepare a report of findings and recommendations. The information developed during the circulator tests will be compiled in a technical report. The conclusions and recommendations of the report will serve as a guide for potential future expanded deployment of circulators in Copco and Iron Gate reservoirs.

PacifiCorp plans to complete the work itemized above according to the schedule summarized in the following table:

Activity/Milestone	Date or Period
Additional Pilot Testing of Solar-Powered Circulators in Copco Reservoir	
Final planning of circulator pilot tests	March-April 2008
Circulator deployment, testing, and monitoring	May-October 2008
Technical report	Winter 2009

B.4.5 <u>Model-Based Analysis of Potential Drawdowns of Copco and Iron Gate Reservoirs</u>

PacifiCorp plans to conduct a detailed model-based evaluation of potential drawdowns of Iron Gate and Copco reservoirs to minimum operating pool as described in Section B.3 above. The model-based evaluation will utilize PacifiCorp's detailed models of the reservoirs to quantify water quality and hydraulic effects from these potential drawdowns. The tasks and activities associated with this analysis will include:

- Establish objectives and approaches of potential reservoir drawdowns. In order to inform and set-up modeling analyses, PacifiCorp will consult with the State Water Board and other applicable regulatory authorities to establish the objectives and approaches to reservoir drawdowns, including the specific water quality and juvenile fish passage objectives to be met, and the specific timing and magnitude of potential drawdowns of the reservoirs desired to meet these objectives. Important decision constraints will also be indentified, such as requirements for subsequent reservoir refilling and or maintaining cool water storage (e.g., to supply the Iron Gate hatchery).

- Perform modeling of potential reservoir drawdown scenarios. Modeling will be performed using PacifiCorp's water quality modeling framework that was developed for the Project's FERC relicensing studies (PacifiCorp 2004b, 2006). The modeling framework consists of linked reservoir and river models. The reservoir models consist of the two-dimensional longitudinal/vertical hydrodynamic and water quality model CE-QUAL-W2, which is capable of representing a wide range of water quality processes include physical, chemical, and biological processes. The river models consist of a suite of models produced by RMA, including RMA-2, a finite element hydrodynamic model, and the water quality model RMA-11, a full water quality finite element model. Modeling will be performed on scenarios of drawdowns of Iron Gate and Copco reservoirs to minimum operating pool (about 22 feet below the normal pool level in both reservoirs) from May through November using representative model years 2000 through 2004. The model will be used to simulate and evaluate potential effects on reservoir hydraulic and water quality conditions, including hydraulic residence time, mean water column velocities, water temperature and thermal stratification, dissolved oxygen, pH, nutrients, and algal production.
- Prepare a report of findings and recommendations. The information developed from the modeling analysis will be compiled in a technical report. The conclusions and recommendations of the report will serve as a guide for potential future follow-up or actions related to drawdowns of Copco and Iron Gate reservoirs.

PacifiCorp plans to complete the work itemized above according to the schedule summarized in the following table:

Activity/Milestone	**Date or Period**
Analysis of Potential Drawdown of Copco and Iron Gate Reservoirs	
Establish analysis objectives and approaches	Spring 2008
Modeling and analysis	Summer 2008
Technical report	Fall 2008

B.4.6 Effectiveness Testing of Sodium Carbonate Peroxyhydrate (PAK™27) Applications in Copco and Iron Gate Reservoirs

PacifiCorp plans to conduct testing of sodium carbonate peroxyhydrate (PAK™27) applications in Copco and Iron Gate reservoirs for controlling blooms of blue-green algae such as *Microcytis* as described in Section B.3 above. Test applications will be limited to confined areas of the reservoirs or suitable separate enclosures using water taken from the reservoirs. The tasks and activities associated with these test applications will include:

- Consult with applicable regulatory agencies. PacifiCorp will consult with and acquire approvals as needed from the State Water Board and other applicable regulatory authorities prior to testing of sodium carbonate peroxyhydrate (PAK™27) applications in Copco and Iron Gate reservoirs.

- Conduct test applications of sodium carbonate peroxyhydrate (PAK™27). PacifiCorp will conduct test applications during the summer in limited or confined areas in the reservoirs, or suitable separate enclosures using water taken from the reservoirs. For test applications, PacifiCorp will consult with technical experts and manufacturers on the most appropriate application techniques and dosages to use, and will retain the services of experienced and certified (if necessary) professional specialists to perform the applications. Laboratory bench-testing may be conducted to determine these requirements prior to potential limited field tests.
- Monitor effectiveness of test applications. Water quality will be monitored before, during, and after test applications, and will include in-situ sampling of water clarity (i.e., Secchi depth), vertical profiles (of temperature, dissolved oxygen, and pH), epilimnetic chlorophyll *a*, phytoplankton composition, and microcystin concentration. Monitoring will occur in the "treated" areas and other "untreated" areas in the reservoirs to assess the effectiveness of the test applications.
- Prepare a report of findings and recommendations. The information developed during the test applications will be compiled in a technical report. The conclusions and recommendations of the report will serve as a guide for potential future expanded applications of sodium carbonate peroxyhydrate (PAK™27) in Copco and Iron Gate reservoirs.

PacifiCorp plans to complete the work itemized above according to the schedule summarized in the following table:

Activity/Milestone	**Date or Period**
Effectiveness Testing of PAK™27 Applications	
Consultation and final planning	Spring 2008
Test applications and monitoring	Summer 2008
Technical report	Fall 2008

B.4.7 Water Quality Monitoring

PacifiCorp plans to conduct water quality monitoring in the vicinity of the Project during 2008 (monitoring after 2008 will be proposed as appropriate in subsequent revisions or updates of the plan). This monitoring will provide key information for PacifiCorp's on-going assessment of reservoir management plan actions in support of PacifiCorp's application for water quality certification for the Project from the State Water Board and the Oregon Department of Environmental Quality (DEQ).

B.4.7.1 Basic Water Quality Monitoring

Basic water quality monitoring will be done in conjunction with the above studies as a continuation of work carried out in 2001, 2002, 2003, 2004, 2005 and 2007 to describe water quality conditions in the Project area. This monitoring will occur at the following 15 locations:

- Upper Klamath Lake at Fremont Bridge
- Link River
- Klamath River below Keno dam
- Klamath River above J.C. Boyle reservoir
- J.C. Boyle reservoir lower end near log boom
- Klamath River below J.C. Boyle dam
- Klamath River above J.C. Boyle powerhouse
- Klamath River below J.C. Boyle powerhouse
- Klamath River above Copco reservoir (above Shovel Creek)
- Copco reservoir lower end near dam
- Klamath River below Copco No. 2 powerhouse
- Iron Gate reservoir lower end near dam
- Klamath River below Iron Gate dam
- Klamath River at the I-5 rest area
- Klamath River at Walker Road Bridge

Samples and measurements will be taken at the river and reservoir sites monthly January through May, November, and December, and biweekly May through October. This sampling will include instantaneous acquisition of physical parameters (with multi-probe instrumentation) and grab samples for laboratory analysis of water chemistry and phytoplankton. The acquisition of physical parameters will include measurements of water temperature, dissolved oxygen, pH, and specific conductance. These measurements will be taken at the reservoir sites as profiles (at 1 to 3-meter intervals depending on total depth) and at the river sites just beneath the surface (approximately 0.5 m depth). Secchi disk measurements will also be taken at reservoir sites.

Grab samples for laboratory analysis of water chemistry will occur immediately following the physical measurements. Water chemistry samples will be taken in Copco and Iron Gate reservoir at multiple depths at 8 meter intervals, and from the river sites will be taken in the current at approximately 0.5 meter below the surface. Water chemistry samples will be analyzed for nutrients, including ammonia (NH3), nitrate + nitrite (NO3 + NO2), total Kjeldahl nitrogen (TKN), total phosphorous (TP), and orthophosphate (OP). These samples will also be analyzed for total suspended solids (TSS), total volatile solids (TVS), and dissolved organic carbon (DOC).

Grab samples for laboratory analysis of phytoplankton also will occur following the physical measurements. Phytoplankton samples will be analyzed for chlorophyll a, algae speciation, density, and biovolume, as well as microcystin (using the ELISA method). At the Copco and Iron Gate reservoir sites, two phytoplankton samples will be taken: (1) an integrated vertical sample from the surface to 8 meters depth, and (2) a horizontal integrated transect at 0.5 meters depth. Phytoplankton samples from the river sites will be taken as grab samples offshore in the current at approximately 0.5 meter below the surface.

The results of the monitoring program will be used to assess the water quality conditions in the Project area and to examine trends and relationships in these water quality conditions. A technical report describing the results and interpretation will be prepared after the conclusion of the sampling effort.

B.4.7.2 Continuous Monitoring

PacifiCorp will install a continuous automated water quality station below Iron Gate dam to measure water temperature, pH, dissolved oxygen, specific conductance, chlorophyll *a*, and phycocyanin (blue-green algae), and approximate discharge by automated multiparameter data sonde. This will ultimately be a permanent station, but until such time as a permanent structure can be designed and built, a temporary station will be installed in the vicinity of the hatchery bridge below Iron Gate dam.

B.4.7.3 Presence of *Microcystis* and Microcystin Toxins

The presence and quantities of *Microcystis* and associated microcystin toxins will be monitored at several of the sampling locations as described above under the basic water quality monitoring program (see Section B.4.7.1), including the following sites at UKL and in the Klamath River:

- Upper Klamath Lake at Fremont Bridge
- Link River
- Klamath River below Keno dam
- J.C. Boyle reservoir lower end near log boom
- Klamath River below J.C. Boyle dam
- Klamath River above Copco reservoir (above Shovel Creek)
- Copco reservoir lower end near dam
- Iron Gate reservoir lower end near dam
- Klamath River below Iron Gate dam
- Klamath River at the I-5 rest area
- Klamath River at Walker Road Bridge

The phytoplankton samples will be analyzed using a modified counting regime when necessary to more accurately enumerate *Microcystis* in the presence of high numbers of other species (e.g., *Aphanizomenon flos-aquae*). The samples will also be analyzed for microcystin content using the ELISA immunoassay method.

In addition, PacifiCorp will monitor the presence and abundance of *Microcystis* and the concentration of bound and free microcystin in the water during the algaecide treatment trials described in Section B.4.6 above.

B.5 FINAL IMPLEMENTATION AND MONITORING OF WATER QUALITY IMPROVEMENT TECHNIQUES IN COPCO AND IRON GATE RESERVOIRS

Following the various actions, monitoring, and analysis described above, PacifiCorp anticipates preparing a revision to this reservoir management plan that will propose additional decisions and steps to be taken with regard to implementing specific reservoir water quality management actions in Copco and Iron Gate reservoirs. The revision to this reservoir management plan will propose specific technologies and equipment to be implemented, including a specific implementation and monitoring plan, including monitoring components, protocols, locations, and schedules to be followed. PacifiCorp will consult with the State Water Board for implementation and monitoring of these measures.

Monitoring will be a key activity support the reservoir management plan process. Monitoring will provide essential feedback information to assess the effectiveness of the selected techniques in achieving water quality improvements caused by or resulting from loads of organic and nutrient matter from upstream sources (such as summertime algae blooms, dissolved oxygen, and pH). Specific monitoring components, protocols, locations, and schedule will follow the implementation and monitoring plan as developed in consultation with the State Water Board. This step will also involve analyzing data from the monitoring program, assessing results, and incorporating results into future decisions and actions as needed to adjust the reservoir management measures.

B.6 REFERENCES

Asarian, E. and J. Kann. 2006. Klamath River Nitrogen Loading and Retention Dynamics, 1996-2004. Kier Associates Final Technical Report to the Yurok Tribe Environmental Program, Klamath, California. 56 pp. + appendices.

City of Klamath Falls. 1986. Application for License for the Salt Caves Hydroelectric Project. Volume II: Exhibit E. Sections 1.0, 2.0, and 3.0. Submitted to the Federal Energy Regulatory Commission. November 1986.

Cooke, G.D., and Kennedy, R.H. 1989. “Water quality management for reservoirs and tailwaters: report 1, in reservoir water quality management techniques,” Technical Report E-89-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cooke, G.D., E.B. Welch, S. Peterson, and S.A. Nichols. 2005. Restoration and management of lakes and reservoirs. Third edition. Taylor and Francis/CRC Press. 616 pp.

FERC. 2007. Final Environmental Impact Statement for Hydropower License. Klamath Hydroelectric Project. FERC Project No. 2082-027, Oregon and California. Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing. Washington, DC. FERC/EIS-0201F. November 2007.

Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. North American Lake Management Society and Terrene Institute, in cooperation with the U.S. Environmental Protection Agency. Distributed for the North American Lake Management Society. December 2002. 382 pp.

Kann, J., and E. Asarian. 2005. 2002 Nutrient and Hydrologic Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Dept. of Natural Resources, Orleans, California. 59 pp. plus appendices.

Kann, J., and Asarian, E. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005-May 2006. Final Technical Report to the State Water Resources Control Board, Sacramento, California

Knud-Hansen, C., J. Eilers, and S. Walker. 2007. Final Report. SolarBee Circulation Pilot Demonstration Project, Beaver Cove at Copco Reservoir on the Klamath River System, Siskiyou County, California. August - October 2007. Report prepared by SolarBee, Inc., Dickinson, ND. November 26, 2007.

Mobley Engineering Inc. (MEI). 2005. Iron Gate Hydroelectric Project Dissolved Oxygen Enhancement Measures Feasibility Evaluation Report. Prepared for PacifiCorp, Portland, Oregon. Prepared by Mobley Engineering Inc. with assistance from Principia Research Corporation, Hydro Performance Processes Inc., and Reservoir Environmental Management Inc. May 2005. 21 pp. (Attached as Appendix C to PacifiCorp's February 2008 401 Application to the California State Water Resources Control Board).

Mobley Engineering Inc. (MEI). 2007. Reservoir Oxygenation Feasibility Evaluation Report for Copco and Iron Gate Reservoirs. Prepared for PacifiCorp, Portland, Oregon. Prepared by Mobley Engineering Inc. with assistance from WolffWare and Reservoir Environmental Management Inc. October 2007. 41 pp. (Attached as Appendix D to PacifiCorp's February 2008 401 Application to the California State Water Resources Control Board).

PacifiCorp. 2004a. Final License Application. Volume 2. Exhibit E—Environmental Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004b. Final Technical Report, Water Resources. Klamath Hydroelectric Project (FERC Project No. 2082). February 2004.

PacifiCorp. 2006. Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. November 2006. 71 pp.

PacifiCorp. 2007a. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board, Division of Water Quality, Water Quality Certification Unit, Sacramento. Prepared by: PacifiCorp, Portland, Oregon. February 2007

PacifiCorp. 2007b. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2007.

Thornton, K.W., Kimmel, B.L., and Payne, F.E. 1990. Reservoir Limnology, Ecological Perspectives. Wiley-Interscience Publication, John Wiley & Sons, Inc., New York, NY.

United Nations Environment Program (UNEP). 2004. Integrated Watershed Management – Ecohydrology & Phytotechnology – Manual. UNEP, Division of Technology, Industry and Economics, International Environmental Technology Center. 246 pp.